Ministry of Road Transport and Highways
(GOVERNMENT OF INDIA)

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Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III) (Silchar-Vairengte (49.9 km), Vairengte-Sairang (111 km), Silchar-Jiribam (55 km)).

GEOTECHNICAL INTERPRETIVE REPORT (Silchar-Jiribam Tunnel)

Revision -2

From Km 24+910 to Km 25+680

NOVEMBER 2024

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1. INTRODUCTION

Bharatmala Pariyojana is a mega plan of the government and the second-largest highways project after the NHDP. Many defined highway stretches totalling about 50,000 km are proposed to be developed as "Economic Corridors, Inter Corridors & Feeder Routes" under "Bharatmala Pariyojna".

Economic corridors are integrated networks of infrastructure within a geographical area designed to stimulate economic development. These corridors are generally developed to link cities or countries, manufacturing hubs, areas with high supply and demand, and manufacturers of value-added goods, whereas 44nos of corridors are identified. Inter Corridors & Inter-connection between different economic corridors, development of first mile & last mile connectivity. Development of these corridors will help in decongesting 30 top cities in the country by building ring roads and logistics hubs along these corridors. These stretches pass through and connect major hubs of economic activities such as manufacturing clusters, ports etc. Under 'Logistic Efficiency Enhancement Programme', these are proposed to be developed by taking an end-to-end corridor view, rather than stretch-by-stretch road construction view to ensure consistent infrastructure along the corridor.

As a first step towards this task, preparation of DPR for development of Economic Corridors, Inter Corridors and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojana is being undertaken by National Highways Authority of India (NHAI). Numbers of consultants have been appointed by National Highway Authority of India (NHAI), to prepare the Detailed Project Report for identified economic corridors, inter corridors & feeder routes under Bharatmala Pariyojana.

The National Highways & Infrastructure Development Corporation Limited (NHIDCL) has been constituted through an Act of Parliament for faster, economical and quality Road Construction work throughout India.

National Highways and Infrastructure Development Corporation is a fully owned company of the Ministry of Road Transport & Highways, Government of India. The company promotes surveys, establishes, designs, builds, operates, maintains and upgrades National Highways and Strategic Roads including interconnecting roads in parts of the country which share international boundaries with neighbouring countries. The regional connectivity so enhanced would promote cross border trade and commerce and help safeguard India's international borders. This would lead to the formation of a more integrated and economically consolidated South and South East Asia. In addition, there would be overall economic

benefits for the local population and help integrate the peripheral areas with the mainstream in a more robust manner. An approximate aggregate length of 10,000 kms has been identified to begin with for development through this company. The company envisages creating customized and specialized skills in terms of addressing issues like complexities of geographical terrains and addressing extensive coordination requirements with security agencies. The company would also endeavour to undertake infrastructure projects including but not restricted to urban infrastructure and urban or city transport and to act as an agency for development of all types of Infrastructure. The company envisages working towards cross sharing of technical know-how and enhancing opportunities for business development with other nations and their agencies including the multilateral organizations and institutions.

The company also proposes to improve road connectivity and efficiency of the international trade corridor, by expanding about 500 KMs of roads in the North Bengal and Northeastern region of India to enable efficient and safe transport regionally with other South Asia Sub-regional economic Cooperation (SASEC) member countries. These projects are being funded by ADB (Asian Development Bank).

M/s. Transys Consulting Pvt. Ltd. has been appointed as consultants by National Highway Infrastructure Development Corporation Limited (NHIDCL), to prepare the Detailed Project Report for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India (Lot-1, Package-II) for Silchar- Vairengte (49.9) km section of NH-306), Vairengte-Sairang (111 km) section of NH-306 and NH-06 and Silchar-Jiribam (55 km)) section of NH-37 for a total length of 215.9 km.

NHIDCL will be the employer and executing agency for the consultancy services and the standards of output required from the appointed consultants are of international level both in terms of quality and adherence to the agreed time schedule. The consultancy firm will solely be responsible for submission of quality work in the stipulated period.

The Letter of Acceptance was issued on 22nd March 2018 vide letter ref no NHIDCL/Bharatmala/DPR/Phase-I/Lot-1/Package-III/2017/66 and the letter regarding commencement of services was issued on 02nd July 2018 vide letter ref no. NHIDCL/Bharatmala/DPR/Phase-I/Lot-1/Package-III/2017/107. The contract agreement was signed on 19.06.2018.

However, after successful submission of Draft DPR vide through letter Transys / B'Lore /410/Silchar-Sairang/ 2021-22/40386, it was conveyed by NHIDCL that pkg. pertaining to Silchar – Jiribam (SJ)

section shall be on hold as the project stretch has not been included in the priority list in FY 2022-2023 due to uncertainty of 4-lane development of said stretch.

Later, in the month of May 2023 the said project had been reopened under the direction of MD & D (T) during VC meeting and DPR had been asked to accelerate the remaining pending assignment pertaining to said project as the project stretch was included under current year (FY 23-24) development plan.

Final DPR was submitted vide through letter no. Transys / B'Lore /410/Silchar-Sairang/ 2022-23/404037 dated but collectively decision was taken to bifurcate the project corridor in to two (02) packages due to tunnel proposal & its cost implication and several other constraints.

Hence, project corridor has been divided in to two packages. The current Tunnel design study falls under Package: SJ-2 under Change of Scope (COS) vide through letter no. NHIDCL/Assam/DPR/Lot-I/2023/230635/2998 dated 05.02.2024.

1.1 Project Background and Objectives

Recognising the need for improvement of capacity of road network in tune with intensity of traffic, the Ministry of Road Transport and Highways (MoRT&H) acting through the National Highways Infrastructure Development Corporation Ltd. (NHIDCL) has decided to take up the development of various National Highways stretches/Corridors of 10,000 kms out of 50,000 kms under proposed Bharatmala Pariyojna.

The project roads under Lot-1/ Package-3 comprise of following three stretches which are part of four Economic Corridors.

1) Silchar to Vairengte (Part of Silchar-Aizawl Economic Corridor NER) in the state of Assam and Mizoram.

2) Vairengte to Sairang (Part of Silchar-Aizawl Economic Corridor NER) in the state of Mizoram.

3) Silchar to Jiribam (Part of Silchar-Imphal Economic Corridor NER) in the state of Assam and Manipur.

The main objectives of the Consultancy Services are to establish the technical, economical, and financial viability of the project and prepare detailed project reports for development of economic corridors, Inter-corridors and feeder routes, as the case may be. These corridors are proposed for development to at least

4-lane access controlled (fully access control for Economic Corridors), however, DPR for access controlled 6-laning/8-laning may be required, in certain stretches, depending upon traffic.

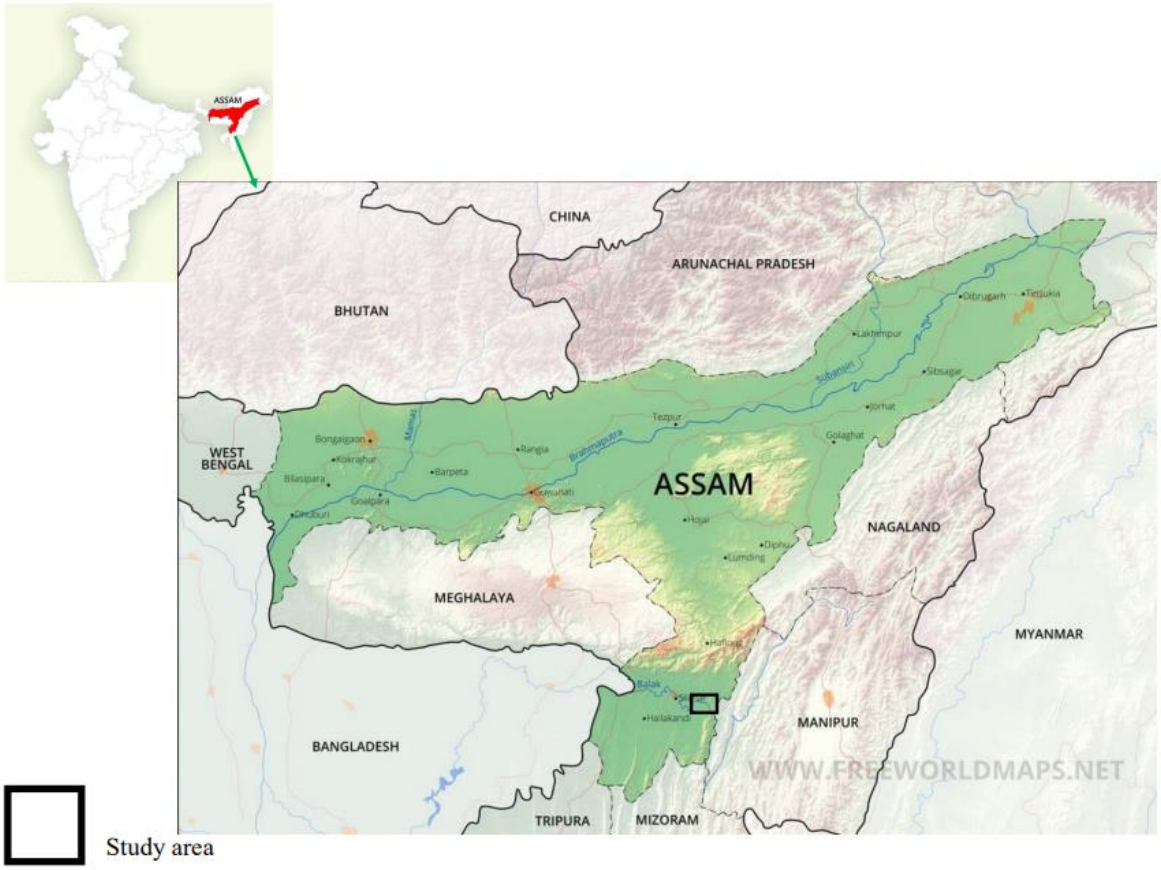


Figure 1: Location Map of Silchar Tunnel

1.2 Project Road (Silchar to Jiribam)

Project road from Silchar to Jiribam starts existing at Km 260+000 (Design Ch. 4+560) of NH-3 and end with existing km 212+060 (D. Ch. 37+650) of NH-37. Total Design length of the proposed 4-lane road turn into 33.09 km corresponding to existing length 47.940 km. The project corridor further divided in to 2 packages viz.

1. Package: SJ-1 (Existing km 260+000=D. Ch. 4+560 to existing km NA= D. Ch 24+560).
2. Package: SJ-2 (Existing km NA= D. Ch 24+560 to Existing km 212+060=D. Ch 37+650).

Table 1: Silchar to Jiribam Stretch Details

Sl. No	Construction Packages	Design chainage			Existing chainage			Bypassing to
		From	To	Length (KM)	From	To	Length (KM)	
1	Package SJ-1	4+560	24+560	20	260+000 on NH-37, Assam	233+000 on NH-37, Assam	27.000	(Kasipur,Banshkandi, Paiilapool,Fulertal, etc.)
2	Package SJ-2	24+560	37+650	13.09	233+000 on NH-37, Assam	212+060 on NH-37, Assam	20.940	Uttar Lalpani, Jirighat,Jiribam, etc.)
Total Design Length				**33.09**	**Total Existing Length**		**47.940**	

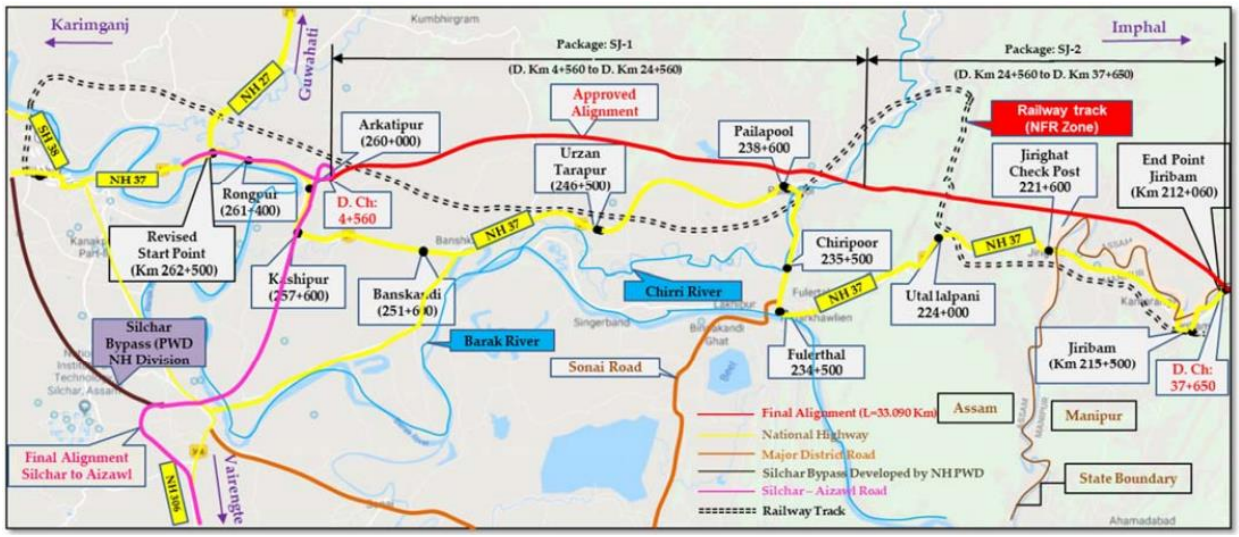


Figure 2: Project Corridor as per CA (Silchar -Jiribam)

1.3 Project Aim and Scope

Road tunnels are feasible alternatives to cross a water body or traverse through physical barriers such as mountains, existing roadways, railroads, or facilities; or to satisfy environmental or ecological requirements. In addition, road tunnels are viable means to minimize potential environmental impact such as traffic congestion, pedestrian movement, air quality, noise pollution, or visual intrusion; to protect areas of special cultural or historical value such as conservation of districts, buildings or private properties; or for other sustainability reasons such as to avoid the impact on natural habit or reduce disturbance to surface land.

Tunnels are expensive highway structures. Therefore, the construction costs and the operating and maintenance expenses should be considered at the design stage of a highway project. Design elements

such as the alignment and the cross-section should be determined in such a way as to find the right balance between the driver's comfort and safety, on the one hand, and the cost of the tunnel, on the other hand. This report presents a method that will enable to selection of the optimal cross-section and alignment by evaluating the economic costs and benefits of a tunnelling project at an early planning stage.

The proposed green field alignment was crossing the Jirighat forest area fromd design Ch. Km 23+600 to design Ch. Km 27+000. In order to reduce the length of the alignment and to avoid huge cut and fill, a tunnel of length approx. 770m has been proposed. The approximate length along green filed alignment comes to is 33.090 Kms as compared to existing road length of 47.700 Kms causing a drastic reduction in length due to the proposed tunnel. The twin tube tunnel proposal was discussed during the presentation furnished on 15th January 2019 and 14th August 2019 at NHIDCL HQ, Delhi and green filed alignment (Option-V) was agreed by all the delegates during the presentation followed by letter no NHIDCL/Bharatmla/V-S/ DPR/ Mizoram/2019-20//353 on 23rd October 2019.

1.4 Location Details

The project road is part of NH-37 (old NH-53) (Sutarakandi-Bhali NH road), connecting Sutarakandi, silchar and Jirighat having a total existing length of 55.00km from Silchar to Jiribam corresponding to design length of 33.090 km. The proposed tunnel is a part of package SJ-2, from Design Chainage Ch 24+560 to Design Chainage 37+650 with a total length of 13+090km. Details of the proposed tunnel is given in the table below.

Table 2: Twin Tube Tunnel details

Sl. No	Type	D.Chainage of West Portal	D.Chainage of East Portal	Tentative length (m)
1	Twin Tube Tunnel	24+910	25+680	770m

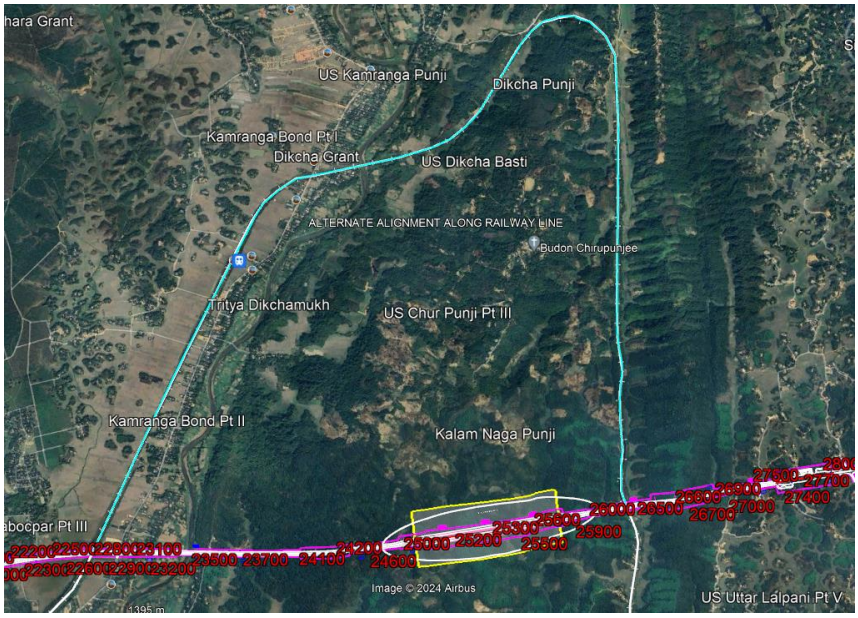


Figure 3: The Old and New Alignment

Figure 4: Plan and Elevation Profile of Proposed Tunnel

1.5 Seismicity

Earthquakes are a harsh reality for all tectonically active regions. Constraints in earthquake prediction amplify the importance of effective planning, preparedness, and mitigation for saving lives and property and reducing the misery of the affected population. Assessment of seismic vulnerability is however a necessary precondition for realistic planning and effective mitigation. Rapid Visual Screening (RVS), together with Geographical Information System (GIS) and remote sensing tools, have been utilized in the

present study for assessing seismic vulnerability of the built environment of project area that fall in seismic Zone V (Fig 5) of Seismic Zoning Map of India.

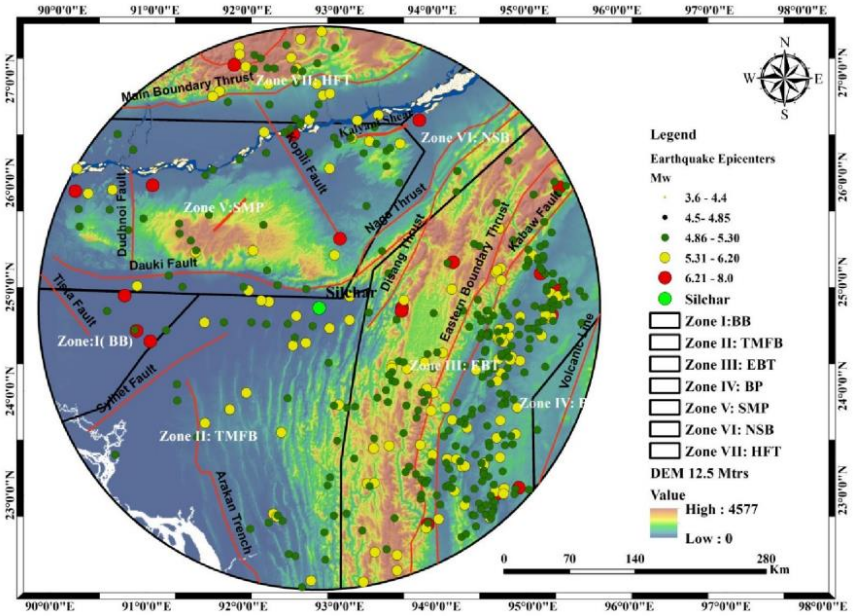


Figure 5: Seismotectonic map showing earthquake epicentres around 300km radius of Silchar.

The entire north-eastern region lies in the highest seismic zone i.e., zone –V in the seismic zonation map (BIS 98) of the country.

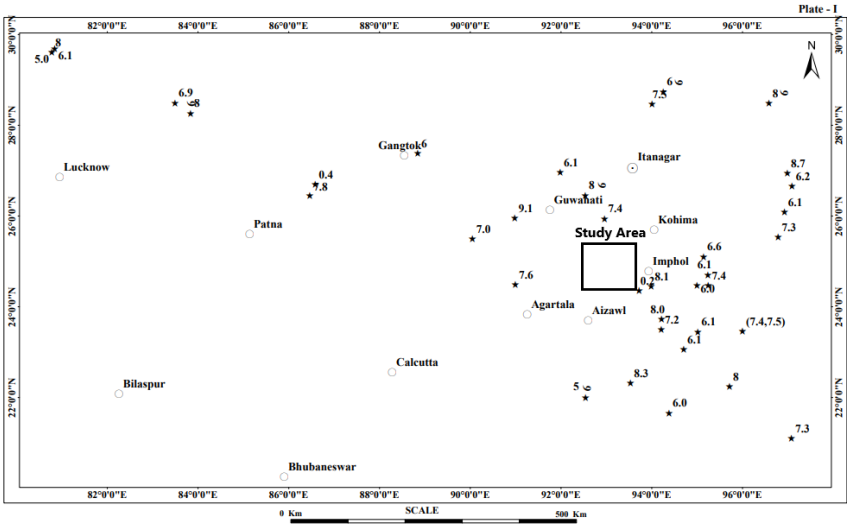


Figure 6: Epioentral plot of earthquakes with Mb A = 8 for the period 1827 - 1900

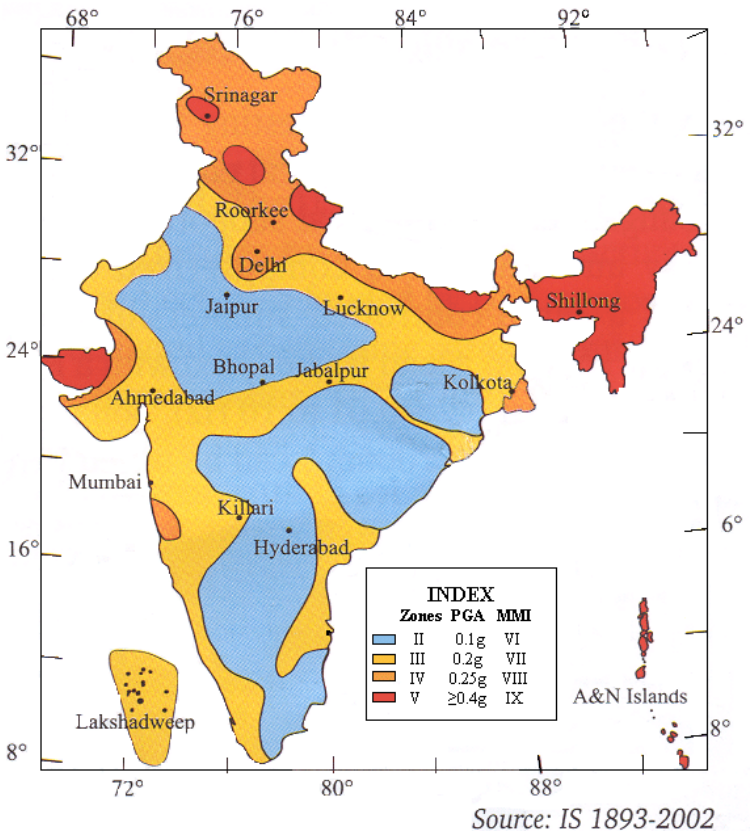


Figure 7: Seismic Zonation Map of India

1.6 Climate and Rainfall

The climate of the Silchar District is largely controlled by the South-West monsoon and seasonal winds. The district experiences a fairly high temperature for most part of the year. The rainfall varies from place to place and the average rainfall recorded is 350 cms, of which more than two-thirds occur during the monsoon and the winter being practically dry. Normally the district receives maximum rainfall during the month of July to August where it began to recedes towards the end of October.

Minimum temperature recorded during the month of January is 11.32°C and the maximum in the month of August which is 36.58°C as per the annual temperature for the year 2019. The climate of District is warm and humid, except in winter. The average annual rainfall is about 1,150 cm. The study area experiences sub-tropical and humid climate. The total annual rainfall is 1,145 mm. The seasonal distribution of rainfall is 31.85% in pre-monsoon, 54.87% in monsoon, 9.77% in post monsoon and 3.56% in winter season (Central Ground Water Board, NER, 2013).

Silchar has a borderline tropical monsoon climate slightly too hot in the summer and cool season during winter or to qualify as a humid subtropical climate. During this cool season the weather is generally warm and dry with cool to mild mornings; however, the "wet" season begins early as the monsoon moves into the region during April, with the result that for seven months of the year Silchar has very hot and humid weather with heavy thunderstorms almost every afternoon until the middle of October, when there is usually a brief period of hot and relatively dry weather before the "cool" season sets in during November. The average annual temperature in Silchar is 24.9 °C | 76.8 °F.

YEAR	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEPT		OCT		NOV		DEC	
	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP
2014	0.0	-100	17.4	-65	43.2	-74	155.2	-41	634.4	64	530.8	0	591.9	12	491.8	4	434.3	20	74.2	-59	0.1	-99	0.0	-100
2015	4.6	-66	11.1	-78	13.1	-92	470.7	79	301.9	-22	419.8	-21	442.4	-16	417.9	-11	335.3	-7	91.8	-50	6.8	-81	11.3	-1
2016	3.5	-74	63.8	27	82.4	-51	565.9	116	460.4	19	336.1	-37	451.5	-14	346.6	-26	526.7	46	186.5	2	65.3	88	10.8	-5
2017	0.0	-100	38.5	-23	318.7	89	408.6	56	306.2	-21	584.2	10	480.0	-9	564.5	20	200.3	-44	362.7	99	10.2	-71	101.0	786
2018	3.4	-75	14.5	-71	133.3	-21	212.8	-19	387.8	0	546.3	3	342.0	-35	363.1	-23	400.5	11	122.5	-33	14.6	-58	30.8	171

Figure 8: Rainfall data of Cachar district, Assam (in mm) from 2014 to 2018.

1.7 Groundwater

The presence of favorable sandstone aquifers in the Middle and Upper Bhuban formations leads to the extraction of ample potable water from borewells drilled into these horizons. Groundwater is accessible in the valley areas, while the ridges may not always have an adequate supply of groundwater, as rainfall on the hill slopes quickly drains into the valleys as surface runoff along the slope planes. Springs are seldom observed in the lower sections of the region in specific locations. The region is moderately sloped and groundwater from the spring drains to valley area.

As per CGWB 2013 report, the ground water occurs in phreatic condition in shallow aquifer and semiconfined condition in deeper condition. The area mainly represents a water-logged area. Premonsoon water level is 1.05m bgl, while post-monsoon water level is 1.62m bgl. The water level fluctuation in Cachar district is generally <1m. However, the area near Mohanpur, Srikona and Rongpur the water table ranges from 4.412 to 6.96m bgl.

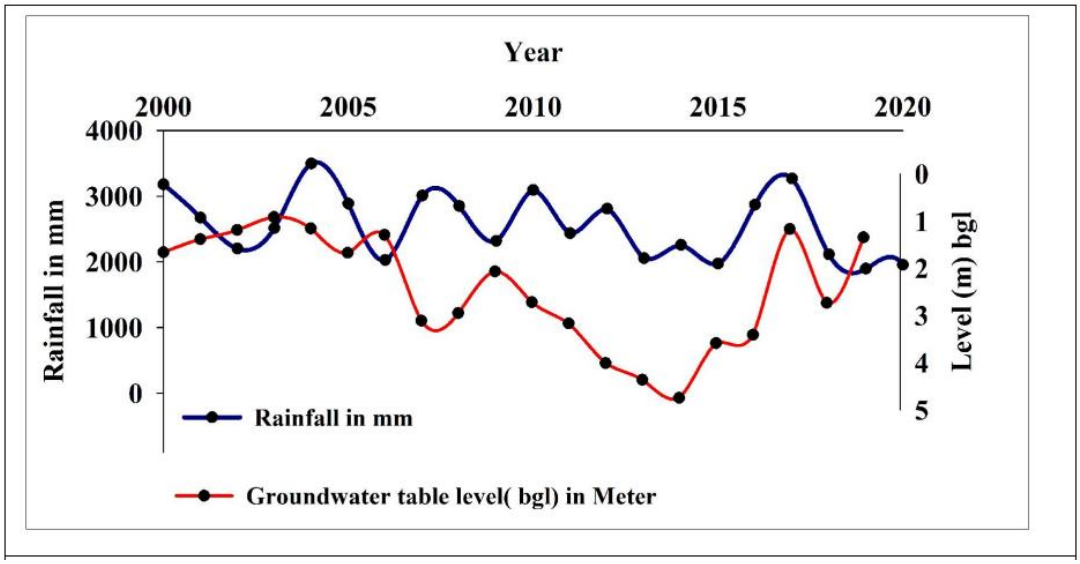


Figure 9: Rainfall from 2000 -2020 in Silchar

1.8 Geomorphology

The scientific study of topography and regional geology is enumerated in this report. The entire Cachar district is surrounded on three sides by the hill ranges of Manipur, Mizoram & Meghalaya. The district is characterized by undulating topography with rugged hill terrains with plain low lands in between. The ridge coincides with the elongated anticlinal structures, part of Assam-Arkan fold belt. The intervening area corresponds to synclinal trough, which exhibit an immature topography. The river valleys constitute the plains of the area. Apart from the main Barak valley, the other valleys are Madhura, Dalu and Tikal etc. Madhura, Dalu and Tikal river having southerly flow and finally meet the Barak river.

1.9 Flora and Fauna

In Silchar, the vegetation is mostly of Tropical evergreen and there are large tracts of Rainforests in the northern and southern parts of the district, which holds Tiger, Asian elephants, hoolock gibbon, Gaur etc. The forests of Cachar were once rich in wildlife but now vanishing due to human onslaught. Rare species found are Hoolock gibbon, Phayre's leaf monkey, Pig-tailed macaque, Stump-tailed macaque, Masked Finfoot, White-winged Wood Duck etc. The Asian elephant is already extinct. Dhaleswari wildlife sanctuary and Borail Wildlife Sanctuary are the wildlife sanctuary of the district as well as in Barak valley region.

2. REGIONAL GEOLOGY

The Barak valley, comprising a contiguous region of three south Assam districts of Cachar, Hailiakandi and Karimganj, represents a ridge and valley province with meridional to submeridional anticlinal hills and synclinal valleys (Nandy, 1989; Lasker and Phukon, 2013). Thin skinned tectonic resulted in the deformation of Neogene clastics which manifested in the form of anticline and synclines. The study area falls within the Cachar district forms part of the Tripura-Cachar-Mizorma frontal fold within the greater Assam-Arakan geosynclinals basin. The total sediment cover in this area is about 10-12 km with Neogene rocks forming the bulk.

Cachar-Tripura-Mizoram Frontal Fold Belt within the greater Assam-Arakan Tectono – sedimentary basin is part of a foredeep accretionary basin between Indian craton and IndoBurmese plate collision Zone. The general depositional events of the area consist of a repetitive succession of Neogene arenaceous and argillaceous sediments, known as rhythmites, with thinning upward sequence (Nandy, 2001).

The area exposes geosynclinal Tertiary sediments of Barail, Surma, Tipam, Dupi Tila and Dihing Groups with recent formations. These Groups have been divided into different formations based on the dominance of clastic components and have been tentatively correlated with the standard sub-division of the rocks of Surma valley. The oldest rock present in the area belongs to Barail Group which consists of repetition of arenaceous and argillaceous sediments. The repeated cycle of arenaceous and argillaceous facies in Barail Group of rocks indicate synsedimentary upheaval of the basin floor and its rhythmic subsidence's matching with the sedimentation. Barail Group is comformably overlain by Bhuban Formation of Surma Group. In the Surma foredeep, simultaneous sedimentation and sinking gave rise to a huge pile of sediments of Surma Group. Intraformational conglomerate within the Surmas may indicate the existence of land condition from time to time. The comparative coarse sediments, sandstone/shale ratio and micaceous nature of Surma Group of rocks represent molasse condition of deposition. Bhuban Formation is essentially an alternation of sandstone, shale, siltstone and intraformational conglomerate. Boka Bil Formation of Surma Group is predominantly argillaceous in nature. This formation is conformably overlain by Tipam Sandstone Formation of Tipam Group. Tipam Sandstone Formation comprises of medium to coarse grained, massive, profusely current bedded sandstone. On top of Tipam Sandstone Formation there is a pronounced unconformity over which rocks of Dupi Tila Group are deposited

followed by rocks of Dihing Formation and recent formation. Quaternary deposits comprises mainly of terrace and alluvium.

Terrace bed in the area represents older alluvium occurring in strips at a level of 15 m to 30 m above the present alluvial level. Structurally the area is characterised by a serious of meridional to sub-meridional, arcuate, elongated, doubly plunging, asymmetric folds arranged in an en-echelon pattern, trending N-S to NNE-SSW with slight convexity towards west (Ganguly , 1983, 1984). The fold belt region is tectonically bounded towards the north by the Dauki Fault and Haflong-Disang Thrust in the east and in the south by Arakan –Yoma Fold Belt, while, in the west it is bounded by the Hail-Haka-Lulu Lineament and Chandpur-Barisal High (Nandy et al. 1983) Seshavataram et al.1998 reported major seven folding in the Cachar area, they are as follows,

a) Adamtila-Patharia

b) Longgai-Chorgola

c) Chhatachura-Kanchanpur-Chandipur-Badarpur-Hilara-Narayanchara-Shahbazpur

d) Bhairabi-Masimpur-Indranagar

e) Rengete-Pathimara

f) Teidukhan-Ramphan-Tukbai

g) Bhuban –Digli

These anticlines separated by synclines as follows

a) Nilambazar

b) Singla

c) Katakhal

d) Silchar

e) Labak

The following generalised litho-stratigraphic succession established for the Cachar area by Sharma et al. 1976 & GSI Misc. Publ. No. 30, Part-IV.

Table 3: The General Lithographic Structure of the Study Area

Age		Group	Lithological Description
Quaternary	Recent to Pleistocene		Pebble bed (Terrace), clay, sand, silt, river shingles
			Unconformity
Tertiary	Pliocene	Dihing	Dihing Formation: Pebble bed, soft clay, mottled sandstone
	Mio-Pliocene	Dupi Tila	Dupi Tila Formation: Soft friable ferruginous sandstone,mottled clay,blocks of latertic conglomerate with pockets and layers of pebbles
			Unconformity
	Miocene to Pliocene	Tipam	Tipam Formation: Medium to coarse grained, bluish grey to ferruginous sandstone with clay and shale and conglomerate; fossilwood common
	Miocene	Surma	Boka Bil Formation: Shale, sandy shale, Calcareous shale, siltstone, mudstone and lenticular ferruginous sandstone with Intra-forma tional conglomerate Bhuban Formation: Alternations of sandstone, shale,siltstone and thin conglomerate bands with fossil wood
			Unconformity
	Eocene to Oligocene	Barail	Renji Formation: Massive and bedded sandstone and shale layers Jenam Formation: Shale, Sandy shale, corbonacerus shales, with streaks of coal

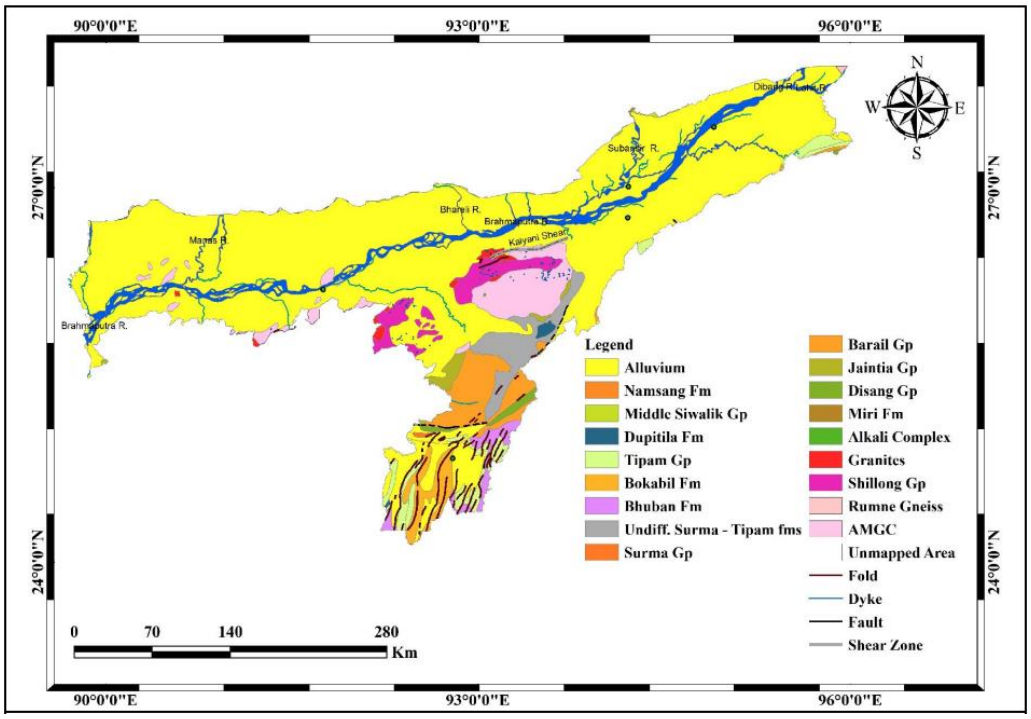


Figure 10: The Regional Geological Map of Assam

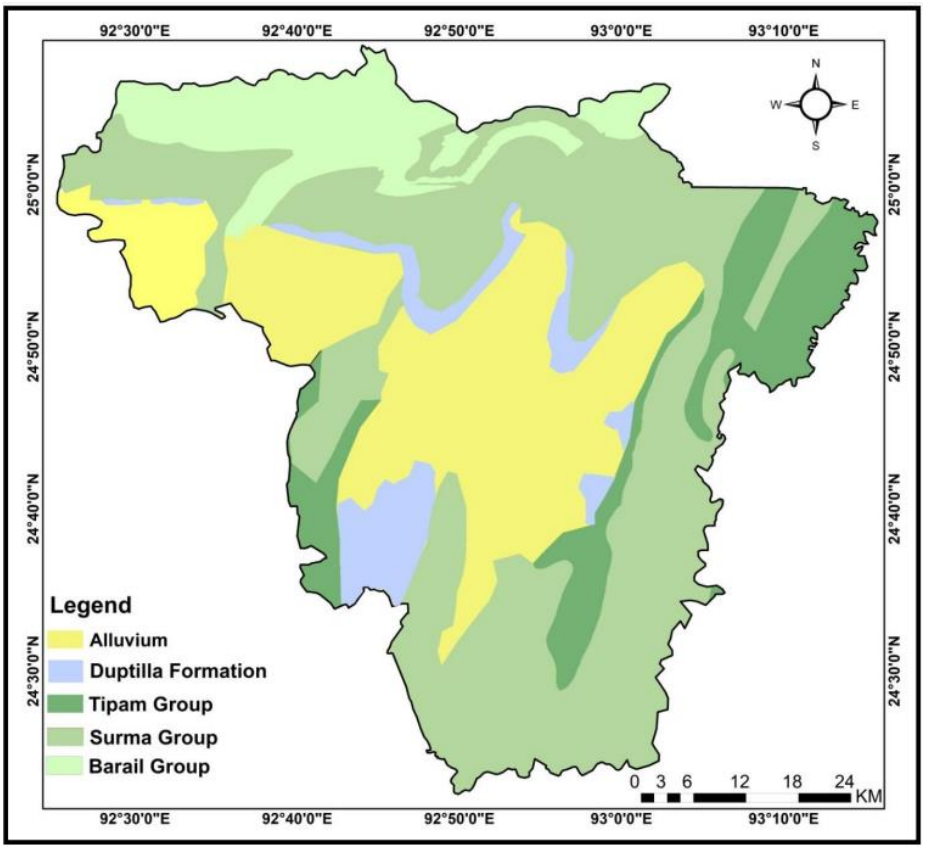


Figure 11: Geological Map of Cacher District

The area under study comprises of geosynclinal sediments from Miocene to recent. The area contains following lithounits as per the initial study.

- **SURMA GROUP**

The Indo-Burmese Ranges (IBR) is comprised of the syn-collisional flysch and post collisional molásse sediments (Khaidem 2015). The flysch sediments are represented by the Disang Group (Late Cretaceous to Late Eocene) and the Barail Group (Late Eocene to Late Oligocene). The molásse sediments are represented by the Surma Group (Late Oligocene to Miocene). The Surma Group is divided into a lower arenaceous facies-Bhuban Formation and the upper argillaceous facies-Boka Bil Formation.

- **Bhuban Formation**

Bhuban Formation comprise an alternation of sandstone sandy shale, siltstone with intervening thin layers of shale and conglomerate. Bhuban further classified into Lower, Middle and Upper based on the change in facies. Lower Bhubans are alterations of well bedded sandstone and shale/siltstone having

conglomerates at the base representing the regional unconrfinmity with underlying Barail Formation and type are for this is Bhuban Hills in Cachar District. The sandstone of lower Bhuban is medium to thick bedded , fine to medium grained , hard and compact , grey to bluish grey in colour. Middle Bhuban sequence grades into an argillaceous facies represented by massive and conchoidal shales with one or two thin bands of sandstone. Whereas, in Upper Bhuban the middle Bhuban shale gradually pass into a dominantly arenaceous facies represented by massive to bedded sandstone with minor claystone /shale. The Bhuban sediments found in the core of Masimpur anticline with massive sandstone with interbedded shale dissected by numerous strike faults and cross faults. This makes cascades and waterfalls.

- **Boka Bil Formation**

The youngest formation of the Surma Group is represented by the Boka Bil formation predominantly argillaceous in nature. The type area for the Boka Bil formation is Masimpur, Silchar. This is dominantly a soft shale sequence with good amount of silty sandstone. The shales are grey, greenish grey, soft fissile and often micaceous.

- **TIPAM GROUP**

Tipam Formation is in gradational contract with underlying Boka Bil Formation of Surma Group. It is manly arenaceous in nature with thick to massive multi storied sandstone, with bluish grey to light grey in colour , medium to coarse grained with bleached nature enriched with mica and ferromagnesium minerals. In most of the place this formation is associated with crossbeds, herringbone structure, rhythmites etc. The interbedded shale or siltstone in Tipam formation are of bluish grey to grey, hard and compact in nature.

- **DUPI TILA GROUP**

The youngest Formation of the Neogene, Dupi Tila Formation exposed in this area is mainly represented by coarse, gritty sandstone with minor clay and siltstone. It has an unconfomable contact at the base as well as the top. This unit is made up of mottled claystone with frequent lenticular interbeds of white sandstone. The claystone is blusih grey in colour (mottled with verigated colours at places), silty, poorly laminated to lumpy in nature. Hard iron stone like siliceous thin interbed and siltstone bands are common. The interbeded sandstone are white in colour due to weathered feldspar, fine grained and micaeous at

some places. This sandstone are highly laterised with hard ferruginous encrustation on weathered surfaces and lignite bands at some places. Occasionally, clay, pebble rich zones are seen within the sandstone.

- **DIHING GROUP**

The name was first given by Mallet 1876 after the River Dihing in upper Assam, type section. Dihing group consists of conglomerates, grits, sandstones and clays. Within the study area this is exposed near Dudhpatil as an isolated hill/hillock but mostly weathered, and in Salganga river section near Silkuri area.

- **QUARTERNARY SEDIMENTS**

Quaternary deposits in Silchar mainly comprises of terrace bed and alluvium. Within the city master plan area, Quaternary deposits comprises only of recent flood plain deposit or younger alluvium. Younger alluvium in the Barak basin comprises point bars, channel bars, levee, backswamp, flood basins etc. This surface is confined to the main channel of Barak River and the extensive low lying area on either side of the Barak River. Bil complexes, meandering cut offs and Ox-bow lakes forms the older alluvium, where the settlements exist. In rainy season the flood water crosses the danger mark in Barak River. The quaternary sediments within the valley is characterised by Sand, silt and clay.

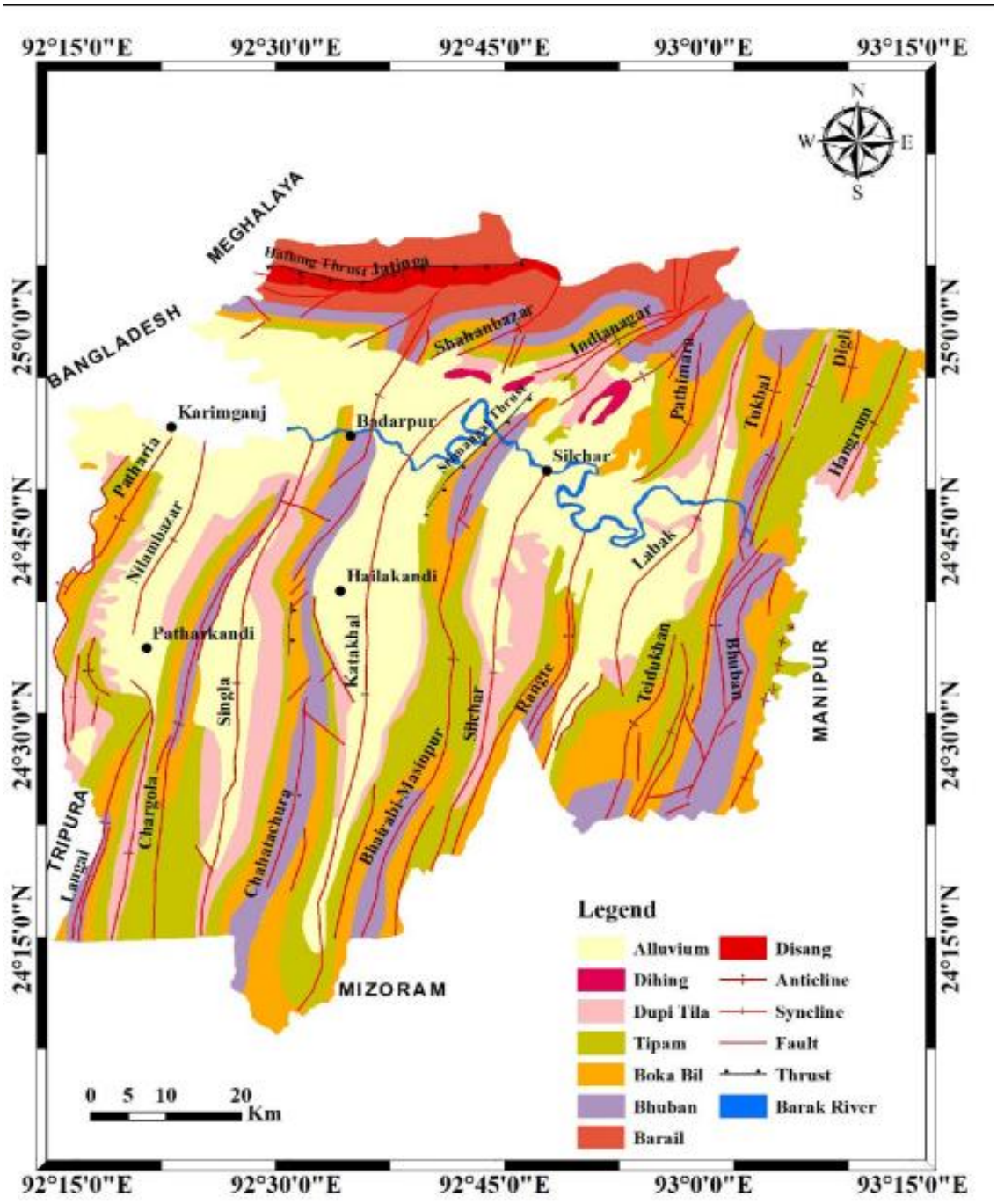


Figure 12: Geological Map of the Project Area

2.1 Primary and Secondary Structures

Structurally study area is mainly consisting of Bhairabi – Masimpur (B-M) anticline in the NW and Silchar Syncline in the Central part of the area. Western boundary of B-M anticline is bounded by Srikona Thrust (Part of Srimangal Thrust) in the west and Kaladan Fault in the Far East. The Neogene clastic arenaceous and argillaceous sediments are well preserved with primary and secondary sedimentary structures, as follows: Primary structures like bedding plane and laminations are observed in all formation, which are easly distinguishable in Dupi Tila, Boka Bil and Bhuban Formations. On the other hand, in Tipam Formation, false bedding, herringbone, rythemites, flames etc were observed near Dulo TE and Sildubi. Ripple marks mainly observed in middle Bhuban near Kukumpari and Massimpur part –II. Secondary sedimentary structures like Penecontemporaneous deformation structures (PCD) such as flame, slump, clay balls, load cast, paleo sand dykes etc were observed mainly in the transitional contact area between Boka Bil and Tipam near Sildubi, Natun Kanchanpara and Halter TG areas. Iron encrustations in the form of nodules and tabular (pseudo tracefossils?) forms are seen near Chenkoori.

2.2 Depositional Environment

Middle Oligocene Baril ranges undergone orogeny and opened a foredeep in Miocene, where an open sea hosts the sediments of Bhuban. Later progressive upliftment and slow sedimentation caused formation of a lacustrine to lagoonal environment and gave rise to the Boka Bil rythmite with alternate shale-siltstone. This slow progress in the facies is visible in the gradational contact of marine Bhuban to lagoonal Boka Bil (Surma) in many parts of Silchar. During middle Miocene, further upliftment in Barail ranges caused the crumbling of Surma foredeep and caused fresh water condition with current direction from north to south and south east, and formed high energy fluvial Tipam Sediments. Top of the crumbled sediment were above water level and exposed for aerial oxidation. Rapid deposition of clastic sediment from Northern Province due to continuous tectonic disturbances characterised Tipam sandstone with gritty nature and occasional silt and clay indicate calm environment. Further, presence of herringbone structure in lower Tipam indicate tidal environment. Fossil wood in Tipam sandstone indicate warm climate condition (Shrivastava, 1974, Dutta and Mohanty, 1974, Buragohain and Sarma, 1999). Road section along Silchar-Hafflong is the best place to observe all depositional environment like tidal channel, tidal flat and fluvial channel in the form of herringbone, tidal rythmites and cross beds in Tipam formation. At the end of Pliocene, the folded belts have undergone further deformation and opened fresh water basin

and high energy fluvial, point bar, channel bar, lag deposits of Dupi Tila formation got deposited with angular unconformity with underlying Tipam and Surma group of rocks. Endogenetic process is still going on in this area.

2.3 Tectonic Frame Work of the Study

The Cachar is bounded by many active fault systems, among which Dauki Fault and Naga Thrust is present in the north and Gumti fault in the north west region; Chittagong Coastal Fault (CCF) in the west and Kaladan Fault (KF), Churachandpur-Mao Fault (CMF), Kabaw Fault (KF) and Sagaing Fault (SF)are in the east.

The northward movement of Indian plate has been slow down and led to a counter clockwise rotation of Indian plate initiating its NNE movement and an oblique subduction. This NNE movement of Indian plate further caused the Indo-Burma-Andaman Block to rotate clockwise (Acharya, 1998, Alam et al., 2003) from its initial E-W orientation. This also led to a hard Continent-Continent Collision of Indian plate with Eurasian plate with hyper oblique subduction (Aung et al.2020) of oceanic crust below the Burmese Plate in the east resulting the formation of Indo-Burman accretionary wedge. Tectonic evolution of Cachar area has three stages.

1. The collision of Indian and Burmese plate resulted first compressive stress deformation (D1) and formed N-S trending westward verging thrust and a series of parallel anticline and syncliene(F1) during early Miocene involving the Neogene succession in a thin skin tectonism (Alam et al., 2003). The deformation is limited in west by Chittagong Coastal Fault (CCF).
2. Further, opening of Andaman Sea caused the clockwise rotation of Indian plate (D2). Andaman sea has caused a major right lateral transform, which changed from subduction to strike slip convergence (Curray, 2005). This opening and widening of Andaman Sea led to the formation of a tectonic entity called Burmese silver platelet (Steckler et al., 2008; Khan and Chakroborty, 2005), which is bounded by Sagaing Fault in the east and probably Kaladan Fault in the west. This plate is considered to advance over the Indian Plate sliding sideways along its bounding faults. This caused the NE-SW trending strike slip deformation resulting in a block couple rotation and formed NE-SW and NW-SE cross faults (F2), which caused the rotation of N-S anticline and syncline to NNE-SSW.

3. The activity of Dauki fault and the upliftment of Shillong Massif (D3) induced a N-S compression resulted E-W trending reverse fault(F3).Due to this compression the earlier developed parallel NNE-SSW anticlines (A1) got bend and diverged outward and formed tight anticline and broad syncline (Mazumder et al. 2016).

2.4 Faults and Thrusts

The present study area, Silchar, part of Cachar District, Assam, falls in Cachar –Tripura thrust –fold belts, which is the central compressive front of Assam-Arakan thrust and fold complex, which are developed as an accretionary wedge due to the subduction of Indian Indian plate under Burmese plate. The strike slip movement was confined to the east of Kaladan fault and along the N-S trending Sagaing fault while the compressive front propagated westward forming Cachar-Tripura fold belt in its wake. Major structural elements of the area are a series of N-S to NE-SW trending anticlines arranged in en-echelon pattern separated by broad synclinal valley (Laskar and Phukon 2013). These folded lithounits in the study are dissected by strike fault (NE-SW trending major Faults with minor faults of NW-SE). These faults forming step like apprearance in Ghagra river near Chenkoori and Masimpur area. Indication of Srikona thrust is observed in Masimpur Part II, Madhura Quarry and new Kanchanpara areas.

2.5 Folds

Rocks in the study area are folded in N-S to NE-SW trend of Silchar syncline and Masimpur anticlines. The folds are sub parallel and en-echeolon type. The anticline is tight forming geomorphological hills with Neogene sediments, and differential erosion in the lithounits of anticline have resulted in the formation of series of geomorphic features like linear cuesta ridges and strike valleys whereas synclines are broad forming valleys (Laskar and Phukon 2013). The steeper flanks of the anticline in the western and eastern part are generally dislocated by longitudinal listric reverse faults. Also, the cross fault leads to upward warping of syncline troughs known as structural inversions, as a result pseudo anticline is formed at the trough of the syncline, which forms denudation ‘Tila’ in valleys.

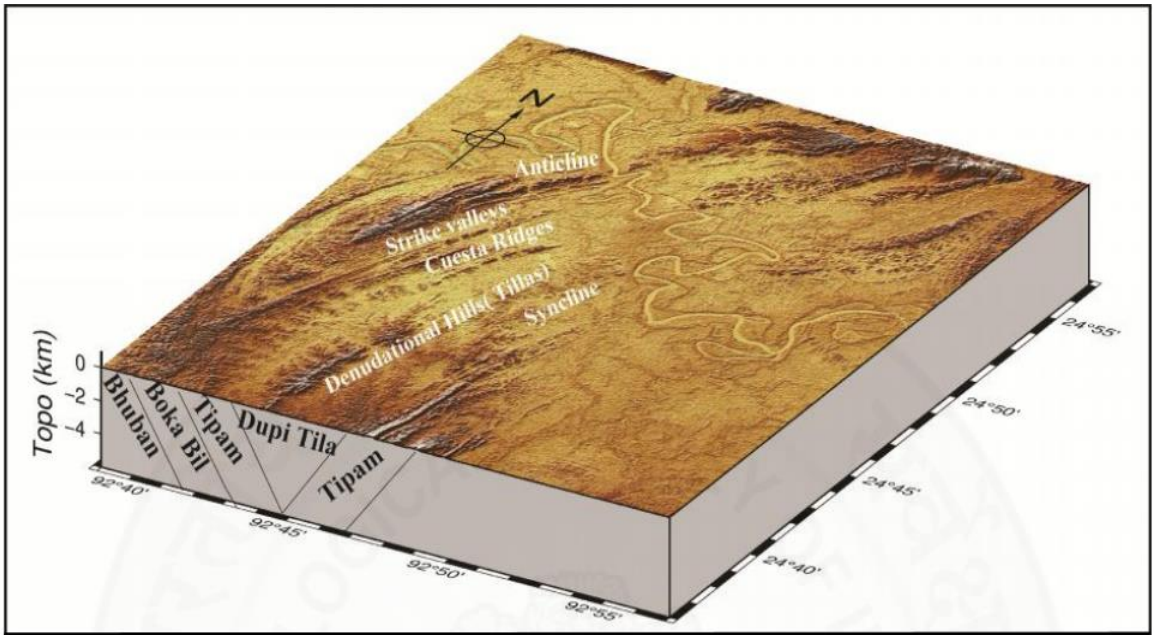


Figure 13: Geological Structures in the Geological Formations

3. INVESTIGATIONS

3.1 Topographic Survey

Detailed component specific topographic survey of the project area has been completed and detail topographic survey plans and sections have been developed under various scales.

3.2 Geological Mapping

The detailed geological mapping of the project area has been completed and geological plan and sections have been developed under various scales. The list of geological plan and sections has been provided in Table below and drawings have been enclosed in Geological Survey Report.

Table 4: Details of Geological Mapping

Project No	Designation	Doc-Type	Content
23018	Transys-NH37-TUNNEL-DPR_GEO-001	DR	REGIONAL GEOLOGICAL MAP SILCHAR JIRIBAM TUNNEL
23018	Transys-NH37-TUNNEL-DPR_GEO-002&003	DR	GEOLOGICAL PLAN OF SILCHAR-JIRIBAM TUNNEL
23018	Transys-NH37-TUNNEL-DPR_GEO-004	DR	GEOLOGICAL L SECTION SILCHAR JIRIBHAM TUNNEL(LHS)
23018	Transys-NH37-TUNNEL-DPR_GEO-005	DR	GEOLOGICAL L SECTION SILCHAR JIRIBHAM TUNNEL(RHS)
23018	Transys-NH37-TUNNEL-DPR_GEO-006	DR	LHS WEST PORTAL GEOLOGICAL L SECTION
23018	Transys-NH37-TUNNEL-DPR_GEO-007	DR	LHS EAST PORTAL GEOLOGICAL L SECTION
23018	Transys-NH37-TUNNEL-DPR_GEO-008	DR	RHS WEST PORTAL GEOLOGICAL L SECTION
23018	Transys-NH37-TUNNEL-DPR_GEO-009	DR	RHS EAST PORTAL GEOLOGICAL L SECTION
23018	Transys-NH37-TUNNEL-DPR_GEO-010	DR	GEOLOGICAL CROSS SECTION A-A' AT WEST PORTAL SILCHAR JIRIBAM TUNNEL
23018	Transys-NH37-TUNNEL-DPR_GEO-011	DR	GEOLOGICAL CROSS SECTION B-B' AT WEST PORTAL SILCHAR JIRIBAM TUNNEL
23018	Transys-NH37-TUNNEL-DPR_GEO-012	DR	GEOLOGICAL CROSS SECTION C-C' AT EAST PORTAL SILCHAR JIRIBAM TUNNEL
23018	Transys-NH37-TUNNEL-DPR_GEO-013	DR	GEOLOGICAL CROSS SECTION D-D' AT WEST PORTAL SILCHAR JIRIBAM TUNNEL
23018	Transys-NH37-TUNNEL-DPR_GEO-014	DR	PLAN OF EAST PORTAL AREA SILCHAR JIRIBAM TUNNEL
23018	Transys-NH37-TUNNEL-DPR_GEO-015	DR	PLAN OF WEST PORTAL AREA SILCHAR JIRIBAM TUNNEL

3.3 Geotechnical Drilling Investigations

Total four drill holes were drilled with 2 each on the both portals of the tunnel. The drill holes are drilled in the portal locations of each tube of the tunnel. Bore holes along tunnel alignment were drilled to explore the quality of bed rock and determine the mechanical properties of rock mass. Details of the bore holes are provided in Geotechnical drilling report and in the table below.

Table 5: Details of Geotechnical Drilling

Sl no	Borehole no	Location	Coordinates	Depth (m)	Elevation (m)
1	BH-01	East Portal LHS	E-507074.3584, N-2746110.2722	50	104
2	BH-02	East Portal RHS	E- 507067.983, N-2746065.726	50	97
3	BH-03	West Portal LHS	E-506381.4191, N-2746209.444	50	99
4	BH-04	West Portal RHS	E,506375.0437, N-2746164.898	50	121

3.4 Rock Mechanic Tests

Rock mechanic tests were conducted in two phases; initially on samples collected from outcrops in the portal areas that served primarily to provide rock mechanic parameters for portal design. In the second phase the drill cores were tested in the laboratory to ascertain the mechanical properties of rock. Details of the bore holes are provided in the geotechnical investigation part in the report.

4. GEOLOGICAL MAPPING OF TUNNEL AREA

The area under study comprises of sedimentary rock strata of Miocene. The area contains rock mass of Boka Bil formation of Surma group of rock. Shale-Siltstone alteration with lenticular micaceous sandstone is exposed in the tunnel location. The geological map of the project area is given below.

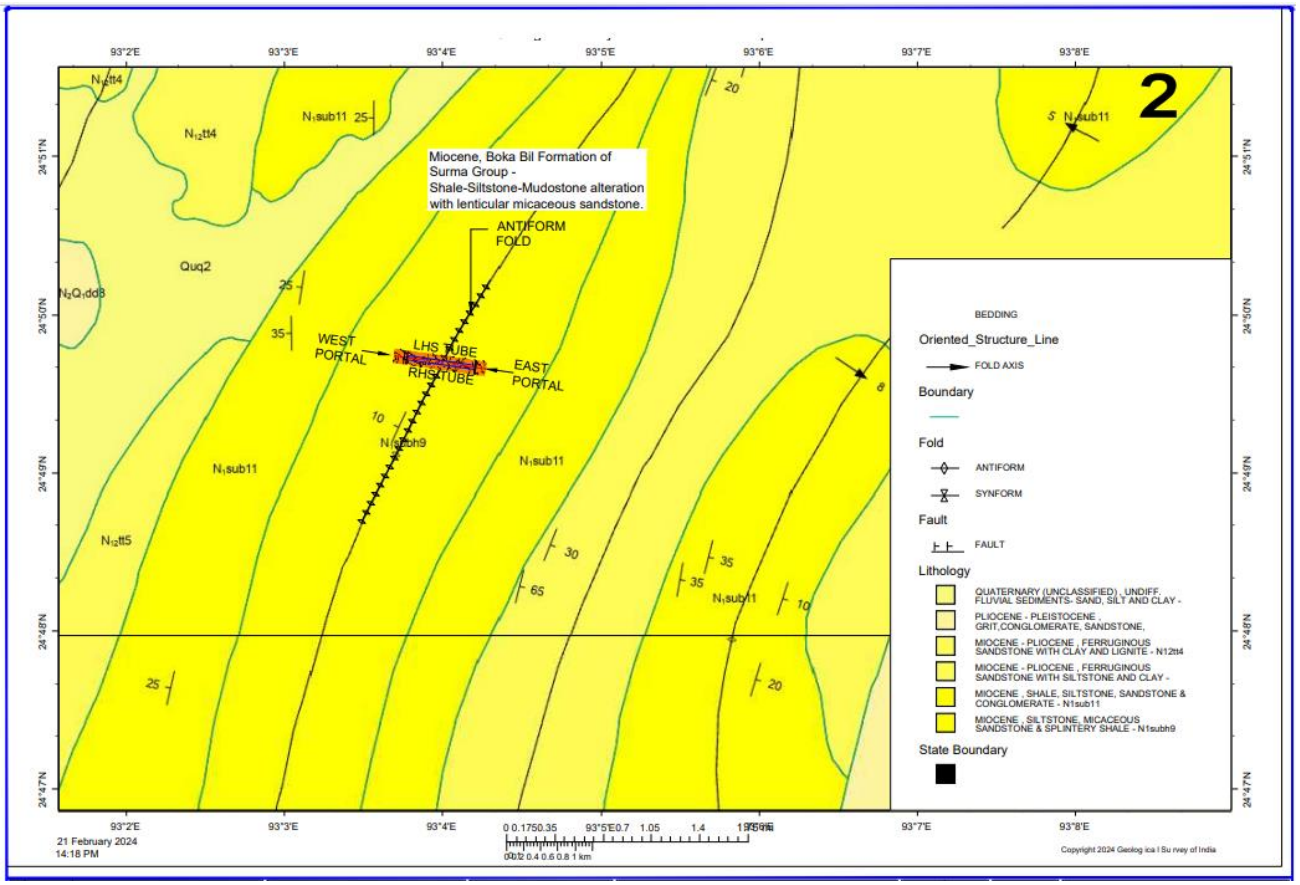


Figure 14: Geological Map of Tunnel Location

The youngest formation of the Surma Group is represented by the Boka Bil formation predominantly argillaceous in nature. This is dominantly a siltstone/sandstone rock mass with intercalation of shale rock exposure. The tunnel location is exposed with Boka Bil formation.

4.1 Surface Geological Mapping around East Portal

The tunnel, trending in an east-west direction, features a northeast-facing east portal. The E–W trending tunnel has NE facing east portal. The invert of the portal is proposed at an altitude of 62m above MSL. The topography surrounding the proposed east portal consists of a hill that slopes gently towards the east, gradually becoming steeper. The elevation of the hill observed in the east portal varies from 62m to 135m. This area is densely covered with vegetation, and a soil layer of 3-5 meters is anticipated. The portal is in close proximity to Uttar Lalpani village.

Figure 15: East Portal Location

The hill exhibits a gradient ranging from moderate to steep, with a pronounced steep face that varies in elevation from 75 meters to 185 meters in the top of the hill. The maximum overburden of the entire tunnel is observed near to the east portal region. The overburden depth varies from 15m to 90m in the east portal region. Most of the hill slopes are, in general, covered by soil cover that supports moderate to high vegetation dominated by bamboo trees. Though the ridge of the hill is covered by soil cover, the thickness of this overburden is around 3m, thus should yield rock at a shallow depth of less than 4m. Rock out crops are mostly exposed along the stream valleys, cuttings and some on the ridges of the hill.

As a part of surface investigations, detailed geological mapping of proposed portal around east portal section comprising was carried out on 1:100 scales. Also two longitudinal sections has been developed for the better understanding of the geology along the tunnel alignment. Two cross-sections C-C' and D-D' were executed with C-C' being on the design chainage 25+650 while D-D' on the design chainage 25+660. The drawings has been attached in Appendix-2 of this same report.

The rock strata along the tunnel alignment has been extrapolated from the surface geological mapping and the geotechnical investigations carried out along the tunnel alignment. Two borehole drilling of 50m each has been carried out in the east portal area, one each on the RHS & LHS tubes.

All the accessible bedrock outcrops along with their structural details were picked up during the course of surface geological mapping. The discontinuity details recorded during surface geological mapping include their attitude, persistence, spacing, aperture, roughness, filling, etc. Besides the above parameters, extent of weathering, geological structures etc. were also recorded.

Detailed geological map of the area covering east portal is provided as drawing in the Appendix 2 of this report. Geological plan, Geological L section of both LHS and RHS of east portal, two cross-sections C-C' and D-D' were executed with C-C' being on the design chainage 25+650 while D-D' on the design chainage 25+660 has been provided in the appendix 2 of this report. The Geological mapping around the proposed east portal is marked by two rock types: siltstone/sandstone with intercalation of shale rock.

Figure 16: Horizontal Bedding of Siltstone/Sandstone in East Portal

Figure 17: Silt stone Exposure in Portal Location

Figure 18: Joint Set Observed in Portal Expoure

Figure 19: High Vegetation Observed in East Portal

Figure 20: Soil Cover Observed in East Portal

Figure 21: Rock Bolder in EP

Figure 22: Sub vertical Bedding Observed in Portal Location

The east portal is characterized by siltstone and sandstone bedrock, with intercalations of shale rock. Limited rock exposure is observed in this area due to the dense vegetation and soil cover. The portal is distinguished by the predominance of sandstone and siltstone rock types, which have been mapped at the top of the portal (left-hand side borehole location) and in the cut regions of the stream valley.

The exposed siltstone/ sandstone with shale bands in the region are fine-grained, horizontally bedded, weak, and highly jointed. Tunnel formation level is expected to be encountered by siltstone/sandstone with intercalations of shale rock. The general bedding of the siltstone/sandstone have a strike of 310°-130°, which is at an angle of 20° from the tunnel alignment. The hill where the tunnel alignment is located forms part of an antiform fold, influencing the strike and dip of the joint sets in the range of 20° to 30°.

Four sets of joints, including the bedding plane, are observed in the portal location, and details of these joint sets are provided in the discontinuity section. The overburden above the tunnel hill primarily consists of residual soil with sandy silt-sized particles and a substantial amount of organic components. The portal area is predominantly covered by overburden, and analysis indicates that the vertical overburden above the proposed left-hand side (LHS) portal is 12.5 meters, while the vertical overburden above the proposed right-hand side (RHS) portal is 13 meters.

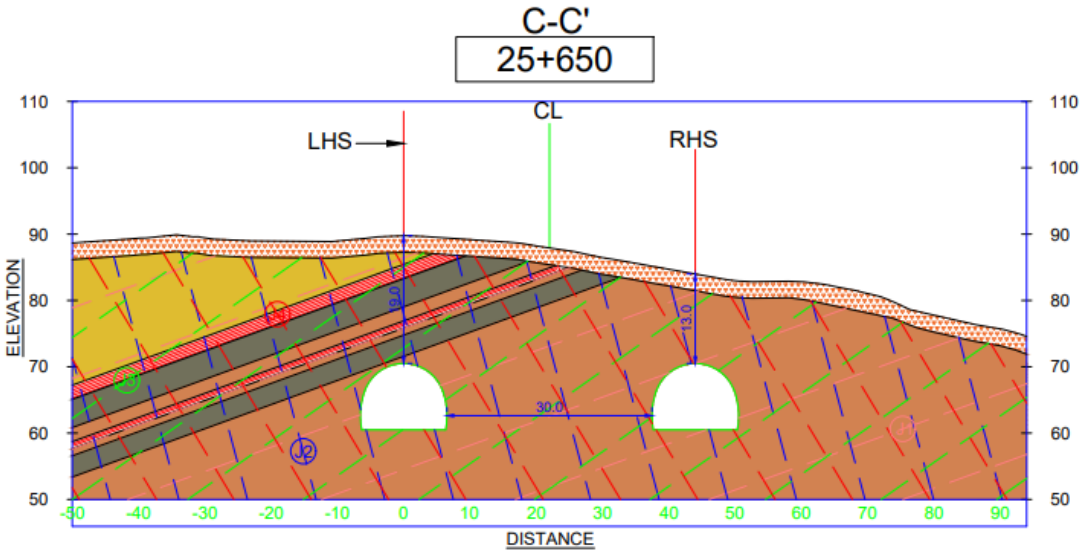


Figure 23: X-section showing vertical and lateral cover at Eastern Portal

During the geological mapping of the east portal region, RMR calculation has been carried out for understanding the rock mass characteristics. The rock mass rating table of the east portal has been given below.

CONTINUOUS RMR (BASED ON BIENIAWSKI 1989)

Location Id	East Portal			
Strength of Intact Rock	UCS	12.5	MPa	
◉ UCS/PLSI ○ R Value (N-Type)				
Rock Quality Designation	10.0	%		
Spacing of Discontinuities	60	mm		
Ground Water Condition				
○ Measured ◉ General	Dripping	Or 0.0		
Adjustment Rating (F0)	Tunnels & Mi	and fair	Or 0.0	
Conditions of Discontinuity:				
◉ Parameter based ○ Overall				
Persistence	10.00	m		
Aperture	3.0	mm		
Roughness (JRC)	5.0	(0-20)		
Infilling	Soft	2.5	mm	
Weathering (*I5)	20.0	Ru5 10.0	Rw1	

RMR 19

BASIC RMR 24

Parameters	Rating
UCS	2.1
RQD	2.5
Joint Spacing	5.6
Ground Water	4
Persistence	1.5
Aperture	1.1
Roughness	1.5
Soft Infilling	3.8
Weathering	2.1
Adjustment Rating	-5

Figure 24: RMR Rating Table, East Portal

4.1.1. Analysis of Discontinuity Data (East Portal)

The discontinuity data collected during the course of detailed geological mapping from rock outcrops on the east portal area has been analysed with the help of "DIPS" software. The stereographic projection and major plane projections of surface rock data along with tunnel alignment have been prepared and given in below figure.

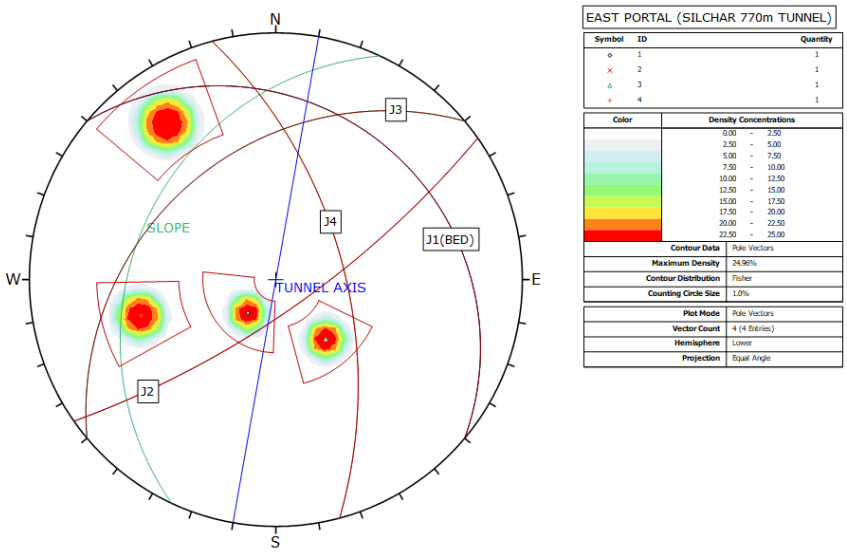


Figure 25: Stereographic Projection of East Portal, Silchar Tunnel

The analysis of data on discontinuities traversing the rock mass collected during the course of detailed geological mapping is summarized in Table below.

Table 6: Average orientation of discontinuities around proposed at East portal.

Set	Aver. Dip Amount	Aver. Dip Direction	Continuity (m)	Spacing (cm)	Aperture (mm)	Rough-ness	Alteration	Filling
J1 (Bedding)	20°	N040°	10-20	<6	0.1	Smooth	NIL	Soft Clay
J2	75°	N145°	1-3	6-20	0.1 to 1	Rough-Smooth	NIL	NIL
J3	35°	N320°	3-10	<6	Tight	Rough-Smooth	NIL	Soft Clay
J4	59°	N075°	1 - 3	<6	0.1 to 1.0	Rough - Smooth	NIL	Soft Clay

It is observed on site that the bedding plane is the most prominent joint set, here named as J1. It is evident from table that the bedding plane joint set J1 on a dip of 20º towards N040º. However, dips ranging between 10º and 25º and dip direction ranging between N020º and N060º have been recorded at the site. This is due to the antiform fold observed in the tunnel area. The joints belonging to set J2 appear to be as next most prominent joint set. These, on a dip of 75º towards N145º. Other set of joints in order of prominence is J3 which on an average 35º dips towards N320º while the last set of joint J4 observed with a dip of 59º towards 075°.

It is observed that the average strike of the bedding joint set J1 strike sub-parallel to the tunnel alignment making angles of 025°. While joint set J2,J3 & J4 strikes sub vertical to the tunnel alignment making angles of 40°, 025° & 025° respectively. The discontinuity data along with the tunnel dimensions were studied using UNWEDGE software.

Keeping in view the large size of the tunnel, wedge analysis has been carried out by using 'Un wedge' software from the portal. The parameters considered for the unwedge analysis are unit weight of rock as 2.1 ton/m2, angle of internal friction as 25° and cohesion as 0.078 MPa. Analysis has been carried out by considering different combinations of joint sets but the combination supposed to give the worst impact on the structure has finally been projected in this report.

Wedge analysis has been carried out by considering the alignment of tunnel in N285° direction with combination of joint sets J1, J2, J3 and J4. The results of the analysis are shown below.

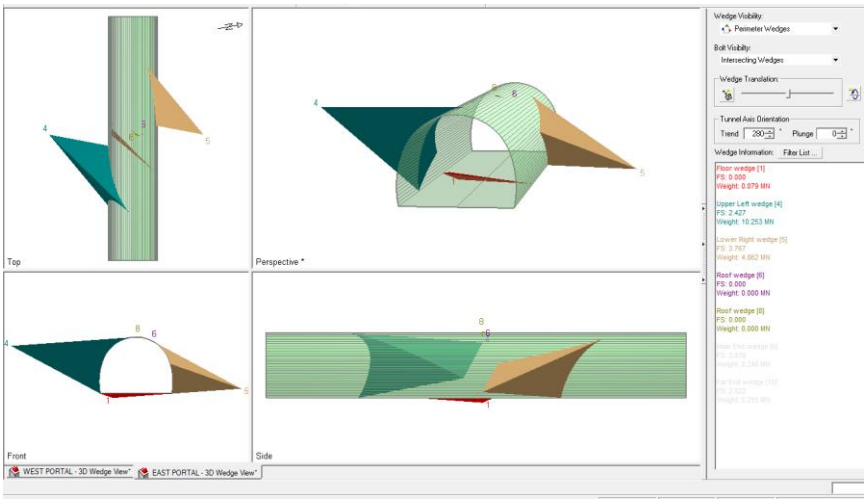


Figure 26: Factor of Safety of Wedges in East Portal

The results of wedge analysis from the portal of tunnel indicate that the wedges formed in the floor is having a less factor of safety. All other wedges formed in the crown portion and sidewall are stable and higher FOS except floor wedges. These wedges may be stabilized by providing shotcrete, rock bolt etc. Other wedges to be expected by intersection of various joints are stable with high factor of safety. The wedges formed due to the intersection of joint sets can be stabilized with proper support installations.

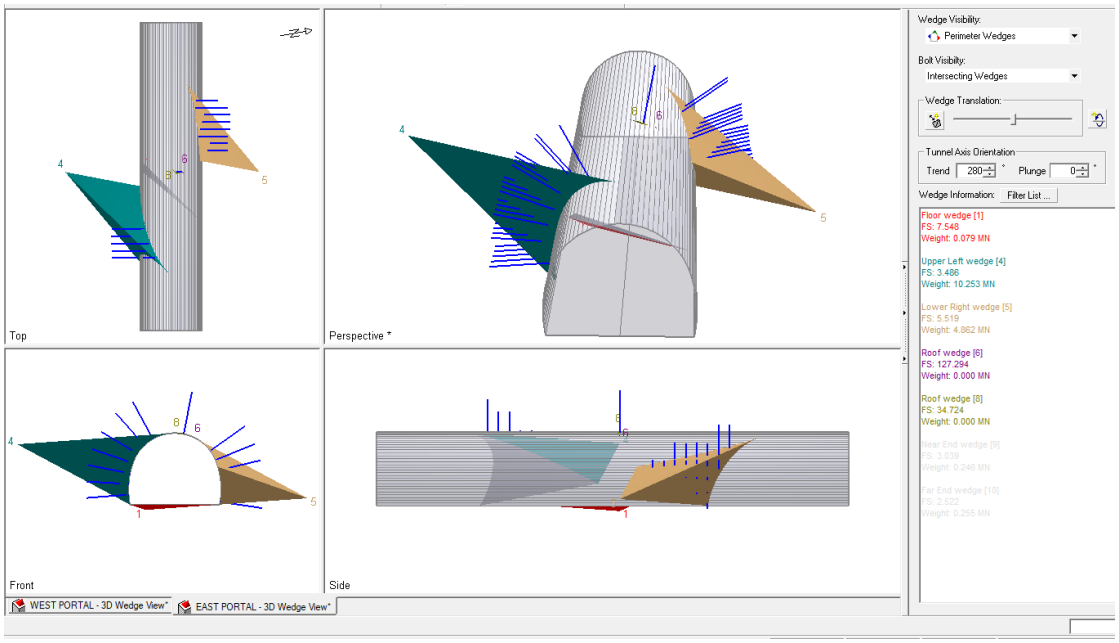


Figure 27: Factor of Safety of Wedges after Supporting

4.2 Surface Geological Mapping around West Portal

The E–W trending tunnel has NW facing west portal. The invert of the portal is proposed at an altitude of 74m above MSL. The topography of the hill of proposed east portal in general is characterized westerly plunging gentle hill. The elevation of the hill observed in the east portal varies from 74m to 120m. The area is highly vegetated and a soil cover of 2-4m is expected in this region.

Figure 28: West Portal Location

The hill has a moderate to gentle gradient. The hill is having a moderate to gentle face varying from 74m to 130m in the top of the hill. The overburden of the tunnel above the crown level is comparatively less in the west portal region. The overburden varies from 13m to 40m in the west portal region. Most of the hill slopes are, in general, covered by overburden that supports moderate to high vegetation. Though the ridge of the hill is covered by overburden, the thickness of this overburden is less than 3 m thus should yield rock at a shallow depth of less than 3m. Rock out crops are generally exposed in the stream cut slope in the down part of tunnel.

As a part of surface investigations, detailed geological mapping of proposed portal around east portal section comprising was carried out on 1:100 scales. Also two longitudinal sections has been developed for the better understanding of the geology along the tunnel alignment. Two cross-sections A-A' and B-B' were executed with A-A' being on the design chainage 24+890 while B-B' on the design chainage 24+920. The drawings has been attached in Appendix of this same report.

The rock strata along the tunnel alignment has been extrapolated from the surface geological mapping and the geotechnical investigations carried out along the tunnel alignment. Two borehole drilling of 50m each has been carried out in the east portal area, one each on the RHS & LHS tubes.

All the accessible bedrock outcrops along with their structural details were picked up during the course of surface geological mapping. The discontinuity details recorded during surface geological mapping

include their attitude, persistence, spacing, aperture, roughness, filling, etc. Besides the above parameters, extent of weathering, geological structures etc. were also recorded.

Detailed geological map of the area covering east portal is provided as drawing in the Appendix 2 of this report. Geological plan, Geological L section of both LHS and RHS of east portal, two cross-sections A-A' and B-B' were executed with A-A' being on the design chainage 24+890 while B-B' on the design chainage 24+920 has been provided in the appendix 2 of this report. The Geological mapping around the proposed east portal is marked by one rock strata: shale rock with siltstone/sandstone.

Figure 29: Horizontal Bedding of Shale rock in West Portal

Figure 30: Nala Flowing in the lower region of WP

Figure 31: High Vegetation Observed in West Portal

Figure 32: 2-4m Overburden in West Portal

Figure 33: Siltstone Exposure in Stream Bed

Figure 34: Joint Sets Observed in West Portal

The western portal is exposed by shale rock with siltstone/ sandstone bands. Due to the high vegetation and soil cover, limited rock exposure is noticed in the west portal. The portal region is marked by the presence of shale rock with sandstone/siltstone band rock type. The shale rock have been mapped in the stream cut regions in the lower elevation of the portal.

The shale/siltstone exposed in the area is fine grained, horizontally bedded, weak and jointed rock. Tunnel level is expected to be encountered by shale rock mass with bands of siltstone/sandstone rock. The general bedding of the shale have a strike of 255°-075°, which is at an angle of 15° from the tunnel alignment. The hill through which tunnel passes is a part of antiform fold. The strike and dip amount of joint set varies in a range of 10° to 25° due to the presence of antiform fold observed in the tunnel location. Four sets of joints are noticed in the portal location, including the bedding plane. The horizontally dipping bedding plane is observed in vertical due to the presence of antiform fold in the region. The details of the joint sets are incorporated in the discontinuity part.

Overburden above the tunnel hill is primarily composed of residual soil of sandy silt size particles with substantial amount of organic components. The portal area is mostly exposed with overburden. Analysis of the portal section reveals that the vertical overburden above the proposed LHS portal is 13m and the vertical overburden above the proposed RHS portal is 13.5m respectively.

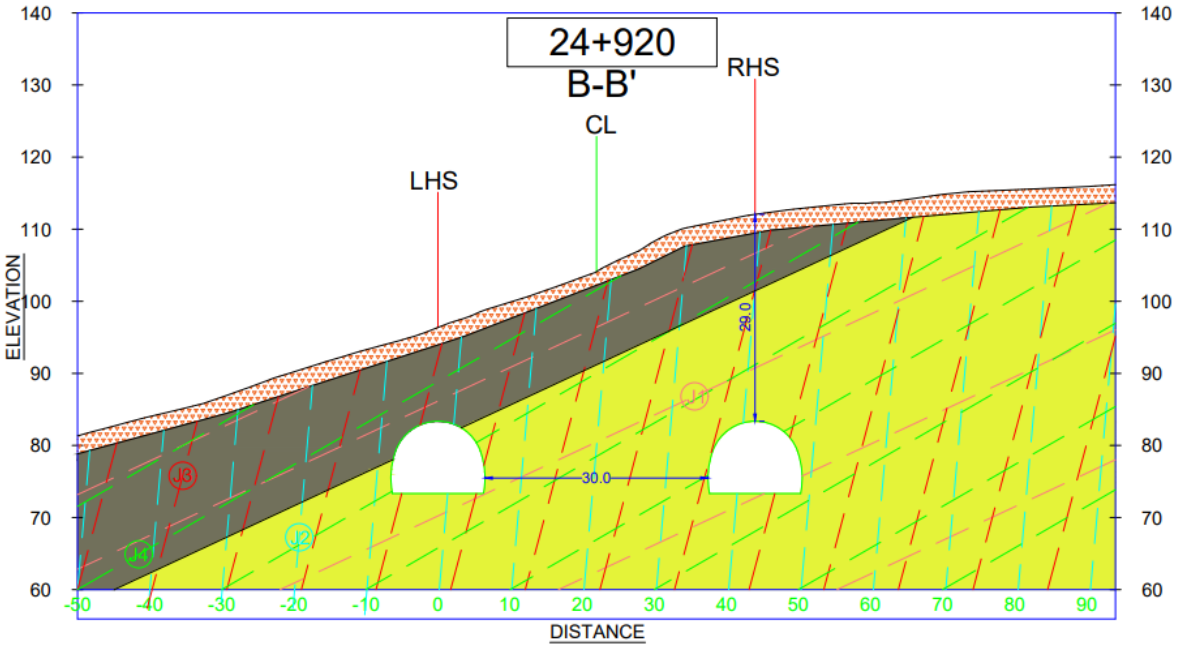


Figure 35: Section showing vertical and lateral cover at Western Portal

During the geological mapping of the west portal region, RMR calculation has been carried out for understanding the rock mass characteristics. The rock mass rating table of the west portal has been given below.

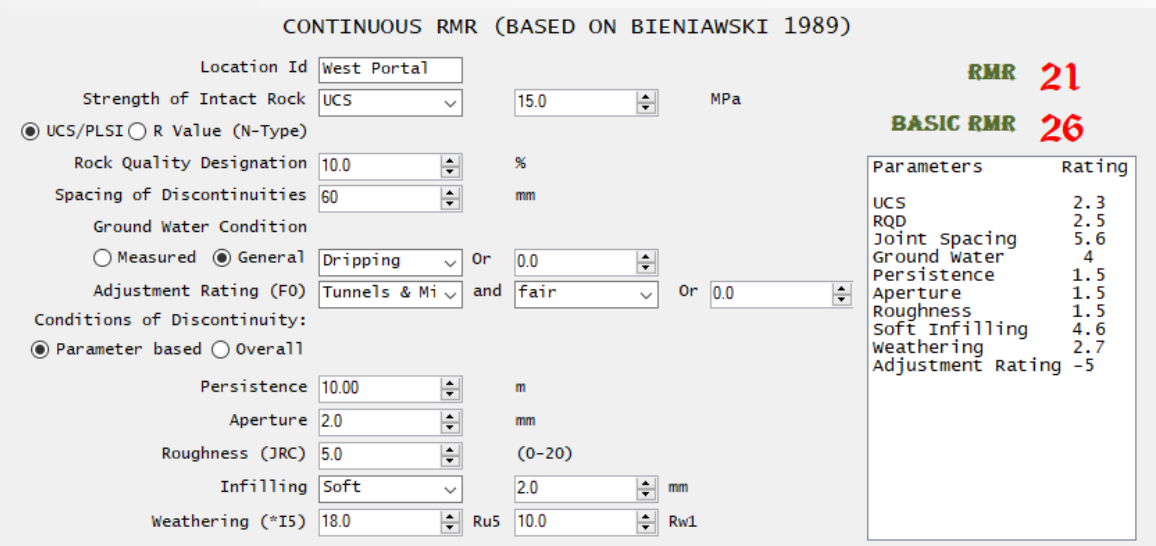


Figure 36: RMR Table of West Portal

4.2.1. Analysis of Discontinuity Data (West Portal)

The discontinuity data collected during the course of detailed geological mapping from rock outcrops on the east portal area has been analysed with the help of "DIPS" software. The stereographic projection and major plane projections of surface rock data along with tunnel alignment have been prepared and given in below figure.

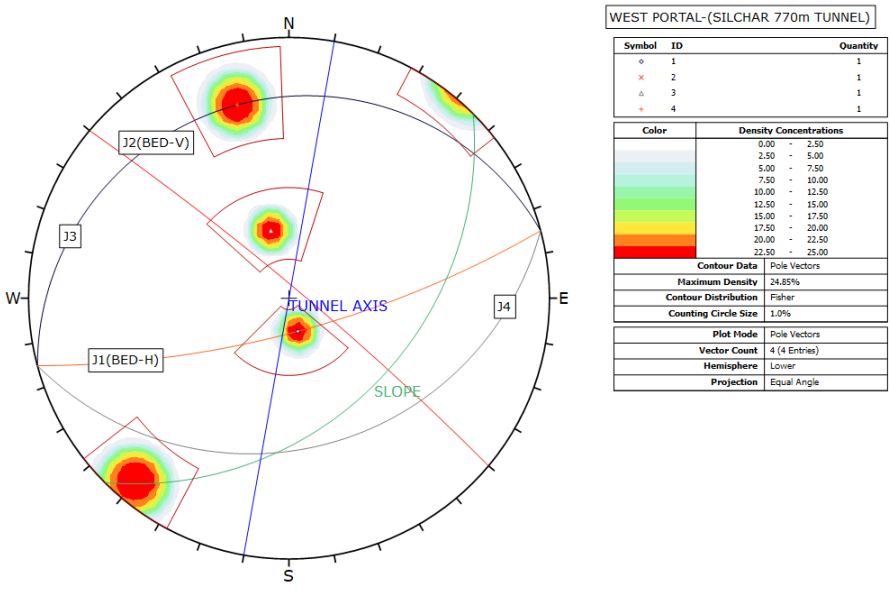


Figure 37: Stereographic Projection of West Portal, Silchar Tunnel

The analysis of data on discontinuities traversing the rock mass collected during the course of detailed geological mapping is summarized in Table below.

Set	Aver. Dip Amount	Aver. Dip Direction	Continuity (m)	Spacing (cm)	Aperture (mm)	Rough-ness	Alteration	Filling
J1 (Bedding)	15°	N345°	10-20	<6	<0.1	Planar Smooth	NIL	Soft Clay
J2 (Bedding)	85°	N040°	1-3	<6	<0.1	Planar Smooth	NIL	NIL
J3	30°	N165°	1-3	6-20	<0.1	Planar Smooth	NIL	Soft Clay
J4	75°	N165°	1 - 3	6-20	<0.1	Smooth	NIL	Soft Clay

Table 7: Average orientation of discontinuities around proposed at West portal.

It is observed on site that the bedding plane is the most prominent joint set, here named as J1. It is evident from table that the bedding plane joint set J1 on a dip of 15º towards N345º. However, dips ranging between 10º and 25º and dip direction ranging between N330º and N350º have been recorded at the site. This is due to the antiform fold observed in the tunnel region. The joints belonging to set J2 is also the bedding plane due to the antiform folding observed in the region, appear to be as next most prominent joint set. These, on a dip of 85º towards N40º. Other set of joints in order of prominence is J3 which on an average 30º dips towards N165º while the last set of joint J4 observed with a dip of 75º towards 165°.

It is observed that the average strike of the bedding joint set J1,J2, J3 & J4 strike sub-parallel to the tunnel alignment making angles of 030°,025°,030° and 030° respectively. The discontinuity data along with the tunnel dimensions were studied using UNWEDGE software.

Keeping in view the large size of the tunnel, wedge analysis has been carried out by using 'Un wedge' software from the portal. The parameters considered for the unwedge analysis are unit weight of rock as 2.1 ton/m2, angle of internal friction as 25° and cohesion as 0.078 MPa. Analysis has been carried out by considering different combinations of joint sets but the combination supposed to give the worst impact on the structure has finally been projected in this report.

Wedge analysis has been carried out by considering the alignment of tunnel in N105° direction with combination of joint sets J1, J2, J3 and J4. The results of the analysis are shown below.

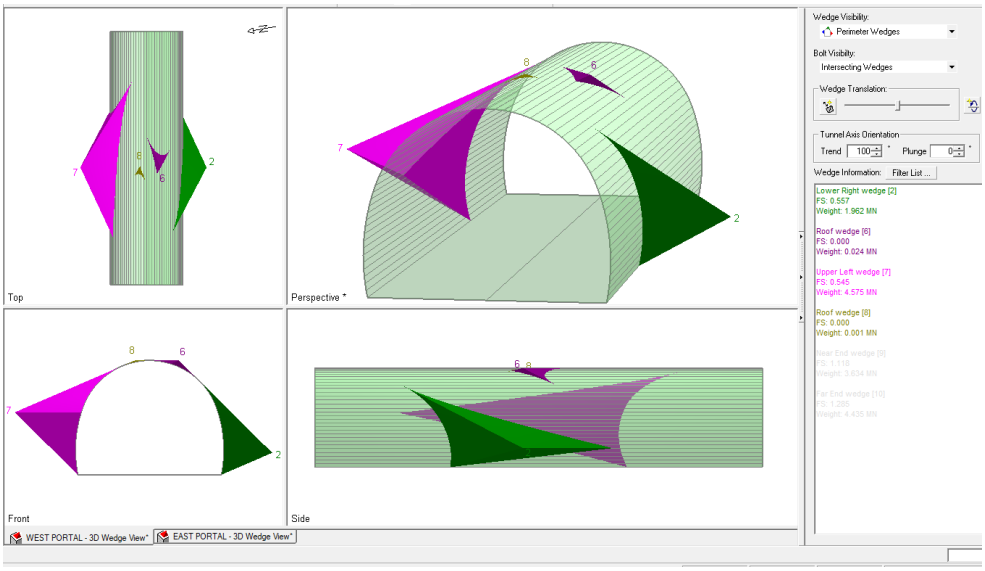


Figure 38: Factor of Safety of Wedges in West Portal

The results of wedge analysis from the portal of tunnel indicate that the wedges formed in the floor, sidewalls and crown is having a less factor of safety. These wedges are getting stabilized by providing shotcrete, rock bolt etc. The wedges formed due to the intersection of joint sets can be stabilized with proper support installations.

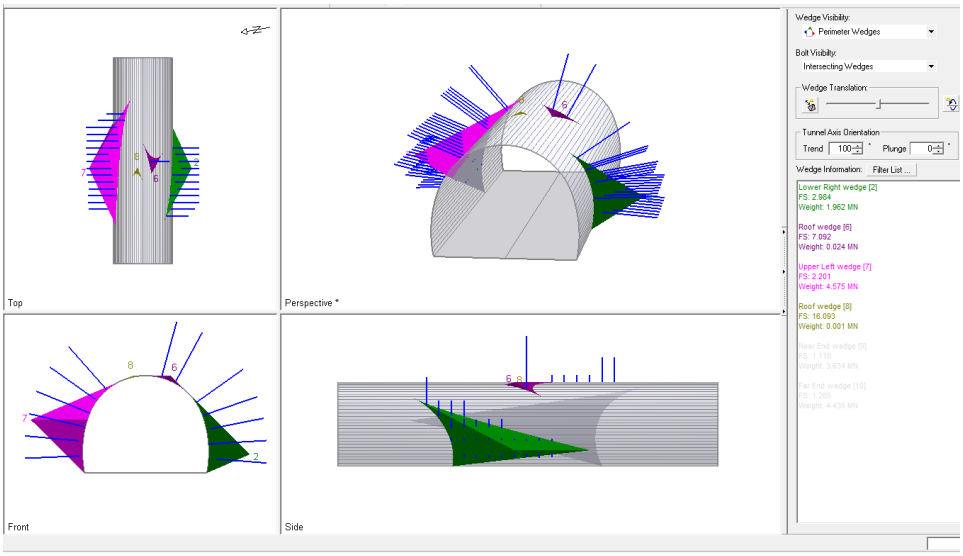


Figure 39: Factor of Safety of Wedges after Supporting (WP)

4.3 Geological Setting along the Tunnel Alignment

The tunnel is having an E–W trend with a maximum elevation of 160m above mean sea level (MSL). The elevation of the tunnel varies from 64m to 160m with a maximum overburden above crown level of 97m and 92 m in RHS and LHS tube respectively. The area is moderately vegetated and a soil cover of 2-5m is expected in the entire tunnel alignment region. The west portal is placed approximately 2km from Lalang kitta village and Chri River. The east portal is placed approximately 1.5 km from Uttar Lalpani village area.

Rocks within the entire tunnel alignment area have been classified as Boka Bil formation of Surma Group consisting of siltstone, Shale and micaceous Sandstone. The general strike of the primary bedding is 220°-270° with a dip amount of 10°-25°. The bedding plane is observed with a vertical dip amount in the alignment due to the antiformal fold observed in the tunnel alignment.

Figure 40: Horizontal Bedding along the Alignment

Figure 41: Vegetation Observed in the Top of the Alignment

Figure 42: Siltstone Exposure in the Alignment

Figure 43: Stream with Sub vertical Bedding Plane (Due to Antiform Folding)

Figure 44: Horizontal Bedding Observed in the Alignment

Figure 45: Vegetation near West Portal

Figure 46: Stream with Water Flow, (Near LHS Tube)

The hill has a moderate to steep gradient. The alignment is observed with lot of depressions and surface water runoff is expected in the monsoon time. The maximum elevation of the top most region of the tunnel alignment is 165m. The entire tunnel alignment is observed with a maximum overburden of 3m of sandy silt soil. Though the ridge of the hill is covered by overburden, the thickness of this overburden is less than 3 m thus should yield rock at a shallow depth of less than 3m. Rock out crops are generally exposed in the stream cut slope and the ridge area in the top of the alignment.

The entire tunnel alignment is exposed with siltstone/ sand stone and shale rock exposure which is a part of Boka Bil formation of Surma group. The whole tunnel alignment is exposed with Boka-Bil formation rock. The siltstone/sandstone and shale exposed in the area is fine grained, horizontally bedded, weak and jointed rock. Tunnel level is expected to be encountered by siltstone/sandstone with minor intercalations of shale rock. The bedding plane is observed vertical in the alignment due to the antiform fold observed in the tunnel alignment. The centre of the alignment is expected to have the fold axis of the above mentioned antiform fold. The west portal region is expected to be encountered by shale rock with intercalation of siltstone/sandstone and the east portal is expected to be encountered by siltstone/ fine grained sandstone with minor intercalation of shale rock.

The bedding plane of both shale and siltstone/ fine grained sandstone is dipping horizontally/ sub horizontally. Due to the erosion and folding going on from millions of years, various bedding planes have been eroded. The horizontal bedding plane has been observed vertical to sub vertical in the alignment due to the antiform folding. This antiform fold axis and vertical bedding plane shows clear chances of vertical tension cracks along the tunnel alignment.

A small nala is passing through the north side of the LHS tube of the tunnel. The nala starts from the top of the hill, near to the east portal and flows towards the west portal region. The drainage pattern along the tunnel alignment is given in the figure below.

Nala grouting is proposed to prevent the ingress of water . The nala is lined by PCC grade M15 100 mm thick and 50 mm dia holes shall be drilled 4m deep and grouted with cement .

Figure 47: Drainage Pattern in the Alignment

4.3.1 Lithology

The alignment area is dominated by siltstone/ sandstone with intercalation of shale rock in the east portal region and shale rock with intercalation of siltstone/ fine grained sandstone in the west portal. The rock is weak, highly weathered and fractured, fine grained, brown to green coloured. The rock exposure is weak (Approximately UCS 10 MPa to 20 MPa).

The joint details observed along the tunnel alignment is given in the table below.

Table 8: Joint Details along the Tunnel Alignment

Set	Aver. Dip Amount	Aver. Dip Direction	Continuity (m)	Spacing (cm)	Aperture (mm)	Rough-ness	Alteration	Filling
J1 (Bedding)	10°-25°	N270°-N350°	10-20	<6	<0.1	Planar Smooth	NIL	Soft Clay
J2 (Bedding)	75 -85°	N110°-N300°	1-3	<6	<0.1	Planar Smooth	NIL	Soft Clay
J3	75 -80°	N005°-N065°	1-3	6-20	<0.1	Planar Smooth	NIL	Soft Clay

5. THIN SECTION STUDY

During the time of field visits and geological mapping two rock types were identified on the outcrop and hand specimen scale, they are, fine grained siltstone/ sandstone and shale rock. Same lithology has been named in various geological literatures and papers corresponding to this area. However, to further authenticate the observations thin section analysis were carried out on three samples that are typical and representative of overall lithology and lithological variations present in the area.

5.1 SAMPLE-01 (East Portal)

The given core sample is grey to buff in colour, fine grained with iron dust n gives efflorescence with dilute hydrochloric acid. The given sample examined under microscope is fine to medium grained, in equigranular, laminated rock composed of dominantly calcite and minor quartz with iron dust. Sparitic calcite are also observed. The rock observed lamination with fine iron dust at many places.

Calcite- Dominantly micritic and minor sparitic calcite are present. Micrite is fine grained while spiritic is coarse grained, subhedral, colourless and higher order interference color.

Quartz- It is colour less, anhedral in shape, shows grey interference colour and wavy extinction.

The thin sections of the sample studied under microscopic observations on the given rock sample were showed most abundant mineral in the sample was identified as calcite with quartz. Based on the texture and mineralogy the given sample is classified as limestone which is included under limestone group and falls under the trade group of sedimentary rocks as per IS:383-2016, Annex-C, Clause C-2.2.

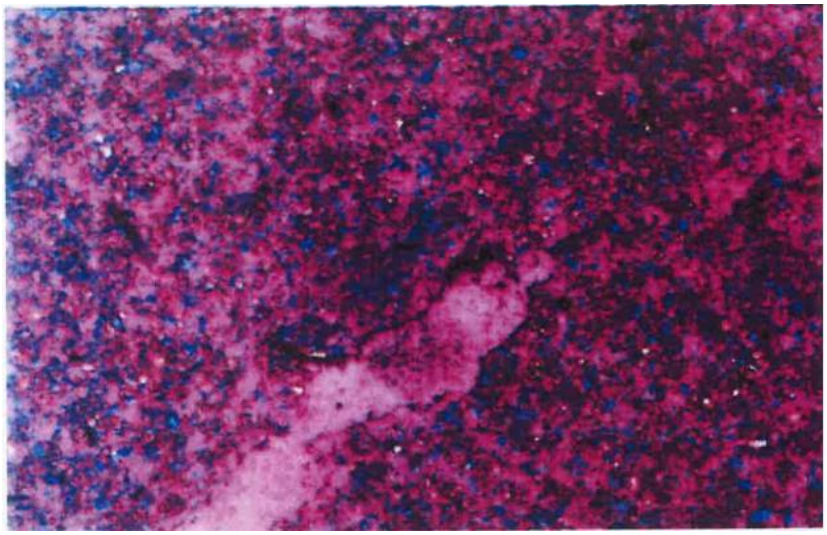


Figure 48: Core Sample-40m (East Portal)

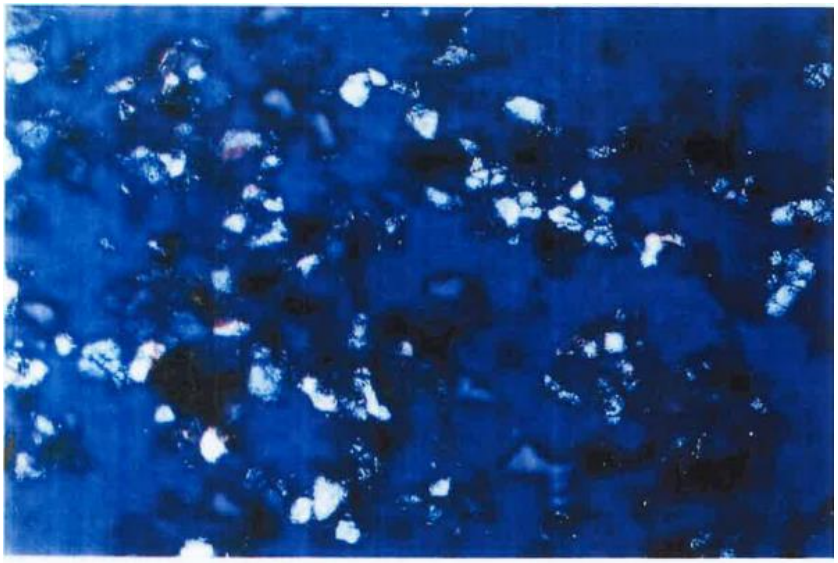


Figure 49: Core sample-22-25m (East Portal)

5.2 SAMPLE-02 (West Portal)

The given core sample is light grey in colour, fine grained with thinly laminated rock and gives efflorescence with dilute hydrochloric acid. The given sample examined under microscope is fine grained, laminated rock composed of micritic carbonate (Mainly calcite) and quartz. The rock exhibits fine grained micritic texture, resorbed margins, and thin laminations. Elongation with variation of grain size is observed at places.

Calcite- It is colour less, euhedral in shape, very fine laminated and cleavage, shows higher order birefringence.

Quartz- It is colour less, anhedral in shape, shows grey interference colour and wavy extinction.

The thin sections of the sample studied under microscopic observations on the given rock sample were showed most abundant mineral in the sample was identified as calcite with quartz. Based on the texture and mineralogy the given sample is classified as limestone which is included under limestone group and falls under the trade group of sedimentary rocks as per IS:383-2016, Annex-C, Clause C-2.2.

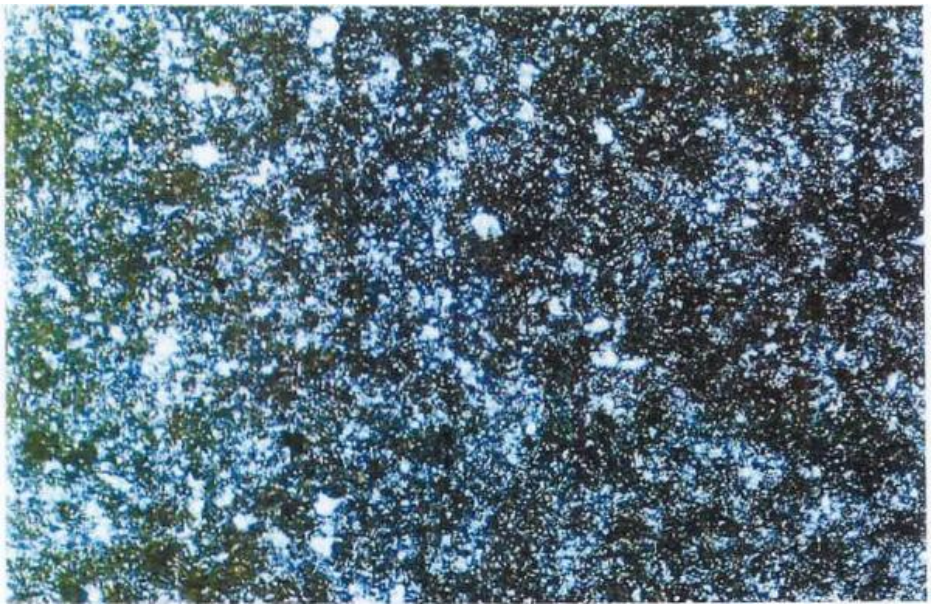


Figure 50: Core Sample-40m (West Portal)

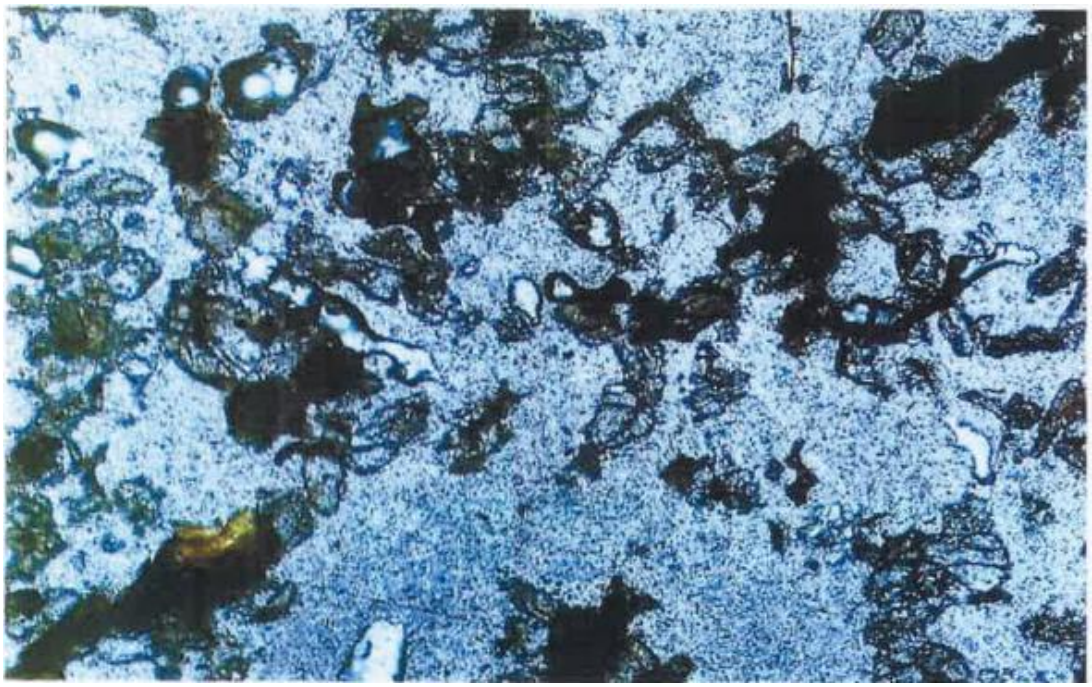


Figure 51: Core sample-22-25m (West Portal)

6. GEOTECHNICAL INVESTIGATIONS

Subsurface investigations in the field include *drilling of 04 drill holes* with the objective of estimating depth of bedrock, quality of bed rock likely to be encountered during tunnel excavation, determining the ground water table depth along the tunnel alignment. All the drill holes were drilled vertically. Summary of these drill holes is given in Table below. Drill hole BH-01, BH-02 were drilled at the east portal region and west portal region. All drill holes have been drilled at least 0.5D below the tunnel invert level. All above mentioned drill holes are 50m depth. Water pressure tests with a view to assess the permeability of the rock mass in the area have been conducted in selected sections/tunnel level (Packer Test) in these drill holes. Drill holes have also been utilized to collect rock samples for determination of physio-mechanical properties of the rock.

Table 9: Borehole Details

Tunnel BH No.	Existing Chainage	Tunnel BH.No's	Longitude	Latitude	Ground level	Termination Depth(m)	Progress of work
BH-02	24+940	West Portal (LHS)	93.063149	24.830753	99.000	50.0	Completed
BH-01		West Portal (RH	93.063089	24.830347	121.000	50.0	Completed
BH-01	25+640	East Portal (LHS)	93.070006	24.829856	104.000	50.0	Completed
BH-02		East Portal (RHS)	93.069937	24.829450	97.000	50.0	Completed

Based on the sub-soil exploration and field tests, the following soil / rock profile were identified at given location. The summarized log of drill holes are given in the table below.

Table 10: Summarized Log of Drill Holes

Borehole No	Depth of strata (m)	Description
West Portal (LHS)	0.00-1.00	Clayey materials mixed with gravel and Pebble fragments.
	1.00-8.00	Rock encountered at 1.0m.The encountered rock is slightly to moderately weathered, laminated, grey to yellowish grey colored, medium to fine grained, weak to very weak shale. Thin Layer of Sandstone band has been noted.
	8.00-20.00	Slightly weathered, laminated, yellowish grey colored, medium to fine grained, weak to very weak shale with thin layers of sandstone
	20.00-21.00	Fresh to slightly weathered, laminated, grey colored, fine grained, weak to very weak shale with thin layers of sandstone
	21.00-34.00	Fresh to slightly weathered, laminated, grey colored, fine grained, weak shale with thin layer of sandstone.
	34.00-50.00	Fresh to slightly weathered, laminated grey to dark grey colored, fine grained weak to very weak shale with thin layers of sandstone
West Portal (RHS)	0.00-2.00	The bore hole starts from rock. The encountered rock is slightly weathered, laminated, yellowish grey colored medium to fine grained, weak, moderately to intensely fractured shale.

Borehole No	Depth of strata (m)	Description
	2.00-7.00	Slightly weathered, laminated, yellowish grey colure medium to fine grained, weak to very weak shale.
West Portal (RHS)	7.00-13.00	Slightly weathered, laminated, yellowish grey colored, medium to fine grained, weak to very weak shale with thin layers of sandstone.
	13.00-15.00	Moderately to slightly weathered, Weathering grade changes to moderately laminated, yellowish grey colored, medium to fine grained, weak to very weak shale with thin layers of sandstone.
	15.00-50.00	Fresh to slightly weathered, laminated, grey to dark grey colored, fine grained, weak to very weak shale with thin layers of sandstone.
East Portal (LHS)	0.00-2.00	Top Soil material comprises of weathered & crushed Sandstone, yellowish colour.
	2.00-7.00	Yellowish colour, medium grained weak sandstone, Weathering Grade: W1
	7.50-8.00	Weak Sandstone with intercalation of shale. Weathering Grade: W1
	8.00-9.00	Gougy Material
	9.00-10.00	
	10.00-14.00	Shale Rock, very weak in nature, grey colour. Slightly Weathered, Weathering Grade: W1
	14.00-16.00	Fine grained sandstone with intercalation of Shale, weak in nature, grey colour. Weathering Grade: W1
	16.00-17.00	Gougy Material & Shale Rock, very weak in nature, grey colour. Weathering Grade: W1
	17.00-18.00	Fine grained sandstone with intercalation of Shale, weak in nature, grey colour. Weathering Grade: W1
	18.00-21.00	Shale Rock, very weak in nature, grey colour. Weathering Grade: W1
	21.00-50.00	Weak, grey colour, medium grain sandstone with intercalation of shale. Weathering Grade: W1
East Portal (RHS)	0.00-2.00	Overburden comprising of silty soil with sand
	2.00-6.00	Rock encountered at 2.0m. The encountered rock is slightly weathered to fresh, laminated, light brownish colored medium to fine grained, weak sandstone.
	6.00-11.00	Fresh to slightly weathered, laminated, light brownish to grey colored medium to fine grained, weak sandstone with Shale intercalations.

Borehole No	Depth of strata (m)	Description
East Portal (RHS)	11.00-17.00	Fresh to slightly weathered, laminated, light brownish to grey colored medium to fine grained, weak sandstone with shale intercalations. Weathering grade changes from slightly to moderately from 17.0m.
	17.00-19.00	Slightly to moderately weathered, laminated, light brownish coloured medium to fine grained, weak sandstone Weathering grade changes to slightly to moderately from 17.0m.
	19.00-21.00	Fresh to slightly weathered, laminated, light brownish coloured medium to fine grained, weak sandstone.
	21.00-34.00	Fresh to slightly weathered, grey coloured, medium to fine grained, medium strong to weak sandstone. Change in colour variation from brownish to grey colour in sandstone is noted.
	34.00-38.00	Fresh to slightly weathered, laminated, light brownish to grey coloured medium to fine grained, weak sandstone with shale intercalations.
	38.00-50.00	Fresh to slightly weathered, laminated, light brownish coloured medium to fine grained, weak sandstone with intercalation of shale. Intercalations of shale parallel to lamination is recorded. Some patches of moderately weathered sandstone is noted from 47.0m.

Insitu and laboratory tests has been carried out for the selected samples in each boreholes, a summary of the geotechnical properties is given in the annexure.

7. ROCK MASS CLASSIFICATION

7.1 Methodology

One of the essential principles of the NATM geotechnical design procedure (rock mass classification) is to identify hazards, which might arise during excavation of an underground structure, then devise methods to mitigate those hazards, and arrive at a safe and economical construction. To be able to identify the potential hazards (or modes of failure), a geological model has to be established, including distinguishing rock types as well as structural characteristics and singularities (joint setup, faults, etc.), and the determination of factors influencing the behaviour (stresses, water, size and shape of underground opening, etc.). In a next step, analyses for an unsupported tunnel are done to identify the potential hazards. Depending on the type of potential failure mode of the unsupported tunnel a construction concept is devised with the aim of optimally applying construction measures to mitigate the expected hazards. This allows addressing local and project or site specific problems and requirements.

This common practice of design procedure in Austria has been summarized and published in a guideline in 2001, which has been revised in 2008 and translated to English in 2009. In the following the basic design procedure according to the guideline is briefly outlined. The geotechnical design, as part of the tunnel design, serves as a basis for approval procedures, the tender documents (determination of excavation classes and their distribution) and the determination of the excavation and support methods used on site. The flow chart below shows the basic procedure to develop the geotechnical design, beginning with the determination of the ground types and ending with the definition of excavation classes.

The procedure incorporates following steps:

Step 1 – Establishment of geological model and determination of Ground Types

The first step starts with the establishment of the geologic model and proceeds by defining geotechnically relevant parameters for each Ground Type. The key parameters values and distributions are determined from available information and/or estimated with engineering and geological judgment. Ground with similar properties is classified into Ground Types (GT). The number of Ground Types elaborated depends on the project specific geological conditions.

Step 2 – Determination of Ground Behaviour and assignment to Behaviour Types

The second step involves evaluating the potential ground behaviours considering each Ground Type and local influencing factors, including the relative orientation of relevant discontinuities to the excavation, ground water conditions, stress situation, etc. For each section, which has similar ground properties and influencing factors, the Behaviour Type is determined. The ground behaviour has to be evaluated for the full cross sectional area without considering any modifications including the excavation method or sequence and support or other auxiliary measures. The evaluated project specific ground behaviours shall be assigned to basic Behaviour Types. Project specific conditions may require a further subdivision of the Ground Behaviour Types as well as a detailed description of the single expected behaviours. Basically this step shall identify potential hazards, like type of possible failure mode, magnitude and characteristics of displacements, amount of water inflows and its effects on ground stability. The knowledge of the potential hazards is an important basis for the selection of the construction concept.

Step 3 – Selection of construction concept

Based on the ground characteristics and the determined ground behaviour for each characteristic situation a feasible construction concept is chosen, consisting of excavation method, sequence of excavation, support and auxiliary methods. The target of the selected construction concept is to mitigate the hazards identified in step 2 in an efficient and economical way.

Step 4 – Assessment of system behaviour in the excavation area

Under consideration of the construction concept, including sequence of construction, stability of the face and perimeter, and the spatial stress distribution, the system behaviour in the excavation area is assessed.

Step 5 – Detailed determination of the excavation and support method and evaluation of system behaviour in the supported area

The excavation and support methods are fixed in quality and quantity, considering probable further excavation steps, and the system behaviour is determined. The evaluated system behaviour is then compared to the requirements. In case the system behaviour does not comply with the requirements, excavation and support methods have to be modified, and the system behaviour evaluated again.

Step 6 - Geotechnical report - baseline construction plan

Based on steps 1 through 5 the alignment is divided into sections with similar excavation and support requirements. The baseline construction plan (e.g. geotechnical longitudinal section) indicates the

excavation and support methods recommended for each section, and contains limits and criteria for possible variations or modifications on site if necessary.

Step 7 - Determination of excavation classes

In the final step of the design process excavation classes are defined, based on the evaluation of the excavation and support measures. The excavation classes form a basis for compensation clauses in the tender documents.

It should be mentioned that the selection of an appropriate construction concept besides pure geotechnical aspects depends on a number of factors, like requirements the underground structure has to meet, site conditions, contractors experience, legal regulations and environmental requirements. As each project to a certain extent is a prototype, those factors have to be carefully assessed to arrive at a safe, economical and sustainable design, which meets all the requirements of users, authorities and the public.

As could be seen from the procedure outlined above, with the NATM design approach each case is treated separately, by identifying the inherent hazards and designing appropriate mitigation measures under consideration of project specific requirements and boundary conditions. Simplifications have to be limited to the absolutely necessary minimum, and are allowed only, if they do not influence dominant mechanisms.

Guideline for the Geotechnical Design of Underground Structures with Conventional Excavation – Austrian Society for Geo mechanics (2010) defined procedure of geotechnical design as an array of studies depicted in the flow chart below.

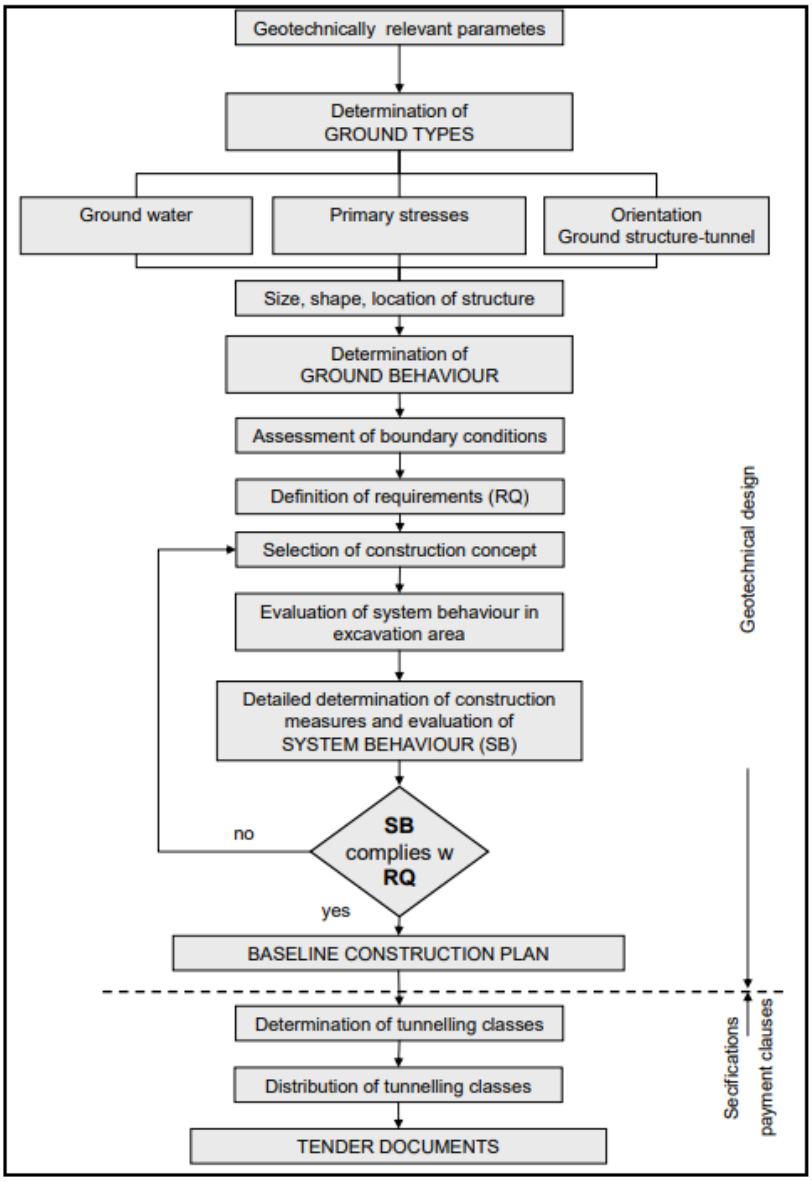


Figure 52: Basic procedure for the geotechnical design of underground openings

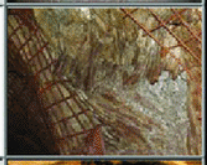
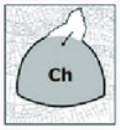
TUNNEL BEHAVIOUR TYPES			
St	**Stable ground:** Stable tunnel section with local gravity failures. Rock mass is compact with limited and isolated discontinuities		
Br	**Brittle failure:** Brittle failure or rock bursting at great depths		
Wg	**Wedge failure:** Wedge sliding or gravity driven failures. Insignificant strains. The rock mass is blocky to very blocky, blocks can fall or slide. The stability is controlled by the geometrical and mechanical characteristics of the discontinuities. The ratio of rock mass strength to the in situ stress (σ_{cm}/p_o) is high (>0.6-0.7) and there are very small strains (ε<1%)		
Ch	**Chimney type failure:** Rock mass is highly fractured, maintaining most of the time its structure (or at least that of the surrounded rock mass). Rock mass does not have good interlocking (open structure) and in combination with low confinement (lateral stress) can tend to block falls which develop to larger overbreaks of chimney type. The overbreaks may be stopped and "bridged" by better quality rock masses, depending on the in situ conditions. This type may be applied also in cases of brecciated and disintegrated rock mass in ground with high confinement (high lateral stress)		
Rv	**Ravelling ground:** The rock mass is brecciated and disintegrated or foliated with practically zero cohesion and depending on the intact rock interlocking (Rv1 case: without infilling) and possible secondary hosted geomaterial, (Rv2 case: with infilling, e.g. clay), rock mass can generate immediate rock mass ravelling in face and tunnel perimeter. The difference with Ch type lies in the block size, which is very small here, the self support timing, which is very limited here and the failure extension, where it is unrestricted due to the lack of better rock mass quality in the surrounding zone		
Fl	**Flowing ground:** The rock mass is disintegrated with practically zero cohesion and intense groundwater presence along the discontinuities. Rock fragments flow with water inside the tunnel		
Sh	**Shear failure:** Minor to medium strains, with the development of shear failures close to the perimeter around the tunnel. Rock mass is characterized by low strength intact rocks (σ_{ci}<15MPa) while the rock mass structure reduces the overall the rock mass strength. Strains develop either at a small to medium tunnel cover (around 50-70m) in case of poor sheared rock masses, or in larger cover in case of better quality rock masses. The ratio of rock mass strength to the in situ stress (σ_{cm}/p_o) is low (0.3<σ_{cm}/p_o <0.45) and strains are measured or expected to be medium (1-2.5 %)		
Sq	**Squeezing ground:** Large strains, due to overstressing with the development of shear failures in an extended zone around the tunnel. Rock mass consists of low strength intact rocks while the rock mass structure reduces the overall rock mass strength. The ratio of rock mass strength to the in situ stress (σ_{cm}/p_o) is very low (σ_{cm}/p_o <0.3) and strains are measured or expected to be >2.5%, and they can be also take place at the face		
Sw	**Swelling ground:** Rock mass contains a significant amount of swelling minerals (montmorillonite, smectite, anhydrite) which swell and deform in the presence of groundwater. Swelling often occurs in the tunnel floor when the support ring is not fully closed		
San	**Anisotropic strains:** The rock mass is stratified or schistose or consists of specific weak zones and develops increased strain characteristics along a direction defined by the schistosity.		

Figure 53: General categories of different Ground Behaviours in Tunnel

As demonstrated in the above flowchart developing geotechnical framework plan begins with the determination of ground types through understanding various ground parameters like ground water, primary stress etc. This eventually leads to determination of ground behaviour types which form the primary information source for geotechnical evaluation and support structure design.

7.2 Ground Types

Different Ground Types have different characteristic parameters that influence their mechanical behaviour. To determine different ground types relevant key parameters have to be evaluated and defined. Different ground masses with similar combinations of relevant parameters are defined as one Ground Type. The definition of the Ground Types has to be based on the current knowledge in each project stage, considering their importance for the successful completion of the project.

The number of defined Ground Types is project specific and depends on the design phase, as well as on the complexity of the geological conditions in the project area. In general, in early design phases, a rough discrimination will be sufficient, with increased information in subsequent design phases the distinction of the single Ground Types will be, and has to be more precise.

For the geotechnical design of Silchar Jiribam Tunnel the relevant rock mass is classified into Ground Types. 4 Ground Types with similar geotechnical properties have been developed basing on the existing geological and geotechnical data. The values for the key parameters and the additional parameters of each Ground Type are evaluated from available data from geological and geotechnical site investigation and/or estimated based on experience from other tunnel projects in comparable ground conditions as well as from geotechnical literature.

The rock mass in the project area can be separated into two basic groups, the metamorphic bedrock and the overlaying debris material.

For the definition of the Ground Types within the metamorphic bedrock the following key parameters are defined:

- Lithology
- Uniaxial compression strength of the intact rock
- Spacing of dominating discontinuity set

Apart of these key parameters the following additional parameters are given for the intact rock and the discontinuities:

- Intact rock parameters (Density weight, Hoek constant mi, Poisson's ratio, Young's modulus)
- Discontinuity properties (Joint Roughness Coefficient - JRC)

Based on the available data the following rock mass parameters are determined:

- GSI
- Rock mass strength (UCS, cohesion, friction)
- Young's modulus

For the definition of the Ground Types within the debris material the following key parameters are defined:

- Lithology
- Block size
- Grain size of Matrix

Based on the available data the following rock mass parameters for the debris material are determined:

- Block properties (UCS, cohesion, friction, Young's modulus)
- Properties of block contact planes (friction)
- Matrix properties (friction, cohesion, Young's modulus).

The total tunnel alignment is divided into four ground types as per the above mentioned parameters and geological mapping investigation carried out along the tunnel alignment.

- **GROUND TYPE-01:**

Fine grained Sandstone or Siltstone with minor intercalation of shale rock.

Moderately weathered and fractured rock mass with horizontal to sub horizontal bedding.

Bedding planes are thinly to medium spaced (6-25 cm). The spacing of bedding plane varies in the given range. Discontinuity surfaces are predominantly undulating to planar and rough to smooth. The rock mass is generally slightly - moderately weathered, weak with an UCS of 25-35 MPa.

- **GROUND TYPE -02**

Fine grained Sandstone/ Siltstone and Shale rock

Moderately to Highly weathered and fractured rock mass of sandstone/ siltstone / shale rock. The bedding planes are horizontal to sub horizontal with three sets of joints.

Bedding planes are thinly spaced (<6 cm). The spacing of bedding plane varies in the given range. Discontinuity surfaces are predominantly planar and rough to smooth. The rock mass is generally moderately to highly weathered, weak with an UCS of 20-25 MPa.

- **GROUND TYPE -03**

Fine grained Sandstone/ Siltstone and Shale rock with gouge material in between.

Highly weathered and fractured rock mass of sandstone/ siltstone / shale rock with gouge material of maximum 1m in between. The bedding planes are horizontal to sub horizontal with three to four sets of joints.

Bedding planes are thinly spaced (<6 cm). The spacing of bedding plane varies in the given range. Discontinuity surfaces are predominantly planar and smooth. The rock mass is generally highly weathered, weak with an UCS of 15-20 MPa.

- **GROUND TYPE -04**

Fine grained Sandstone/ Siltstone and Shale rock with gouge material and highly folded region.

Highly weathered and fractured rock mass of sandstone/ siltstone / shale rock with gouge material of maximum 1m and folded region. The bedding planes are horizontal to sub horizontal with three to four

sets of joints. The rock mass represents the portal region with 10-20m overburden and the folded region expected in the center of the tunnel alignment.

Bedding planes are thinly spaced (<6 cm). The spacing of bedding plane varies in the given range. Discontinuity surfaces are predominantly planar and smooth to slickensided. The rock mass is generally highly weathered, weak with an UCS of 10-15 MPa.

The detailed Ground Type (GT) details of tunnel is given below,

Ground Type	GT 01			
Lithology and Stratigraphy	Moderately weathered and fractured bed rock of Boka Bil Formation			
Geologic description	Grey coloured, fine grained, Comapact and Blocky			
Rock type	Sandstone or Siltstone with Intercalation of Shale rock			
Over burden(m)	60-90			
Intercalations	Present			
Persistence of joint plane	3-10			
Joint Spacing	10-30cm			
Joint surface characteristics	Undulating to Planar and Rough to Smooth			
Joint length (extension) following ISRM 1978	1-3m			
Joint opening	0.1mm to tight			
Joint fillings	clay filling			
KEY PARAMETERS (INTACT ROCK) - AWAITED GT REPORT				
Lithology	Siltstone/ Finegrained sandstone with intercalation of shale rock			
Uniaxial compression strength	UCS	[MPa]	30	taken from lab test results.
Young Module (E coefficient)	E	[MPa]	12000.0	taken from lab test results.
Hoek-Brown criterion	mi	[-]	13.0	taken from lab test results.
Cohesion	c	[MPa]	2.50	taken from lab test results.
Friction angle	ϕ	[°]	22	taken from lab test results.
Poisson Number	p	[-]	0.25	taken from lab test results.
KEY PARAMETERS (ROCK MASS)				
Density	γ	[kN/m³]	26	Taken average from lab test results.
Geological Strength Index	GSI	[-]	37	Estimated from field data
Over burden		[M]	80	Derived from L-section
Uniaxial compression strength	UCS	[MPa]	1.015	RocLab
Young Module (E coefficient)	E	[MPa]	1559.8	RocLab
Cohesion	c	[MPa]	0.329	RocLab
Friction angle	ϕ	[°]	42.90	RocLab
RQD (%)	25%			
RMR according to Bieniawski	42			
Q System	0.9259			
ADDITIONAL DESCRIPTION				

Figure 54: GT-01 Details

Ground Type	GT 02			
Lithology and Stratigraphy	Highly to moderately weathered and fractured bed rock of Boka Bil Formation			
Geologic description	Grey to green coloured, fine grained			
Rock type	Sandstone/ Silt stone and shale rock			
Over burden(m)	40-60			
Intercalations	Present			
Persistence of joint plane	3-15m			
Joint Spacing	6-20cm			
Joint surface characteristics	Planar Rough to Smooth			
Joint length (extension) following ISRM 1978	1-3m			
Joint opening	0.1 - 0.5 mm			
Joint fillings	Moderate clay filling			
KEY PARAMETERS (INTACT ROCK)				
Lithology	Moderately to Highly Weathered sandstone/ siltstone and shale rock mass			
Uniaxial compression strength	UCS	[MPa]	23	taken from lab test results.
Young Module (E coefficient)	E	[MPa]	8625.0	taken from lab test results.
Hoek-Brown criterion	mi	[-]	10.0	taken from lab test results.
Cohesion	c	[MPa]	2.20	taken from lab test results.
Friction angle	ϕ	[°]	20	taken from lab test results.
Poisson Number	p	[-]	0.27	taken from lab test results.
KEY PARAMETERS (ROCK MASS)				
Density	γ	[kN/m³]	26	Taken average from lab test results.
Geological Strength Index	GSI	[-]	27	Estimated from field data
Over burden		[M]	60	Derived from L-section
Uniaxial compression strength	UCS	[MPa]	0.573	RocLab
Young Module (E coefficient)	E	[MPa]	581.55	RocLab
Cohesion	c	[MPa]	0.163	RocLab
Friction angle	ϕ	[°]	41.67	RocLab
RQD (%)	20%			
RMR according to Bieniawski	32			
Q System	0.073			
ADDITIONAL DESCRIPTION				

Figure 55: GT-02 Details

Ground Type	GT 03			
Lithology and Stratigraphy	Highly Weathered and fractured bed rock / Shear gauge of Boka Bil Formation			
Geologic description	grey to green coloured, fine grained, disintegrated			
Rock type	Sandstone/ siltstone/ shale with gouge material			
Over burden(m)	20-40			
Intercalations	Present (gauge of 5-50cm)			
Persistence of joint plane	10-20m			
Joint Spacing	<6cm			
Joint surface characteristics	Planar and Smooth			
Joint length (extension) following ISRM 1978	1-3m			
Joint opening	0.1 to 0.5 mm			
Joint fillings	clay filling			
KEY PARAMETERS (INTACT ROCK)				
Lithology	Sandstone/ siltstone/ shale with gouge material			
Uniaxial compression strength	UCS	[MPa]	18	taken from lab test results.
Young Module (E coefficient)	E	[MPa]	6750.0	taken from lab test results.
Hoek-Brown criterion	mi	[-]	10.0	taken from lab test results.
Cohesion	c	[MPa]	2.00	taken from lab test results.
Friction angle	ϕ	[°]	18	taken from lab test results.
Poisson Number	p	[-]	0.3	taken from lab test results.
KEY PARAMETERS (ROCK MASS)				
Density	γ	[kN/m³]	25.5	Taken average from lab test results.
Geological Strength Index	GSI	[-]	18	Estimated from field data
Over burden		[M]	30	Derived from L-section
Uniaxial compression strength	UCS	[MPa]	0.372	RocLab
Young Module (E coefficient)	E	[MPa]	280.09	RocLab
Cohesion	c	[MPa]	0.086	RocLab
Friction angle	ϕ	[°]	38.89	RocLab
RQD (%)	15%			
RMR according to Bieniawski	21			
Q System	0.031			
ADDITIONAL DESCRIPTION				

Figure 56: GT-03 Details

Ground Type	GT 04			
Lithology and Stratigraphy	Highly Weathered and fractured bed rock / Shear gauge of Boka Bil Formation			
Geologic description	Grey coloured, fine grained, Decomposed or disintegrated			
Rock type	Sandstone/ siltstone/ shale			
Over burden(m)	10-20			
Intercalations	Present (Shear gauge of 50-100cm)			
Persistence of joint plane	10-25m			
Joint Spacing	<6cm			
Joint surface characteristics	Smooth and slickensided			
Joint length (extension) following ISRM 1978	1-3m			
Joint opening	0.5 - 5 mm			
Joint fillings	Thick clay filling			
KEY PARAMETERS (INTACT ROCK)				
Lithology	Sandstone/ siltstone/ shale with gouge intercalations			
Uniaxial compression strength	UCS	[MPa]	12	taken from lab test results.
Young Module (E coefficient)	E	[MPa]	4200.0	taken from lab test results.
Hoek-Brown criterion	mi	[-]	10.0	taken from lab test results.
Cohesion	c	[MPa]	1.80	taken from lab test results.
Friction angle	ϕ	[°]	17	taken from lab test results.
Poisson Number	p	[-]	0.33	taken from lab test results.
KEY PARAMETERS (ROCK MASS)				
Density	γ	[kN/m³]	25	Taken average from lab test results.
Geological Strength Index	GSI	[-]	13	Estimated from field data
Over burden		[M]	15	Derived from L-section
Uniaxial compression strength	UCS	[MPa]	0.125	RocLab
Young Module (E coefficient)	E	[MPa]	141.76	RocLab
Cohesion	c	[MPa]	0.029	RocLab
Friction angle	ϕ	[°]	40.89	RocLab
RQD (%)	10%			
RMR according to Bieniawski	15			
Q System	0.005			
ADDITIONAL DESCRIPTION				

Figure 57: GT-04 Details

7.3 Behaviour Types (BT)

7.3.1. General

The Ground Behaviour represents the determined behaviour of the rock mass due to the excavation of the tunnel without any support measures. To determine the ground behaviour the Ground Types are combined with the predicted ground conditions represented by the influencing factors which are the primary stress condition, the water condition and the orientation of discontinuities.

The influencing factors are described more detailed in the geological and geotechnical investigation reports and the geological and geotechnical evaluation in chapter 2. All relevant data (Ground Type and influencing factors), the resulting rock mass behaviour, typical failure modes and accompanying information are presented systematically in tables. A drawing illustrates the typical behaviour of the rock mass. Additionally the behaviour of the face without support measures is given. The classified Behaviour Types are the basis for the design of appropriate measures to achieve stable tunnel conditions.

In this design phase the Behaviour Types for the main tunnel geometry are determined. The behaviour for the other tunnel geometries such as parallel egress tunnel, cross passages, lay-by, and ventilation tunnel of ventilation cavern shall be investigated in the detailed design.

7.3.2. Criteria for Behaviour Types

Different failure modes occur under different conditions. To be able to identify the applicable Behaviour Types, criteria need to be established. Considering the geological ground condition, the stress situation, the geometry and size of the opening, and other influencing factors like ground water, the criteria are used to identify different behaviour Types. In the following these criteria, which are used for the identification of different Behaviour Types, are briefly described. Note that combinations of different Behaviour Types can occur, for example stress induced failure of the ground in combination with discontinuity controlled over break.

- **Behaviour Type 1: Stable**

"Stable rock mass with the potential of small local gravity induced falling or sliding of blocks". No failure except minor gravity induced falling of blocks with a volume of less than 0,2 m^3.

- **Behaviour Type 2: Stable with the potential of discontinuity controlled block fall**

"Deep reaching discontinuity controlled, gravity induced falling and sliding of blocks, occasional local shear failure. A minimum of 3 joint sets is required to allow the falling or sliding of blocks kinematically. The joint spacing has to be smaller than the tunnel diameter. The block volume has to be more than 0.2 m^3. Influencing factors are joints' orientation, persistence and spacing. Analytical analyses are used to estimate the volume of gravity induced falling and sliding of blocks.

- **Behaviour Type 3: Shallow shear failure**

"Shallow stress induced shear failures in combination with discontinuity and gravity controlled failure of the rock mass". The depth of shear failure or plastic zone is investigated with analytical and numerical analysis with/without fault zones. Main influencing factors are the strength parameters of the rock mass and the primary stress condition. If the plastic zone outside the underground excavation is smaller than 25% of the tunnel diameter (~ 3 m) Behaviour Type 3 is assigned.

- **Behaviour Type 4: Deep seated shear failure**

"Deep seated stress induced shear failures and large deformation". The depth of shear failure or plastic zone is investigated with analytical and numerical analysis with/without fault zones. The main influencing factors are the strength parameters of the rock mass and the primary stress condition. If the plastic zone outside the excavation exceeds 25% of the tunnel diameter (~ 3 m) Behaviour Type 4 is assigned.

- **Behaviour Type 5: Rock burst**

"Sudden and violent failure of the rock mass, caused by highly stressed brittle rocks and the rapid release of accumulated strain energy". To evaluate the potential for rock burst the approach by Wang & Park [L3] is used, including four conditions for the development of rock burst. The rock mass must have a potential for storing considerable elastic strain energy as well as brittle post peak behaviour, and the stresses must be near the peak strength of the rock mass.

- **Behaviour Type 6: Buckling failure**

"Buckling of rocks with a narrowly spaced discontinuity set, frequently associated with shear failure". Feder and Arwanitakis 1976 [L4] proposed a solution for the determination of buckling failure. The proposed criterion can be used to assign Behaviour Type 6 (buckling failure), based on the bedding plane

thickness. The solution is based on the primary stress condition and the friction between the buckling planes. If the actual thickness of the bedding planes is smaller than the critical thickness t buckling will occur. Main influencing factors are the primary stress state, joint orientation and spacing (thickness of bedding planes), strength parameters of joints, elastic parameters of the rock mass and strength parameters of the rock mass.

- **Behaviour Type 7: Shear failure under low confining pressure**

"Potential for excessive overbreak and progressive shear failure with the development chimney type failure, caused mainly by a deficiency of side pressure". The solution is based on the comparison of the block weight to the resisting shear forces along the vertical sliding planes. If the weight of the block is higher than the sum of resisting forces in the two sliding planes, a chimney type failure will occur.

Main influencing factors are overburden, lateral confining coefficient and the friction angle of the rock mass.

- **Behaviour Type 8: Ravelling ground**

"Flow of cohesionless dry or moist, intensely fractured rocks or Soil". Influencing parameters for the determination of ravelling ground conditions are the size and shape of the ground particles as well as the grain size distribution. Additionally, the joints' cohesion of the highly fractured rock affects the potential for failure. For ravelling ground the spacing of discontinuities must be smaller than 10 cm and the block volume of the loose material must be smaller than 0,001 m^3. Additionally the cohesion of the joints cj must be less than limit = 50 kPa. If both criteria are fulfilled, potential for ravelling ground can is assigned. Main influencing factors are block size of the loose material, and the cohesion of the joints between the blocks.

- **Behaviour Type 9: Flowing ground**

"Flow of intensively fractured rocks or soil with high water content". Important factors for the determination of flowing ground conditions are the existence of water in the rock mass, the size and shape of single ground particles as well as the grain size distribution. Additionally, the ground permeability around the excavation affects the potential for failure. The critical grain size distribution is characterised with two parameters, d90 and d10. These parameters represent the grain size for 90 and 10 percent of grains (weight proportion) smaller than d90 and d10, respectively.

The following two values have been defined: d90 = 20 mm and d10 = 0.2 mm. Ground conditions with the associated characteristic values d10 and d90 within the limits mentioned above as well as ground water up to the tunnel crown (or higher) will result in the assignment of Behaviour Type 10. The limits for both values were chosen to characterise medium sand to medium gravel, which generally has a high potential for flowing ground. Influencing factors are the grain size of the rock mass material and existence of high water pressure.

- **Behaviour Type 10: Swelling**

Time dependent volume increase of the rock mass caused by physical-chemical reaction of rock and water in combination with stress relief, leading to inward movement of the tunnel perimeter. A swelling potential can be identified, if the rock mass contains a certain percentage of swelling minerals (for example clay minerals) and water is present. An additional condition is a stress release, which is always associated with tunnel excavation.

- **Behaviour Type 11: Heterogeneous rock with frequently changing deformation characteristics**

"Rapid variations of stresses and deformations (for example in heterogeneous fault zones; block-in-matrix rock, tectonic melanges)". Basic requirements for this Behaviour Type are frequently changing ground conditions which result in heterogeneous displacements of the excavation. Presence of heterogeneous fault zones or "block-in-matrix structured rock" forms the basis for the criterion of this Type. This Behaviour Type is assigned if it is not possible to assign specific Behaviour Types due to the rapid variation of ground conditions.

7.3.1 Behaviour Types of Tunnel

According to the defined criteria the following Behaviour Types are expected in the project area for the main tunnel. In the portal areas and folded region highly weathered and fractured (GT4) can be expected which is evaluated as the most difficult concerning the ground condition. Highly weathered and fractured rock mass with water presence and gouge material of 1m thickness is expected in this ground type. These influencing factors lead to BT-06 (Buckling) BT7 (Crown Failure), BT8 (Ravelling Ground) and predominant BT10 (Swelling Ground) behaviour types expected in GT-04.

Highly weathered rock mass with 20-50cm gouge material (GT-03) is expected inside the tunnel alignment where overburden of tunnel is in between 20-40m. BT-04 (Voluminous Stress Induced Failures), BT-07 (Crown Failures), BT-08 (Ravelling Ground) and BT-10 (Swelling ground) behaviour types are expected in this GT-03.

Highly to moderately weathered sandstone/ siltstone/ shale rock mass (GT-02) is expected in overburden in between 40-60m. BT-03 (Shallow Failures) BT-04 (Voluminous Stress Induced Failures), BT-07 (Crown Failures) behaviour types are expected in this GT-02.

Moderately weathered sandstone/ siltstone/ shale rock mass (GT-01) is expected in overburden in between 60-90m. BT-03 (Shallow Failures) and BT-02 (Potential of discontinuity controlled block fall) behaviour types are expected in this GT-01.

The distribution of behaviour types as per the ground types is given in the table below.

GROUND TYPES (GT)	BEHAVIOUR TYPES (BT)
GT-01	BT-02, BT-03
GT-02	BT-03, BT-04, BT-07
GT-03	BT-04, BT-07, BT-08, BT-10
GT-04	BT-06, BT-07, BT-08, BT-10

7.4 Support Class Details of Tunnel

The support class distribution and properties of LHS and RHS tube according to the respective behaviour type is given in the table below along with RocLab files.

Table 11: Support Class Properties and Distribution- LHS

SILCHIR-JIRIBAM 770m TUNNEL-LHS															
Sl no	SC	BT	Length (m)	%	Over Burden (m)	RMR/ GSI	UCS (Mpa)	Unit Weight (MN/m3)	Poissons Ratio	Youngs Modulus (Mpa)	mi	MR	C -Mpa (RL)	Phi (RL)	Deformation Modulus (Mpa) (RL)
1	SC-01		0	0											
2	SC-02		0	0											
3	SC-03	BT-02, BT-03	60.0	7.9	85	42/37	30	0.026	0.25	12000	13	400	0.329	42.9	1559.8
4	SC-04	BT-03, BT-04, BT-07	330.0	43.6	45	32/27	23	0.026	0.27	8625	10	375	0.163	41.67	581.55
5	SC-05	BT-06,BT-07, BT-10	185.0	24.5	30	21/18	18	0.0255	0.30	6750	10	375	0.086	38.89	280.09
6	SC-05A	BT-06, BT-08, BT-10	181.5	24.0	15	15/13	12	0.025	0.33	4200	10	350	0.029	40.89	141.76

Table 12: Support Class Properties and Distribution- RHS

SILCHIR-JIRIBAM 770m TUNNEL-RHS															
Sl no	SC	BT	Length (m)	%	Over Burden (m)	RMR/ GSI	UCS (Mpa)	Unit Weight (MN/m3)	Poissons Ratio	Youngs Modulus (Mpa)	mi	MR	C -Mpa (RL)	Phi (RL)	Deformation Modulus (Mpa) (RL)
1	SC-01		0	0											
2	SC-02		0	0											
3	SC-03	BT-02, BT-03	30	4	80	42/37	30	0.026	0.25	12000	13	400	0.364	44.7	1559.8
4	SC-04	BT-03, BT-04, BT-07	480	61.9	40	32/27	23	0.026	0.27	8625	10	375	0.163	41.7	581.55
5	SC-05	BT-06,BT-07, BT-10	175	22.6	30	21/18	18	0.0255	0.30	6750	10	375	0.086	38.9	280.09
6	SC-05A	BT-06, BT-08, BT-10	91	11.7	15	15/13	12	0.025	0.33	4200	10	350	0.038	38.1	141.76

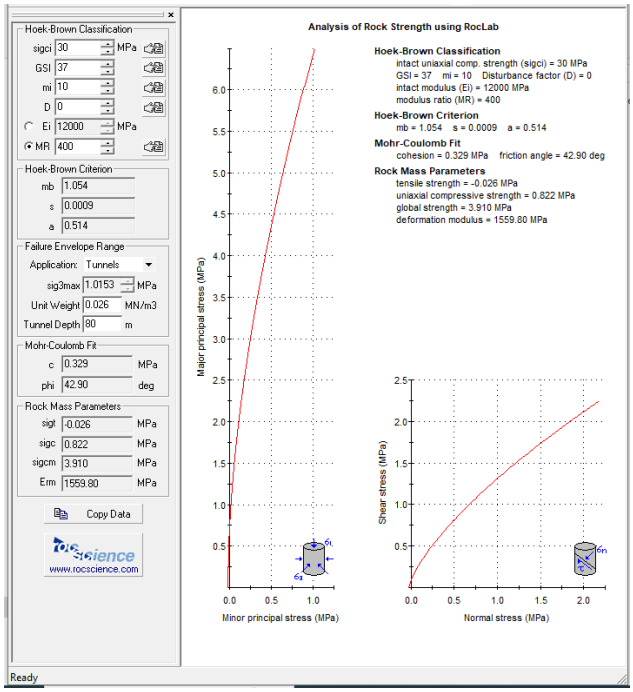


Figure 58: RocLab file-SC-03

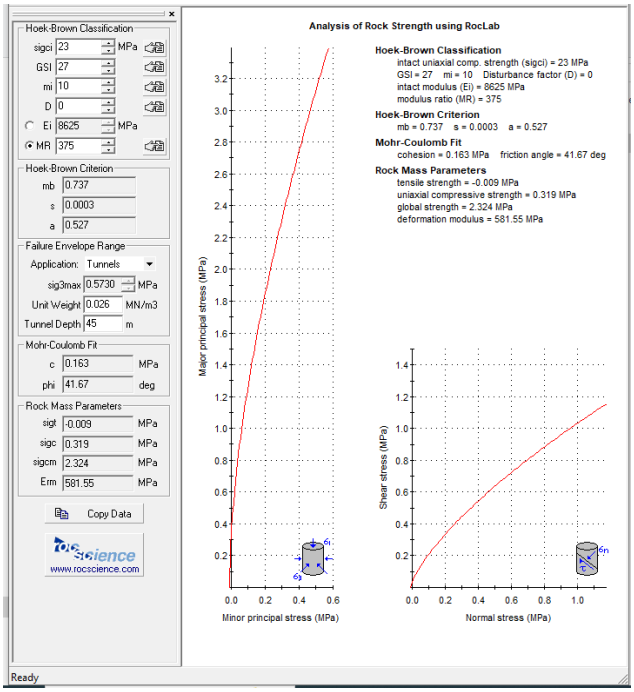


Figure 59: RocLab file-SC-04

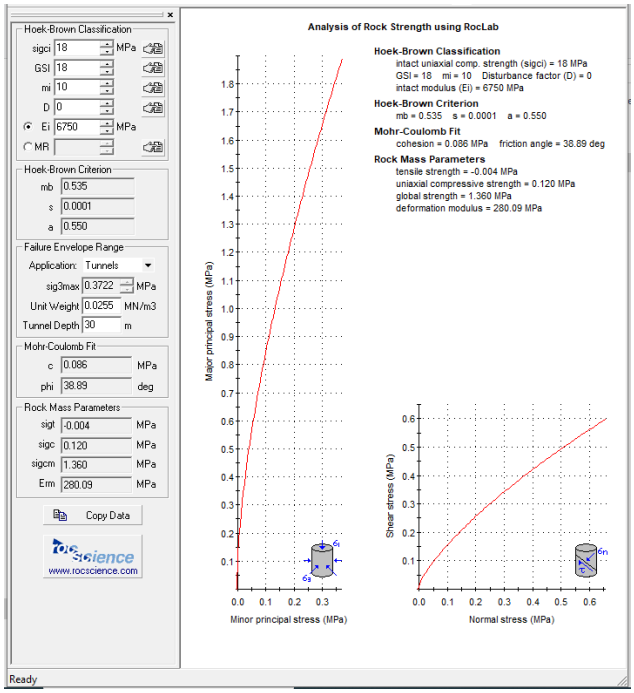


Figure 60: RocLab file-SC-05

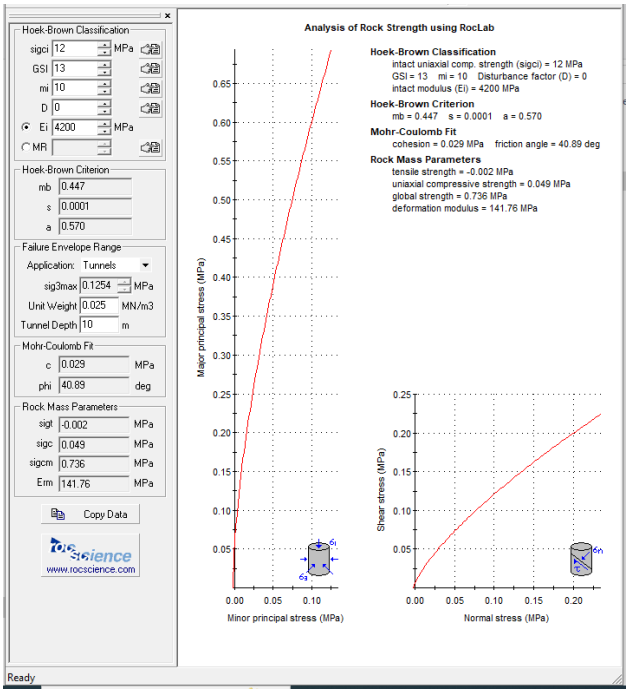


Figure 61: RocLab file-SC-05A

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- https://glovis.usgs.gov/app?fullscreen=0 (USGS portal for satellite data)
- https://earthquake.usgs.gov/earthquakes(USGS portal for earthquake catalogue)
- http://www.unavco.org/software/visualization/GPS-Velocity-Viewer/GPS-Velocity-Viewer.htmls:

APPENDIX 1:

GSS SHEETS

EXCELLING GEO & ENGINEERING CONSULTANT Pvt. Ltd.

GSS SHEET: DATA SHEET FOR ROCK MASS BEHAVIOUR/ROCKMASS CLASIFICATION

Location: Silchar | Sub Location: East portal (RHS) | Date of Observation: 28/02/24

N28° 28' 44.81 E 77° 18' 14.00" (GL- 82)

Description of Joints:

Set Number	J1									J2										
Dip amount	59°									20°										
Dip Direction	N75°									N40°										
Persistence (m)	<1	1 - 3 ✓		3-10			10-20		>20	<1	1 - 3		3-10 ✓			10-20			>20	
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR			XD	
Spacing (cm)	<6cm ✓	6-20cm		20-60cm			60-200cm		>200cm	<6cm ✓	6-20cm		20-60cm			60-200cm			>200cm	
Aperture (mm)	None	<.1mm		.1-1.0mm ✓			1-5mm		>5mm	None	<.1mm ✓		.1-1.0mm			1-5mm			>5mm	
Roughness Condition	Stepped			Undulating			Planar ✓			Stepped			Undulating			Planar ✓				
	RI	S	SL	RI	S	SL	RI	S ✓	SL	RI	S	SL	RI	S	SL	RI	S ✓	SL		
Filling	V Soft	Soft Clay ✓		Firm Clay		Stiff Clay		V S Clay	H Clay	V Soft	Soft Clay ✓		Firm Clay		Stiff Clay		V S Clay		H Clay	
JRC	2-4									2-5										
JCS(Mpa)																				
Set Number																				
Dip amount																				
Dip Direction																				
Persistence (m)	<1	1 - 3		3-10			10-20		>20	<1	1 - 3		3-10			10-20			>20	
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR			XD	
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm		20-60cm			60-200cm			>200cm	
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm	None	<.1mm		.1-1.0mm			1-5mm			>5mm	
Roughness Condition	Stepped			Undulating			Planar			Stepped			Undulating			Planar				
	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL		
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay		H Clay	
JRC																				
JCS(Mpa)																				
Set Number																				
Dip amount																				
Dip Direction																				
Persistence (m)	<1	1 - 3		3-10			10-20		>20	<1	1 - 3		3-10			10-20			>20	
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR			XD	
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm		20-60cm			60-200cm			>200cm	
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm	None	<.1mm		.1-1.0mm			1-5mm			>5mm	
Roughness Condition	Stepped			Undulating			Planar			Stepped			Undulating			Planar				
	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL		
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay		H Clay	
JRC																				
JCS(Mpa)																				

Slope →

Slope direction → N100°

Dip amount → 30°- 45°

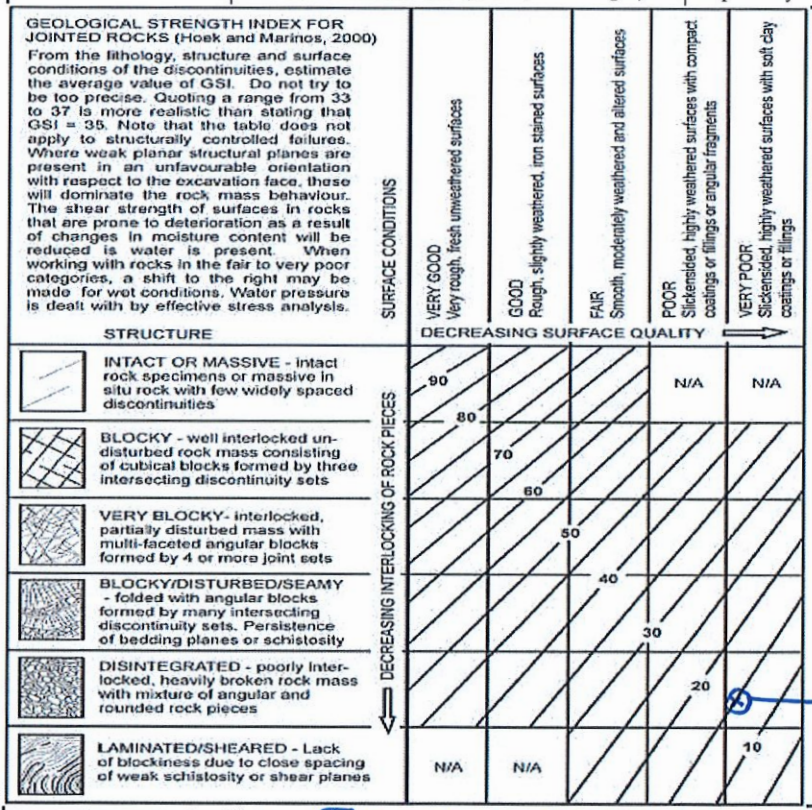
Max Height → -

Description of Rock Mass:

Rock type	Siltstone with minor intercalation of shale.										
UCS (Mpa)	>200		60-200			20-60		6-20. ✓	10-15	<6	
Schmidt Hammer Readings	Geological Hammer.										
No. of Joints /m3 (Jv)											
RQD	90% - 100%		75% - 90%			50% - 75%		25% - 50%	<25% ✓	<10%	
Joint frequency of critical joints											
Block Size/ Dimension (m3)	1.Very large blocks (Jv = 1.0)					2. Large Blocks (Jv= 1 - 3)		3.Medium sized blocks (Jv=3 - 10)			
	4. Small blocks (Jv= 10 - 30)					5. Very small block (Jv= >30) ✓					
Geological Structures	1. Massive(M)		2.Slightly jointed(SJ)			3.Modertately jointed(MJ)		4. Intensely Jointed(IJ) ✓			
	5. Slightly faulted(SFA)					6. Moderately faulted(MFA)		7. Intensely faulted(IFA)			
	8. Slightly folded (SFO) ✓					9.Moderately folded (MFO)		10.Intensely folded (IFO)			

Description of Boundary Conditions:

Degree of weathering	1. Unweathered					2. Slightly weathered		3.Moderately Weathered			
	4. Highly weathered ✓					5. Completely weathered/ Decomposed					
Ground water / Water inflow	~~Dry~~ Damp ✓					Dripping		Medium inflow 10-25 (l/min/10m length)			
	Major Inflow 25-125 (l/min/10m length)					Exeptionaly high inflow >125 (l/min/10m length)					



General Description If Any: The area is moderately sloped (40°-50°) and the rock mass observed is highly weathered & fractured Siltstone with minor intercalation of shale. The area is highly vegetated with an intact rock strength (UCS) of 10-15 Mpa. The area is damp with water presence.

SREERAJ MELOTH

EXCELLING GEO & ENGINEERING CONSULTANT Pvt. Ltd.

GSS SHEET: DATA SHEET FOR ROCK MASS BEHAVIOUR/ROCKMASS CLASIFICATION

Location: Silchar | Sub Location: EP, LHS (Near Borehole) | Date of Observation: 28/02/24.

N 24° 49' 49.67", E 93° 04' 12.46" E (GL → 113m)

Description of Joints:

Set Number	J1									J2										
Dip amount	18°									75°										
Dip Direction	N40°									N145°										
Persistence (m)	<1	1 - 3		3-10 ✓			10-20		>20	<1	1 - 3 ✓			3-10			10-20			>20
Type of Termination	XX	RR		DD			XR		XD	XX	RR			DD			XR			XD
Spacing (cm)	<6cm ✓	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm ✓			20-60cm			60-200cm			>200cm
Aperture (mm)	None	<.1mm ✓		.1-1.0mm			1-5mm		>5mm	None	<.1mm			.1-1.0mm ✓			1-5mm			>5mm
Roughness Condition	Stepped			Undulating			Planar ✓			Stepped			Undulating			Planar ✓				
	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S ✓	SL		
Filling	V Soft	Soft Clay ✓		Firm Clay		Stiff Clay		V S Clay	H Clay	V Soft	Soft Clay ✓		Firm Clay		Stiff Clay		V S Clay	H Clay		
JRC	2-4									2-5										
JCS(Mpa)																				
Set Number																				
Dip amount																				
Dip Direction																				
Persistence (m)	<1	1 - 3		3-10			10-20		>20	<1	1 - 3			3-10			10-20			>20
Type of Termination	XX	RR		DD			XR		XD	XX	RR			DD			XR			XD
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm			20-60cm			60-200cm			>200cm
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm	None	<.1mm			.1-1.0mm			1-5mm			>5mm
Roughness Condition	Stepped			Undulating			Planar			Stepped			Undulating			Planar				
	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL		
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay		
JRC																				
JCS(Mpa)																				
Set Number																				
Dip amount																				
Dip Direction																				
Persistence (m)	<1	1 - 3		3-10			10-20		>20	<1	1 - 3			3-10			10-20			>20
Type of Termination	XX	RR		DD			XR		XD	XX	RR			DD			XR			XD
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm			20-60cm			60-200cm			>200cm
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm	None	<.1mm			.1-1.0mm			1-5mm			>5mm
Roughness Condition	Stepped			Undulating			Planar			Stepped			Undulating			Planar				
	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL		
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay		
JRC																				
JCS(Mpa)																				

Description of Rock Mass:

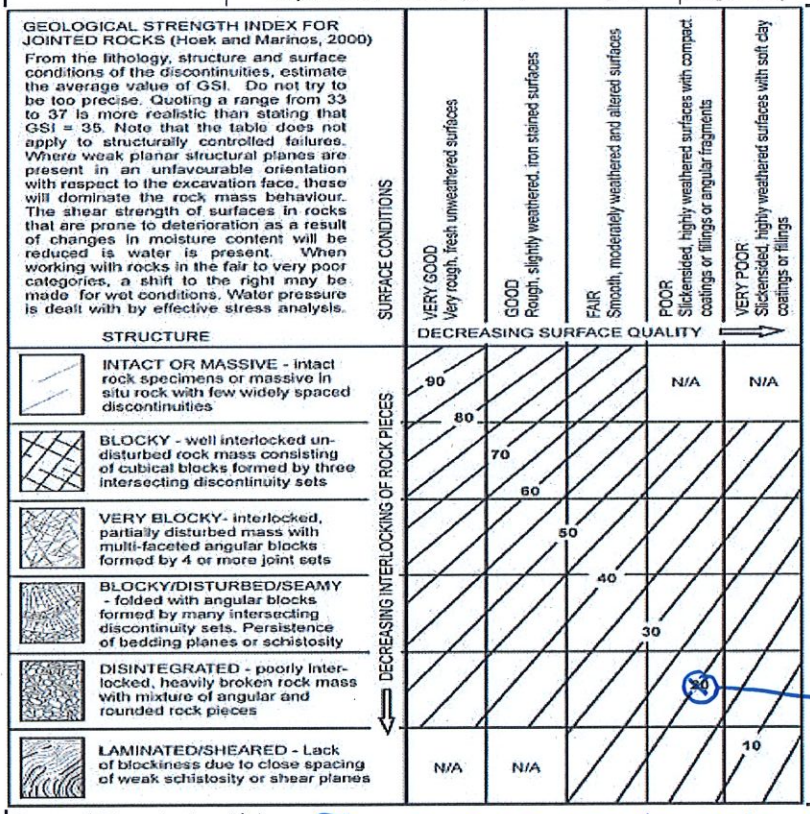
Rock type	Siltstone & Sandstone bedding with intercalation of shale								
UCS (Mpa)	>200	60-200		20-60		✓ 6-20. 10-15		<6	
Schmidt Hammer Readings	Geological Hammer.								
No. of Joints /m3 (Jv)									
RQD	90% - 100%	75% - 90%		50% - 75%		25% - 50%	<25% ✓	<10%	
Joint frequency of critical joints									
Block Size/ Dimension (m3)	1.Very large blocks (Jv = 1.0)			2. Large Blocks (Jv= 1 - 3)		3.Medium sized blocks (Jv=3 - 10)			
	4. Small blocks (Jv= 10 - 30)			5. Very small block (Jv= >30) ✓					
Geological Structures	1. Massive(M)	2.Slightly jointed(SJ)		3.Modertately jointed(MJ)		4. Intensely Jointed(IJ) ✓			
	5. Slightly faulted(SFA) ✓		✓	6. Moderately faulted(MFA)		7. Intensely faulted(IFA)			
	8. Slightly folded (SFO) ✓			9.Moderately folded (MFO)		10.Intensely folded (IFO)			

Description of Boundary Conditions:

Degree of weathering	1. Unweathered			2. Slightly weathered		3.Moderately Weathered			
	4. Highly weathered ✓			5. Completely weathered/ Decomposed					
Ground water / Water inflow	~~Dry~~ Damp ✓			Dripping		Medium inflow 10-25 (l/min/10m length)			
	Major Inflow 25-125 (l/min/10m length)			Exeptionaly high inflow >125 (l/min/10m length)					

GEOLOGICAL STRENGTH INDEX FOR JOINTED ROCKS (Hoek and Marinos, 2000)

From the lithology, structure and surface conditions of the discontinuities, estimate the average value of GSI. Do not try to be too precise. Quoting a range from 33 to 37 is more realistic than stating that GSI = 35. Note that the table does not apply to structurally controlled failures. Where weak planar structural planes are present in an unfavourable orientation with respect to the excavation face, these will dominate the rock mass behaviour. The shear strength of surfaces in rocks that are prone to deterioration as a result of changes in moisture content will be reduced is water is present. When working with rocks in the fair to very poor categories, a shift to the right may be made for wet conditions. Water pressure is dealt with by effective stress analysis.



→ A GSI of 20 is observed.

General Description If Any: The area is moderately steep (50°-60°) with moderate-High Vegetation. A Soil Cover of 3-5m is observed with damp Ground water Condition. The rock mass of Siltstone & Sandstone band is moderately – highly weathered fractured & jointed. The horizontal-subvertical ~~is the~~ Bedding Plane is most observed & prominent discontinuity plane.

SREERAJ. MELOTH

EXCELLING GEO & ENGINEERING CONSULTANT Pvt. Ltd.

GSS SHEET: DATA SHEET FOR ROCK MASS BEHAVIOUR/ROCKMASS CLASIFICATION

Location: Silchar. | Sub Location: Near LHS, EP | Date of Observation: 28/02/24.

N24°49'47.11", E93°04'12.33". (GL→109m)

Description of Joints:

Set Number	J1									J2									
Dip amount	35°									80°									
Dip Direction	N320°									N145°									
Persistence (m)	<1	1 - 3		3-10			10-20		>20	<1	1 - 3		3-10			10-20			>20
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR			XD
Spacing (cm)	<6cm	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm		20-60cm			60-200cm			>200cm
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm	None	<.1mm		.1-1.0mm			1-5mm			>5mm
Roughness Condition	Stepped			Undulating			Planar			Stepped			Undulating			Planar			
	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay	V S Clay		H Clay	V Soft	Soft Clay		Firm Clay		Stiff Clay	V S Clay		H Clay	
JRC	2-4									4-6									
JCS(Mpa)																			

Set Number																			
Dip amount																			
Dip Direction																			
Persistence (m)	<1	1 - 3		3-10			10-20		>20	<1	1 - 3		3-10			10-20			>20
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR			XD
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm		20-60cm			60-200cm			>200cm
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm	None	<.1mm		.1-1.0mm			1-5mm			>5mm
Roughness Condition	Stepped			Undulating			Planar			Stepped			Undulating			Planar			
	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay	V S Clay		H Clay	V Soft	Soft Clay		Firm Clay		Stiff Clay	V S Clay		H Clay	
JRC																			
JCS(Mpa)																			

Set Number																			
Dip amount																			
Dip Direction																			
Persistence (m)	<1	1 - 3		3-10			10-20		>20	<1	1 - 3		3-10			10-20			>20
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR			XD
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm		20-60cm			60-200cm			>200cm
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm	None	<.1mm		.1-1.0mm			1-5mm			>5mm
Roughness Condition	Stepped			Undulating			Planar			Stepped			Undulating			Planar			
	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay	V S Clay		H Clay	V Soft	Soft Clay		Firm Clay		Stiff Clay	V S Clay		H Clay	
JRC																			
JCS(Mpa)																			

Slope details →

Slope direction → N115°

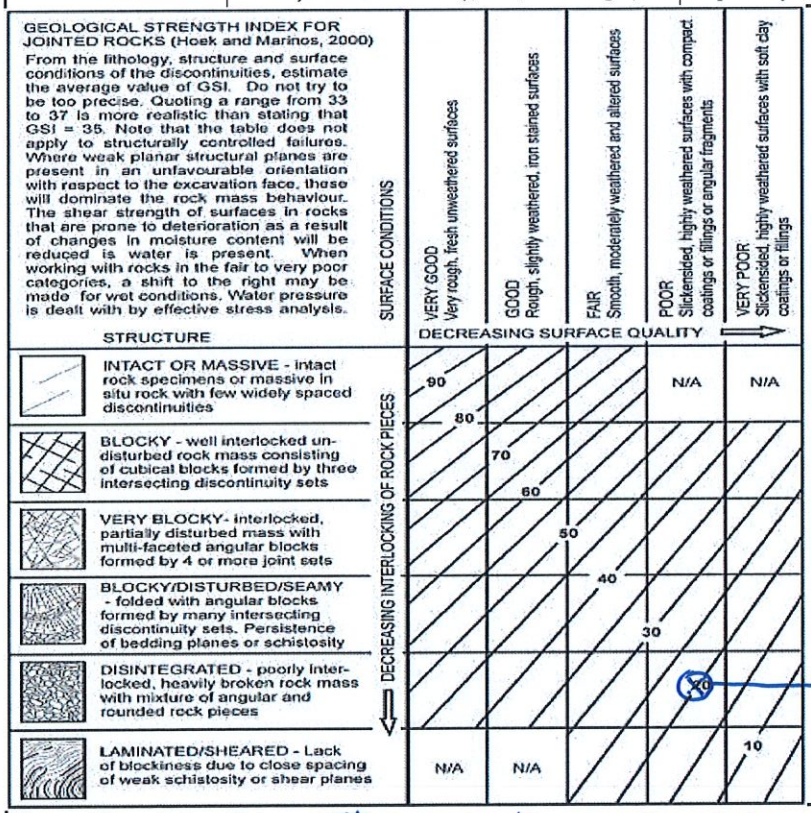
Dip amount → 55°-60°

Description of Rock Mass:

Rock type	Siltstone, Sandstone interbed with minor intercalation of Shale									
UCS (Mpa)	>200		60-200		20-60		6-20. ✓ 15-25 MPa //		<6	
Schmidt Hammer Readings	Geological Hammer.									
No. of Joints /m3 (Jv)										
RQD	90% - 100%		75% - 90%		50% - 75%		25% - 50%	<25% ✓	<10%.	
Joint frequency of critical joints										
Block Size/ Dimension (m3)	1.Very large blocks (Jv = 1.0)				2. Large Blocks (Jv= 1 - 3)		3.Medium sized blocks (Jv=3 - 10)			
	4. Small blocks (Jv= 10 - 30)				5. Very small block (Jv= >30) ✓					
Geological Structures	1. Massive(M)		2.Slightly jointed(SJ)		3.Modertately jointed(MJ)		4. Intensely Jointed(IJ) ✓			
	5. Slightly faulted(SFA) ✓				6. Moderately faulted(MFA)		7. Intensely faulted(IFA)			
	8. Slightly folded (SFO)				9.Moderately folded (MFO)		10.Intensely folded (IFO)			

Description of Boundary Conditions:

Degree of weathering	1. Unweathered				2. Slightly weathered		3.Moderately Weathered			
	4. Highly weathered ✓				5. Completely weathered/ Decomposed					
Ground water / Water inflow	Dry to damp ✓				Dripping		Medium inflow 10-25 (l/min/10m length)			
	Major Inflow 25-125 (l/min/10m length)				Exeptionaly high inflow >125 (l/min/10m length)					



→ A GSI of 15-25 is observed.

General Description If Any: The area is moderately steep (50°-60°) with high vegetation. A Soil cover of 2-6m is expected with dry to damp ground water condition. The rock mass of Siltstone & Sandstone band is moderately to highly weathered & Jointed.

SREERAJ MELOTH

EXCELLING GEO & ENGINEERING CONSULTANT Pvt. Ltd.

GSS SHEET: DATA SHEET FOR ROCK MASS BEHAVIOUR/ROCKMASS CLASIFICATION

Location: Silchar | Sub Location: Near Nala (WP) | Date of Observation: 28/01/2024

N24°49' 51.54" E 93°03'44.58" (GL→94m)

Description of Joints:

Set Number	J1 (Bedding plane)										J2									
Dip amount	15-20°										70-75°									
Dip Direction	N346°										N165°.									
Persistence (m)	<1	1 - 3		3-10			10-20		>20		<1	1 - 3		3-10			10-20		>20	
Type of Termination	XX	RR		DD			XR		XD		XX	RR		DD			XR		XD	
Spacing (cm)	<6cm	6-20cm		20-60cm			60-200cm		>200cm		<6cm	6-20cm		20-60cm			60-200cm		>200cm	
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm		None	<.1mm		.1-1.0mm			1-5mm		>5mm	
Roughness Condition	Stepped			Undulating			Planar				Stepped			Undulating			Planar			
	RI	S	SL	RI	S	SL	RI	S	SL		RI	S	SL	RI	S	SL	RI	S	SL	
Filling	V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay					V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay				
JRC	2-4//										4-6//									
JCS(Mpa)																				
Set Number																				
Dip amount																				
Dip Direction																				
Persistence (m)	<1	1 - 3		3-10			10-20		>20		<1	1 - 3		3-10			10-20		>20	
Type of Termination	XX	RR		DD			XR		XD		XX	RR		DD			XR		XD	
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm		<6cm	6-20cm		20-60cm			60-200cm		>200cm	
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm		None	<.1mm		.1-1.0mm			1-5mm		>5mm	
Roughness Condition	Stepped			Undulating			Planar				Stepped			Undulating			Planar			
	RI	S	SL	RI	S	SL	RI	S	SL		RI	S	SL	RI	S	SL	RI	S	SL	
Filling	V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay					V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay				
JRC																				
JCS(Mpa)																				
Set Number																				
Dip amount																				
Dip Direction																				
Persistence (m)	<1	1 - 3		3-10			10-20		>20		<1	1 - 3		3-10			10-20		>20	
Type of Termination	XX	RR		DD			XR		XD		XX	RR		DD			XR		XD	
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm		<6cm	6-20cm		20-60cm			60-200cm		>200cm	
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm		None	<.1mm		.1-1.0mm			1-5mm		>5mm	
Roughness Condition	Stepped			Undulating			Planar				Stepped			Undulating			Planar			
	RI	S	SL	RI	S	SL	RI	S	SL		RI	S	SL	RI	S	SL	RI	S	SL	
Filling	V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay					V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay				
JRC																				
JCS(Mpa)																				

Slope details →

Dip direction → N315°

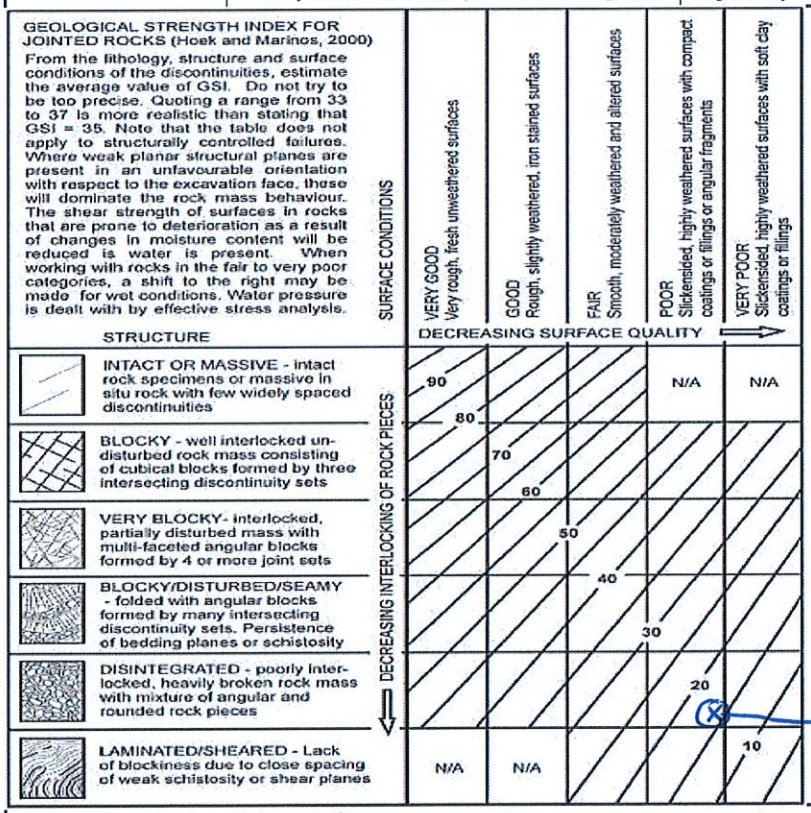
Dip amount → 40° - 50°

Description of Rock Mass:

Rock type	Siltstone.									
UCS (Mpa)	>200		60-200		20-60		6-20. ✓	5-15 Mpa.	<6	
Schmidt Hammer Readings	Geological Hammer									
No. of Joints /m3 (Jv)										
RQD	90% - 100%		75% - 90%		50% - 75%		25% - 50%	<25% ✓	<10%.	
Joint frequency of critical joints										
Block Size/ Dimension (m3)	1.Very large blocks (Jv = 1.0)				2. Large Blocks (Jv= 1 - 3)		3.Medium sized blocks (Jv=3 - 10)			
	4. Small blocks (Jv= 10 - 30)				5. Very small block (Jv= >30) ✓					
Geological Structures	1. Massive(M)		2.Slightly jointed(SJ)		3.Modertately jointed(MJ)		4. Intensely Jointed(IJ)			
	5. Slightly faulted(SFA) ✓				6. Moderately faulted(MFA)		7. Intensely faulted(IFA)			
	8. Slightly folded (SFO) ✓				9.Moderately folded (MFO)		10.Intensely folded (IFO)			

Description of Boundary Conditions:

Degree of weathering	1. Unweathered				2. Slightly weathered		3.Moderately Weathered			
	4. Highly weathered ✓				5. Completely weathered/ Decomposed					
Ground water / Water inflow	~~Dry~~ Damp ✓				Dripping		Medium inflow 10-25 (l/min/10m length)			
	Major Inflow 25-125 (l/min/10m length)				Exeptionaly high inflow >125 (l/min/10m length)					



→ A GSI of 15-20 is observed.

General Description If Any: The area is moderately to steep sloped (60°-70°) with high vegetation and water flow. Surface water drainage is observed in this region. Due to the high vegetation & soil cover (3-6m) limited rock exposure is observed in the west portal.

SREERAJ MELOTH.

EXCELLING GEO & ENGINEERING CONSULTANT Pvt. Ltd.

GSS SHEET: DATA SHEET FOR ROCK MASS BEHAVIOUR/ROCKMASS CLASIFICATION

Location: Silchar. | Sub Location: LHS(NP) | Date of Observation: 28/02/24.

N 24°44'51.65", E 93°03'42.96" (GL → 91m)

Description of Joints:

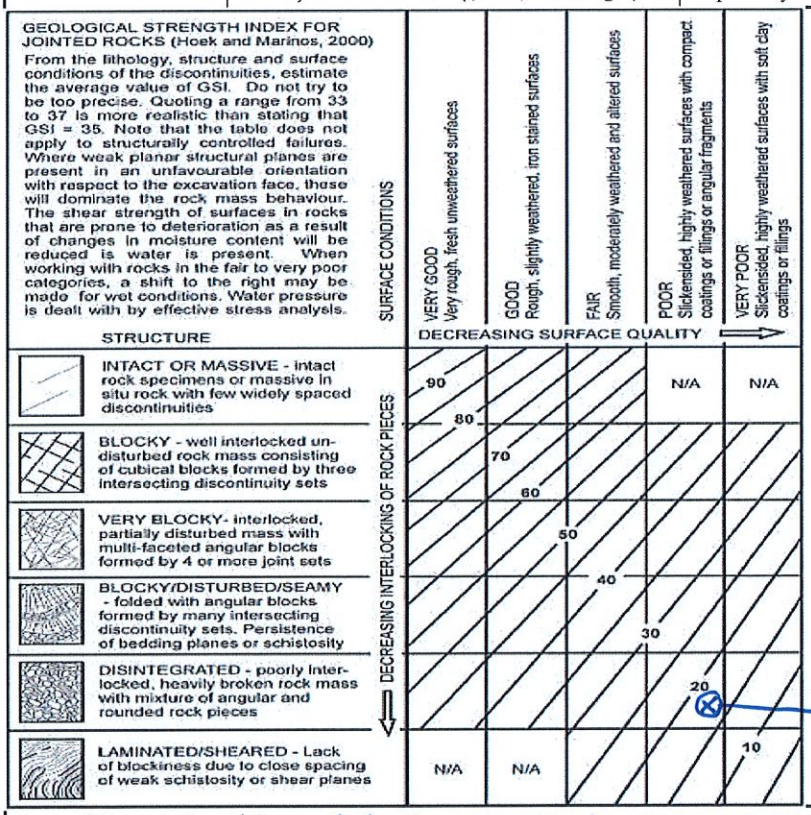
Set Number	J1 (Bedding plane)										J2									
Dip amount	85°										32°									
Dip Direction	N 50°										N165°									
Persistence (m)	<1	1 - 3		3-10			10-20		>20		<1	1 - 3		3-10			10-20		>20	
Type of Termination	XX	RR		DD			XR		XD		XX	RR		DD			XR		XD	
Spacing (cm)	<6cm	6-20cm		20-60cm			60-200cm		>200cm		<6cm	6-20cm		20-60cm			60-200cm		>200cm	
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm		None	<.1mm		.1-1.0mm			1-5mm		>5mm	
Roughness Condition	Stepped			Undulating			Planar				Stepped			Undulating			Planar			
	RI	S	SL	RI	S	SL	RI	S	SL		RI	S	SL	RI	S	SL	RI	S	SL	
Filling	V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay					V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay				
JRC	2-4										2-4									
JCS(Mpa)																				
Set Number																				
Dip amount																				
Dip Direction																				
Persistence (m)	<1	1 - 3		3-10			10-20		>20		<1	1 - 3		3-10			10-20		>20	
Type of Termination	XX	RR		DD			XR		XD		XX	RR		DD			XR		XD	
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm		<6cm	6-20cm		20-60cm			60-200cm		>200cm	
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm		None	<.1mm		.1-1.0mm			1-5mm		>5mm	
Roughness Condition	Stepped			Undulating			Planar				Stepped			Undulating			Planar			
	RI	S	SL	RI	S	SL	RI	S	SL		RI	S	SL	RI	S	SL	RI	S	SL	
Filling	V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay					V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay				
JRC																				
JCS(Mpa)																				
Set Number																				
Dip amount																				
Dip Direction																				
Persistence (m)	<1	1 - 3		3-10			10-20		>20		<1	1 - 3		3-10			10-20		>20	
Type of Termination	XX	RR		DD			XR		XD		XX	RR		DD			XR		XD	
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm		<6cm	6-20cm		20-60cm			60-200cm		>200cm	
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm		None	<.1mm		.1-1.0mm			1-5mm		>5mm	
Roughness Condition	Stepped			Undulating			Planar				Stepped			Undulating			Planar			
	RI	S	SL	RI	S	SL	RI	S	SL		RI	S	SL	RI	S	SL	RI	S	SL	
Filling	V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay					V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay				
JRC																				
JCS(Mpa)																				

Description of Rock Mass:

Rock type	Silt Stone + Sand stone.										
UCS (Mpa)	>200	60-200		20-60		6-20. ✓	10-20	<6			
Schmidt Hammer Readings	Geological Hammer.										
No. of Joints /m3 (Jv)											
RQD	90% - 100%	75% - 90%		50% - 75%		25% - 50%	<25% ✓	<10%			
Joint frequency of critical joints											
Block Size/ Dimension (m3)	1.Very large blocks (Jv = 1.0)			2. Large Blocks (Jv= 1 - 3)		3.Medium sized blocks (Jv=3 - 10)					
	4. Small blocks (Jv= 10 - 30)			5. Very small block (Jv= >30) ✓							
Geological Structures	1. Massive(M)	2.Slightly jointed(SJ)		3.Modertately jointed(MJ)		4. Intensely Jointed(IJ) ✓					
	5. Slightly faulted(SFA) ✓			6. Moderately faulted(MFA)		7. Intensely faulted(IFA)					
	8. Slightly folded (SFO) ✓			9.Moderately folded (MFO)		10.Intensely folded (IFO)					

Description of Boundary Conditions:

Degree of weathering	1. Unweathered				2. Slightly weathered		3.Moderately Weathered				
	4. Highly weathered ✓				5. Completely weathered/ Decomposed						
Ground water / Water inflow	~~Dry~~ Damp ✓				Dripping		Medium inflow 10-25 (l/min/10m length)				
	Major Inflow 25-125 (l/min/10m length)				Exeptionaly high inflow >125 (l/min/10m length)						



General Description If Any: Moderately to steep sloped, highly vegetated & surface drainage area. Due to this & Moderate soil cover (4-6m) limited rock exposure is observed. The main bedding plane is Vertical

SREERAJ MELOTH

EXCELLING GEO & ENGINEERING CONSULTANT Pvt. Ltd.

GSS SHEET: DATA SHEET FOR ROCK MASS BEHAVIOUR/ROCKMASS CLASIFICATION

(Left side of the LHS)

Location: Silchar. | Sub Location: Along the Alignment | Date of Observation: 29/02/24.

N24° 49' 53.14" E 93° 03' 46.86" E (GL-95m)

Description of Joints:

Set Number	J1					J2				
Dip amount	23°					75°				
Dip Direction	N310°					N65°				
Persistence (m)	<1	1 - 3	3-10	10-20	>20	<1	1 - 3	3-10	10-20	>20
Type of Termination	XX	RR	DD	XR	XD	XX	RR	DD	XR	XD
Spacing (cm)	<6cm	6-20cm	20-60cm	60-200cm	>200cm	<6cm	6-20cm	20-60cm	60-200cm	>200cm
Aperture (mm)	None	<.1mm	.1-1.0mm	1-5mm	>5mm	None	<.1mm	.1-1.0mm	1-5mm	>5mm
Roughness Condition	Stepped		Undulating		Planar	Stepped		Undulating		Planar
	RI	S SL	RI S SL	RI	S SL	RI S SL		RI S SL		RI S SL
Filling	V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay	V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay
JRC	2-4					2-5				
JCS(Mpa)										

Set Number										
Dip amount										
Dip Direction										
Persistence (m)	<1	1 - 3	3-10	10-20	>20	<1	1 - 3	3-10	10-20	>20
Type of Termination	XX	RR	DD	XR	XD	XX	RR	DD	XR	XD
Spacing	<6cm	6-20cm	20-60cm	60-200cm	>200cm	<6cm	6-20cm	20-60cm	60-200cm	>200cm
Aperture (mm)	None	<.1mm	.1-1.0mm	1-5mm	>5mm	None	<.1mm	.1-1.0mm	1-5mm	>5mm
Roughness Condition	Stepped		Undulating		Planar	Stepped		Undulating		Planar
	RI	S SL	RI S SL	RI	S SL	RI S SL		RI S SL		RI S SL
Filling	V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay	V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay
JRC										
JCS(Mpa)										

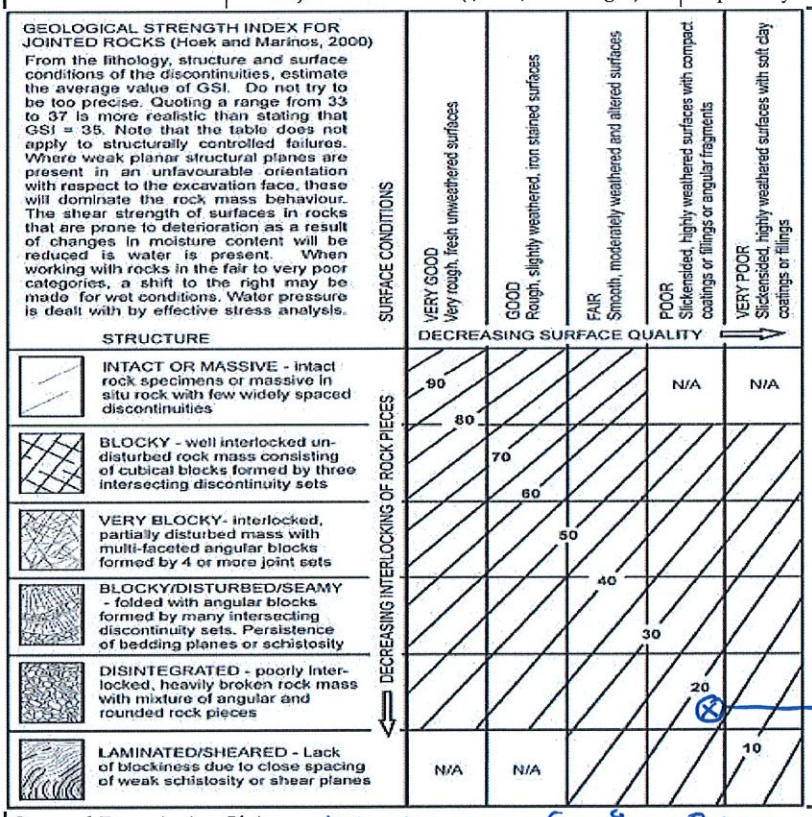
Set Number										
Dip amount										
Dip Direction										
Persistence (m)	<1	1 - 3	3-10	10-20	>20	<1	1 - 3	3-10	10-20	>20
Type of Termination	XX	RR	DD	XR	XD	XX	RR	DD	XR	XD
Spacing	<6cm	6-20cm	20-60cm	60-200cm	>200cm	<6cm	6-20cm	20-60cm	60-200cm	>200cm
Aperture (mm)	None	<.1mm	.1-1.0mm	1-5mm	>5mm	None	<.1mm	.1-1.0mm	1-5mm	>5mm
Roughness Condition	Stepped		Undulating		Planar	Stepped		Undulating		Planar
	RI	S SL	RI S SL	RI	S SL	RI S SL		RI S SL		RI S SL
Filling	V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay	V Soft	Soft Clay	Firm Clay	Stiff Clay	V S Clay	H Clay
JRC										
JCS(Mpa)										

Description of Rock Mass:

Rock type	Siltstone + minor micaceous Sandstone bands									
UCS (Mpa)	>200		60-200		20-60		6-20. ✓	5-15 MPa	<6	
Schmidt Hammer Readings	Geological Hammer.									
No. of Joints /m3 (Jv)										
RQD	90% - 100%		75% - 90%		50% - 75%		25% - 50%	<25% ✓	<10%.	
Joint frequency of critical joints										
Block Size/ Dimension (m3)	1.Very large blocks (Jv = 1.0)				2. Large Blocks (Jv= 1 - 3)		3.Medium sized blocks (Jv=3 - 10)			
	4. Small blocks (Jv= 10 - 30)				5. Very small block (Jv= >30) ✓					
Geological Structures	1. Massive(M)		2.Slightly jointed(SJ)		3.Modertately jointed(MJ)		4. Intensely Jointed(IJ) ✓			
	5. Slightly faulted(SFA)				6. Moderately faulted(MFA)		7. Intensely faulted(IFA)			
	8. Slightly folded (SFO) ✓				9.Moderately folded (MFO)		10.Intensely folded (IFO)			

Description of Boundary Conditions:

Degree of weathering	1. Unweathered				2. Slightly weathered		3.Moderately Weathered			
	4. Highly weathered ✓				5. Completely weathered/ Decomposed					
Ground water / Water inflow	~~Dry~~ Damp-dripping ✓				Dripping		Medium inflow 10-25 (l/min/10m length)			
	Major Inflow 25-125 (l/min/10m length)				Exeptionaly high inflow >125 (l/min/10m length)					



General Description If Any: Moderate (40°-60°) slope, high vegetation is observed with Soil cover of 4-5m. The rockmass observed in the nala cut region is horizontal - Sub Vertical Bedding. The rock mass is weak, moderately to highly weathered & Jointed.

SREERAJ MELOTH

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EXCELLING GEO & ENGINEERING CONSULTANT Pvt. Ltd.

GSS SHEET: DATA SHEET FOR ROCK MASS BEHAVIOUR/ROCKMASS CLASIFICATION

Location: Silchar. | Sub Location: | Date of Observation: 29/02/24.

N24° 49' 55.86" E 93° 03' 53.57" (GL - 102m)

Description of Joints:

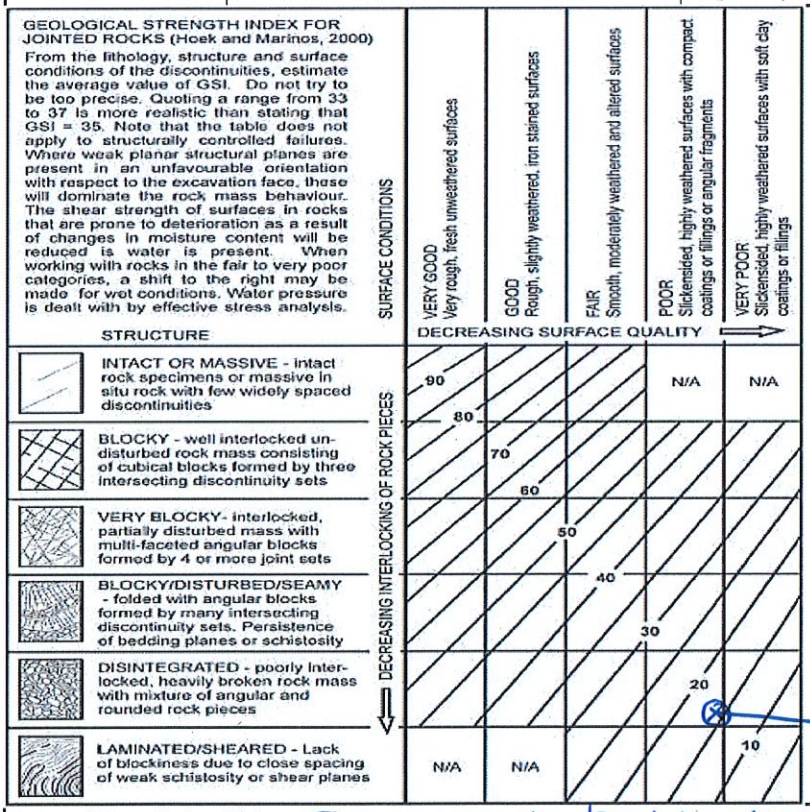
Set Number	J1 (Bedding									J2										
Dip amount	5-10°									75°-80° (vertical)										
Dip Direction	N350°									N110°										
Persistence (m)	<1	1 - 3		3-10 ✓			10-20		>20	<1	1 - 3 ✓		3-10			10-20			>20	
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR			XD	
Spacing (cm)	<6cm ✓	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm ✓		20-60cm			60-200cm			>200cm	
Aperture (mm)	None ✓	<.1mm ✓		.1-1.0mm			1-5mm		>5mm	None	<.1mm ✓		.1-1.0mm			1-5mm			>5mm	
Roughness Condition	Stepped			Undulating			Planar ✓			Stepped			Undulating			Planar ✓				
	RI	S	SL	RI	S	SL	RI	S ✓	SL	RI	S	SL	RI	S	SL	RI	S ✓	SL		
Filling	V Soft ✓	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay	V Soft	Soft Clay ✓		Firm Clay		Stiff Clay		V S Clay	H Clay		
JRC	2-4									2-4										
JCS(Mpa)																				
Set Number																				
Dip amount																				
Dip Direction																				
Persistence (m)	<1	1 - 3		3-10			10-20		>20	<1	1 - 3		3-10			10-20			>20	
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR			XD	
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm		20-60cm			60-200cm			>200cm	
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm	None	<.1mm		.1-1.0mm			1-5mm			>5mm	
Roughness Condition	Stepped			Undulating			Planar			Stepped			Undulating			Planar				
	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL		
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay		
JRC																				
JCS(Mpa)																				
Set Number																				
Dip amount																				
Dip Direction																				
Persistence (m)	<1	1 - 3		3-10			10-20		>20	<1	1 - 3		3-10			10-20			>20	
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR			XD	
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm		20-60cm			60-200cm			>200cm	
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm	None	<.1mm		.1-1.0mm			1-5mm			>5mm	
Roughness Condition	Stepped			Undulating			Planar			Stepped			Undulating			Planar				
	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL		
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay		
JRC																				
JCS(Mpa)																				

Description of Rock Mass:

Rock type	Siltstone bedding :										
UCS (Mpa)	>200		60-200			20-60		6-20. ✓	5-15 MPa //	<6	
Schmidt Hammer Readings	Geological Hammer.										
No. of Joints /m3 (Jv)											
RQD	90% - 100%		75% - 90%			50% - 75%		25% - 50%	<25%	<10%.	
Joint frequency of critical joints											
Block Size/ Dimension (m3)	1.Very large blocks (Jv = 1.0)					2. Large Blocks (Jv= 1 - 3)		3.Medium sized blocks (Jv=3 - 10)			
	4. Small blocks (Jv= 10 - 30)					5. Very small block (Jv= >30) ✓					
Geological Structures	1. Massive(M)		2.Slightly jointed(SJ)			3.Modertately jointed(MJ)		4. Intensely Jointed(IJ)			
	5. Slightly faulted(SFA)					6. Moderately faulted(MFA)		7. Intensely faulted(IFA)			
	8. Slightly folded (SFO) ✓					9.Moderately folded (MFO)		10.Intensely folded (IFO)			

Description of Boundary Conditions:

Degree of weathering	1. Unweathered					2. Slightly weathered		3.Moderately Weathered			
	4. Highly weathered ✓					5. Completely weathered/ Decomposed					
Ground water / Water inflow	~~Dry~~ Damp ✓					Dripping		Medium inflow 10-25 (l/min/10m length)			
	Major Inflow 25-125 (l/min/10m length)					Exeptionaly high inflow >125 (l/min/10m length)					



General Description If Any: The area is highly vegetated & steep - moderate slope. The area is in the LHS of the tunnel and it is a drainage location (Surface). The Rockmass observed is highly weathered, Jointed & weak Siltstone with minor interbedding of Sandstone.

SREERAJ MELOTH

Sreeraj

EXCELLING GEO & ENGINEERING CONSULTANT Pvt. Ltd.

GSS SHEET: DATA SHEET FOR ROCK MASS BEHAVIOUR/ROCKMASS CLASIFICATION

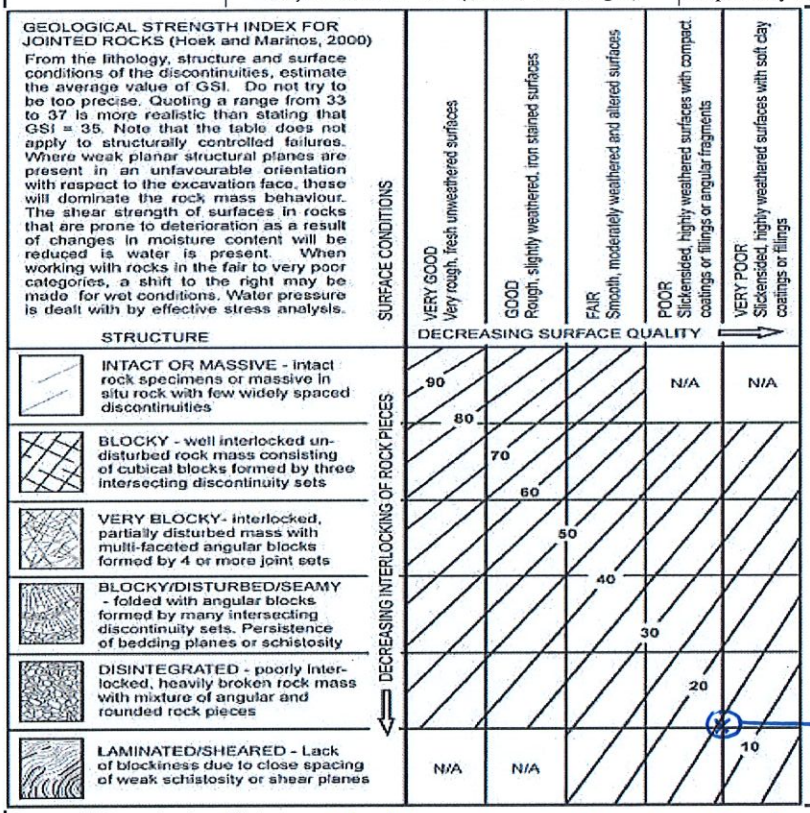
Location: Silchar. | Sub Location: Nala, Centre of the | Date of Observation: 29/02/24

N24°49'53.59", E 93°3'56.26" (GL-140m) Alignment

Description of Joints:

Set Number	J1										J2									
Dip amount	25										75-80°									
Dip Direction	N270°										N									
Persistence (m)	<1		1 - 3		3-10 ✓		10-20		>20		<1		1 - 3 ✓		3-10		10-20		>20	
Type of Termination	XX		RR		DD		XR		XD		XX		RR		DD		XR		XD	
Spacing (cm)	<6cm ✓		6-20cm		20-60cm		60-200cm		>200cm		<6cm		6-20cm ✓		20-60cm		60-200cm		>200cm	
Aperture (mm)	None ✓		<.1mm		.1-1.0mm		1-5mm		>5mm		None		<.1mm ✓		.1-1.0mm		1-5mm		>5mm	
Roughness Condition	Stepped			Undulating			Planar ✓				Stepped			Undulating			Planar ✓			
	RI	S	SL	RI	S	SL	RI	S ✓	SL		RI	S	SL	RI	S	SL	RI	S ✓	SL	
Filling	V Soft ✓	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay		V Soft ✓	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay	
JRC	2-4										4-5									
JCS(Mpa)																				
Set Number																				
Dip amount																				
Dip Direction																				
Persistence (m)	<1		1 - 3		3-10		10-20		>20		<1		1 - 3		3-10		10-20		>20	
Type of Termination	XX		RR		DD		XR		XD		XX		RR		DD		XR		XD	
Spacing	<6cm		6-20cm		20-60cm		60-200cm		>200cm		<6cm		6-20cm		20-60cm		60-200cm		>200cm	
Aperture (mm)	None		<.1mm		.1-1.0mm		1-5mm		>5mm		None		<.1mm		.1-1.0mm		1-5mm		>5mm	
Roughness Condition	Stepped			Undulating			Planar				Stepped			Undulating			Planar			
	RI	S	SL	RI	S	SL	RI	S	SL		RI	S	SL	RI	S	SL	RI	S	SL	
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay		V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay	
JRC																				
JCS(Mpa)																				
Set Number																				
Dip amount																				
Dip Direction																				
Persistence (m)	<1		1 - 3		3-10		10-20		>20		<1		1 - 3		3-10		10-20		>20	
Type of Termination	XX		RR		DD		XR		XD		XX		RR		DD		XR		XD	
Spacing	<6cm		6-20cm		20-60cm		60-200cm		>200cm		<6cm		6-20cm		20-60cm		60-200cm		>200cm	
Aperture (mm)	None		<.1mm		.1-1.0mm		1-5mm		>5mm		None		<.1mm		.1-1.0mm		1-5mm		>5mm	
Roughness Condition	Stepped			Undulating			Planar				Stepped			Undulating			Planar			
	RI	S	SL	RI	S	SL	RI	S	SL		RI	S	SL	RI	S	SL	RI	S	SL	
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay		V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay	
JRC																				
JCS(Mpa)																				

Description of Rock Mass:										
Rock type	Siltstone + Sandstone interbeds.									
UCS (Mpa)	>200		60-200		20-60		6-20. ✓	10-20 MPa //	<6	
Schmidt Hammer Readings	Geological Hammer.									
No. of Joints /m3 (Jv)										
RQD	90% - 100%		75% - 90%		50% - 75%		25% - 50%	<25% ✓	<10%	
Joint frequency of critical joints										
Block Size/ Dimension (m3)	1.Very large blocks (Jv = 1.0)			2. Large Blocks (Jv= 1 - 3)		3.Medium sized blocks (Jv=3 - 10)				
	4. Small blocks (Jv= 10 - 30)			5. Very small block (Jv= >30) ✓						
Geological Structures	1. Massive(M)		2.Slightly jointed(SJ)		3.Modertately jointed(MJ)		4. Intensely Jointed(IJ) ✓			
	5. Slightly faulted(SFA)			6. Moderately faulted(MFA)			7. Intensely faulted(IFA)			
	8. Slightly folded (SFO) ✓			9.Moderately folded (MFO)			10.Intensely folded (IFO)			
Description of Boundary Conditions:										
Degree of weathering	1. Unweathered			2. Slightly weathered			3.Moderately Weathered			
	4. Highly weathered ✓			5. Completely weathered/ Decomposed						
Ground water / Water inflow	~~Dry~~ Damp ✓			Dripping			Medium inflow 10-25 (l/min/10m length)			
	Major Inflow 25-125 (l/min/10m length)			Exeptionaly high inflow >125 (l/min/10m length)						



General Description If Any: Highly vegetated, Moderately sloped, highly weathered & Jointed Siltstone + Sandstone interbeds is observed.

SREERAJ MELOTH

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GSS SHEET: DATA SHEET FOR ROCK MASS BEHAVIOUR/ROCKMASS CLASIFICATION

Location: Silchar | Sub Location: Alignment (LHS) Near EP | Date of Observation: 29/02/24

N24°49'56.03" E 93°04'04.32" (GL+160m)

Description of Joints:

Set Number	J1 (change in dip direction due to folding)									J2									
Dip amount	80°									60°									
Dip Direction	N295°									N110°									
Persistence (m)	<1	1 - 3 ✓		3-10			10-20		>20	<1	1 - 3 ✓		3-10			10-20			>20
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR			XD
Spacing (cm)	<6cm ✓	6-20cm		20-60cm			60-200cm		>200cm	<6cm ✓	6-20cm		20-60cm			60-200cm			>200cm
Aperture (mm)	None	<.1mm ✓		.1-1.0mm			1-5mm		>5mm	None	<.1mm ✓		.1-1.0mm			1-5mm			>5mm
Roughness Condition	Stepped			Undulating			Planar ✓			Stepped			Undulating			Planar ✓			
	RI	S	SL	RI	S	SL	RI	S ✓	SL	RI	S	SL	RI	S	SL	RI	S ✓		SL
Filling	V Soft ✓	Soft Clay		Firm Clay		Stiff Clay	V S Clay		H Clay	V Soft	Soft Clay ✓		Firm Clay		Stiff Clay	V S Clay			H Clay
JRC	2-4									2-5									
JCS(Mpa)																			

Set Number	J3																		
Dip amount	15°																		
Dip Direction	N285°																		
Persistence (m)	<1 ✓	1 - 3		3-10			10-20		>20	<1	1 - 3		3-10			10-20			>20
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR			XD
Spacing	<6cm	6-20cm ✓		20-60cm			60-200cm		>200cm	<6cm	6-20cm		20-60cm			60-200cm			>200cm
Aperture (mm)	None ✓	<.1mm		.1-1.0mm			1-5mm		>5mm	None	<.1mm		.1-1.0mm			1-5mm			>5mm
Roughness Condition	Stepped			Undulating			Planar ✓			Stepped			Undulating			Planar			
	RI	S	SL	RI	S	SL	RI	S ✓	SL	RI	S	SL	RI	S	SL	RI	S		SL
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay	V S Clay		H Clay	V Soft	Soft Clay		Firm Clay		Stiff Clay	V S Clay			H Clay
JRC	2-4																		
JCS(Mpa)																			

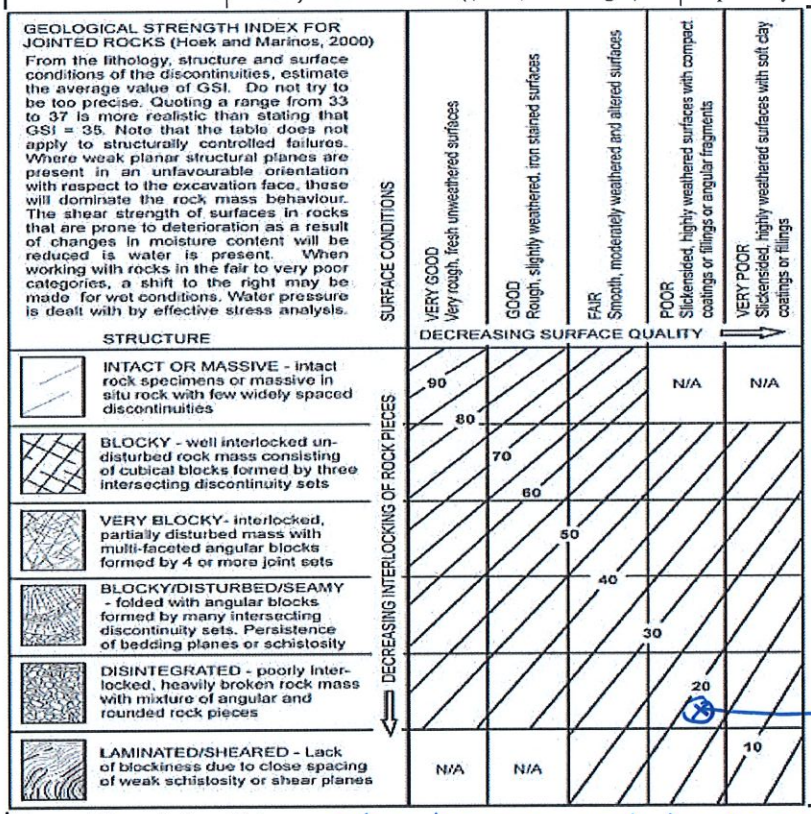
Set Number																			
Dip amount																			
Dip Direction																			
Persistence (m)	<1	1 - 3		3-10			10-20		>20	<1	1 - 3		3-10			10-20			>20
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR			XD
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm		20-60cm			60-200cm			>200cm
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm	None	<.1mm		.1-1.0mm			1-5mm			>5mm
Roughness Condition	Stepped			Undulating			Planar			Stepped			Undulating			Planar			
	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S		SL
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay	V S Clay		H Clay	V Soft	Soft Clay		Firm Clay		Stiff Clay	V S Clay			H Clay
JRC																			
JCS(Mpa)																			

Description of Rock Mass:

Rock type	Siltstone									
UCS (Mpa)	>200		60-200		20-60		6-20. ✓	5-20	<6	
Schmidt Hammer Readings	Geological Hammer									
No. of Joints /m3 (Jv)										
RQD	90% - 100%		75% - 90%		50% - 75%		25% - 50%	<25% ✓	<10/.	
Joint frequency of critical joints										
Block Size/ Dimension (m3)	1.Very large blocks (Jv = 1.0)				2. Large Blocks (Jv= 1 - 3)		3.Medium sized blocks (Jv=3 - 10)			
	4. Small blocks (Jv= 10 - 30)				5. Very small block (Jv= >30) ✓					
Geological Structures	1. Massive(M)		2.Slightly jointed(SJ)		3.Modertately jointed(MJ)		4. Intensely Jointed(IJ) ✓			
	5. Slightly faulted(SFA)				6. Moderately faulted(MFA)		7. Intensely faulted(IFA)			
	8. Slightly folded (SFO) ✓				9.Moderately folded (MFO)		10.Intensely folded (IFO)			

Description of Boundary Conditions:

Degree of weathering	1. Unweathered				2. Slightly weathered		3.Moderately Weathered			
	4. Highly weathered ✓				5. Completely weathered/ Decomposed					
Ground water / Water inflow	Dry ~~Dry~~ Damp ✓				Dripping		Medium inflow 10-25 (l/min/10m length)			
	Major Inflow 25-125 (l/min/10m length)				Exeptionaly high inflow >125 (l/min/10m length)					



A GSI of 15-20 is observed.

General Description If Any: The horizontal bedding plane has become Vertical to subvertical due to the Synclinal fold.

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GSS SHEET: DATA SHEET FOR ROCK MASS BEHAVIOUR/ROCKMASS CLASIFICATION

Location: Silchar | Sub Location: Near EP (Alignment) | Date of Observation: 29/01/24

N 24° 49' 55.02" E 93° 04' 07.68" E, (GL → 177m)

Description of Joints:

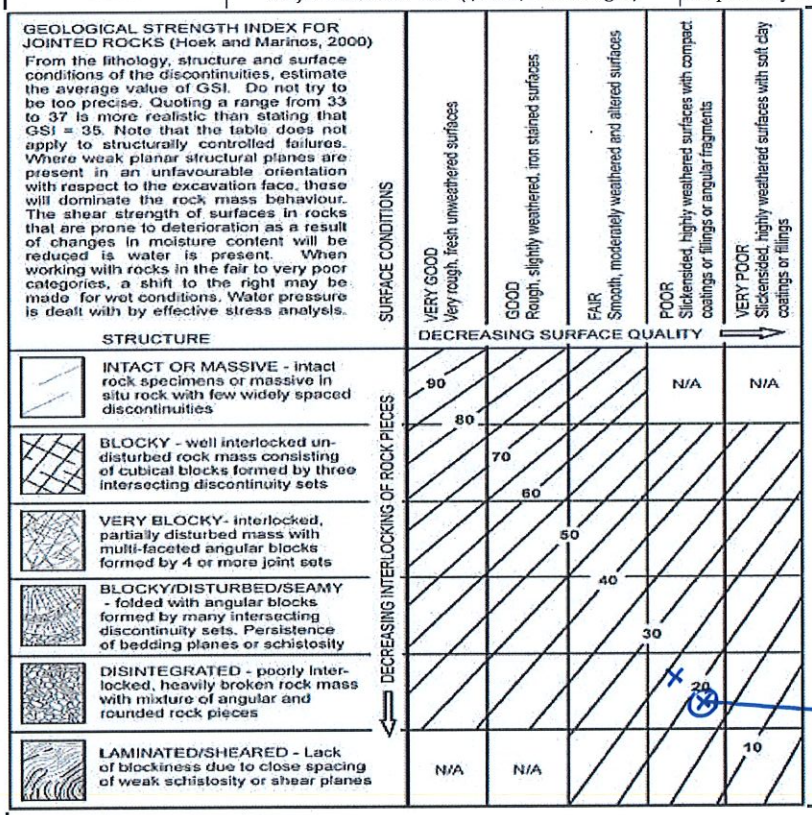
Set Number	J1 changing due to folding									J2								
Dip amount	25-50°									55°-60°								
Dip Direction	N 180°-220°									N 60°								
Persistence (m)	<1	1-3 ✓		3-10			10-20		>20	<1	1-3 ✓		3-10			10-20		>20
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR		XD
Spacing (cm)	<6cm ✓	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm ✓		20-60cm			60-200cm		>200cm
Aperture (mm)	None ✓	<.1mm ✓		.1-1.0mm			1-5mm		>5mm	None	<.1mm ✓		.1-1.0mm			1-5mm		>5mm
Roughness Condition	Stepped			Undulating			Planar ✓			Stepped			Undulating			Planar ✓		
	RI	S	SL	RI	S	SL	RI	S ✓	SL	RI	S	SL	RI	S	SL	RI	S ✓	SL
Filling	V Soft ✓	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay	V Soft ✓	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay
JRC	2-4									2-4								
JCS(Mpa)																		
Set Number																		
Dip amount																		
Dip Direction																		
Persistence (m)	<1	1 - 3		3-10			10-20		>20	<1	1 - 3		3-10			10-20		>20
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR		XD
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm		20-60cm			60-200cm		>200cm
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm	None	<.1mm		.1-1.0mm			1-5mm		>5mm
Roughness Condition	Stepped			Undulating			Planar			Stepped			Undulating			Planar		
	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay
JRC																		
JCS(Mpa)																		
Set Number																		
Dip amount																		
Dip Direction																		
Persistence (m)	<1	1 - 3		3-10			10-20		>20	<1	1 - 3		3-10			10-20		>20
Type of Termination	XX	RR		DD			XR		XD	XX	RR		DD			XR		XD
Spacing	<6cm	6-20cm		20-60cm			60-200cm		>200cm	<6cm	6-20cm		20-60cm			60-200cm		>200cm
Aperture (mm)	None	<.1mm		.1-1.0mm			1-5mm		>5mm	None	<.1mm		.1-1.0mm			1-5mm		>5mm
Roughness Condition	Stepped			Undulating			Planar			Stepped			Undulating			Planar		
	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL	RI	S	SL
Filling	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay	V Soft	Soft Clay		Firm Clay		Stiff Clay		V S Clay	H Clay
JRC																		
JCS(Mpa)																		

Description of Rock Mass:

Rock type	Siltstone & sandstone (weak)									
UCS (Mpa)	>200	60-200		20-60		6-20. ✓	10-20 ✗6			
Schmidt Hammer Readings	Geological Hammer									
No. of Joints /m3 (Jv)										
RQD	90% - 100%	75% - 90%		50% - 75%		25% - 50%	<25% ✓	<10%		
Joint frequency of critical joints										
Block Size/ Dimension (m3)	1.Very large blocks (Jv = 1.0)			2. Large Blocks (Jv= 1 - 3)		3.Medium sized blocks (Jv=3 - 10)				
	4. Small blocks (Jv= 10 - 30)			5. Very small block (Jv= >30) ✓						
Geological Structures	1. Massive(M)	2.Slightly jointed(SJ)		3.Modertately jointed(MJ)		4. Intensely Jointed(IJ) ✓				
	5. Slightly faulted(SFA)			6. Moderately faulted(MFA)		7. Intensely faulted(IFA)				
	8. Slightly folded (SFO) ✓		✓	9.Moderately folded (MFO)		10.Intensely folded (IFO)				

Description of Boundary Conditions:

Degree of weathering	1. Unweathered				2. Slightly weathered		3.Moderately Weathered			
	4. Highly weathered ✓				5. Completely weathered/ Decomposed					
Ground water / Water inflow	~~Dry~~ Damp ✓				Dripping		Medium inflow 10-25 (l/min/10m length)			
	Major Inflow 25-125 (l/min/10m length)				Exeptionaly high inflow >125 (l/min/10m length)					



General Description If Any:

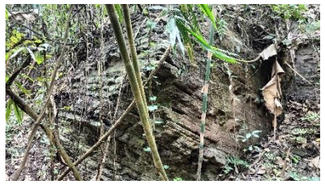
APPENDIX 2:

GPS COORDINATE TABLE

GPS COORDINATES (GEOLOGICAL MAPPING)			
SL NO	**GPS NO**	**Northing (N)**	**Easting ('E)**
1	GPS-01	24°49'46.35"	93°04'13.90"
2	GPS-02	24°49'47.67"	93°04'12.46"
3	GPS-03	24°49'47.11"	93°04'12.33"
4	GPS-04	24°49'51.54"	93°03'44.58"
5	GPS-05	24°49'51.65"	93°03'42.96"
6	GPS-06	24°49'53.14"	93°03'46.86"
7	GPS-07	24°49'55.86"	93°03'53.57"
8	GPS-08	24°49'53.59"	93°03'56.26"
9	GPS-09	24°49'56.03"	93°04'04.32"
10	GPS-10	24°49'55.02"	93°04'07.68"

APPENDIX 3:

JOINT DETAILS SHEET

	28/02/2024-29/02/2024: SILCHAR-JIRIBAM TUNNEL (770m)										
Sl No	**GPS No**	**Location**	**Sub location (if any)**	**Geo-structural Survey**	**Rock type**	**GSI**	**Joint Detail**	**Photo date and time**	**Photo 1**	**Photo2**	**Photo3**	**Photo4**
1.	**001**	**EP**	**EP-RHS**	**GSS-01**	**Siltstone /Sandstone with silty clay overburden**	**15-20**	**060-070/55-65 040-045/15-25**	**03:00 PM to 03:30 PM**				
2.	**002**	**EP**	**EP-LHS Near Borehole**	**GSS-02**	**Siltstone/Sandstone with 3m Overburden**	**15-25**	**040-045/15-25 140-150/70-80**	**03:30 PM to 04:00 PM**				
3.	**003**	**EP**	**EP-LHS**	**GSS-03**	**Siltstone/ Sandstone exposure**	**15-25**	**315-325/30-40 140-150/75-85**	**04:00 PM to 04:30 PM**				
4.	**004**	**WP**	**Near Nala, Downstream**	**GSS-04**	**Sandstone/ Siltstone with 3m silty clay soil cover**	**10-20**	**340-350/15-20 160-170/70-75**	**05:00 PM to 05:30 PM**				
5.	**005**	**WP**	**WP-LHS**	**GSS-05**	**Sandstone/ Siltstone with 3m silty clay soil cover**	**15-20**	**050-055/80-85 160-170/30-35**	**05:30PM to 06:00PM**				

6.	006	ALIGNMENT	Near WP Left Side	GSS-06	Sandstone/ Siltstone with 2m silty clay soil cover. Exposure in the stream cut.	15-20	305-315/20-25 060-070/75-85	08:00AM to 08:30AM				
7.	007	ALIGNMENT	Near WP Left Side	GSS-07	Sandstone/ Siltstone with 2m soil cover. Horizontal bedding in stream cut.	15-20	345-355/05-15 105-115/75-85	08:30AM to 09:00AM				
8.	008	ALIGNMENT	Centre of the Alignment	GSS-08	Sandstone/ Siltstone	10-20	270-280/20-30 355-005/75-80	09:00AM to 09:30AM				
9.	009	ALIGNMENT	Near EP	GSS-09	Sandstone/ Siltstone	15-20	290-300/80-85 110-115/55-65	09:30AM to 10:00AM				
10.	010	ALIGNMENT	Near EP	GSS-10	Sandstone/ Siltstone	15-20	180-220/25-50 060-070/55-60	10:00AM to 10:30AM				

Geological and Geotechnical properties at East Portal (770m Tunnel)											
S. No.	Proposed Civil Structure	GPS No.	Geological Group / Formation	Rock Types	Anticipated Intact rock Strength (Mpa)	Discontinuity Details	Blockiness	Discontinuity condition	Geological Strength Index (GSI)- Observed		Remark
									Siltstone/ SST	Shale	
1	Tunnel-770m, EP (RHS)	001-003	Boka Bil Formation Surma Group	Sandstone/Siltstone with shale intercalation	10-15	060-070/55-65 040-045/15-25	Weak, Poorly Interlocked with high persistence due to horizontal bedding plane. 3 joint sets are observed.	Highly Weathered, Planar, Smooth with clayey Infillings	10-20	-	-
2	Tunnel-770m, EP (LHS)	001-003	Boka Bil Formation Surma Group	Sandstone/Siltstone with shale intercalation	10-15	040-045/15-25 140-150/70-80	Weak, Poorly Interlocked with high persistence due to horizontal bedding plane.	Highly Weathered, Planar, Smooth with clayey Infillings	10-15	-	-
3	Tunnel-770m, EP (LHS)	001-003	Boka Bil Formation Surma Group	Sandstone/Siltstone with shale intercalation	10-15 & 15-25	315-325/30-40 140-150/75-85	Weak, Poorly Interlocked with high persistence due to horizontal bedding plane.	Highly to moderately Weathered, Planar, Smooth with clayey Infillings	10-25	10-20	-

Geological and Geotechnical properties along alignment (Silchar 770m Tunnel)											
S. No.	Proposed Civil Structure	GPS No.	Geological Group / Formation	Rock Types	Anticipated Intact rock Strength (Mpa)	Discontinuity Details	Blockiness	Discontinuity condition	Geological Strength Index (GSI)- Observed		Remark
									Siltstone/SST	Shale	
1	Tunnel-770m, Alignment, WP	005-010	Boka Bil Formation Surma Group	Sandstone/Siltstone	5-15	305-315/20-25 060-070/75-85	Weak, Poorly Interlocked with high persistence due to horizontal bedding plane. 3 joint sets are observed.	Highly Weathered, planar and smooth	15-20	-	-
2	Tunnel-770m, Alignment, WP	005-010	Boka Bil Formation Surma Group	Sandstone/Siltstone	5-15	345-355/05-15 105-115/75-85	Weak, Poorly Interlocked with high persistence due to horizontal bedding plane. 3 joint sets are observed.	Highly Weathered, planar and smooth	15-25	-	-
3	Tunnel-770m, Alignment, Centre	005-010	Boka Bil Formation Surma Group	Sandstone/Siltstone	10-20	270-280/20-30 355-005/75-80	Weak, Poorly Interlocked with high persistence due to horizontal bedding plane. 3 joint sets are observed.	Highly Weathered, planar and smooth	15-20	-	-
4	Tunnel-770m, Alignment, EP	005-010	Boka Bil Formation Surma Group	Sandstone/Siltstone with intercalation of shale	5-20	290-300/80-85 110-115/55-65	Weak, Poorly Interlocked with high persistence due to horizontal bedding plane. 3 joint sets are observed.	Highly Weathered, planar and smooth	10-20	-	-
5	Tunnel-770m, Alignment, EP	005-010	Boka Bil Formation Surma Group	Sandstone/Siltstone with intercalation of shale	10-20	180-220/25-50 060-070/55-60	Weak, Poorly Interlocked with high persistence due to horizontal bedding plane. 3 joint sets are observed.	Highly Weathered, planar and smooth	15-20		-

Geological and Geotechnical properties at West Portal (Silchar 770m Tunnel)											
S. No.	Proposed Civil Structure	GPS No.	Geological Group / Formation	Rock Types	Anticipated Intact rock Strength (Mpa)	Discontinuity Details	Blockiness	Discontinuity condition	Geological Strength Index (GSI)- Observed		Remark
									Siltstone/ SST	Shale	
1	Tunnel-770m, WP (NALA)	002-004	Boka Bil Formation Surma Group	Sandstone/siltstone	05-15	340-350/15-20 160-170/70-75	Weak, Poorly Interlocked with high persistence due to horizontal bedding plane. 3 joint sets are observed.	Highly Weathered, Planar and Smooth with high persistence	15-20	-	-
2	Road Cut to Portal	002-004	Boka Bil Formation Surma Group	Sandstone/siltstone	10-20	050-055/80-85 160-170/30-35	Weak, Poorly Interlocked with high persistence due to horizontal bedding plane.	Highly Weathered, Planar and Smooth with lower persistence	15-20	-	-

APPENDIX 4:

ROCKMASS CHARACTERISATION TABLE

The input data given and the calculated results

Project: SILCHAR TUNNEL **Date:**

Tunnel: SILCHAR 770m TUNNEL **Location:** EAST PORTAL

Observer: SREERAJ MELOTH **Note:**

Rock(s): SILTSTONE/SANDSTONE WITH INTERCALATION OF SHALE ROCK

Input parameters				Input values and ratings used		
				RMR 1989	**Q** 1993	**RMi** 2008
Tunnel data		Tunnel span (m)		Span = 8.5	Span = 8.5	Dt = 8.5
		Wall height (m)		Wall = 5.5	Wall = 5.5	Wt = 5.5
A. Rock	A1	Compressive strength of intact rock:		A1 = 2	-	σ_c = 12.5 MPa
B. Degree of jointing	B1	Rock Quality Designation (RQD):		A2 = 5	RQD = 10	-
	B2	Block volume:		-	-	Vb = 0.563 dm3
	B3	Joint spacing:		A3 = 5	-	-
C. Jointing pattern	C1	Block shape factor:		-	-	β = 250
	C2	Number of joint sets:		-	Jn = 9	Nj = 1
	C3	Orientation of main joint set	in roof:	B = -5	-	Co = 1.5
	C4		in walls:	-	-	Co = 1.5
D. Joint charac-teristics	D1	Joint smoothness:	roughness:	A4c = 0	Jr = 1	js = 1
	D2	Joint undulation:		-		jw = 1
	D3	Joint alteration	weathering:	A4e = 0	Ja = 8	jA = 8
			filling:	A4d = 2		
	D4	Joint length or persisstence:		A4a = 2	-	jL = 1
	D5	Joint separation or aperture:		A4b = 4	-	-
E. Inter-locking	E	Compactness of rockmass:		-	-	IL = 0.5
F. Ground water	F	Ground water inflow:		A5 = 4	Jw = 0.5	GW = 2.5
G. Rock stresses	G1	Stress level:		-	SRF = 2.5	SL = 0.1
	G2	Stress ratio//ground competency:		-		Cg = -
H. Weakness zones	H1	Type of weakness zone:		-		-
	H2	Thickness or width of zone:		-	-	Tz = -
	H3	Orientation of zone	in roof:	-	-	Co = -
	H4		in walls:	-	-	Co = -

Note that swelling rock is not included

RESULTS FROM CALCULATIONS (for conditions in tunnel or cavern)

		RMR	Q	RMi
Continuity of rockmass (related to tunnel) →		-	-	*Discontinuous*
Interlocking of rockmass structure →				*Poorly interlocked*
Rock mass quality (approx. strength, σ_{cm})		-	-	σ_{cm} ≈ **RMi = 0.01**
				Extremely low
Ground quality (related to stability)	in roof	**RMR = 19**	**Q = 0.027778**	**Gc = 0**
		Very poor	*Extremely poor*	*Extremely poor*
	in walls	RMR = 19	Q_{wall} = 0.027778	Gc_{wall} = 0
Blockiness (related to block instability)	in roof	-	-	**Sr = 16.7**
				Fair
	in walls	-	-	Sr_{wall} = 10.8
				Fair
Weakness zone		-		
Rockmass stresses		-	*Very low stress level (in portals)*	
Potential stress problems →				*Poor interlocking*
Limitations				Beyond the limit of RMi support method

The input data given and the calculated results

Project: SILCHAR TUNNEL **Date:**

Tunnel: SILCHAR 770m TUNNEL **Location:** WEST PORTAL

Observer: SREERAJ MELOTH **Note:**

Rock(s): SILTSTONE/SANDSTONE WITH INTERCALATION OF SHALE ROCK

Input parameters				Input values and ratings used		
				RMR 1989	**Q** 1993	**RMi** 2008
Tunnel data		Tunnel span (m)		Span = 8.5	Span = 8.5	Dt = 8.5
		Wall height (m)		Wall = 5.5	Wall = 5.5	Wt = 5.5
A. Rock	A1	Compressive strength of intact rock:		A1 = 2	-	σ_c = 15 MPa
B. Degree of jointing	B1	Rock Quality Designation (RQD):		A2 = 5	RQD = 13	-
	B2	Block volume:		-	-	Vb = 0.607 dm3
	B3	Joint spacing:		A3 = 5	-	-
C. Jointing pattern	C1	Block shape factor:		-	-	β = 250
	C2	Number of joint sets:		-	Jn = 6	Nj = 1.2
	C3	Orientation of main joint set	in roof:	B = -5	-	Co = 1.5
	C4		in walls:	-	-	Co = 1.5
D. Joint charac-teristics	D1	Joint smoothness:	roughness:	A4c = 0	Jr = 1	js = 1
	D2	Joint undulation:		-		jw = 1
	D3	Joint alteration	weathering:	A4e = 0	Ja = 6	jA = 6
			filling:	A4d = 4		
	D4	Joint length or persisstence:		A4a = 2	-	jL = 1
	D5	Joint separation or aperture:		A4b = 4	-	-
E. Inter-locking	E	Compactness of rockmass:		-	-	IL = 0.8
F. Ground water	F	Ground water inflow:		A5 = 4	Jw = 0.5	GW = 2.5
G. Rock stresses	G1	Stress level:		-	SRF = 2.5	SL = 0.5
	G2	Stress ratio//ground competency:		-		Cg = -
H. Weakness zones	H1	Type of weakness zone:		-		-
	H2	Thickness or width of zone:		-	-	Tz = -
	H3	Orientation of zone	in roof:	-	-	Co = -
	H4		in walls:	-	-	Co = -

Note that swelling rock is not included

RESULTS FROM CALCULATIONS (for conditions in tunnel or cavern)

		RMR	Q	RMi
Continuity of rockmass (related to tunnel) →		-	-	*Discontinuous*
Interlocking of rockmass structure →				*Disturbed / open*
Rock mass quality (approx. strength, σ_{cm})		-	-	$\sigma_{cm} \approx$ **RMi = 0.02**
				Extremely low
Ground quality (related to stability)	in roof	**RMR = 21**	**Q = 0.069444**	**Gc = 0**
		Poor	*Extremely poor*	*Extremely poor*
	in walls	RMR = 21	Q_{wall} = 0.069444	Gc_{wall} = 0.02
Blockiness (related to block instability)	in roof	-	-	**Sr = 13.6**
				Fair
	in walls	-	-	Sr_{wall} = 8.8
				Favourable
Weakness zone		-		
Rockmass stresses		-	*Low stress level*	
Potential stress problems →				*Loose structure*
Limitations				Beyond the limit of RMi support method

The input data given and the calculated results

Project: SILCHAR TUNNEL **Date:**

Tunnel: SILCHAR 770m TUNNEL **Location:** SC-03

Observer: SREERAJ MELOTH **Note:**

Rock(s): SILTSTONE/SANDSTONE WITH MINOR INTERCALATION OF SHALE ROCK

Input parameters				Input values and ratings used		
				RMR 1989	**Q** 1993	**RMi** 2008
Tunnel data		Tunnel span (m)		Span = 10	Span = 10	Dt = 10
		Wall height (m)		Wall = 5.5	Wall = 5.5	Wt = 5.5
A. Rock	A1	Compressive strength of intact rock:		A1 = 4	-	σ_c = 30 MPa
B. Degree of jointing	B1	Rock Quality Designation (RQD):		A2 = 8	RQD = 48	-
	B2	Block volume:		-	-	Vb = 2.304 dm3
	B3	Joint spacing:		A3 = 10	-	-
C. Jointing pattern	C1	Block shape factor:		-	-	β = 75
	C2	Number of joint sets:		-	Jn = 6	Nj = 1.2
	C3	Orientation of main joint set	in roof:	B = -2	-	Co = 1
	C4		in walls:	-	-	Co = 1
D. Joint charac-teristics	D1	Joint smoothness:	roughness:	A4c = 1	Jr = 1.4	js = 1
	D2	Joint undulation:		-		jw = 1.4
	D3	Joint alteration	weathering:	A4e = 0	Ja = 4	jA = 4
			filling:	A4d = 6		
	D4	Joint length or persisstence:		A4a = 1	-	jL = 0.75
	D5	Joint separation or aperture:		A4b = 4	-	-
E. Inter-locking	E	Compactness of rockmass:		-	-	IL = 0.8
F. Ground water	F	Ground water inflow:		A5 = 10	Jw = 1	GW = 1
G. Rock stresses	G1	Stress level:		-	SRF = 1	SL = 1
	G2	Stress ratio//ground competency:		-		Cg = -
H. Weakness zones	H1	Type of weakness zone:		-		-
	H2	Thickness or width of zone:		-	-	Tz = -
	H3	Orientation of zone	in roof:	-	-	Co = -
	H4		in walls:	-	-	Co = -

Note that swelling rock is not included

RESULTS FROM CALCULATIONS (for conditions in tunnel or cavern)

		RMR	Q	RMi
Continuity of rockmass (related to tunnel) →		-	-	*Discontinuous*
Interlocking of rockmass structure →				*Disturbed / open*
Rock mass quality (approx. strength, σ_{cm})		-	-	σ_{cm} ≈ **RMi = 0.13**
				Very low
Ground quality (related to stability)	in roof	**RMR = 42**	**Q = 2.770833**	**Gc = 0.13**
		Fair	*Poor*	*Very poor*
	in walls	RMR = 42	Q_{wall} = 6.927083	Gc_{wall} = 0.65
Blockiness (related to block instability)	in roof	-	-	**Sr = 22.7**
				Fair
	in walls	-	-	Sr_{wall} = 12.5
				Fair
Weakness zone		-		
Rockmass stresses		-	*Medium stress level*	
Potential stress problems →				*Minor*
Limitations				

The input data given and the calculated results

Project: SILCHAR TUNNEL **Date:**

Tunnel: SILCHAR 770m TUNNEL **Location:** SC-04

Observer: SREERAJ MELOTH **Note:**

Rock(s): SILTSTONE/SANDSTONE WITH INTERCALATION OF SHALE ROCK

Input parameters				Input values and ratings used		
				RMR 1989	**Q** 1993	**RMi** 2008
Tunnel data		Tunnel span (m)		Span = 10	Span = 10	Dt = 10
		Wall height (m)		Wall = 5.5	Wall = 5.5	Wt = 5.5
A. Rock	A1	Compressive strength of intact rock:		A1 = 2	-	σ_c = 23 MPa
B. Degree of jointing	B1	Rock Quality Designation (RQD):		A2 = 8	RQD = 28	-
	B2	Block volume:		-	-	Vb = 1.002 dm3
	B3	Joint spacing:		A3 = 8	-	-
C. Jointing pattern	C1	Block shape factor:		-	-	β = 75
	C2	Number of joint sets:		-	Jn = 9	Nj = 1
	C3	Orientation of main joint set	in roof:	B = -5	-	Co = 1.5
	C4		in walls:	-	-	Co = 1.5
D. Joint charac-teristics	D1	Joint smoothness:	roughness:	A4c = 0	Jr = 1.05	js = 0.75
	D2	Joint undulation:		-		jw = 1.4
	D3	Joint alteration	weathering:	A4e = 0	Ja = 4	jA = 4
			filling:	A4d = 6		
	D4	Joint length or persisstence:		A4a = 1	-	jL = 0.75
	D5	Joint separation or aperture:		A4b = 4	-	-
E. Inter-locking	E	Compactness of rockmass:		-	-	IL = 0.8
F. Ground water	F	Ground water inflow:		A5 = 7	Jw = 0.66	GW = 1
G. Rock stresses	G1	Stress level:		-	SRF = 10	SL = 1
	G2	Stress ratio//ground competency:		-		Cg = 0.75
H. Weakness zones	H1	Type of weakness zone:		-		-
	H2	Thickness or width of zone:		-	-	Tz = -
	H3	Orientation of zone	in roof:	-	-	Co = -
	H4		in walls:	-	-	Co = -

Note that swelling rock is not included

RESULTS FROM CALCULATIONS (for conditions in tunnel or cavern)

		RMR	**Q**	**RMi**
Continuity of rockmass (related to tunnel) →		-	-	*Discontinuous*
Interlocking of rockmass structure →				*Disturbed / open*
Rock mass quality (approx. strength, σ_{cm})		-	-	$\sigma_{cm} \approx$ **RMi = 0.05**
				Extremely low
Ground quality (related to stability)	in roof	**RMR = 31**	**Q = 0.052938**	**Gc = 0.05**
		Poor	*Extremely poor*	*Extremely poor*
	in walls	RMR = 31	Q_{wall} = 0.052938	Gc_{wall} = 0.24
Blockiness (related to block instability)	in roof	-	-	**Sr = 54.0**
				Unfavourable
	in walls	-	-	Sr_{wall} = 29.7
				Fair
Weakness zone		-		
Rockmass stresses		-	*Overstressing*	
Potential stress problems →			*Mild squeezing*	*Squeezing*
Limitations		Outside stress limit of RMR	Potential limitations for squeezing ground	Squeezing may need further evaluations

The input data given and the calculated results

Project: SILCHAR TUNNEL **Date:**

Tunnel: SILCHAR 770m TUNNEL **Location:** SC-05

Observer: SREERAJ MELOTH **Note:**

Rock(s): SILTSTONE/SANDSTONE/SHALE WITH MINOR GOUGE MATERIAL

Input parameters				Input values and ratings used		
				RMR 1989	**Q** 1993	**RMi** 2008
Tunnel data		Tunnel span (m)		Span = 10	Span = 10	Dt = 10
		Wall height (m)		Wall = 5.5	Wall = 5.5	Wt = 5.5
A. Rock	A1	Compressive strength of intact rock:		A1 = 2	-	σ_c = 18 MPa
B. Degree of jointing	B1	Rock Quality Designation (RQD):		A2 = 5	RQD = 15	-
	B2	Block volume:		-	-	Vb = 0.656 dm3
	B3	Joint spacing:		A3 = 8	-	-
C. Jointing pattern	C1	Block shape factor:		-	-	β = 250
	C2	Number of joint sets:		-	Jn = 12	Nj = 0.85
	C3	Orientation of main joint set	in roof:	B = -5	-	Co = 1.5
	C4		in walls:	-	-	Co = 1.5
D. Joint charac-teristics	D1	Joint smoothness:	roughness:	A4c = 0	Jr = 0.5	js = 0.5
	D2	Joint undulation:		-		jw = 1
	D3	Joint alteration	weathering:	A4e = 0	Ja = 4	jA = 4
			filling:	A4d = 6		
	D4	Joint length or persisstence:		A4a = 1	-	jL = 0.75
	D5	Joint separation or aperture:		A4b = 0	-	-
E. Inter-locking	E	Compactness of rockmass:		-	-	IL = 0.5
F. Ground water	F	Ground water inflow:		A5 = 4	Jw = 0.5	GW = 2.5
G. Rock stresses	G1	Stress level:		-	SRF = 10	SL = 1
	G2	Stress ratio//ground competency:		-		Cg = 0.75
H. Weakness zones	H1	Type of weakness zone:		-		-
	H2	Thickness or width of zone:		-	-	Tz = -
	H3	Orientation of zone	in roof:	-	-	Co = -
	H4		in walls:	-	-	Co = -

Note that swelling rock is not included

RESULTS FROM CALCULATIONS (for conditions in tunnel or cavern)

		RMR	Q	RMi
Continuity of rockmass (related to tunnel) →		-	-	*Discontinuous*
Interlocking of rockmass structure →				*Poorly interlocked*
Rock mass quality (approx. strength, σ_{cm})		-	-	$\sigma_{cm} \approx$ **RMi = 0.01**
				Extremely low
Ground quality (related to stability)	in roof	**RMR = 21**	**Q = 0.007813**	**Gc = 0**
		Poor	*Exceptionally poor*	*Extremely poor*
	in walls	RMR = 21	Q_{wall} = 0.007813	Gc_{wall} = 0.01
Blockiness (related to block instability)	in roof	-	-	**Sr = 21.9**
				Fair
	in walls	-	-	Sr_{wall} = 12.1
				Fair
Weakness zone		-		
Rockmass stresses		-	*Overstressing*	
Potential stress problems →			*Mild squeezing*	*Squeezing*
Limitations		Outside stress limit of RMR	Potential limitations when Q < 0.01	Squeezing may need further evaluations

The input data given and the calculated results

Project: SILCHAR TUNNEL **Date:**

Tunnel: SILCHAR 770m TUNNEL **Location:** SC-05A

Observer: SREERAJ MELOTH **Note:**

Rock(s): SILT/SANDSTONE WITH INTERCALATION OF SHALE ROCK AND GOUGE MATERIAL

Input parameters				Input values and ratings used		
				RMR 1989	**Q** 1993	**RMi** 2008
Tunnel data		Tunnel span (m)		Span = 10	Span = 10	Dt = 10
		Wall height (m)		Wall = 5.5	Wall = 5.5	Wt = 5.5
A. Rock	A1	Compressive strength of intact rock:		A1 = 2	-	σ_c = 12 MPa
B. Degree of jointing	B1	Rock Quality Designation (RQD):		A2 = 5	RQD = 10	-
	B2	Block volume:		-	-	Vb = 0.563 dm3
	B3	Joint spacing:		A3 = 5	-	-
C. Jointing pattern	C1	Block shape factor:		-	-	β = 250
	C2	Number of joint sets:		-	Jn = 12	Nj = 0.85
	C3	Orientation of main joint set	in roof:	B = -5	-	Co = 1.5
	C4		in walls:	-	-	Co = 1.5
D. Joint charac-teristics	D1	Joint smoothness:	roughness:	A4c = 0	Jr = 0.5	js = 0.5
	D2	Joint undulation:		-		jw = 1
	D3	Joint alteration	weathering:	A4e = 0	Ja = 6	jA = 6
			filling:	A4d = 4		
	D4	Joint length or persisstence:		A4a = 1	-	jL = 0.75
	D5	Joint separation or aperture:		A4b = 0	-	-
E. Inter-locking	E	Compactness of rockmass:		-	-	IL = 0.5
F. Ground water	F	Ground water inflow:		A5 = 4	Jw = 0.5	GW = 2.5
G. Rock stresses	G1	Stress level:		-	SRF = 10	SL = 1
	G2	Stress ratio//ground competency:		-		Cg = 0.75
H. Weakness zones	H1	Type of weakness zone:		-		-
	H2	Thickness or width of zone:		-	-	Tz = -
	H3	Orientation of zone	in roof:	-	-	Co = -
	H4		in walls:	-	-	Co = -

Note that swelling rock is not included

RESULTS FROM CALCULATIONS (for conditions in tunnel or cavern)

		RMR	Q	RMi
Continuity of rockmass (related to tunnel) →		-	-	*Discontinuous*
Interlocking of rockmass structure →				*Poorly interlocked*
Rock mass quality (approx. strength, σ_{cm})		-	-	$\sigma_{cm} \approx$ **RMi = 0.01**
				Extremely low
Ground quality (related to stability)	in roof	**RMR = 16**	**Q = 0.006944**	**Gc = 0**
		Very poor	*Exceptionally poor*	*Extremely poor*
	in walls	RMR = 16	Q_{wall} = 0.006944	Gc_{wall} = 0.01
Blockiness (related to block instability)	in roof	-	-	**Sr = 23.1**
				Fair
	in walls	-	-	Sr_{wall} = 12.7
				Fair
Weakness zone		-		
Rockmass stresses		-	*Overstressing*	
Potential stress problems →			*Mild squeezing*	*Squeezing*
Limitations		Outside stress limit of RMR	Potential limitations when Q < 0.01	Squeezing may need further evaluations

APPENDIX 5:

LAB TEST RESULTS

Test Methods :		IS:13030				IS:9143	IS:8764	IS:13047 1991		IS : 9221	
S.no	Depth(m)	Units wt	Dry Density	Water Absorption	Porosity	Unconfined Compressive Strength	Point Load Index	Angle of internal friction	Cohesion	Modulus of Elasitcity	Poisson's Ratio
		Kn/M3	g/cc	%	%	Mpa			Kg/cm2	MPa	
EAST PORTAL LHS											
1	0.00-1.00	19.74	2.014	4.528	9.120	_	_	_	_	_	_
2	1.00-2.00	19.09	1.948	4.725	9.204	_	_	_	_	_	_
3	2.00-3.00	18.35	1.872	5.545	10.381	_	_	_	_	_	_
4	3.00-4.00	19.29	1.969	4.373	8.609	_	_	_	_	_	_
5	4.00-5.00	19.65	2.005	4.196	8.414	_	_	_	_	_	_
6	5.00-6.00	18.73	1.912	5.519	10.551	_	_	_	_	_	_
7	6.00-7.00	19.31	1.970	4.702	9.264	_	_	_	_	_	_
8	7.00-8.00	18.60	1.898	5.067	9.620	_	_	_	_	_	_
9	8.00-9.00	17.93	1.830	5.913	10.820	_	_	_	_	_	_
10	9.00-10.00	19.11	1.950	5.067	9.882	_	_	_	_	_	_
11	10.00-11.00	17.05	1.740	6.472	11.260	_	_	_	_	_	_
12	11.00-12.00	17.83	1.819	6.117	11.128	_	_	_	_	_	_
13	12.00-13.00	17.21	1.756	6.782	11.910	_	_	_	_	_	_
14	13.00-14.00	19.25	1.964	4.527	8.890	_	_	_	_	_	_
15	14.00-15.00	17.89	1.826	5.067	9.252	_	_	_	_	_	_
16	15.00-16.00	20.41	2.082	3.990	8.308	_	_	_	_	_	_
17	16.00-17.00	19.37	1.976	4.359	8.614	_	_	_	_	_	_

Test Methods :		IS:13030				IS:9143	IS:8764	IS:13047 1991		IS : 9221	
S.no	Depth(m)	Units wt	Dry Density	Water Absorption	Porosity	Unconfined Compressive Strength	Point Load Index	Angle of internal friction	Cohesion	Modulus of Elasitcity	Poisson's Ratio
		Kn/M3	g/cc	%	%	Mpa			Kg/cm2	Mpa	
18	17.00-18.00	18.37	1.874	4.956	9.289	_	_	_	_	_	_
19	18.00-19.00	17.48	1.783	5.232	9.329	_	_	_	_	_	_
20	19.00-20.00	17.82	1.818	5.883	10.696	_	_	_	_	_	_
21	20.00-21.00	18.92	1.931	5.403	10.431	_	_	_	_	_	_
22	21.00-22.00	16.75	1.709	5.883	10.055	_	_	_	_	_	_
23	22.00-23.00	18.80	1.919	4.665	8.950	_	_	_	_	_	_
24	23.00-24.00	17.05	1.740	5.883	10.239	10.51	_	_	_	_	_
25	24.00-25.00	20.07	2.048	3.956	8.100	_	_	_	_	_	_
26	25.00-26.00	16.98	1.733	6.473	11.219	_	_	_	_	_	_
27	26.00-27.00	19.64	2.004	4.257	8.530	_	_	_	_	_	_
28	27.00-28.00	18.53	1.891	4.891	9.250	9.04	_	_	_	_	_
29	28.00-29.00	18.05	1.842	5.217	9.610	_	_	_	_	_	_
30	29.00-30.00	19.03	1.942	4.387	8.520	_	_	_	_	_	_
31	30.00-31.00	18.77	1.916	4.764	9.126	11.31	_	_	_	5890.000	0.310
32	31.00-32.00	17.32	1.768	6.502	11.493	_	_	_	_	_	_
33	32.00-33.00	18.17	1.854	5.972	11.070	_	_	_	_	_	_
34	33.00-34.00	16.85	1.720	6.950	11.950	_	_	_	_	_	_

Test Methods :		IS:13030				IS:9143	IS:8764	IS:13047 1991		IS : 9221	
S.no	Depth(m)	Units wt	Dry Density	Water Absorption	Porosity	Unconfined Compressive Strength	Point Load Index	Angle of internal friction	Cohesion	Modulus of Elasitcity	Poisson's Ratio
		Kn/M3	g/cc	%	%	Mpa			Kg/cm2	Mpa	
35	34.00-35.00	18.24	1.861	5.744	10.690	_	_	19.50	22.56	_	_
36	35.00-36.00	20.19	2.061	4.334	8.930	_	_			_	_
37	36.00-37.00	19.09	1.948	4.662	9.080	12.614				_	_
38	37.00-38.00	19.33	1.972	4.662	9.193	_	_	_	_	_	_
39	38.00-39.00	17.39	1.774	6.690	11.870	_	_	_	_	_	_
40	39.00-40.00	17.73	1.809	6.019	10.890	_	_	_	_	_	_
41	40.00-41.00	19.53	1.993	4.928	9.820	_	_	_	_	_	_
42	41.00-42.00	18.63	1.901	4.719	8.970	_	_	_	_	_	_
43	42.00-43.00	17.20	1.755	6.733	11.820	_	_	_	_	_	_
44	43.00-44.00	18.37	1.875	5.201	9.750	_	_	_	_	_	_
45	44.00-45.00	17.54	1.790	6.062	10.850	_	_	_	_	_	_
46	45.00-46.00	19.14	1.953	4.745	9.628	_	_	_	_	_	_
47	46.00-47.00	20.56	2.098	3.913	8.210	_	_	_	_	_	_
48	47.00-48.00	17.80	1.817	6.154	11.180	11.395	_	_	_	_	_
49	48.00-49.00	17.01	1.736	6.775	11.760	_	_	_	_	_	_
50	49.00-50.00	19.36	1.975	4.176	8.250	_	_	_	_	_	_

Test Methods :		IS:13030				IS:9143	IS:8764	IS:13047 1991		IS : 9221	
S.no	Depth(m)	Units wt	Dry Density	Water Absorption	Porosity	Unconfined Compressive Strength	Point Load Index	Angle of internal friction	Cohesion	Modulus of Elasitcity	Poisson's Ratio
		KN/M3	g/cc	%	%	MPa			Kg/cm2	MPa	
EAST PORTAL RHS											
1	0.00-1.00	17.66	1.802	6.268	11.294	_	_	_	_	_	_
2	1.00-2.00	16.80	1.714	7.047	12.080	_	_	_	_	_	_
3	2.00-3.00	17.75	1.811	6.268	11.349	_	_	_	_	_	_
4	3.00-4.00	18.33	1.871	5.837	10.920	_	_	_	_	_	_
5	4.00-5.00	19.17	1.956	5.016	9.810	_	_	_	_	_	_
6	5.00-6.00	20.36	2.077	5.016	10.420	8.24	_	_	_	_	_
7	6.00-7.00	18.61	1.899	5.099	9.680	_	_	_	_	_	_
8	7.00-8.00	18.95	1.934	4.719	9.125	9.38	_	_	_	_	_
9	8.00-9.00	17.15	1.750	6.502	11.380	_	_	_	_	_	_
10	9.00-10.00	19.61	2.001	4.539	8.720	11.06	_	_	_	_	_
11	10.00-11.00	17.36	1.772	6.727	11.920	_	_	_	_	_	_
12	11.00-12.00	20.60	2.102	3.887	8.170	_	_	_	_	_	_
13	12.00-13.00	18.10	1.846	5.529	10.210	_	_	_	_	_	_
14	13.00-14.00	17.22	1.757	6.367	11.190	_	_	_	_	_	_
15	14.00-15.00	17.89	1.825	5.627	10.270	_	_	_	_	_	_
16	15.00-16.00	17.10	1.745	6.459	11.270	_	_	_	_	_	_
17	16.00-17.00	18.96	1.935	4.61	8.920	_	_	_	_	_	_

Test Methods :		IS:13030				IS:9143	IS:8764	IS:13047 1991		IS : 9221	
S.no	Depth(m)	Units wt	Dry Density	Water Absorption	Porosity	Unconfined Compressive Strength	Point Load Index	Angle of internal friction	Cohesion	Modulus of Elasitcity	Poisson's Ratio
		Kn/M3	g/cc	%	%	MPa			Kg/cm2	MPa	
18	17.00-18.00	17.47	1.783	6.304	11.240	_	_	_	_	_	_
19	18.00-19.00	19.22	1.961	4.681	9.180	_	_	_	_	_	_
20	19.00-20.00	19.86	2.026	4.506	9.130	_	_	_	_	_	_
21	20.00-21.00	17.44	1.780	6.512	11.590	_	_	_	_	_	_
22	21.00-22.00	18.22	1.859	5.846	10.870	_	_	_	_	_	_
23	22.00-23.00	19.89	2.029	4.203	8.530	8.640	_	_	_	_	_
24	23.00-24.00	17.81	1.818	6.173	11.220	_	_	_	_	_	_
25	24.00-25.00	18.95	1.934	4.695	9.080	_	_	_	_	_	_
26	25.00-26.00	17.37	1.773	6.730	11.930	_	_	_	_	_	_
27	26.00-27.00	18.14	1.851	5.985	11.080	_	_	_	_	_	_
28	27.00-28.00	17.72	1.808	6.103	11.035	_	_	_	_	_	_
29	28.00-29.00	16.85	1.719	6.973	11.990	_	_	_	_	_	_
30	29.00-30.00	18.49	1.887	5.785	10.915	_	_	_	_	_	_
31	30.00-31.00	18.71	1.910	5.151	9.836	_	_	_	_	_	_
32	31.00-32.00	17.93	1.830	5.936	10.860	19.17		21.76	20.3	7480.000	0.290
33	32.00-33.00	19.83	2.023	4.142	8.380	21.44	_			_	_
34	33.00-34.00	18.96	1.935	4.408	8.530	24.29	_			_	_
35	34.00-35.00	19.22	1.96	4.2	8.24	_	_	_	_	_	_

Test Methods :		IS:13030				IS:9143	IS:8764	IS:13047 1991		IS : 9221	
S.no	Depth(m)	Units wt	Dry Density	Water Absorption	Porosity	Unconfined Compressive Strength	Point Load Index	Angle of internal friction	Cohesion	Modulus of Elasitcity	Poisson's Ratio
		KN/M3	g/cc	%	%	MPa			Kg/cm2	MPa	
36	35.00-36.00	19.00	1.94	4.78	9.26	_	_	_	_	_	_
37	36.00-37.00	17.04	1.74	6.51	11.32	_	_	_	_	_	_
38	37.00-38.00	20.48	2.09	4.51	9.41	_	_	_	_	_	_
39	38.00-39.00	18.07	1.84	5.63	10.38	_	_	_	_	_	_
40	40.00-41.00	16.97	1.73	6.73	11.66	_	_	_	_	_	_
41	41.00-42.00	19.01	1.940	5.063	9.820	_	_	_	_	_	_
42	42.00-43.00	19.59	1.999	4.497	8.990	_	_	_	_	_	_
43	43.00-44.00	17.44	1.780	6.325	11.256	_	_	_	_	_	_
44	44.00-45.00	18.13	1.850	5.853	10.826	_	_	_	_	_	_
45	45.00-46.00	18.63	1.901	5.985	11.376	_	_	_	_	_	_
46	46.00-47.00	18.27	1.865	6.173	11.509	_	_	_	_	_	_
47	47.00-48.00	19.01	1.939	4.681	9.078	_	_	_	_	_	_
48	48.00-49.00	17.64	1.800	6.304	11.350	_	_	_	_	_	_
49	49.00-50.00	18.56	1.894	4.610	8.731	_	_	_	_	_	_
50	49.00-50.00	17.42	1.778	6.549	11.483	_	_	_	_	_	_

Test Methods :		IS:13030				IS:9143	IS:8764	IS:13047 1991		IS : 9221	
S.no	Depth(m)	Units wt	Dry Density	Water Absorption	Porosity	Unconfined Compressive Strength	Point Load Index	Angle of internal friction	Cohesion	Modulus of Elasitcity	Poisson's Ratio
		Kn/M3	g/cc	%	%	Mpa			Kg/cm2	Mpa	
WEST PORTAL LHS											
1	0.00-1.00	19.97	2.038	4.716	9.610	_	_	_	_	_	_
2	1.00-2.00	18.87	1.926	4.647	8.949	_	_	_	_	_	_
3	2.00-3.00	19.79	2.019	3.976	8.029	_	_	_	_	_	_
4	3.00-4.00	17.59	1.795	5.868	10.532	_	_	_	_	_	_
5	4.00-5.00	17.11	1.746	6.524	11.391	_	_	_	_	_	_
6	5.00-6.00	17.56	1.792	6.564	11.765	_	_	_	_	_	_
7	6.00-7.00	17.87	1.824	6.392	11.658	_	_	_	_	_	_
8	7.00-8.00	17.78	1.815	6.346	11.517	_	_	_	_	_	_
9	8.00-9.00	19.97	2.038	4.250	8.662	9.629	_	_	_	_	_
10	9.00-10.00	20.12	2.053	4.072	8.361	_	_	_	_	_	_
11	10.00-11.00	20.03	2.044	4.111	8.402	_	_	_	_	_	_
12	11.00-12.00	17.88	1.825	6.041	11.024	_	_	_	_	_	_
13	12.00-13.00	17.65	1.801	6.612	11.907	_	_	_	_	_	_
14	13.00-14.00	19.84	2.024	4.215	8.533	_	_	_	_	_	_
15	14.00-15.00	19.87	2.027	4.331	8.780	_	_	_	_	_	_
16	15.00-16.00	20.07	2.047	4.025	8.240	_	_	_	_	_	_
17	16.00-17.00	17.11	1.745	6.566	11.461	10.89	_	_	_	_	_

Test Methods :		IS:13030				IS:9143	IS:8764	IS:13047 1991		IS : 9221	
S.no	Depth(m)	Units wt	Dry Density	Water Absorption	Porosity	Unconfined Compressive Strength	Point Load Index	Angle of internal friction	Cohesion	Modulus of Elasitcity	Poisson's Ratio
		KN/M3	g/cc	%	%	MPa			Kg/cm2	MPa	
18	17.00-18.00	17.11	1.745	6.566	11.461	_	_	_	_	_	_
19	18.00-19.00	17.84	1.82	6.460	11.757	_	_	_	_	_	_
20	19.00-20.00	17.86	1.822	6.232	11.358	_	_	_	_	_	_
21	20.00-21.00	17.74	1.810	6.447	11.670	8.619	_	_	_	_	_
22	21.00-22.00	19.81	2.021	4.139	8.366	_	_	_	_	_	_
23	22.00-23.00	20.67	2.109	3.946	8.323	9.460	_	17.50	24.30	_	_
24	23.00-24.00	20.56	2.098	4.212	8.834	11.268	_	_	_	5784.000	0.280
25	24.00-25.00	20.49	2.091	3.966	8.292	10.415	_	_	_	_	_
26	25.00-26.00	20.39	2.080	4.210	8.758	_	_	_	_	_	_
27	26.00-27.00	20.59	2.101	3.926	8.250	12.189	_	_	_	_	_
28	27.00-28.00	20.32	2.073	4.173	8.652	_	_	_	_	_	_
29	28.00-29.00	18.37	1.875	6.142	11.515	10.470	_	_	_	_	_
30	29.00-30.00	16.62	1.696	6.717	11.393	_	_	_	_	_	_
31	30.00-31.00	16.76	1.710	6.964	11.909	13.791	_	_	_	_	_
32	31.00-32.00	16.73	1.708	6.755	11.535	11.395	_	_	_	_	_
33	32.00-33.00	18.18	1.855	6.199	11.498	_	_	_	_	_	_
34	33.00-34.00	18.25	1.862	6.343	11.809	_	_	_	_	_	_
35	34.00-35.00	19.74	2.015	4.681	9.431	10.348	_	_	_	_	_

Test Methods :		IS:13030				IS:9143	IS:8764	IS:13047 1991		IS : 9221	
S.no	Depth(m)	Units wt	Dry Density	Water Absorption	Porosity	Unconfined Compressive Strength	Point Load Index	Angle of internal friction	Cohesion	Modulus of Elasitcity	Poisson's Ratio
		Kn/M3	g/cc	%	%	Mpa			Kg/cm2	Mpa	
36	35.00-36.00	19.67	2.007	4.864	9.764	_	_	_	_	_	_
37	36.00-37.00	19.09	1.948	5.216	10.163	9.629	_	_	_	_	_
38	37.00-38.00	19.83	2.024	5.141	10.405	_	_	_	_	_	_
39	38.00-39.00	16.65	1.699	7.104	12.071	_	_	_	_	_	_
40	40.00-41.00	17.04	1.739	6.954	12.093	_	_	_	_	_	_
41	41.00-42.00	17.25	1.760	6.813	11.991	_	_	_	_	_	_
42	42.00-43.00	18.39	1.877	6.053	11.360	_	_	_	_	_	_
43	43.00-44.00	19.64	2.004	5.158	10.334	11.163	_	_	_	_	_
44	44.00-45.00	19.53	1.993	5.433	10.826	9.540	_	_	_	_	_
45	45.00-46.00	19.65	2.005	5.117	10.260	11.470	_	_	_	_	_
46	46.00-47.00	19.65	2.006	4.808	9.642	13.510	_	_	_	_	_
47	47.00-48.00	19.73	2.013	4.627	9.314	10.500	_	_	_	_	_
48	48.00-49.00	19.92	2.032	4.450	9.045	9.870	_	_	_	_	_
49	49.00-50.00	19.98	2.039	4.757	9.698	8.640	_	_	_	_	_
50	49.00-50.00	17.67	1.803	6.227	11.226	13.450	_	_	_	_	_

Test Methods :		IS:13030				IS:9143	IS:8764	IS:13047 1991		IS : 9221	
S.no	Depth(m)	Units wt	Dry Density	Water Absorption	Porosity	Unconfined Compressive Strength	Point Load Index	Angle of internal friction	Cohesion	Modulus of Elasitcity	Poisson's Ratio
		KN/M3	g/cc	%	%	MPa			Kg/cm2	MPa	
WEST PORTAL RHS											
1	0.00-1.00	17.67	1.803	6.481	11.686	_	_	_	_	_	_
2	1.00-2.00	17.64	1.800	6.452	11.612	_	_	_	_	_	_
3	2.00-3.00	17.57	1.793	6.548	11.373	_	_	_	_	_	_
4	3.00-4.00	19.74	2.015	4.485	9.035	_	_	_	_	_	_
5	4.00-5.00	19.65	2.005	4.711	9.449	_	_	_	_	_	_
6	5.00-6.00	19.05	1.944	5.466	10.625	_	_	_	_	_	_
7	6.00-7.00	17.36	1.772	6.673	11.823	_	_	_	_	_	_
8	7.00-8.00	19.62	2.002	5.066	10.146	_	_	_	_	_	_
9	8.00-9.00	20.71	2.113	4.056	8.750	_	_	_	_	_	_
10	9.00-10.00	17.10	1.745	6.614	11.538	_	_	_	_	_	_
11	10.00-11.00	20.06	2.047	4.415	9.036	_	_	_	_	_	_
12	11.00-12.00	16.85	1.719	7.032	12.089	_	_	_	_	_	_
13	12.00-13.00	18.27	1.864	6.212	11.580	_	_	_	_	_	_
14	13.00-14.00	17.25	1.760	6.813	11.991	_	_	_	_	_	_
15	14.00-15.00	19.88	2.029	4.874	9.889	_	_	_	_	_	_
16	15.00-16.00	17.14	1.749	6.931	12.124	_	_	_	_	_	_
17	16.00-17.00	17.12	1.747	6.665	11.640	_	_	_	_	_	_

Test Methods :		IS:13030				IS:9143	IS:8764	IS:13047 1991		IS : 9221	
S.no	Depth(m)	Units wt	Dry Density	Water Absorption	Porosity	Unconfined Compressive Strength	Point Load Index	Angle of internal friction	Cohesion	Modulus of Elasitcity	Poisson's Ratio
		KN/M3	g/cc	%	%	MPa			Kg/cm2	MPa	
18	17.00-18.00	19.05	1.944	5.436	10.569	_	_	_	_	_	_
19	18.00-19.00	19.42	1.981	5.323	10.548	_	_	_	_	_	_
20	19.00-20.00	19.85	2.026	4.660	9.439	_	_	_	_	_	_
21	20.00-21.00	19.22	1.961	5.570	10.922	_	_	_	_	_	_
22	21.00-22.00	19.92	2.033	4.485	9.118	_	_	_	_	_	_
23	22.00-23.00	19.48	1.988	5.167	10.271	_	_	_	_	_	_
24	23.00-24.00	20.28	2.070	4.599	9.518	_	_	_	_	_	_
25	24.00-25.00	20.30	2.071	4.859	10.064	_	_	_	_	_	_
26	25.00-26.00	19.30	1.970	5.335	10.509	_	_	_	_	_	_
27	26.00-27.00	19.40	1.980	5.081	10.060	_	_	_	_	_	_
28	27.00-28.00	19.77	2.017	4.708	9.496	_	_	_	_	_	_
29	28.00-29.00	19.36	1.975	5.191	10.254	_	_	_	_	_	_
30	29.00-30.00	19.86	2.026	4.486	9.088	_	_	_	_	_	_
31	30.00-31.00	19.96	2.037	4.360	8.882	_	_	_	_	_	_
32	31.00-32.00	18.31	1.869	6.334	11.838	_	_	_	_	_	_
33	32.00-33.00	19.47	1.987	5.187	10.305	_	_	_	_	_	_
34	33.00-34.00	20.45	2.087	4.795	10.007	_	_	_	_	_	_
35	34.00-35.00	17.97	1.834	6.328	11.607	_	_	_	_	_	_

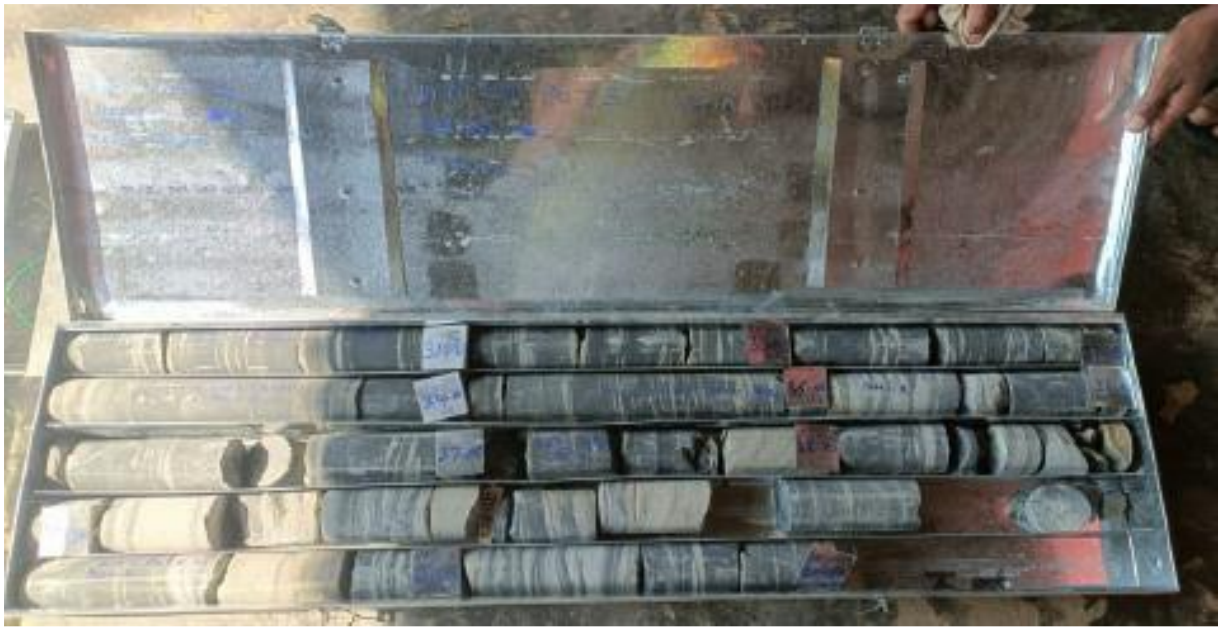
Test Methods :		IS:13030				IS:9143	IS:8764	IS:13047 1991		IS : 9221	
S.no	Depth(m)	Units wt	Dry Density	Water Absorption	Porosity	Unconfined Compressive Strength	Point Load Index	Angle of internal friction	Cohesion	Modulus of Elasitcity	Poisson's Ratio
		Kn/M3	g/cc	%	%	Mpa			Kg/cm2	Mpa	
36	35.00-36.00	18.90	1.929	5.594	10.790	_	_	_	_	_	_
37	36.00-37.00	18.20	1.858	6.112	11.354	_	_	_	_	_	_
38	37.00-38.00	17.98	1.834	6.420	11.776	8.683	_	_	_	_	_
39	38.00-39.00	20.37	2.079	5.773	12.003	_	_	_	_	_	_
40	40.00-41.00	19.66	2.006	4.980	9.989	_	_	_	_	_	_
41	41.00-42.00	18.78	1.917	5.526	10.590	_	_	_	_	_	_
42	42.00-43.00	19.21	1.960	5.444	10.672	_	_	_	_	_	_
43	43.00-44.00	17.65	1.801	6.124	11.027	_	_	_	_	_	_
44	44.00-45.00	16.74	1.709	6.845	11.695	_	_	_	_	_	_
45	45.00-46.00	20.18	2.059	4.857	9.999	10.091	_	_	_	_	_
46	46.00-47.00	16.67	1.701	7.029	11.954	14.53	_	_	_	_	_
47	47.00-48.00	20.28	2.069	4.808	9.948	_	_	_	_	_	_
48	48.00-49.00	18.21	1.858	6.356	11.808	9.713	_	20.00	24.80	5460	0.3
49	49.00-50.00	20.57	2.099	4.704	9.874	12.866	_	_	_	_	_
50	49.00-50.00	19.58	1.998	5.051	10.092	13.84	_	_	_	_	_

APPENDIX 6:

CORE PHOTOGRAPHS

WEST PORTAL, LHS, CORE BOX-1

WEST PORTAL, LHS, CORE BOX-2



WEST PORTAL, LHS, CORE BOX-3

WEST PORTAL, LHS, CORE BOX-4

WEST PORTAL, RHS,, CORE BOX-5

WEST PORTAL, RHS, CORE BOX-6

WEST PORTAL, RHS, CORE BOX-7

EAST PORTAL, LHS, CORE BOX-8

EAST PORTAL, LHS ,CORE BOX-9

EAST PORTAL, LHS, CORE BOX-10

EAST PORTAL, LHS, CORE BOX-11

EAST PORTAL, LHS, CORE BOX-12

EAST PORTAL, RHS, CORE BOX-13

EAST PORTAL, RHS ,CORE BOX-14

EAST PORTAL, RHS ,CORE BOX-15

APPENDIX 7:

GROUND TYPES (GT)

Ground Type	GT 01			
Lithology and Stratigraphy	Moderately weathered and fractured bed rock of Boka Bil Formation			
Geologic description	Grey coloured, fine grained, Comapact and Blocky			
Rock type	Sandstone or Siltstone with Intercalation of Shale rock			
Over burden(m)	60-90			
Intercalations	Present			
Persistence of joint plane	3-10			
Joint Spacing	10-30cm			
Joint surface characteristics	Undulating to Planar and Rough to Smooth			
Joint length (extension) following ISRM 1978	1-3m			
Joint opening	0.1mm to tight			
Joint fillings	clay filling			
KEY PARAMETERS (INTACT ROCK) - AWAITED GT REPORT				
Lithology	Siltstone/ Finegrained sandstone with intercalation of shale rock			
Uniaxial compression strength	UCS	[MPa]	30	taken from lab test results.
Young Module (E coefficient)	E	[MPa]	12000.0	taken from lab test results.
Hoek-Brown criterion	mi	[-]	13.0	taken from lab test results.
Cohesion	c	[MPa]	2.50	taken from lab test results.
Friction angle	ϕ	[°]	22	taken from lab test results.
Poisson Number	p	[-]	0.25	taken from lab test results.
KEY PARAMETERS (ROCK MASS)				
Density	ɣ	[kN/m³]	26	Taken average from lab test results.
Geological Strength Index	GSI	[-]	37	Estimated from field data
Over burden		[M]	80	Derived from L-section
Uniaxial compression strength	UCS	[MPa]	1.015	RocLab
Young Module (E coefficient)	E	[MPa]	1559.8	RocLab
Cohesion	c	[MPa]	0.329	RocLab
Friction angle	ϕ	[°]	42.90	RocLab
RQD (%)	25%			
RMR according to Bieniawski	42			
Q System	0.9259			
ADDITIONAL DESCRIPTION				

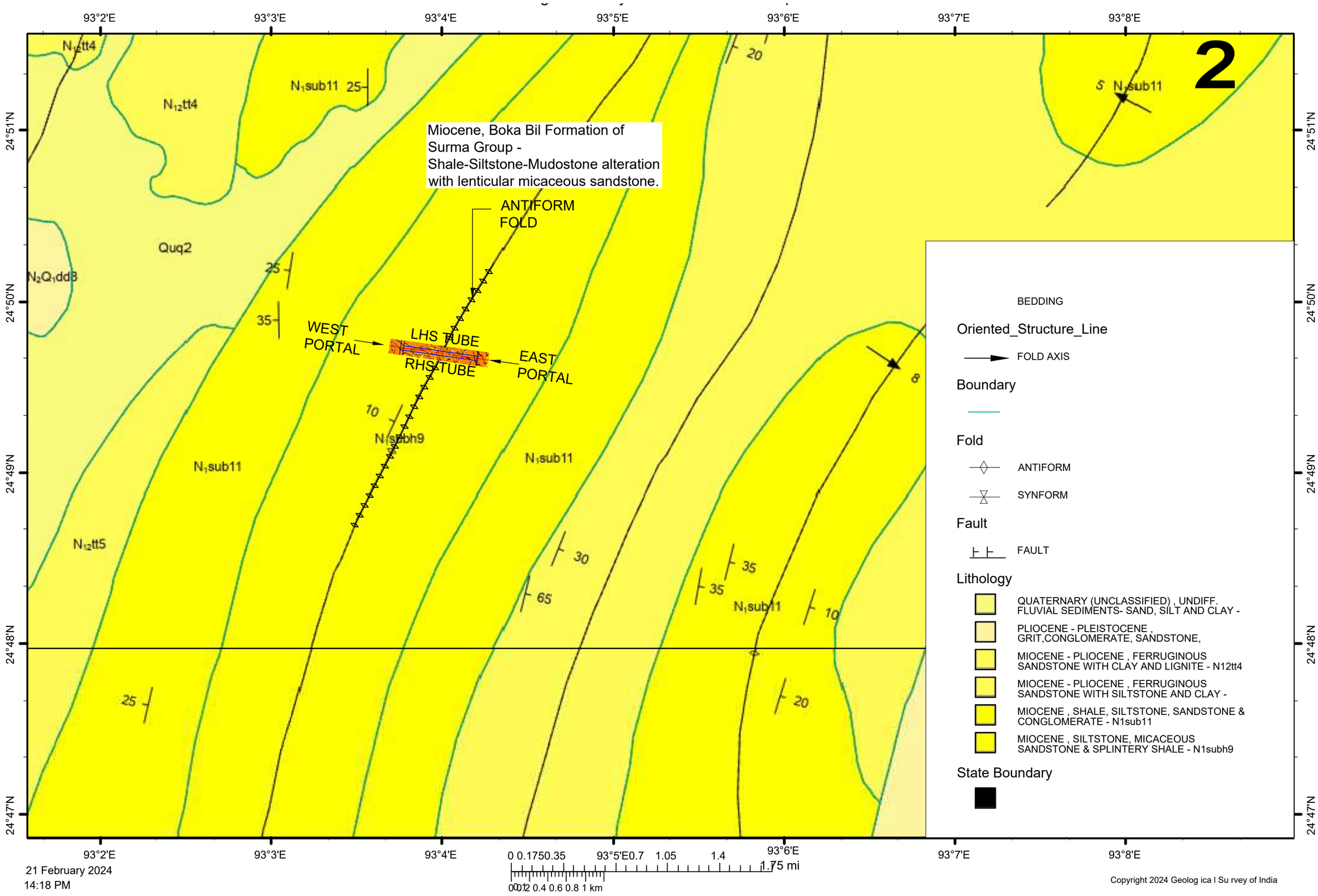
Ground Type	GT 02			
Lithology and Stratigraphy	Highly to moderately weathered and fractured bed rock of Boka Bil Formation			
Geologic description	Grey to green coloured, fine grained			
Rock type	Sandstone/ Silt stone and shale rock			
Over burden(m)	40-60			
Intercalations	Present			
Persistence of joint plane	3-15m			
Joint Spacing	6-20cm			
Joint surface characteristics	Planar Rough to Smooth			
Joint length (extension) following ISRM 1978	1-3m			
Joint opening	0.1 - 0.5 mm			
Joint fillings	Moderate clay filling			
KEY PARAMETERS (INTACT ROCK)				
Lithology	Moderately to Highly Weathered sandstone/ siltstone and shale rock mass			
Uniaxial compression strength	UCS	[MPa]	23	taken from lab test results.
Young Module (E coefficient)	E	[MPa]	8625.0	taken from lab test results.
Hoek-Brown criterion	mi	[-]	10.0	taken from lab test results.
Cohesion	c	[MPa]	2.20	taken from lab test results.
Friction angle	ϕ	[°]	20	taken from lab test results.
Poisson Number	p	[-]	0.27	taken from lab test results.
KEY PARAMETERS (ROCK MASS)				
Density	γ	[kN/m³]	26	Taken average from lab test results.
Geological Strength Index	GSI	[-]	27	Estimated from field data
Over burden		[M]	60	Derived from L-section
Uniaxial compression strength	UCS	[MPa]	0.573	RocLab
Young Module (E coefficient)	E	[MPa]	581.55	RocLab
Cohesion	c	[MPa]	0.163	RocLab
Friction angle	ϕ	[°]	41.67	RocLab
RQD (%)	20%			
RMR according to Bieniawski	32			
Q System	0.073			
ADDITIONAL DESCRIPTION				

Ground Type	GT 03			
Lithology and Stratigraphy	Highly Weathered and fractured bed rock / Shear gauge of Boka Bil Formation			
Geologic description	grey to green coloured, fine grained, disintegrated			
Rock type	Sandstone/ siltstone/ shale with gouge material			
Over burden(m)	20-40			
Intercalations	Present (gauge of 5-50cm)			
Persistence of joint plane	10-20m			
Joint Spacing	<6cm			
Joint surface characteristics	Planar and Smooth			
Joint length (extension) following ISRM 1978	1-3m			
Joint opening	0.1 to 0.5 mm			
Joint fillings	clay filling			
KEY PARAMETERS (INTACT ROCK)				
Lithology	Sandstone/ siltstone/ shale with gouge material			
Uniaxial compression strength	UCS	[MPa]	18	taken from lab test results.
Young Module (E coefficient)	E	[MPa]	6750.0	taken from lab test results.
Hoek-Brown criterion	mi	[-]	10.0	taken from lab test results.
Cohesion	c	[MPa]	2.00	taken from lab test results.
Friction angle	ϕ	[°]	18	taken from lab test results.
Poisson Number	p	[-]	0.3	taken from lab test results.
KEY PARAMETERS (ROCK MASS)				
Density	ɣ	[kN/m³]	25.5	Taken average from lab test results.
Geological Strength Index	GSI	[-]	18	Estimated from field data
Over burden		[M]	30	Derived from L-section
Uniaxial compression strength	UCS	[MPa]	0.372	RocLab
Young Module (E coefficient)	E	[MPa]	280.09	RocLab
Cohesion	c	[MPa]	0.086	RocLab
Friction angle	ϕ	[°]	38.89	RocLab
RQD (%)	15%			
RMR according to Bieniawski	21			
Q System	0.031			
ADDITIONAL DESCRIPTION				

Ground Type	GT 04			
Lithology and Stratigraphy	Highly Weathered and fractured bed rock / Shear gauge of Boka Bil Formation			
Geologic description	Grey coloured, fine grained, Decomposed or disintegrated			
Rock type	Sandstone/ siltstone/ shale			
Over burden(m)	10-20			
Intercalations	Present (Shear gauge of 50-100cm)			
Persistence of joint plane	10-25m			
Joint Spacing	<6cm			
Joint surface characteristics	Smooth and slickensided			
Joint length (extension) following ISRM 1978	1-3m			
Joint opening	0.5 - 5 mm			
Joint fillings	Thick clay filling			
KEY PARAMETERS (INTACT ROCK)				
Lithology	Sandstone/ siltstone/ shale with gouge intercalations			
Uniaxial compression strength	UCS	[MPa]	12	taken from lab test results.
Young Module (E coefficient)	E	[MPa]	4200.0	taken from lab test results.
Hoek-Brown criterion	mi	[-]	10.0	taken from lab test results.
Cohesion	c	[MPa]	1.80	taken from lab test results.
Friction angle	ϕ	[°]	17	taken from lab test results.
Poisson Number	p	[-]	0.33	taken from lab test results.
KEY PARAMETERS (ROCK MASS)				
Density	γ	[kN/m³]	25	Taken average from lab test results.
Geological Strength Index	GSI	[-]	13	Estimated from field data
Over burden		[M]	15	Derived from L-section
Uniaxial compression strength	UCS	[MPa]	0.125	RocLab
Young Module (E coefficient)	E	[MPa]	141.76	RocLab
Cohesion	c	[MPa]	0.029	RocLab
Friction angle	ϕ	[°]	40.89	RocLab
RQD (%)	10%			
RMR according to Bieniawski	15			
Q System	0.005			
ADDITIONAL DESCRIPTION				

APPENDIX 8:

DRAWINGS



21 February 2024
14:18 PM

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Rev.	Date	Description

Authority:
National Highways & Infrastructure Development Corporation Ltd.
(Ministry of Road Transport & Highways)

Design Consultants:
Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

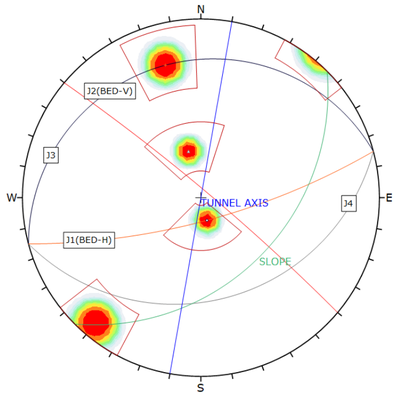
Project:
Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)
Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

FINAL DETAILED PROJECT REPORT

Title: **REGIONAL GEOLOGICAL MAP SILCHAR JIRIBAM TUNNEL**

Size	*Scale*	*Drg. No*	*Rev:*
A3	HOR-1:1000 VER-1:200	**Transys-NH37-TUNNEL_FSR-001**	**R0**



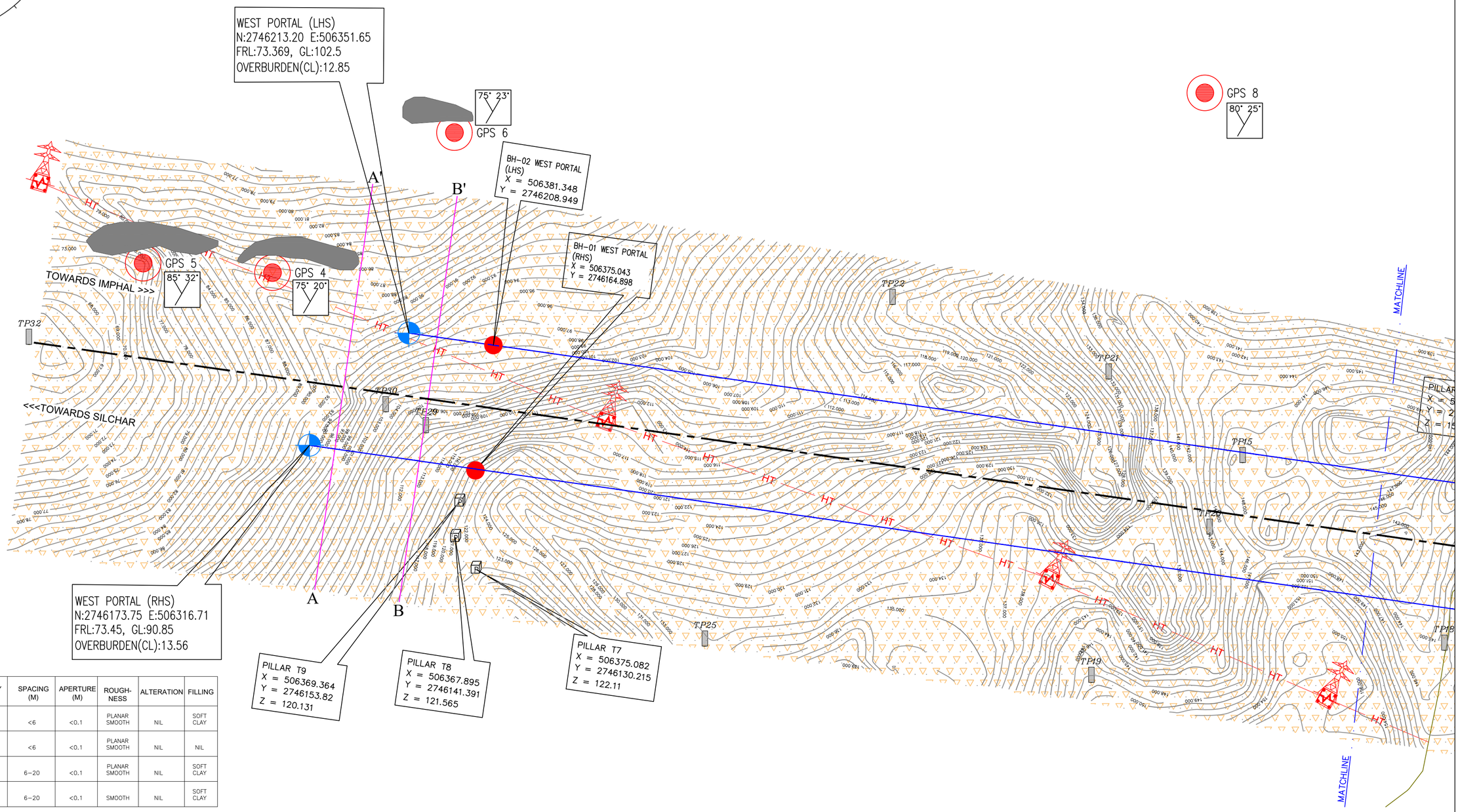
WEST PORTAL-(SILCHAR 770m TUNNEL)

Symbol	ID	Quantity
◇	1	1
×	2	1
△	3	1
▷	4	1

Color	Density Concentrations
	0.00 - 2.50
	2.50 - 5.00
	5.00 - 7.50
	7.50 - 10.00
	10.00 - 12.50
	12.50 - 15.00
	15.00 - 17.50
	17.50 - 20.00
	20.00 - 22.50
	22.50 - 25.00

Contour Data	Pole Vectors
Maximum Density	24.85%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	4 (4 Entries)
Hemisphere	Lower
Projection	Equal Angle



SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
J1 (BEDDING)	15^0	$N345^0$	10–20	<6	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
J2 (BEDDING)	85^0	$N040^0$	1–3	<6	<0.1	PLANAR SMOOTH	NIL	NIL
J3	30^0	$N165^0$	1–3	6–20	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
J4	75^0	$N165^0$	1–3	6–20	<0.1	SMOOTH	NIL	SOFT CLAY

DISCONTINUITY PARAMETERS AND STEREO GRAPHIC PROJECTION AT WEST PORTAL.

SHEET 1 OF 2

Rev.	Date	Description

Authority:
National Highways & Infrastructure Development Corporation Ltd.
(Ministry of Road Transport & Highways)

Design Consultants:
Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

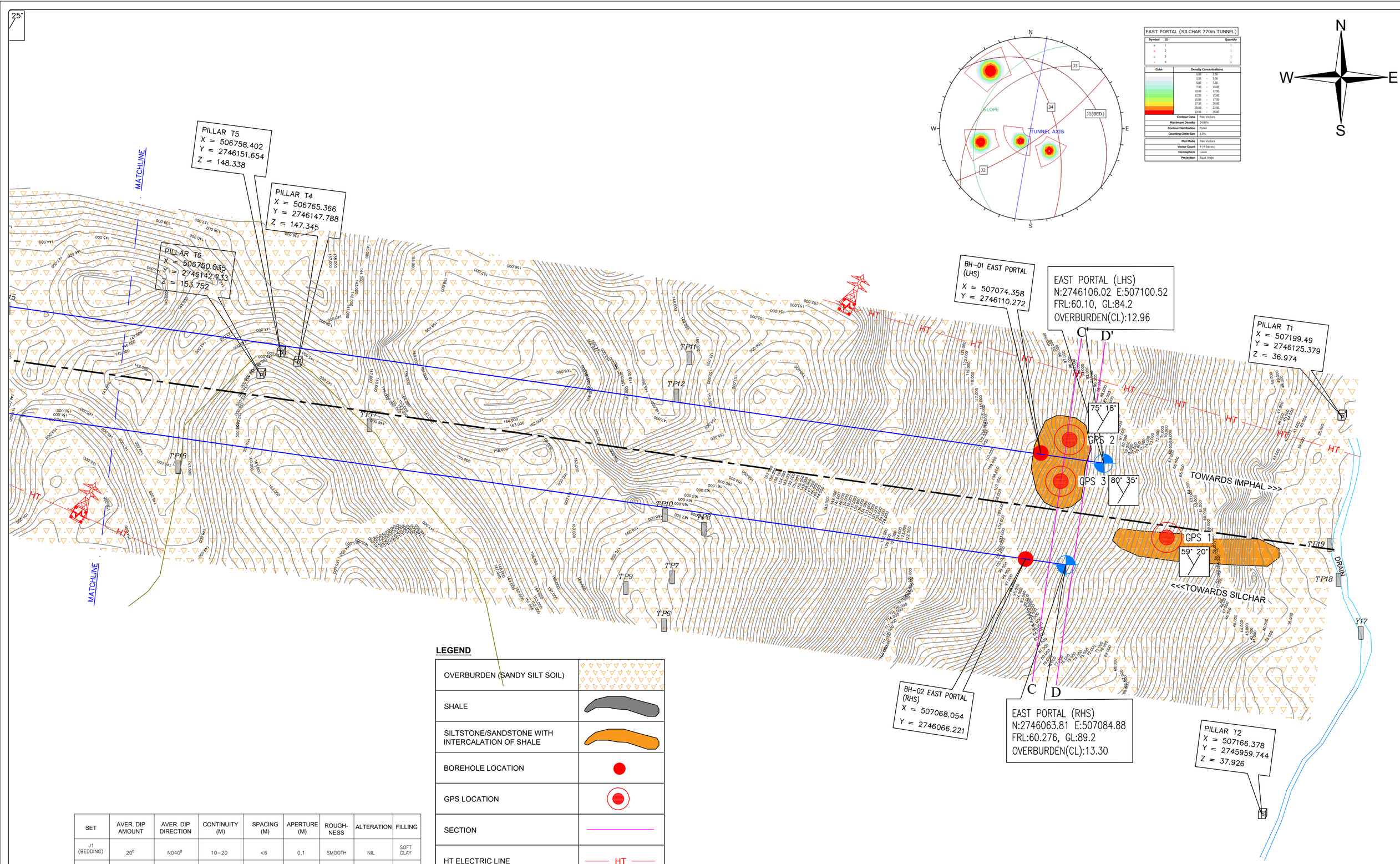
Project:
Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)
Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

FINAL DETAILED PROJECT REPORT

Title: **GEOLOGICAL PLAN OF SILCHAR-JIRIBAM TUNNEL**

Size	*Scale*	*Drg. No*	*Rev:*
A2	HOR-1:1000 VER-1:200	Transys-NH37-TUNNEL_FSR-002	R0



EAST PORTAL (SILCHAR 770m TUNNEL)

Symbol	ID	Quantity
+	1	1
×	2	1
△	3	1
▫	4	1

Color	Density Concentrations
	0.00 - 2.50
	2.50 - 5.00
	5.00 - 7.50
	7.50 - 10.00
	10.00 - 12.50
	12.50 - 15.00
	15.00 - 17.50
	17.50 - 20.00
	20.00 - 22.50
	22.50 - 25.00

Contour Data	Pole Vectors
Maximum Density	24.90%
Contour Distribution	Fisher
Counting Circle Size	1.0%
Plot Mode	Pole Vectors
Vector Count	4 (4 Data)
Hemisphere	Lower
Projection	Equal Angle

LEGEND

OVERBURDEN (SANDY SILT SOIL)	
SHALE	
SILTSTONE/SANDSTONE WITH INTERCALATION OF SHALE	
BOREHOLE LOCATION	
GPS LOCATION	
SECTION	
HT ELECTRIC LINE	HT
STREAM/NALA	
CENTER LINE OF TUNNEL	

SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
J1 (BEDDING)	20^0	$N040^0$	10–20	<6	0.1	SMOOTH	NIL	SOFT CLAY
J2	75^0	$N145^0$	1–3	6–20	0.1 TO 1	ROUGH–SMOOTH	NIL	NIL
J3	35^0	$N320^0$	3–10	<6	TIGHT	ROUGH–SMOOTH	NIL	SOFT CLAY
J4	59^0	$N075^0$	1–3	<6	0.1 TO 1	ROUGH–SMOOTH	NIL	SOFT CLAY

DISCONTINUITY PARAMETERS AND STEREO GRAPHIC PROJECTION AT EAST PORTAL.

Rev.	Date	Description

Authority:
National Highways & Infrastructure Development Corporation Ltd.
(Ministry of Road Transport & Highways)

Design Consultants:
Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

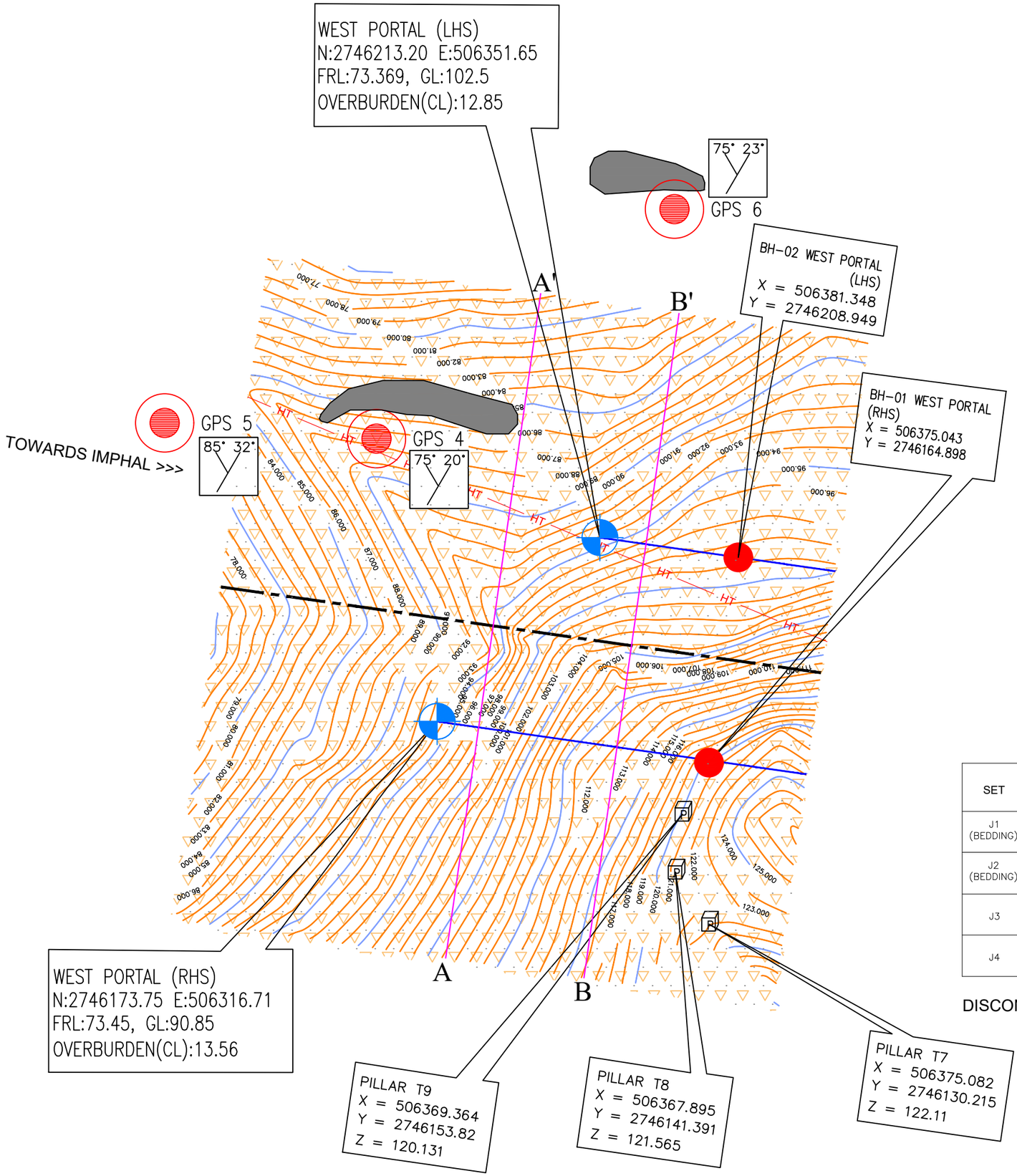
Project:
Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)
Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

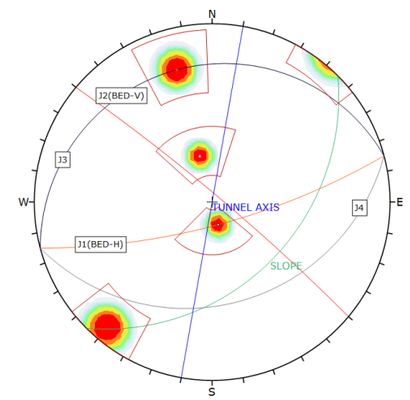
DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

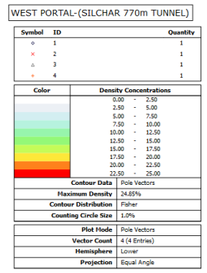
FINAL DETAILED PROJECT REPORT

Title: **GEOLOGICAL PLAN OF SILCHAR-JIRIBAM TUNNEL**

Size	*Scale*	*Drg. No*	*Rev:*
A2	HOR-1:1000 VER-1:200	**Transys-NH37-TUNNEL_FSR-002**	**R0**







WEST PORTAL-(SILCHAR 770m TUNNEL)

Symbol	ID	Quantity
◇	1	1
×	2	1
△	3	1
○	4	1

Color	Density Concentrations
	0.00 - 2.50
	2.50 - 5.00
	5.00 - 7.50
	7.50 - 10.00
	10.00 - 12.50
	12.50 - 15.00
	15.00 - 17.50
	17.50 - 20.00
	20.00 - 22.50
	22.50 - 25.00

Contour Data	Pole Vectors
Maximum Density	24.85%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	4 (4 Entries)
Hemisphere	Lower
Projection	Equal Angle

LEGEND

OVERBURDEN (SANDY SILT SOIL)	
SHALE	
BOREHOLE LOCATION	
GPS LOCATION	
SECTION	
HT ELECTRIC LINE	HT
STREAM/NALA	
CENTER LINE OF TUNNEL	

SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
J1 (BEDDING)	15^0	$N345^0$	10–20	<6	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
J2 (BEDDING)	85^0	$N040^0$	1–3	<6	<0.1	PLANAR SMOOTH	NIL	NIL
J3	30^0	$N165^0$	1–3	6–20	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
J4	75^0	$N165^0$	1–3	6–20	<0.1	SMOOTH	NIL	SOFT CLAY

DISCONTINUITY PARAMETERS AND STEREO GRAPHIC PROJECTION AT WEST PORTAL.

Rev.	Date	Description

Authority:
National Highways & Infrastructure Development Corporation Ltd.
(Ministry of Road Transport & Highways)

Design Consultants:
Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

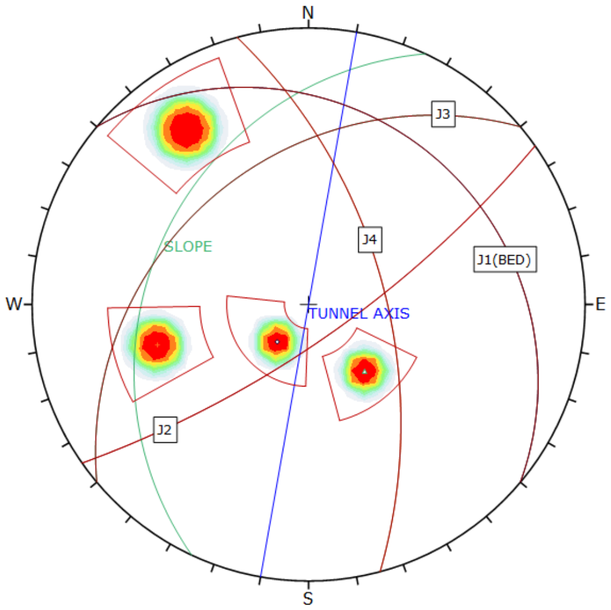
Project:
Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)
Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

FINAL DETAILED PROJECT REPORT

Title: **PLAN OF WEST PORTAL AREA SILCHAR JIRIBAM TUNNEL**

Size	*Scale*	*Drg. No*	*Rev:*
A2	HOR-1:1000 VER-1:200	Transys-NH37-TUNNEL-001	R0



EAST PORTAL (SILCHAR 770m TUNNEL)

Symbol	ID	Quantity
◇	1	1
×	2	1
△	3	1
+	4	1

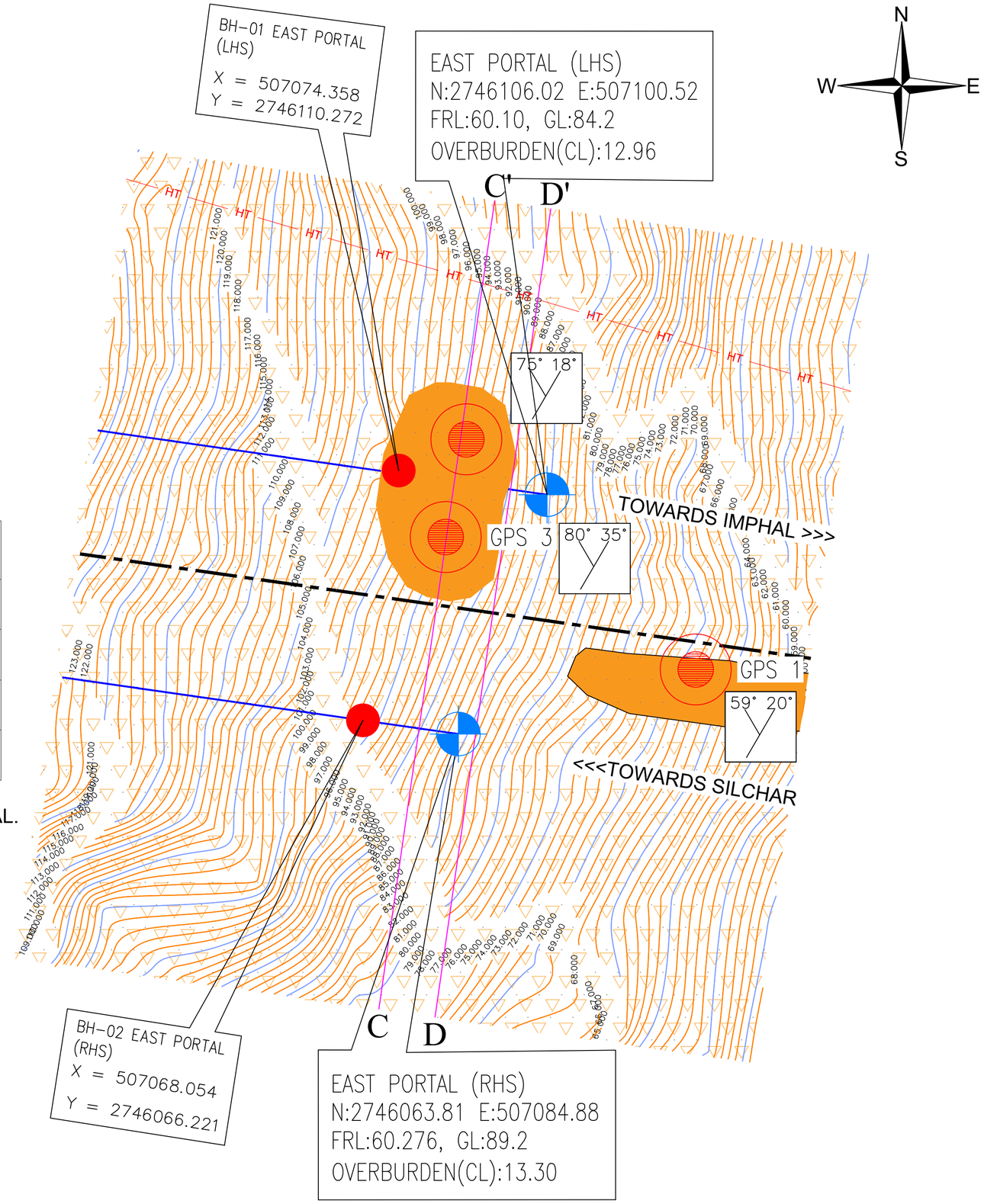
Color	Density Concentrations
	0.00 - 2.50
	2.50 - 5.00
	5.00 - 7.50
	7.50 - 10.00
	10.00 - 12.50
	12.50 - 15.00
	15.00 - 17.50
	17.50 - 20.00
	20.00 - 22.50
	22.50 - 25.00

Contour Data	Pole Vectors
Maximum Density	24.96%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	4 (4 Entries)
Hemisphere	Lower
Projection	Equal Angle

JOINT SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
J1 (BEDDING)	20^0	$N040^0$	10–20	<6	0.1	SMOOTH	NIL	SOFT CLAY
J2	75^0	$N145^0$	1–3	6–20	0.1 TO 1	ROUGH–SMOOTH	NIL	NIL
J3	35^0	$N320^0$	3–10	<6	TIGHT	ROUGH–SMOOTH	NIL	SOFT CLAY
J4	59^0	$N075^0$	1–3	<6	0.1 TO 1	ROUGH–SMOOTH	NIL	SOFT CLAY

DISCONTINUITY PARAMETERS AND STEREO GRAPHIC PROJECTION AT EAST PORTAL.



LEGEND

OVERBURDEN (SANDY SILT SOIL)	
SILTSTONE/SANDSTONE WITH INTERCALATION OF SHALE	
BOREHOLE LOCATION	
GPS LOCATION	
SECTION	
HT ELECTRIC LINE	HT
STREAM/NALA	
CENTER LINE OF TUNNEL	

Rev.	Date	Description

Authority:
National Highways & Infrastructure Development Corporation Ltd.
(Ministry of Road Transport & Highways)

Design Consultants:
Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

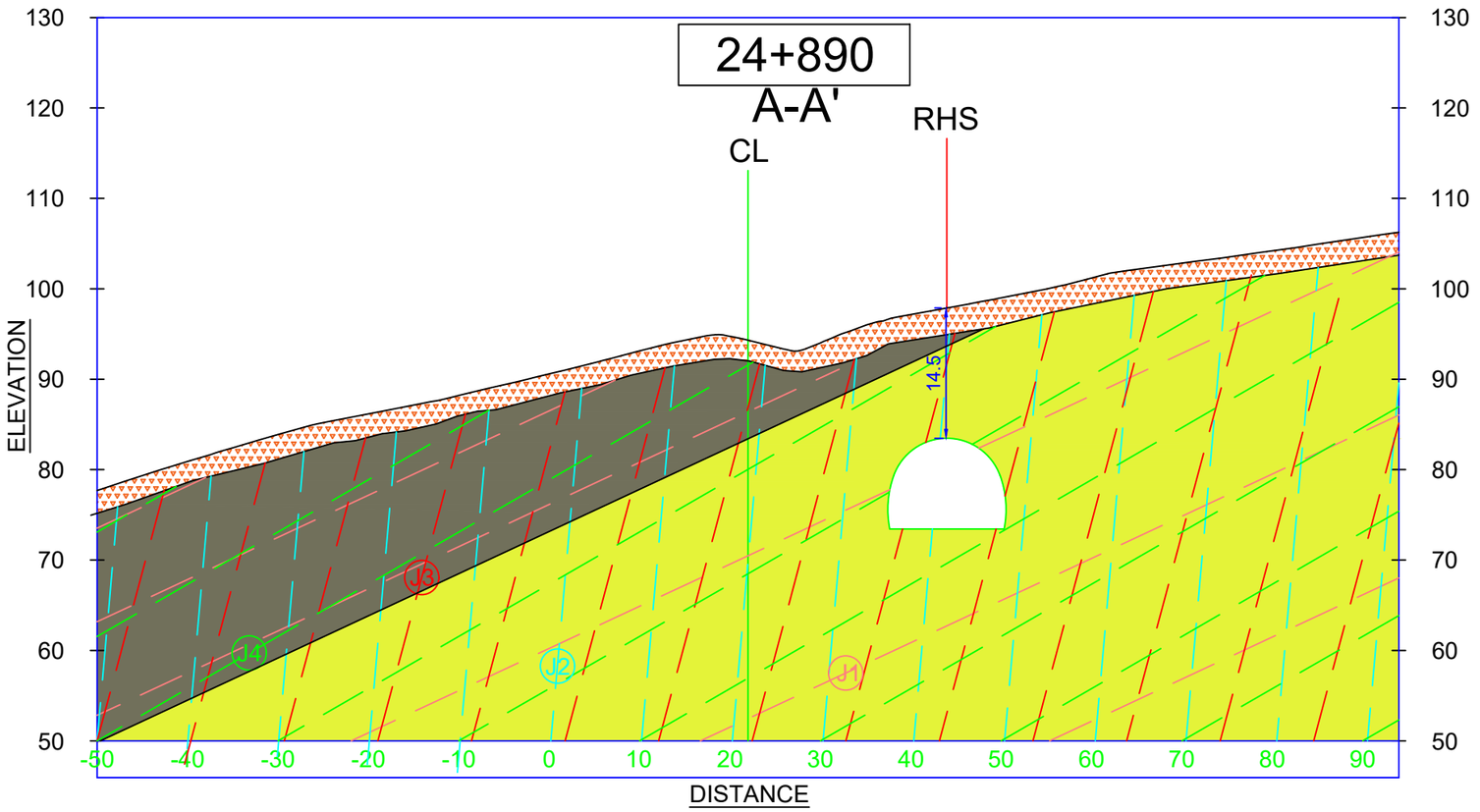
Project:
Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)
Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

FINAL DETAILED PROJECT REPORT

Title: **PLAN OF EAST PORTAL AREA SILCHAR JIRIBAM TUNNEL**

Size	*Scale*	*Drg. No*	*Rev:*
A2	HOR-1:1000 VER-1:200	**Transys-NH37-TUNNEL-001**	**R0**



LEGEND

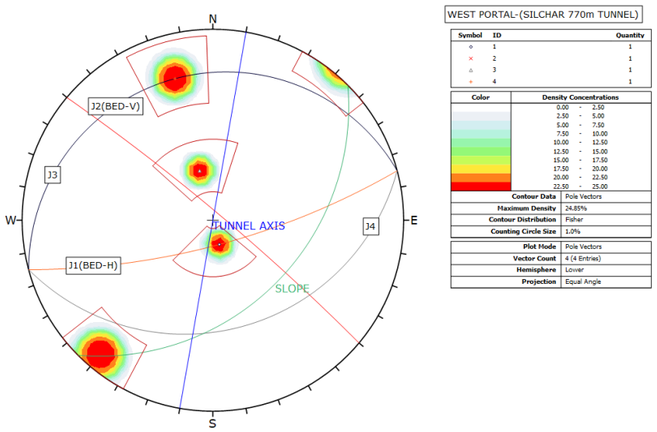
OVERBURDEN	
SHALE	
SHALE WITH MINOR SILTSTONE/SANDSTONE	
JOINT SET	J1, J2, J3, J4

N ⟵ ⟶ S

ROCK DESCRIPTION

ROCK TYPE	Shale with minor intercalation of siltstone /sandstone rock.
UCS (MPa)	10-25.
RQD	<10 %.
GROUND WATER CONDITION	Damp to dripping.

SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
J1 (BEDDING)	15^0	$N345^0$	10–20	<6	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
J2 (BEDDING)	85^0	$N040^0$	1–3	<6	<0.1	PLANAR SMOOTH	NIL	NIL
J3	30^0	$N165^0$	1–3	6–20	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
J4	75^0	$N165^0$	1–3	6–20	<0.1	SMOOTH	NIL	SOFT CLAY



Rev.	Date	Description

Authority:
National Highways & Infrastructure Development Corporation Ltd.
(Ministry of Road Transport & Highways)

Design Consultants:
Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

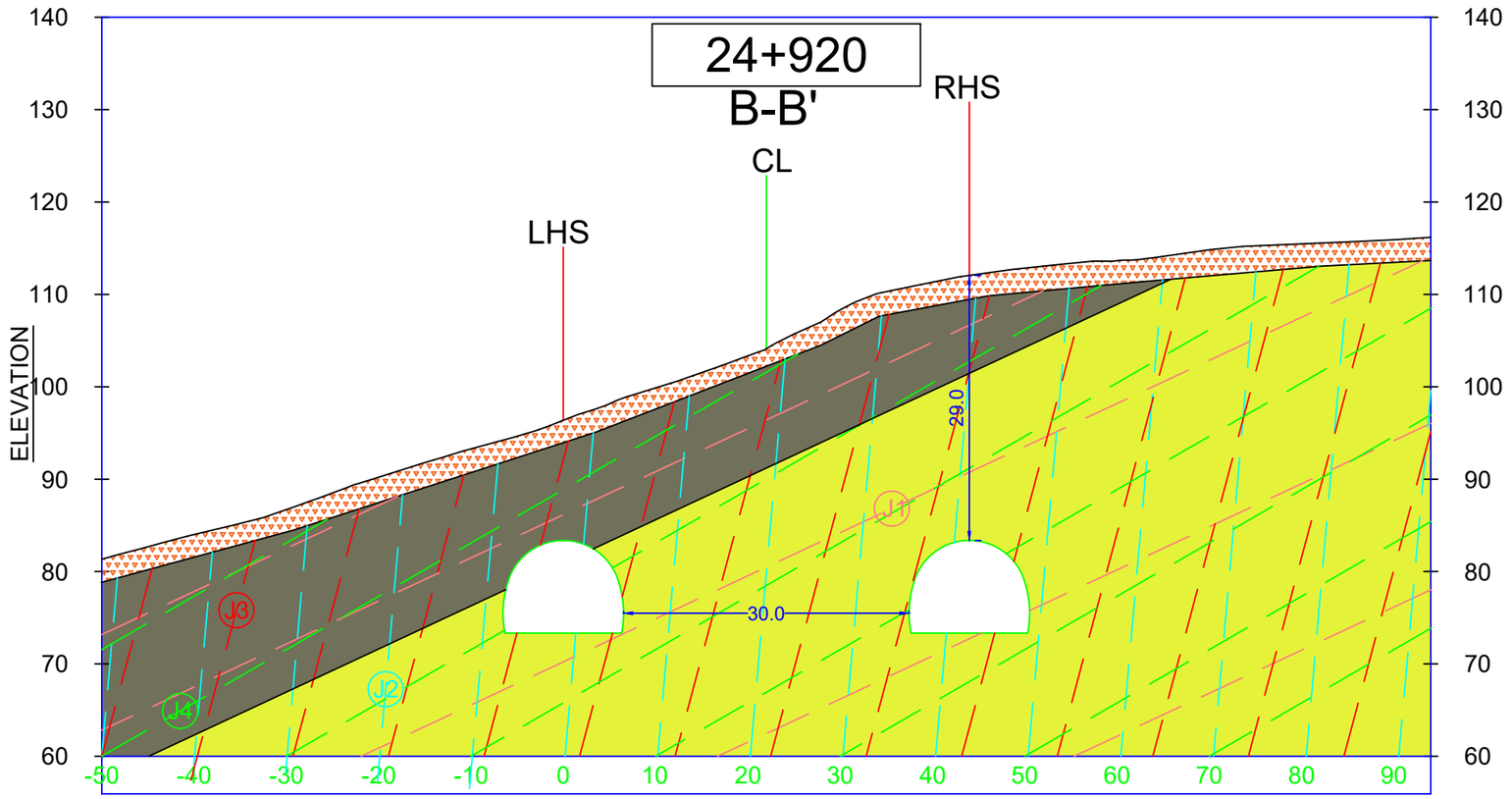
Project:
Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)
Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

FINAL DETAILED PROJECT REPORT

Title: **GEOLOGICAL CROSS SECTION A-A' AT WEST PORTAL SILCHAR JIRIBAM TUNNEL**

Size	*Scale*	*Drg. No*	*Rev:*
A3	HOR-1:1000 VER-1:200	**Transys-NH37-TUNNEL_FSR-005**	**R0**



LEGEND

OVERBURDEN	
SHALE	
SHALE WITH MINOR SILTSTONE/SANDSTONE	
JOINT SET	J1, J2, J3, J4

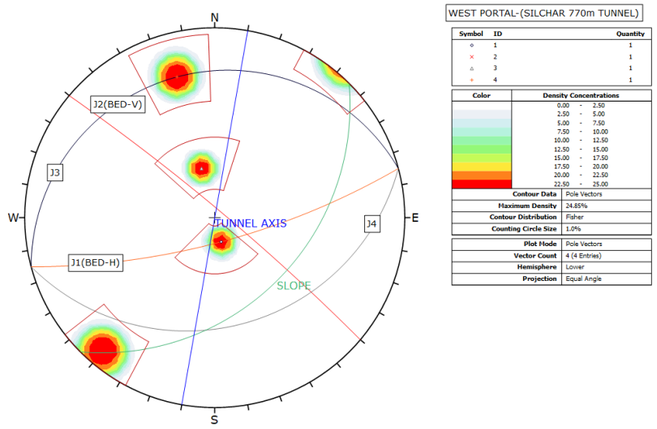
DISTANCE

ROCK DESCRIPTION

N ◄——— ———► S

ROCK TYPE	Shale with minor intercalation of siltstone /sandstone rock.
UCS (MPa)	10-25.
RQD	<10 %.
GROUND WATER CONDITION	Damp to dripping.

SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
J1 (BEDDING)	15^0	$N345^0$	10–20	<6	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
J2 (BEDDING)	85^0	$N040^0$	1–3	<6	<0.1	PLANAR SMOOTH	NIL	NIL
J3	30^0	$N165^0$	1–3	6–20	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
J4	75^0	$N165^0$	1–3	6–20	<0.1	SMOOTH	NIL	SOFT CLAY



WEST PORTAL-(SILCHAR 770m TUNNEL)

Symbol	ID	Quantity
◇	1	1
×	2	1
△	3	1
+	4	1

Color	Density Concentrations
	0.00 - 2.50
	2.50 - 5.00
	5.00 - 7.50
	7.50 - 10.00
	10.00 - 12.50
	12.50 - 15.00
	15.00 - 17.50
	17.50 - 20.00
	20.00 - 22.50
	22.50 - 25.00

Contour Data	Pole Vectors
Maximum Density	24.85%
Contour Distribution	Fisher
Counting Circle Size	1.0%
Plot Mode	Pole Vectors
Vector Count	4 (4 Entries)
Hemisphere	Lower
Projection	Equal Angle

Rev.	Date	Description

Authority:
National Highways & Infrastructure Development Corporation Ltd.
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Design Consultants:
Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001: Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

Project:
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Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

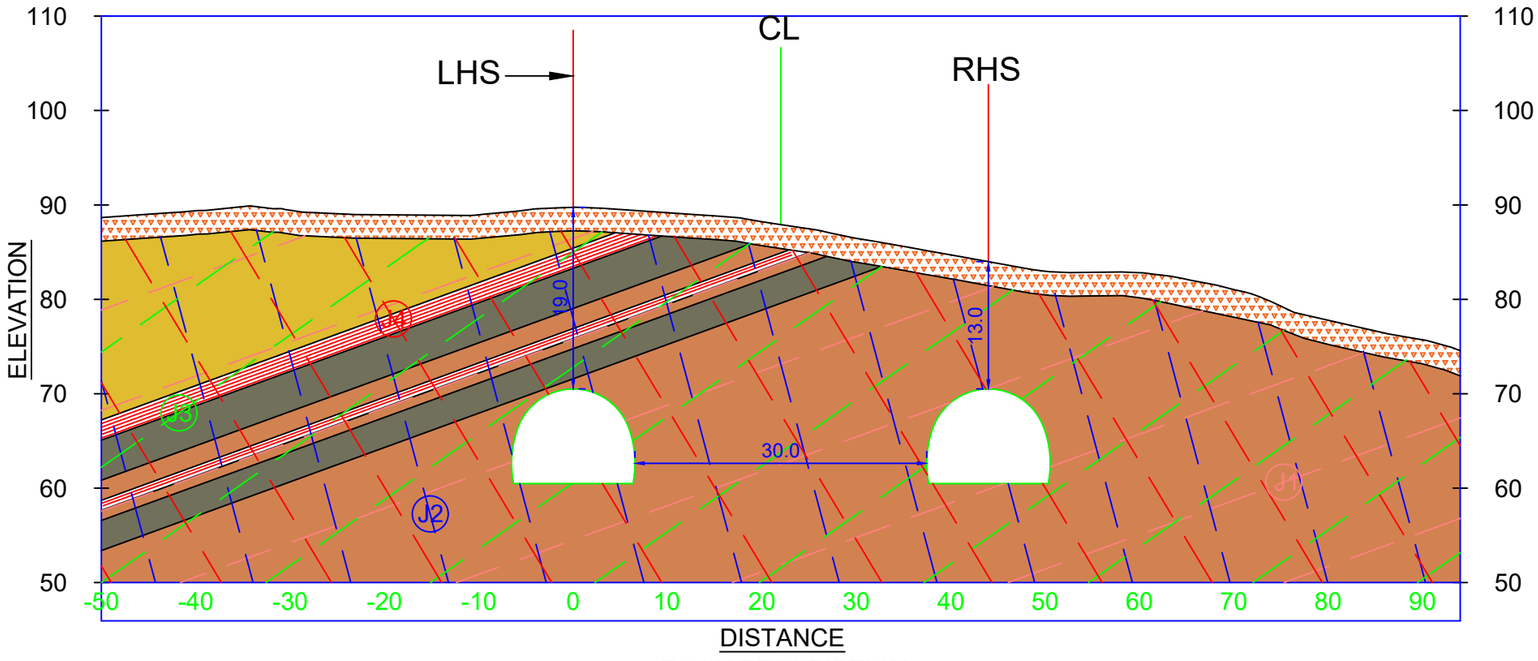
FINAL DETAILED PROJECT REPORT

Title: GEOLOGICAL CROSS SECTION B-B' AT WEST PORTAL SILCHAR JIRIBAM TUNNEL

Size	Scale	Drg. No	Rev:
A3	HOR-1:1000 VER-1:200	Transys-NH37-TUNNEL_FSR-006	R0

C-C'

25+650



DISTANCE

N ◄ ► S

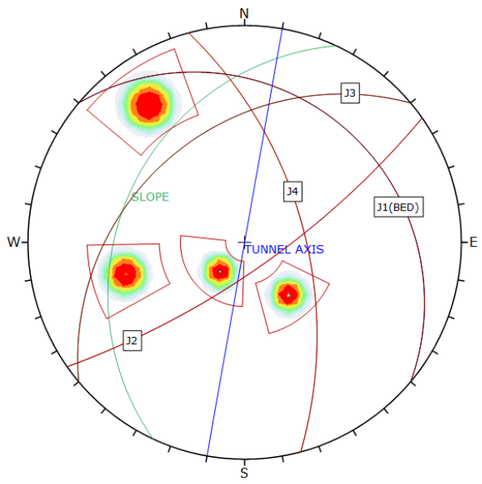
ROCK DESCRIPTION

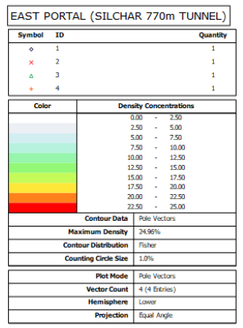
ROCK TYPE	Siltstone / Sandstone with intercalation of shale rock.
UCS (MPa)	10-20.
RQD	<10 %.
GROUND WATER CONDITION	Damp to dripping.

LEGEND

OVERBURDEN	
SILTSTONE / SANDSTONE WITH MINOR INTERCALATION OF SHALE.	
SHALE	
SILTSTONE / SANDSTONE WITH INTERCALATION OF SHALE.	
SHALE / GOUGE MATERIAL	
JOINT SET	J1, J2, J3, J4

SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
J1 (BEDDING)	20^0	$N040^0$	10–20	<6	0.1	SMOOTH	NIL	SOFT CLAY
J2	75^0	$N145^0$	1–3	6–20	0.1 TO 1	ROUGH–SMOOTH	NIL	NIL
J3	35^0	$N320^0$	3–10	<6	TIGHT	ROUGH–SMOOTH	NIL	SOFT CLAY
J4	59^0	$N075^0$	1–3	<6	0.1 TO 1	ROUGH–SMOOTH	NIL	SOFT CLAY





Rev.	Date	Description

Authority:
National Highways & Infrastructure Development Corporation Ltd.
(Ministry of Road Transport & Highways)

Design Consultants:
Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

Project:
Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)
Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

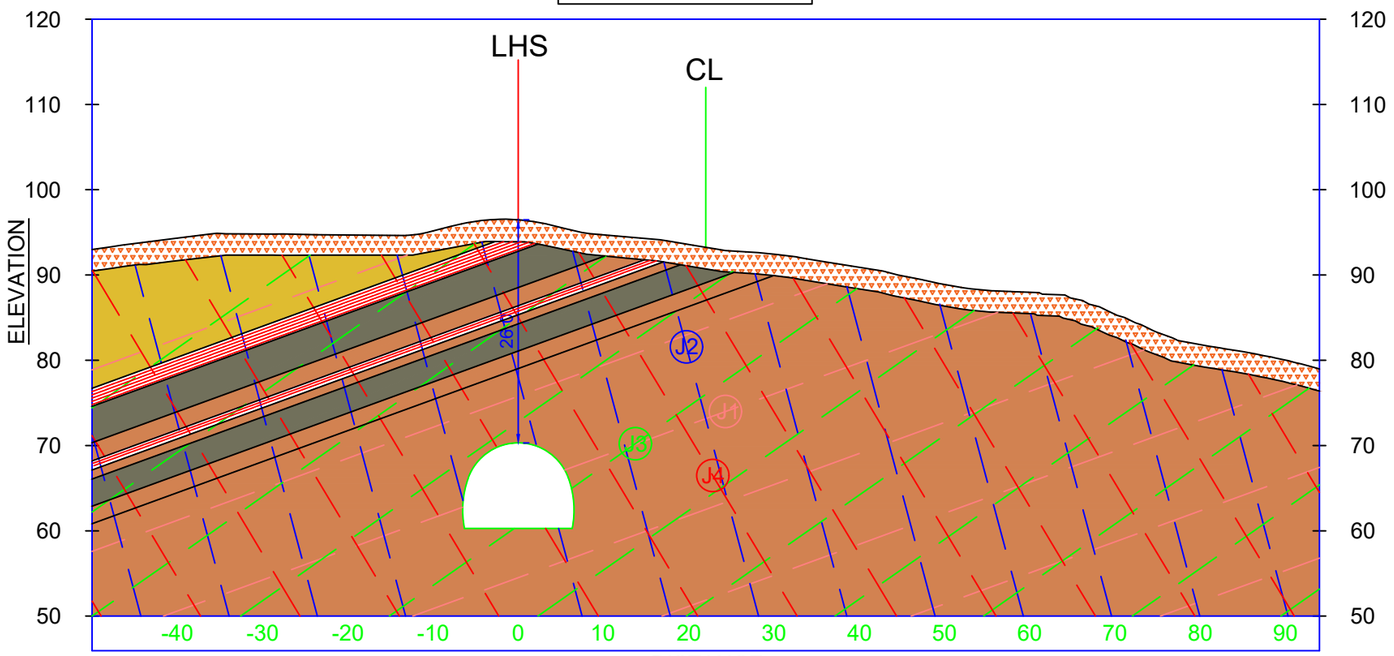
FINAL DETAILED PROJECT REPORT

Title: **GEOLOGICAL CROSS SECTION C-C' AT EAST PORTAL SILCHAR JIRIBAM TUNNEL**

Size	*Scale*	*Drg. No*	*Rev:*
A3	HOR-1:1000 VER-1:200	**Transys-NH37-TUNNEL_FSR-007**	**R0**

D-D'

25+660



N ← → S

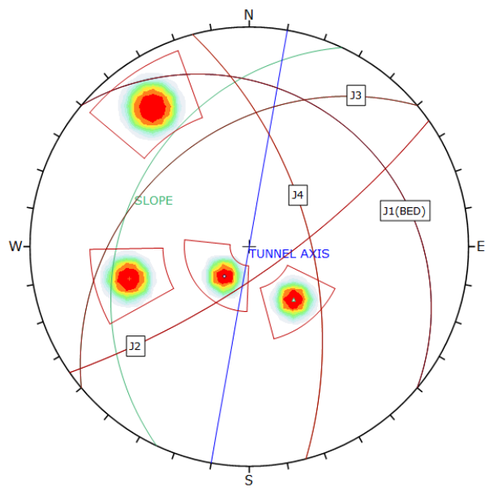
LEGEND

OVERBURDEN	
SILTSTONE / SANDSTONE WITH MINOR INTERCALATION OF SHALE.	
SHALE	
SILTSTONE / SANDSTONE WITH INTERCALATION OF SHALE.	
SHALE / GOUGE MATERIAL	
JOINT SET	J1, J2, J3, J4

ROCK DESCRIPTION

ROCK TYPE	Siltstone / Sandstone with intercalation of shale rock.
UCS (MPa)	10-20.
RQD	<10 %.
GROUND WATER CONDITION	Damp to dripping.

SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
J1 (BEDDING)	20^0	$N040^0$	10–20	<6	0.1	SMOOTH	NIL	SOFT CLAY
J2	75^0	$N145^0$	1–3	6–20	0.1 TO 1	ROUGH–SMOOTH	NIL	NIL
J3	35^0	$N320^0$	3–10	<6	TIGHT	ROUGH–SMOOTH	NIL	SOFT CLAY
J4	59^0	$N075^0$	1–3	<6	0.1 TO 1	ROUGH–SMOOTH	NIL	SOFT CLAY



EAST PORTAL (SILCHAR 770m TUNNEL)

Symbol	ID	Quantity
◇	1	1
×	2	1
△	3	1
+	4	1

Color	Density Concentrations
	0.00 - 2.50
	2.50 - 5.00
	5.00 - 7.50
	7.50 - 10.00
	10.00 - 12.50
	12.50 - 15.00
	15.00 - 17.50
	17.50 - 20.00
	20.00 - 22.50
	22.50 - 25.00

Contour Data	Pole Vectors
Maximum Density	24.96%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	4 (4 Entries)
Hemisphere	Lower
Projection	Equal Angle

Rev.	Date	Description

Authority:
National Highways & Infrastructure Development Corporation Ltd.
(Ministry of Road Transport & Highways)

Design Consultants:
Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

Project:
Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)
Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

FINAL DETAILED PROJECT REPORT

Title: **GEOLOGICAL CROSS SECTION A-A' AT WEST PORTAL SILCHAR JIRIBAM TUNNEL**

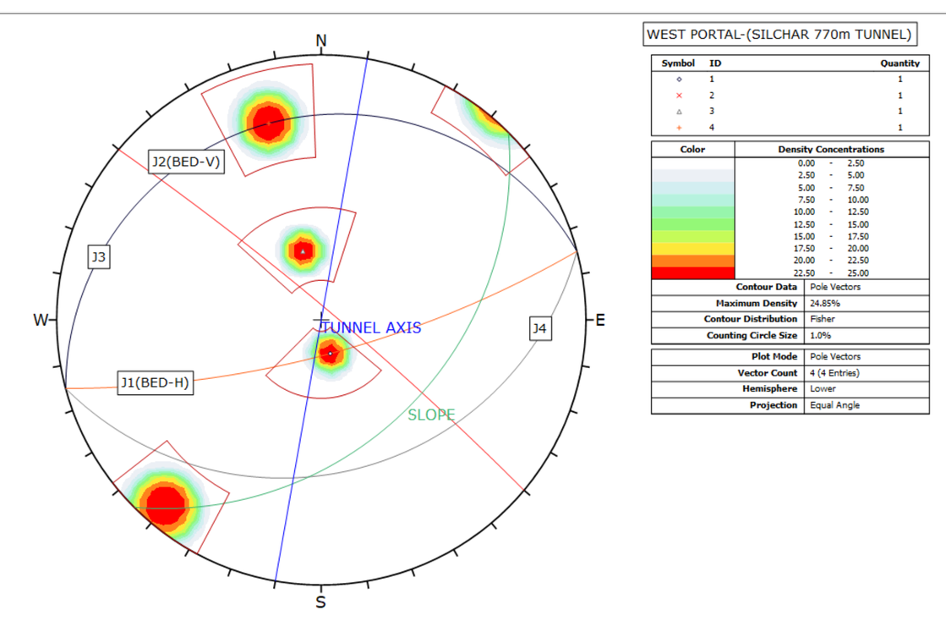
Size	*Scale*	*Drg. No*	*Rev:*
A3	HOR-1:1000 VER-1:200	**Transys-NH37-TUNNEL_FSR-008**	**R0**

LEGEND

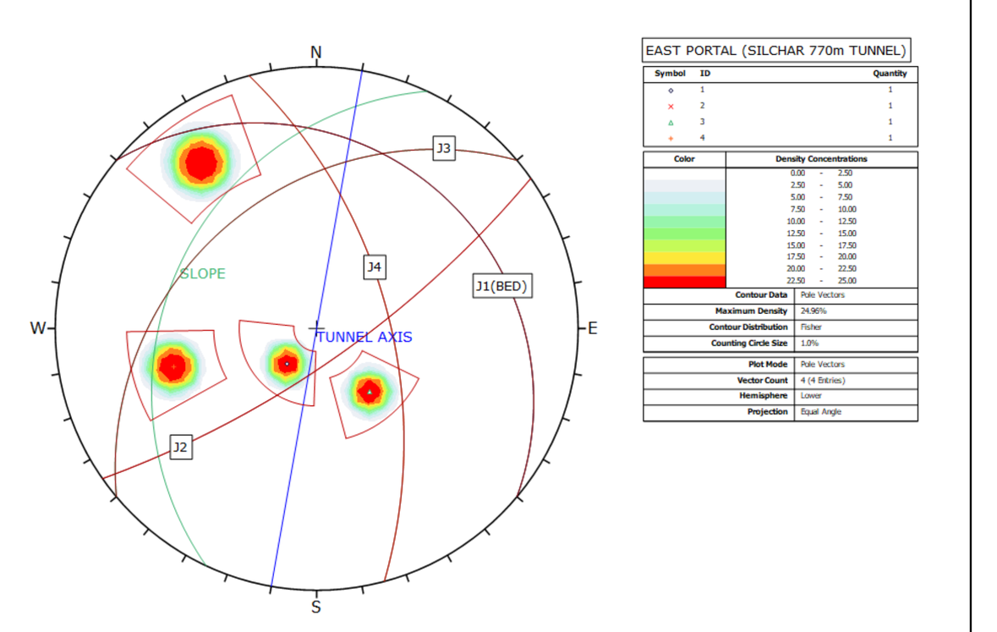
OVERBURDEN	
SILTSTONE / SANDSTONE WITH MINOR INTERCALATION OF SHALE.	
SHALE	
SILTSTONE / SANDSTONE WITH INTERCALATION OF SHALE.	
SHALE / GOUGE MATERIAL	
JOINT SET	J1, J2, J3, J4
SHALE WITH MINOR SILTSTONE/SANDSTONE	

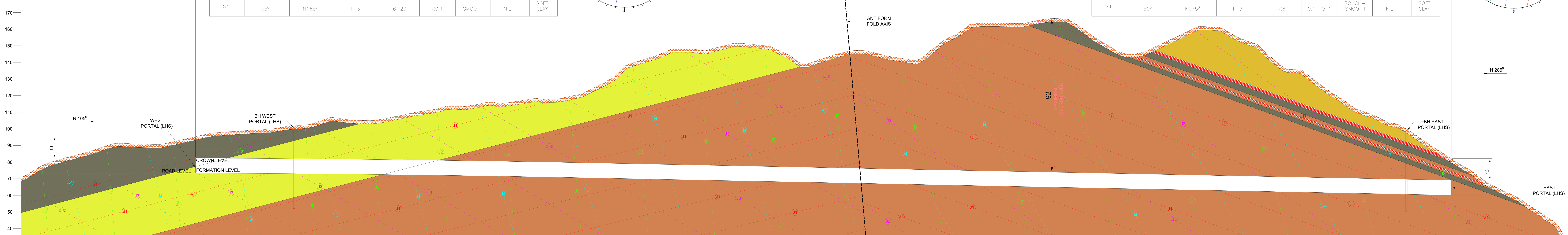
756.5

SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
S1 (BENDDING)	15⁰	N345⁰	10–20	<6	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
S2 (BENDDING)	85⁰	N040⁰	1–3	<6	<0.1	PLANAR SMOOTH	NIL	NIL
S3	30⁰	N165⁰	1–3	6–20	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
S4	75⁰	N165⁰	1–3	6–20	<0.1	SMOOTH	NIL	SOFT CLAY



SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
S1 (BENDDING)	20⁰	N040⁰	10–20	<6	0.1	SMOOTH	NIL	SOFT CLAY
S2	75⁰	N145⁰	1–3	6–20	0.1 TO 1	ROUGH–SMOOTH	NIL	NIL
S3	35⁰	N320⁰	3–10	<6	TIGHT	ROUGH–SMOOTH	NIL	SOFT CLAY
S4	59⁰	N075⁰	1–3	<6	0.1 TO 1	ROUGH–SMOOTH	NIL	SOFT CLAY





Datum : 0

Chainage (m)	Prop. Level at Median Edge	Ground Level below Prop. C/L	Ground Level below MCW at 22m from Prop. C/L – Left	Ground Level below MCW at 22m from Prop. C/L – Right
24810	73.397	69.017	70.471	71.059
24820	73.425	72.815	76.372	73.582
24830	73.447	76.001	80.771	76.077
24840	73.461	78.711	83.294	79.715
24850	73.469	81.383	86.010	83.354
24860	73.469	84.530	89.137	86.329
24870	73.463	87.527	91.499	89.517
24880	73.450	90.851	90.839	93.171
24890	73.430	94.333	90.591	97.794
24900	73.403	99.334	91.827	103.300
24910	73.369	102.508	94.122	109.217
24920	73.328	104.360	96.194	112.162
24930	73.280	104.327	97.823	115.565
24940	73.225	106.709	98.641	119.479
24950	73.163	110.077	99.343	123.238
24960	73.095	111.963	99.594	124.155
24970	73.019	113.643	101.354	122.286
24980	72.937	115.879	102.125	121.056
24990	72.847	115.893	104.632	121.179
25000	72.751	114.476	106.563	120.491
25010	72.648	112.448	105.189	120.738
25020	72.537	112.656	104.905	121.361
25030	72.420	114.183	106.103	121.745
25040	72.296	115.298	108.215	122.186
25050	72.165	117.858	110.309	123.747
25060	72.028	120.035	111.826	125.379
25070	71.883	121.401	113.755	126.955
25080	71.731	123.055	113.781	128.660
25090	71.572	125.641	115.653	130.335
25100	71.407	128.916	115.198	131.691
25110	71.234	129.633	116.616	132.948
25120	71.055	132.146	118.519	135.160
25130	70.869	132.793	117.364	136.969
25140	70.675	131.222	119.201	138.670
25150	70.476	127.354	122.100	136.580
25160	70.276	122.668	127.124	135.111
25170	70.076	127.603	133.882	135.348
25180	69.876	134.014	140.136	133.748
25190	69.676	140.294	143.150	136.072
25200	69.476	145.209	147.265	140.404
25210	69.276	147.891	148.320	145.787
25220	69.076	150.769	147.218	151.938
25230	68.876	147.709	149.125	151.779
25240	68.676	145.105	151.711	152.583
25250	68.476	141.895	150.960	149.652
25260	68.276	139.538	149.843	146.440
25270	68.076	139.798	145.554	141.766
25280	67.876	142.858	139.089	142.966
25290	67.676	145.847	141.273	148.093
25300	67.476	149.418	144.542	154.160
25310	67.276	155.814	146.931	158.054
25320	67.076	157.724	146.743	161.175
25330	66.876	155.945	144.087	162.264
25340	66.676	151.979	142.413	160.546
25350	66.476	147.117	141.249	157.670
25360	66.276	146.888	149.239	152.155
25370	66.076	148.622	155.412	147.023
25380	65.876	153.803	161.405	146.496
25390	65.676	158.544	163.590	147.460
25400	65.476	162.268	163.405	150.853
25410	65.276	163.106	163.220	153.807
25420	65.076	162.147	165.135	155.957
25430	64.876	160.007	166.302	158.524
25440	64.676	160.986	166.439	159.307
25450	64.476	161.763	160.134	161.666
25460	64.276	156.152	153.072	164.480
25470	64.076	149.618	147.231	165.607
25480	63.876	153.266	144.695	168.018
25490	63.676	155.621	147.716	166.519
25500	63.476	157.398	152.505	166.067
25510	63.276	158.344	157.252	164.759
25520	63.076	158.281	161.698	161.285
25530	62.876	155.639	161.139	157.502
25540	62.676	150.580	156.616	151.148
25550	62.476	145.786	152.491	143.890
25560	62.276	140.669	146.164	139.273
25570	62.076	135.459	137.260	132.893
25580	61.876	130.240	135.631	126.975
25590	61.676	125.098	129.317	122.201
25600	61.476	119.535	121.242	117.426
25610	61.276	114.349	114.855	112.575
25620	61.076	108.458	110.442	106.446
25630	60.876	103.506	106.063	101.080
25640	60.676	98.542	102.541	96.377
25650	60.476	93.206	96.553	90.543
25660	60.276	87.925	89.826	84.249
25670	60.076	82.652	82.945	77.955
25680	59.876	77.258	76.990	73.399
25690	59.676	72.301	70.335	69.496
25700	59.476	67.880	64.209	64.579
25710	59.276	61.900	59.397	58.698
25720	59.076	53.536	53.020	52.212
25730	58.876	43.713	46.527	45.271
25740	58.676	38.242	38.187	40.016
25750	58.476	36.810	37.620	38.394
25760	58.276	37.214	37.075	37.079
25770	58.076	39.201	40.471	37.001

SUPPORT CLASS (SC)	LENGTH / PERCENTAGE (SC)	GSI / RMR	OVERBURDEN	DESCRIPTION
SUPPORT CLASS (SC) – V(A)	65 M / 8.6%	10–15 / 10–15	10–20	HIGHLY WEATHERED & FRACTURED SHALE WITH INTERCALATION OF SILTSTONE / SANDSTONE. HIGHLY DEFORMED/SHEARED DUE TO ANTI FORM FOLD . LACK OF BLOCKINESS DUE TO CLOSE SPACING (<6cm) OF WEAK HORIZONTAL BEDDING/FOLD STRUCTURE.
SUPPORT CLASS (SC) – V	125 M / 16.5%	15–20 / 20	20–35	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL OF 1M THICK OR SHALE WITH MINOR SILTSTONE/ SANDSTONE. THE ROCK IS HEAVILY BROKEN AND HORIZONTALLY BEDDED WITH 6–20cm SPACING.
SUPPORT CLASS (SC) – IV	70 M / 9.2%	25 / 30	35 – 60	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH MINOR INTERCALATION OF SHALE ROCK. THE ROCK MASS IS FORMED BY INTERSECTING DISCONTINUITY SETS PERSISTENCE OF BEDDING PLANE.
SUPPORT CLASS (SC) – III	30 M / 3.9%	35 / 40	60 – 90	MODERATELY WEATHERED & FRACTURED SANDSTONE / SILTSTONE THE ROCK MASS IS COMPACT & BLOCKY WITH HORIZONTAL BEDDING .
SUPPORT CLASS (SC) – IV	80 M / 10.5%	25 / 30	35 – 60	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH MINOR INTERCALATION OF SHALE ROCK. THE ROCK MASS IS FORMED BY INTERSECTING DISCONTINUITY SETS PERSISTENCE OF BEDDING PLANE.
SUPPORT CLASS (SC) – V(A)	80 M / 10.5%	10–15 / 10–15	10–20	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL. HIGHLY DEFORMED/SHEARED DUE TO ANTI FORM FOLD . LACK OF BLOCKINESS DUE TO CLOSE SPACING (<6cm) OF WEAK HORIZONTAL BEDDING/FOLD STRUCTURE.
SUPPORT CLASS (SC) – IV	60 M / 7.9%	25 / 30	35 – 60	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH MINOR INTERCALATION OF SHALE ROCK. THE ROCK MASS IS FORMED BY INTERSECTING DISCONTINUITY SETS PERSISTENCE OF BEDDING PLANE.
SUPPORT CLASS (SC) – III	30 M / 3.9%	35 / 40	60 – 90	MODERATELY WEATHERED & FRACTURED SANDSTONE / SILTSTONE THE ROCK MASS IS COMPACT & BLOCKY WITH HORIZONTAL BEDDING .
SUPPORT CLASS (SC) – IV	120 M / 15.8%	25 / 30	35 – 60	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH MINOR INTERCALATION OF SHALE ROCK. THE ROCK MASS IS FORMED BY INTERSECTING DISCONTINUITY SETS PERSISTENCE OF BEDDING PLANE.
SUPPORT CLASS (SC) – V	60 M / 7.9%	15–20 / 20	20–35	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL OF 1M THICK . THE ROCK IS HEAVILY BROKEN AND HORIZONTALLY BEDDED WITH 6–20cm SPACING.
SUPPORT CLASS (SC) – IV	36.5 M / 4.8%	25 / 30	35 – 60	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH MINOR INTERCALATION OF SHALE ROCK. THE ROCK MASS IS FORMED BY INTERSECTING DISCONTINUITY SETS PERSISTENCE OF BEDDING PLANE.

(LHS) GEOLOGICAL L - SECTION

Rev.	Date	Description

Authority:
National Highways & Infrastructure Development Corporation Ltd.
(Ministry of Road Transport & Highways)

Design Consultants:
Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

Project:
Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)
Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

FINAL DETAILED PROJECT REPORT

Title: GEOLOGICAL L-SECTION SILCHAR JIRIBAM TUNNEL(LHS)

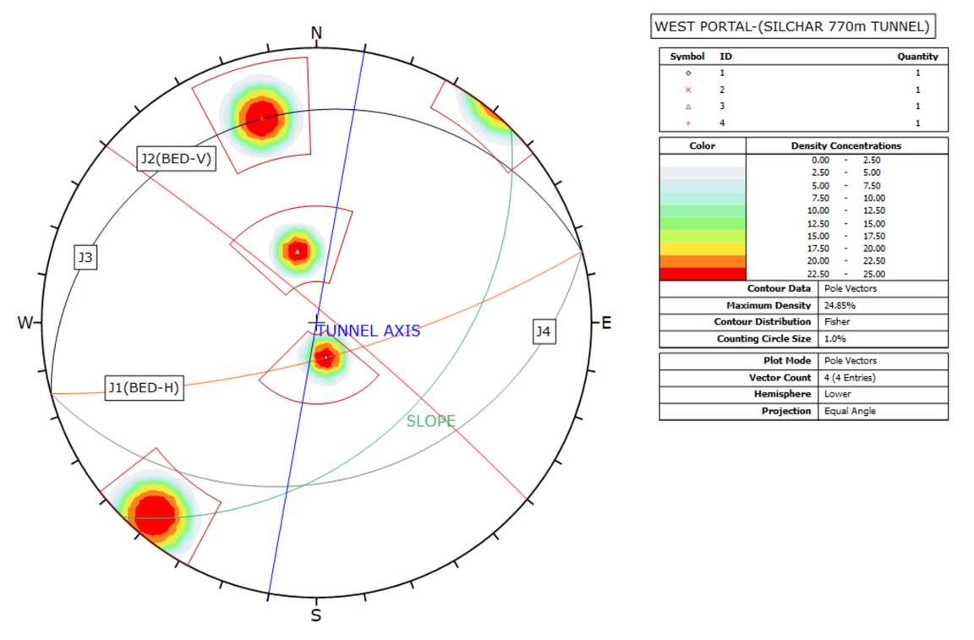
Size	Scale	Drg. No	Rev:
A0	HOR-1:1000 VER-1:200	Transys-NH37-TUNNEL_FSR-009	R0

LEGEND

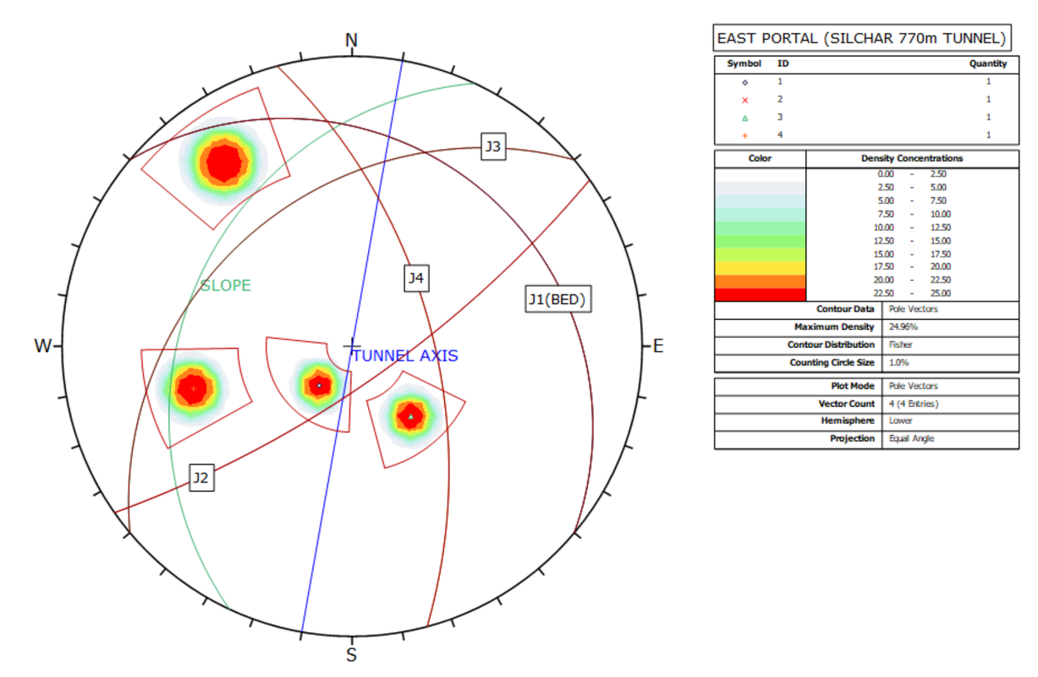
OVERBURDEN	
SILTSTONE / SANDSTONE WITH MINOR INTERCALATION OF SHALE.	
SHALE	
SILTSTONE / SANDSTONE WITH INTERCALATION OF SHALE.	
SHALE / GOUGE MATERIAL	
JOINT SET	J1 J2 J3 J4
SHALE WITH MINOR SILTSTONE/SANDSTONE	

776

SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
S1 (BENDDING)	15⁰	N345⁰	10–20	<6	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
S2 (BENDDING)	85⁰	N040⁰	1–3	<6	<0.1	PLANAR SMOOTH	NIL	NIL
S3	30⁰	N165⁰	1–3	6–20	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
S4	75⁰	N165⁰	1–3	6–20	<0.1	SMOOTH	NIL	SOFT CLAY



SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
S1 (BENDDING)	20⁰	N040⁰	10–20	<6	0.1	SMOOTH	NIL	SOFT CLAY
S2	75⁰	N145⁰	1–3	6–20	0.1 TO 1	ROUGH–SMOOTH	NIL	NIL
S3	35⁰	N320⁰	3–10	<6	TIGHT	ROUGH–SMOOTH	NIL	SOFT CLAY
S4	59⁰	N075⁰	1–3	<6	0.1 TO 1	ROUGH–SMOOTH	NIL	SOFT CLAY



SUPPORT CLASS (SC)	SUPPORT CLASS (SC) – V(A)	SUPPORT CLASS (SC) – V	SUPPORT CLASS (SC) – IV	SUPPORT CLASS (SC) – V	SUPPORT CLASS (SC) – IV	SUPPORT CLASS (SC) – III	SUPPORT CLASS (SC) – IV
LENGTH / PERCENTAGE (SC)	14 M/1.8%	35 M / 4.5%	220 M / 28.3%	40 M / 5.1%	30 M / 3.9%	30 M / 3.9%	20 M/2.5%
GSI / RMR	10–15 / 10–15	15–20 / 20	25 / 30	15–20 / 20	25 / 30	35 / 40	25 / 30
OVERBURDEN	10–20	20–35	35 – 60	20–35	35 – 60	60 – 90	35 – 60
DESCRIPTION	HIGHLY WEATHERED & FRACTURED SHALE WITH INTERCALATION OF SILTSTONE / SANDSTONE. HIGHLY DEFORMED/SHEARED DUE TO ANTI FORM FOLD . LACK OF BLOCKINESS DUE TO CLOSE SPACING (<6cm) OF WEAK HORIZONTAL BEDDING/FOLD STRUCTURE.	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL OF 1M THICK OR SHALE WITH MINOR SILTSTONE/ SANDSTONE. THE ROCK IS HEAVILY BROKEN AND HORIZONTALLY BEDDED WITH 6–20cm SPACING.	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH MINOR INTERCALATION OF SHALE ROCK. THE ROCK MASS IS FORMED BY INTERSECTING DISCONTINUITY SETS PERSISTENCE OF BEDDING PLANE.	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL OF 1M THICK . THE ROCK IS HEAVILY BROKEN AND HORIZONTALLY BEDDED WITH 6–20cm SPACING.	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH MINOR INTERCALATION OF SHALE ROCK. THE ROCK MASS IS FORMED BY INTERSECTING DISCONTINUITY SETS PERSISTENCE OF BEDDING PLANE.	MODERATELY WEATHERED & FRACTURED SANDSTONE / SILTSTONE THE ROCK MASS IS COMPACT & BLOCKY WITH HORIZONTAL BEDDING .	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH MINOR INTERCALATION OF SHALE ROCK. THE ROCK MASS IS FORMED BY INTERSECTING DISCONTINUITY SETS PERSISTENCE OF BEDDING PLANE.

SUPPORT CLASS (SC)	SUPPORT CLASS (SC) – V(A)	SUPPORT CLASS (SC) – V	SUPPORT CLASS (SC) – IV	SUPPORT CLASS (SC) – V	SUPPORT CLASS (SC) – V(A)
LENGTH / PERCENTAGE (SC)	60 M / 7.8%	50 M / 6.5%	210 M / 27.06%	50 M / 6.5%	17 M / 2.2%
GSI / RMR	10–15 / 10–15	15–20 / 20	25 / 30	15–20 / 20	10–15 / 10–15
OVERBURDEN	10–20	20–35	35 – 60	20–35	10–20
DESCRIPTION	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL. HIGHLY DEFORMED/SHEARED DUE TO ANTI FORM FOLD . LACK OF BLOCKINESS DUE TO CLOSE SPACING (<6cm) OF WEAK HORIZONTAL BEDDING/FOLD STRUCTURE.	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL OF 1M THICK . THE ROCK IS HEAVILY BROKEN AND HORIZONTALLY BEDDED WITH 6–20cm SPACING.	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH MINOR INTERCALATION OF SHALE ROCK. THE ROCK MASS IS FORMED BY INTERSECTING DISCONTINUITY SETS PERSISTENCE OF BEDDING PLANE.	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL OF 1M THICK . THE ROCK IS HEAVILY BROKEN AND HORIZONTALLY BEDDED WITH 6–20cm SPACING.	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL. HIGHLY DEFORMED/SHEARED DUE TO ANTI FORM FOLD LACK OF BLOCKINESS DUE TO CLOSE SPACING (<6cm) OF WEAK HORIZONTAL BEDDING/FOLD STRUCTURE.

(RHS) GEOLOGICAL L - SECTION

Rev.	Date	Description

Authority:

National Highways & Infrastructure Development Corporation Ltd.
(Ministry of Road Transport & Highways)

Design Consultants:

Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

Project:

Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)

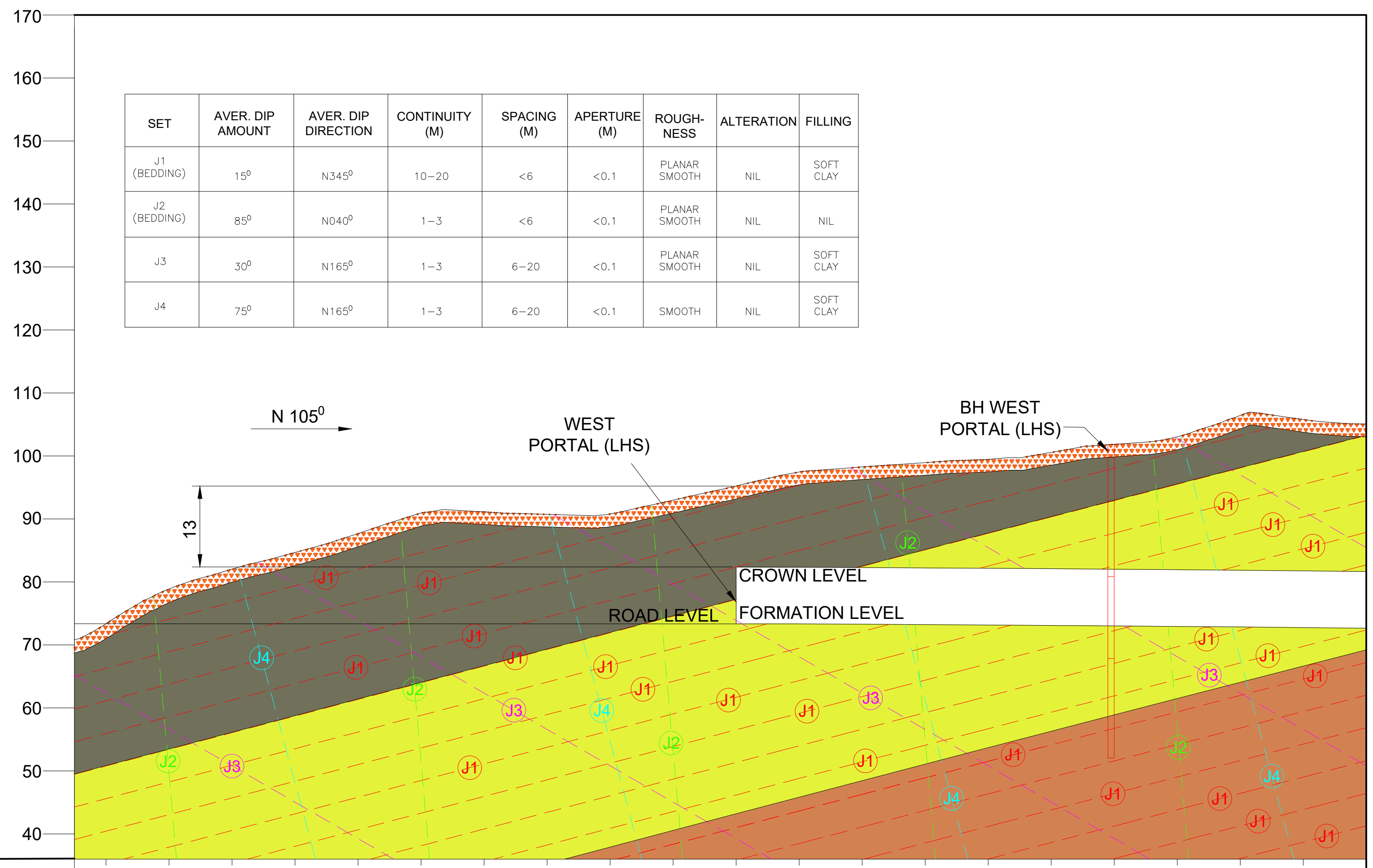
Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

FINAL DETAILED PROJECT REPORT

Title: GEOLOGICAL L-SECTION SILCHAR JIRIBAM TUNNEL(RHS)

Size	*Scale*	*Drg. No*	*Rev:*
A0	HOR-1:1000 VER-1:200	Transys-NH37-TUNNEL_FSR-010	R0



SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
J1 (BEDDING)	15°	N345°	10–20	<6	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
J2 (BEDDING)	85°	N040°	1–3	<6	<0.1	PLANAR SMOOTH	NIL	NIL
J3	30°	N165°	1–3	6–20	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
J4	75°	N165°	1–3	6–20	<0.1	SMOOTH	NIL	SOFT CLAY

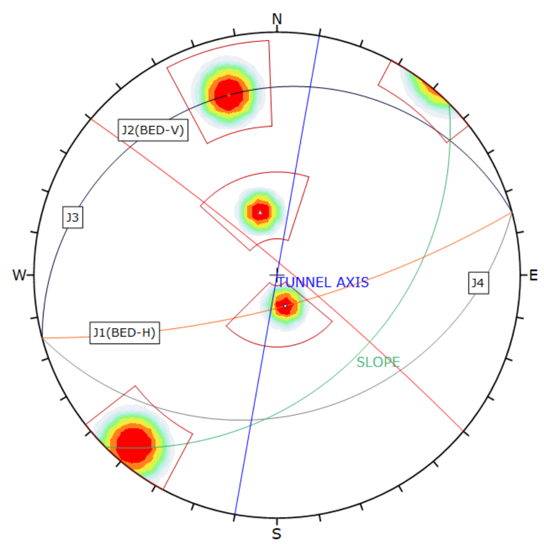
LEGEND

OVERBURDEN	
SHALE WITH MINOR SILTSTONE/SANDSTONE	
SHALE	
SILTSTONE / SANDSTONE WITH INTERCALATION OF SHALE.	
JOINT SET	J1 J2 J3 J4

Datum : 0

Chainage (m)	Prop. Level at Median Edge	Ground Level below Prop. C/L	Ground Level below MCW at 22m from Prop. C/L – Left	Ground Level below MCW at 22m from Prop. C/L – Right
24810	73.397	69.017	70.471	71.059
24820	73.425	72.815	76.372	73.582
24830	73.447	76.001	80.771	76.077
24840	73.461	78.711	83.294	79.715
24850	73.469	81.383	86.010	83.354
24860	73.469	84.530	89.137	86.329
24870	73.463	87.527	91.499	89.517
24880	73.450	90.851	90.839	93.171
24890	73.430	94.333	90.591	97.794
24900	73.403	99.334	91.827	103.300
24910	73.369	102.508	94.122	109.217
24920	73.328	104.360	96.194	112.162
24930	73.280	104.327	97.823	115.565
24940	73.225	106.709	98.641	119.479
24950	73.163	110.077	99.343	123.238
24960	73.095	111.963	99.594	124.155
24970	73.019	113.643	101.354	122.286
24980	72.937	115.879	102.125	121.056
24990	72.847	115.893	104.632	121.179
25000	72.751	114.476	106.563	120.491
25010	72.648	112.448	105.189	120.738

SUPPORT CLASS (SC)	SUPPORT CLASS (SC) – V(A)	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL OF 1M THICK OR SHALE WITH MINOR SILTSTONE/ SANDSTONE. THE ROCK IS HEAVILY BROKEN AND HORIZONTALLY BEDDED WITH 6–20cm SPACING.
LENGTH / PERCENTAGE (SC)	65 M / 8.6%	
GSI / RMR	10–15 / 10–15	
OVERBURDEN	10–20	
DESCRIPTION	HIGHLY WEATHERED & FRACTURED SHALE WITH INTERCALATION OF SILTSTONE / SANDSTONE. HIGHLY DEFORMED/SHEARED DUE TO ANTI FORM FOLD . LACK OF BLOCKINESS DUE TO CLOSE SPACING (<6cm) OF WEAK HORIZONTAL BEDDING/FOLD STRUCTURE.	



WEST PORTAL-(SILCHAR 770m TUNNEL)

Symbol	ID	Quantity
◇	1	1
×	2	1
△	3	1
+	4	1

Color	Density Concentrations
	0.00 - 2.50
	2.50 - 5.00
	5.00 - 7.50
	7.50 - 10.00
	10.00 - 12.50
	12.50 - 15.00
	15.00 - 17.50
	17.50 - 20.00
	20.00 - 22.50
	22.50 - 25.00
Contour Data	Pole Vectors
Maximum Density	24.85%
Contour Distribution	Fisher
Counting Circle Size	1.0%
Plot Mode	Pole Vectors
Vector Count	4 (4 Entries)
Hemisphere	Lower
Projection	Equal Angle

LHS - WEST PORTAL

Rev.	Date	Description

Authority: National Highways & Infrastructure Development Corporation Ltd. (Ministry of Road Transport & Highways)

Design Consultants: Transys Consulting Pvt. Ltd. 001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

Project: **Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)**

Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

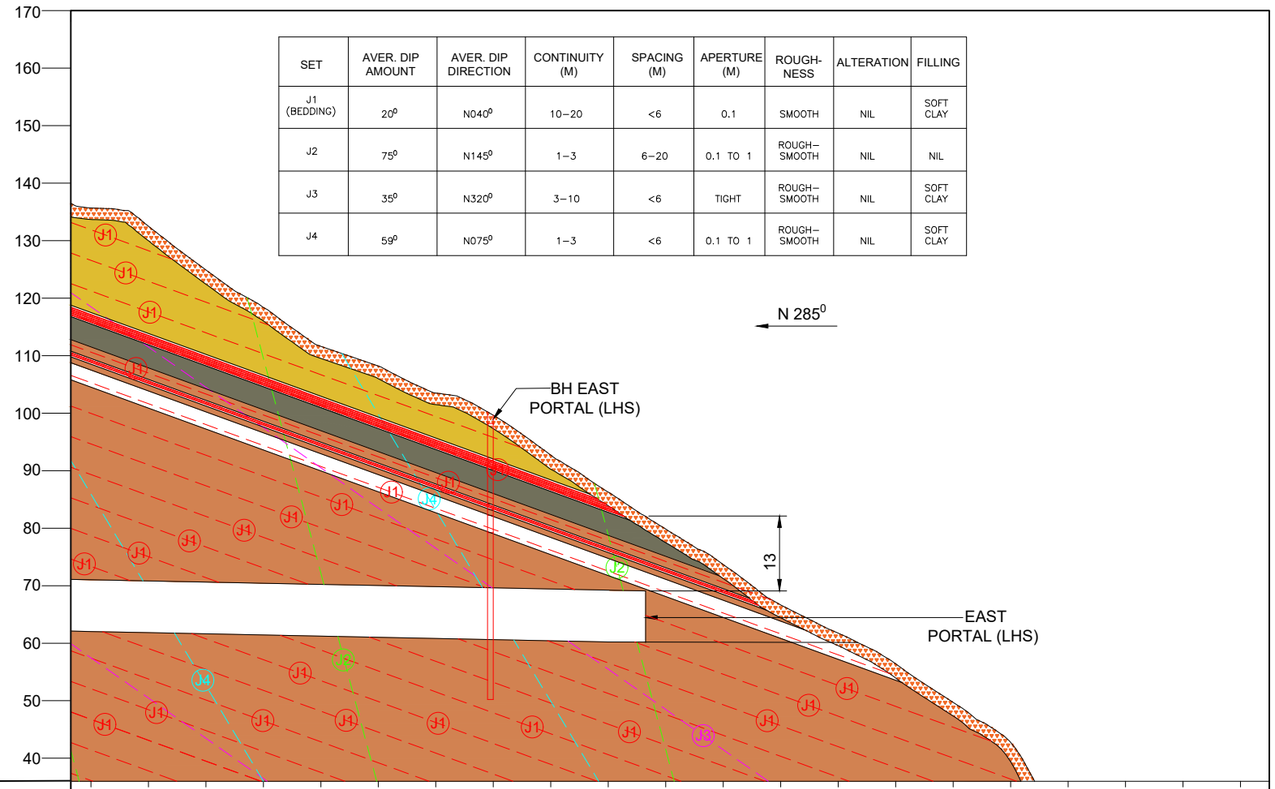
DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

FINAL DETAILED PROJECT REPORT

Title: **RHS EAST PORTAL GEOLOGICAL L-SECTION**

Size	Scale	Drg. No	Rev:
A3	HOR-1:1000 VER-1:200	Transys-NH37-TUNNEL_FSR-011	R0

SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
J1 (BEDDING)	20^0	$N040^0$	10–20	<6	0.1	SMOOTH	NIL	SOFT CLAY
J2	75^0	$N145^0$	1–3	6–20	0.1 TO 1	ROUGH–SMOOTH	NIL	NIL
J3	35^0	$N320^0$	3–10	<6	TIGHT	ROUGH–SMOOTH	NIL	SOFT CLAY
J4	59^0	$N075^0$	1–3	<6	0.1 TO 1	ROUGH–SMOOTH	NIL	SOFT CLAY



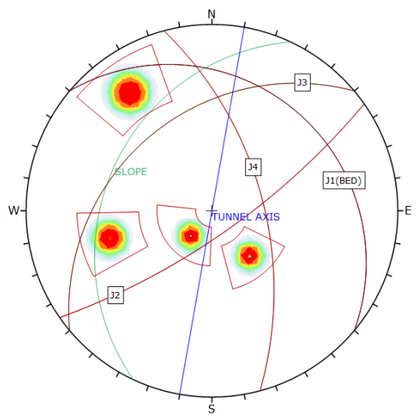
LEGEND

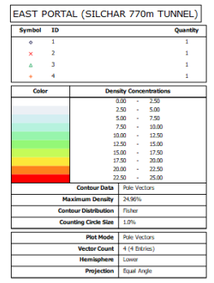
OVERBURDEN	
SILTSTONE / SANDSTONE WITH MINOR INTERCALATION OF SHALE.	
SHALE	
SILTSTONE / SANDSTONE WITH INTERCALATION OF SHALE.	
SHALE / GOUGE MATERIAL	
JOINT SET	J1, J2, J3, J4

Datum : 0

Prop. Level at Median Edge	62.076	61.876	61.676	61.476	61.276	61.076	60.876	60.676	60.476	60.276	60.076	59.876	59.676	59.476	59.276	59.076	58.876	58.676	58.476	58.276	58.076				
Ground Level below Prop. C/L	135.459	130.240	125.098	119.535	114.349	108.458	103.506	98.542	93.206	87.925	82.652	77.258	72.301	67.880	61.900	53.536	43.713	38.242	36.810	37.214	39.201				
Ground Level below MCW at 22m from Prop. C/L – Left	137.260	135.631	129.317	121.242	114.855	110.442	106.063	102.541	96.553	89.826	82.945	76.990	70.335	64.209	59.397	53.020	46.527	38.187	37.620	37.075	40.471				
Ground Level below MCW at 22m from Prop. C/L – Right	132.893	126.975	122.201	117.426	112.575	106.446	101.080	96.377	90.543	84.249	77.955	73.399	69.496	64.579	58.698	52.212	45.271	40.016	38.394	37.079	37.001				
Chainage (m)	25570	25580	25590	25600	25610	25620	25630	25640	25650	25660	25670	25680	25690	25700	25710	25720	25730	25740	25750	25760	25770				

SUPPORT CLASS (SC)	SUPPORT CLASS (SC) – V	SUPPORT CLASS (SC) – IV
LENGTH / PERCENTAGE (SC)	60 M / 7.9%	36.5 M / 4.8%
GSI / RMR	15–20 / 20	25 / 30
OVERBURDEN	20–35	35 – 60
DESCRIPTION	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL OF 1M THICK . THE ROCK IS HEAVILY BROKEN AND HORIZONTALLY BEDDED WITH 6–20cm SPACING.	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH MINOR INTERCALATION OF SHALE ROCK. THE ROCK MASS IS FORMED BY INTERSECTING DISCONTINUITY SETS PERSISTENCE OF BEDDING PLANE.





LHS - EAST PORTAL

Rev.	Date	Description

Authority:
National Highways & Infrastructure Development Corporation Ltd.
(Ministry of Road Transport & Highways)

Design Consultants:
Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

Project:
Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)
Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

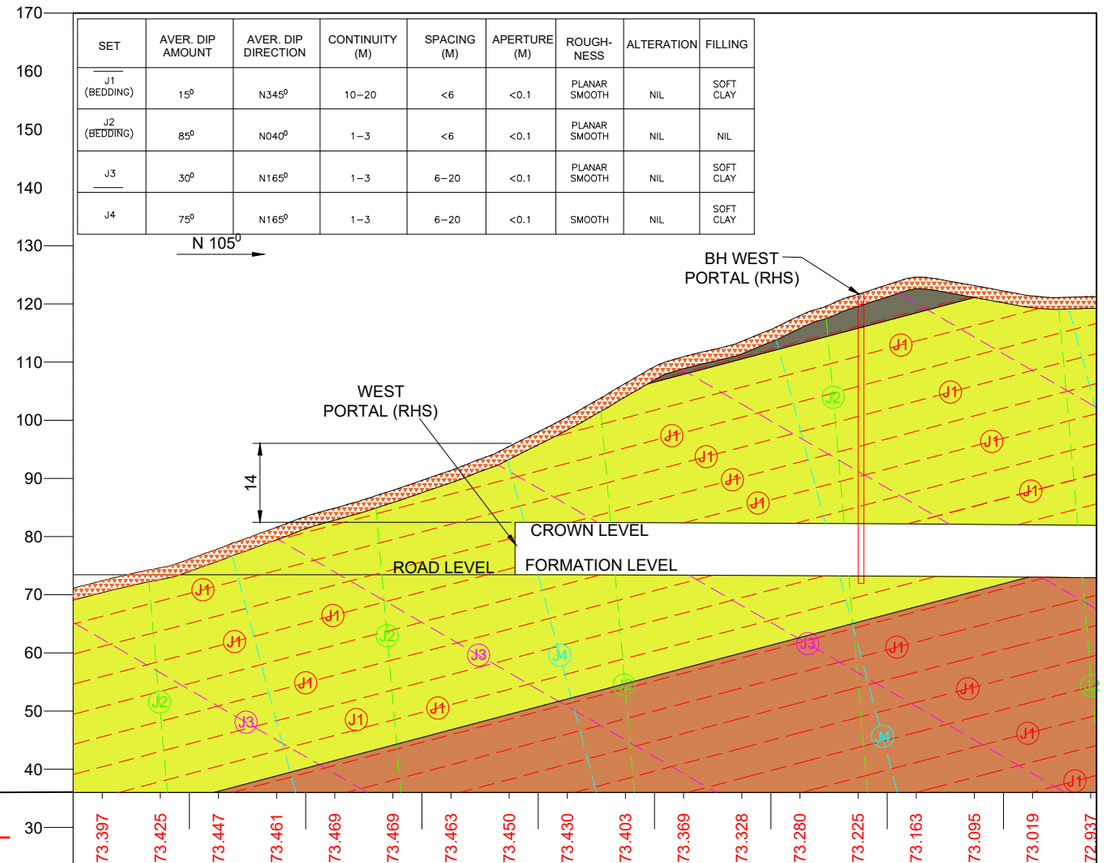
DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

FINAL DETAILED PROJECT REPORT

Title: **RHS EAST PORTAL GEOLOGICAL L-SECTION**

Size	*Scale*	*Drg. No*	*Rev:*
A3	HOR-1:1000 VER-1:200	Transys-NH37-TUNNEL_FSR-012	R0

SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
J1 (BEDDING)	15^0	$N345^0$	10–20	<6	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
J2 (BEDDING)	85^0	$N040^0$	1–3	<6	<0.1	PLANAR SMOOTH	NIL	NIL
J3	30^0	$N165^0$	1–3	6–20	<0.1	PLANAR SMOOTH	NIL	SOFT CLAY
J4	75^0	$N165^0$	1–3	6–20	<0.1	SMOOTH	NIL	SOFT CLAY



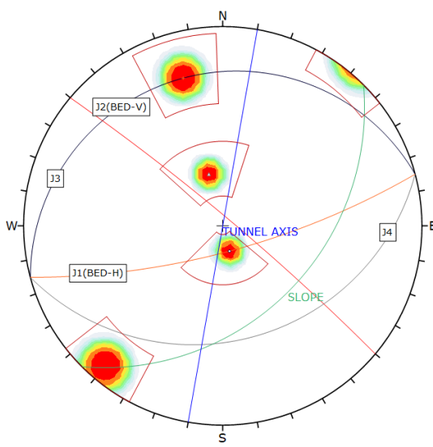
Datum : 0

Prop. Level at Median Edge		73.397	73.425	73.447	73.461	73.469	73.469	73.463	73.450	73.430	73.403	73.369	73.328	73.280	73.225	73.163	73.095	73.019	72.937
Ground Level below Prop. C/L		69.017	72.815	76.001	78.711	81.383	84.530	87.527	90.851	94.333	99.334	102.508	104.360	104.327	106.709	110.077	111.963	113.643	115.879
Ground Level below MCW at 22m from Prop. C/L	Left	70.471	76.372	80.771	83.294	86.010	89.137	91.499	90.839	90.591	91.827	94.122	96.194	97.823	98.641	99.343	99.594	101.354	102.125
	Right	71.059	73.582	76.077	79.715	83.354	86.329	89.517	93.171	97.794	103.300	109.217	112.162	115.565	119.479	123.238	124.155	122.286	121.056
Chainage (m)		24810	24820	24830	24840	24850	24860	24870	24880	24890	24900	24910	24920	24930	24940	24950	24960	24970	24980

SUPPORT CLASS (SC)	SUPPORT CLASS (SC) – V(A)	SUPPORT CLASS (SC) – V	
LENGTH / PERCENTAGE (SC)	14 M/1.8%	35 M / 4.5%	
GSI / RMR	10–15 / 10–15	15–20 / 20	
OVERBURDEN	10–20	20–35	
DESCRIPTION	HIGHLY WEATHERED & FRACTURED SHALE WITH INTERCALATION OF SILTSTONE / SANDSTONE. HIGHLY DEFORMED/SHEARED DUE TO ANTI FORM FOLD . LACK OF BLOCKINESS DUE TO CLOSE SPACING (<6cm) OF WEAK HORIZONTAL BEDDING/FOLD STRUCTURE.	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL OF 1M THICK OR SHALE WITH MINOR SILTSTONE/ SANDSTONE. THE ROCK IS HEAVILY BROKEN AND HORIZONTALLY BEDDED WITH 6–20cm SPACING.	

LEGEND

OVERBURDEN	
SHALE WITH MINOR SILTSTONE/SANDSTONE	
SHALE	
SILTSTONE / SANDSTONE WITH INTERCALATION OF SHALE.	
JOINT SET	J1, J2, J3, J4



WEST PORTAL-(SILCHAR 770m TUNNEL)

Symbol	ID	Quantity
◇	1	1
×	2	1
△	3	1
+	4	1

Color	Density Concentrations
	0.00 - 2.50
	2.50 - 5.00
	5.00 - 7.50
	7.50 - 10.00
	10.00 - 12.50
	12.50 - 15.00
	15.00 - 17.50
	17.50 - 20.00
	20.00 - 22.50
	22.50 - 25.00

Contour Data	Pole Vectors
Maximum Density	24.85%
Contour Distribution	Fisher
Counting Circle Size	1.0%
Plot Mode	Pole Vectors
Vector Count	4 (4 Entries)
Hemisphere	Lower
Projection	Equal Angle

RHS - WEST PORTAL

Rev.	Date	Description

Authority:
National Highways & Infrastructure Development Corporation Ltd.
(Ministry of Road Transport & Highways)

Design Consultants:
Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

Project:
Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)
Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

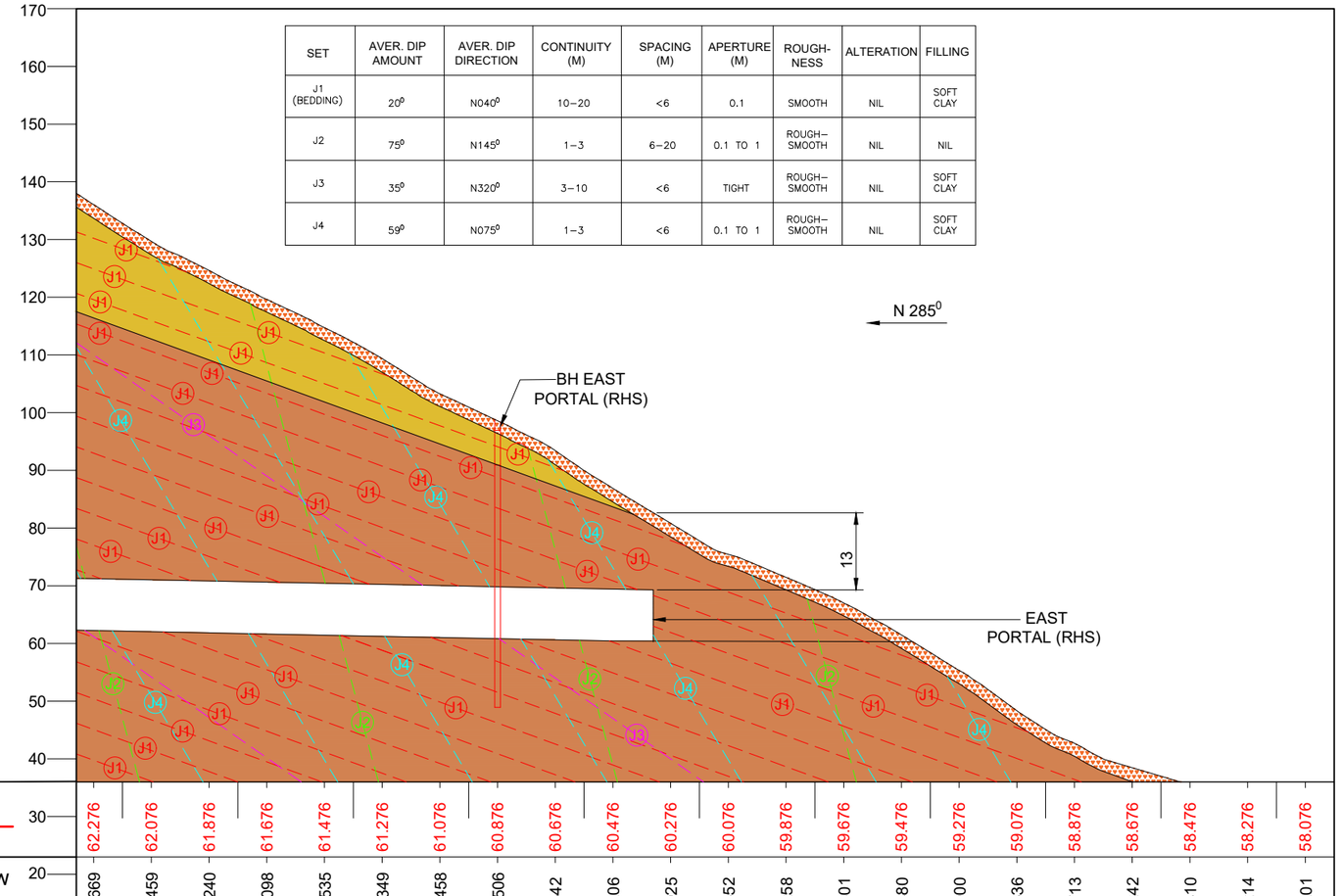
DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

FINAL DETAILED PROJECT REPORT

Title: **RHS EAST PORTAL GEOLOGICAL L-SECTION**

Size	*Scale*	*Drg. No*	*Rev:*
A3	HOR-1:1000 VER-1:200	Transys-NH37-TUNNEL_FSR-013	R0

SET	AVER. DIP AMOUNT	AVER. DIP DIRECTION	CONTINUITY (M)	SPACING (M)	APERTURE (M)	ROUGH-NESS	ALTERATION	FILLING
J1 (BEDDING)	20^0	$N040^0$	10–20	<6	0.1	SMOOTH	NIL	SOFT CLAY
J2	75^0	$N145^0$	1–3	6–20	0.1 TO 1	ROUGH–SMOOTH	NIL	NIL
J3	35^0	$N320^0$	3–10	<6	TIGHT	ROUGH–SMOOTH	NIL	SOFT CLAY
J4	59^0	$N075^0$	1–3	<6	0.1 TO 1	ROUGH–SMOOTH	NIL	SOFT CLAY



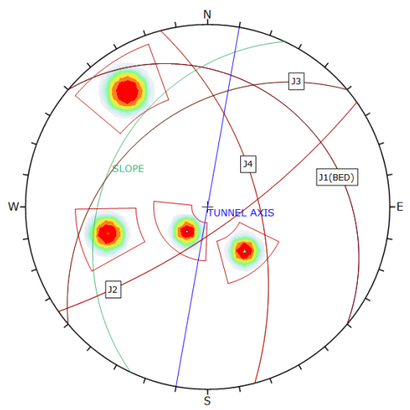
LEGEND

OVERBURDEN	
SILTSTONE / SANDSTONE WITH MINOR INTERCALATION OF SHALE.	
SILTSTONE / SANDSTONE WITH INTERCALATION OF SHALE.	
JOINT SET	J1, J2, J3, J4

Datum : 0

Prop. Level at Median Edge	62.276	62.076	61.876	61.676	61.476	61.276	61.076	60.876	60.676	60.476	60.276	60.076	59.876	59.676	59.476	59.276	59.076	58.876	58.676	58.476	58.276	58.076
Ground Level below Prop. C/L	140.669	135.459	130.240	125.098	119.535	114.349	108.458	103.506	98.542	93.206	87.925	82.652	77.258	72.301	67.880	61.900	53.536	43.713	38.242	36.810	37.214	39.201
Ground Level below MCW at 22m from Prop. C/L – Left	146.164	137.260	135.631	129.317	121.242	114.855	110.442	106.063	102.541	96.553	89.826	82.945	76.990	70.335	64.209	59.397	53.020	46.527	38.187	37.620	37.075	40.471
Ground Level below MCW at 22m from Prop. C/L – Right	139.273	132.893	126.975	122.201	117.426	112.575	106.446	101.080	96.377	90.543	84.249	77.955	73.399	69.496	64.579	58.698	52.212	45.271	40.016	38.394	37.079	37.001
Chainage (m)	25560	25570	25580	25590	25600	25610	25620	25630	25640	25650	25660	25670	25680	25690	25700	25710	25720	25730	25740	25750	25760	25770

SUPPORT CLASS (SC)		SUPPORT CLASS (SC) – V	SUPPORT CLASS (SC) – V(A)	
LENGTH / PERCENTAGE (SC)		50 M / 6.5%	17 M / 2.2%	
GSI / RMR		15–20 / 20	10–15 / 10–15	
OVERBURDEN		20–35	10–20	
DESCRIPTION		HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL OF 1M THICK . THE ROCK IS HEAVILY BROKEN AND HORIZONTALLY BEDDED WITH 6–20cm SPACING.	HIGHLY WEATHERED & FRACTURED SILTSTONE WITH INTERCALATION OF SHALE ROCK/GOUGE MATERIAL. HIGHLY DEFORMED/SHEARED DUE TO ANTI FORM FOLD . LACK OF BLOCKINESS DUE TO CLOSE SPACING (<6cm) OF WEAK HORIZONTAL BEDDING/FOLD STRUCTURE.	



EAST PORTAL (SILCHAR 770m TUNNEL)

Symbol	ID	Quantity
◇	1	1
×	2	1
△	3	1
+	4	1

Color	Density Concentrations
	0.00 - 2.50
	2.50 - 5.00
	5.00 - 7.50
	7.50 - 10.00
	10.00 - 12.50
	12.50 - 15.00
	15.00 - 17.50
	17.50 - 20.00
	20.00 - 22.50
	22.50 - 25.00

Contour Data	Pole Vectors
Maximum Density	24.96%
Contour Distribution	Fisher
Counting Circle Size	1.0%
Plot Mode	Pole Vectors
Vector Count	4 (4 Entries)
Hemisphere	Lower
Projection	Equal Angle

RHS - EAST PORTAL

Rev.	Date	Description

Authority:
National Highways & Infrastructure Development Corporation Ltd.
(Ministry of Road Transport & Highways)

Design Consultants:
Transys Consulting Pvt. Ltd.
001-004, Raheja chambers, No.12, Museum Road, Bengaluru-560001; Tel: 080-41461995; email: transys_blr@transysconsulting.co.in

Project:
Silchar-Jiribam Section of NH-37 (Package: SJ-2 (PNP_TUNNEL), D. Km 24+000 to D. Km 27+000)
Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, and Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1) (Package-III)

DRAWN BY	ROOPA
DESIGNED BY	ROJALEEN
CHECKED BY	VIDYA SAGAR
APPROVED BY	SANJEEV

FINAL DETAILED PROJECT REPORT

Title: **RHS EAST PORTAL GEOLOGICAL L-SECTION**

Size	*Scale*	*Drg. No*	*Rev:*
A3	HOR-1:1000 VER-1:200	Transys-NH37-TUNNEL_FSR-014	R0