

(A Government of India Undertaking)

REPORT ON GEOLOGICAL AND GEOTECHNICAL INVESTIGATION OF SIVOK-RANGPO NEW BG RAILWAY LINE PROJECT

REPORT NO: ADPL/IRCON/2018/06

Revision No: R0

BOREHOLE NO NB-22A, NB-23A, NB-24A & NB-25A IN MELLI YARD HIGH CUTTING AREA



ARIHANT DRILLINGS PVT. LTD.

142/1, ADARS NAGAR, GURGAON -122001

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GEOLOGICAL AND GEOTECHNICAL INVESTIGATION REPORT

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1. INTRODUCTION

IRCON International Limited has been awarded the design and construction of Sivok (W.B.) – Rangpo (Sikkim) new BG Railway line project. The project will improve connections between Sikkim's north-eastern cities – which lie on the Chinese border – and the rest of India. The line is of national importance, as it will make it easier for the Indian Army to deploy soldiers along the border in the region. Once operational, it will be the first time Sikkim has been connected to the main Indian rail network, and as such is expected to boost local tourism and the region's economy

The proposed Railway line passes through steep terrain of Kanchenjunga mountain ranges foothills, dense reserve forest and Teesta Valley of Darjeeling district at West Bengal and East Sikkim district of Sikkim state. Out of the total 52.7km of the rail line, 51.7km will be in West Bengal and 1km in Sikkim. To avoid loss of forests, 14 tunnels have been planned, the longest being approx. 5 km. The total tunnel length is about approx. 38 km, about 72 % of the total route.

2. GEOLOGY

2.1. Regional geology

Sikkim-Darjeeling Himalayas are Techno-stratigraphically defined by four domains with characteristic stratigraphic and structural attributes. From south to north they are:

- i. Foothill belt
- ii. Inner Belt
- iii. Axial Belt and
- iv. Trans-Axial Belt.

The state is mostly covered by Precambrian metamorphic rocks of low to medium grade (Daling Group), high grade gneisses (Darjeeling Gneiss and Kanchendzonga Gneiss), Chungthang Formation (quartzite, calc-silicate rocks, marbles, graphite schist's and occasionally amphibolites) with intrusive granites (Lingtse granite gneiss) and Phanerozoic rocks including Gondwana and Tethyan sedimentaries. The Paleozoic and Mesozoic (Tethyan) sequence in the northern and north-western part of Sikkim are fossiliferous.

The Gondwana super Group consists of sandstone, shale and carbonaceous shale with occasional thin bands of coal and pebbly shale horizon.

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Daling group of rocks can be classified into three formations:

- a. Gorubathan Formation: characterized by quartz-chloride-sericite schists, phyllite and quartzite's.
- b. Reyang Formation: characterized by quartzite's (occasionally calcareous), phyllite interbanded with carbonaceous slate.
- c. Buxa Formation: characterized by the presence of dolomitic limestone occasionally interbanded with phyllite and development of organo sedimentary structure (stromatolites).

The Kanchenjunga Gneiss comprises mainly high-grade gneiss. The Chungthang gneiss is quartz-biotite gneiss. A streaky sheared granite gneiss known as "Lingtse Gneiss" occur as a NE-SW to N-S trending strip of rocks and forms a general line of separation between the Daling and high-grade Kanchenjunga Gneiss. The Tethyan sedimentaries, exposed in the northern part of Sikkim represent Everest Phyllites series (shale's/Phyllites), Mount Everest Limestone series, Lachi Formation (conglomerate with thick diamictite base) and Tso Lhamo Formation (calcareous shale, limestone band, calcareous sandstone).

At the contact of the rocks of Gorubathan Formation and Chungthang Formation, a thick horizon of streaky biotite granite gneiss is observed, which is described as Lingtse granite gneiss.

Gondwana Group of rocks are represented by a basal pebble slate (Ranjit Pebble Bed) followed by coal-bearing sandstone-shale horizons with occasional plant fossils equivalent to the Damuda Group of rocks of the Indian Peninsular shield.

The rocks of Buxa Formation occur as thrusted wedges along the thrusted contact of the rocks of Gorubathan Formation and Gondwanas The boundary between Gondwanas and Dalings and between Dalings and Darjeeling group of rocks is tectonised and thrusted.

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The Generalised Stratigraphic succession Sikkim- Darjeeling Himalayas is given as under:

Group/Formations	Lithology	Age
Sub-aerial deposits	Debris and Overburden	Recent
Alluvial deposits	River Terraces	Quaternary
Siwalik Group	sandstone, conglomerate,	Pleistocene - Mid-Miocene
	siltstone, shale, claystone and	
	limestone	
	Main Boundary Thrust	
Gondwana Group	Sandstone, shale, Coal with plant	Permo-Carboniferous -
	fossils, Lamprophyre	Upper Permian
	Thrust	
Buxa Formations	Dolomites, Ortho quartzite, Slate,	Meso – Neo Proterozoic
	Phyllites, Purple limestone	
	Thrust	
Daling Group	Phyllites, Quartzites, Chlorite	Proterozoic to Pre
	Schist, quartz schist.	Cambrian
Darjeeling Gneiss	Biotite, Garnet	

2.2. Project geology

The Investigated area of the project is lying on the Eastern Himalaya, represents the Gorubathan Sub-group under the Daling Group of rocks ranging the geological age of Middle to Late Proterozoic age.

The rock type of this area is mainly chlorite quartz schist, chlorite schist, phyllite with or without sericite, quartz-sericite schist, sericite quartz schist, slaty phyllites, slates and quartzite.

3. SCOPE OF WORK

IRCON has awarded Arihant Drillings Private Limited to carry out geological and geotechnical investigations along the proposed railway track alignment. Addl. Geo-Technical Investigation for Sivok – Rangpo BG Railway Line project vide LOA no IRCON/2016/Sivok - Rangpo/Addl. GT Invest./58/675 dated on 28.02.2017.

The details of the scope of work are captioned as under:

1. Geotechnical Investigations:

- a. Drilling of Exploratory Drill Holes (40m Maximum).
- b. In-situ Permeability tests in Overburdens and bedrock.
- c. Collection of Rock Sample in Core boxes and Determination of RQD.
- d. Standard Penetration Test (SPT).
- e. Sample collection of disturbed soil samples
- 2. Submission of Geological and Geotechnical Reports.

This report consists of the Geological and Geotechnical data consisting of borehole logging, photographs, in-situ tests. The project consists of 4 nos of proposed boreholes completed in Melly Yard, Rongpo of East Sikkim.

The drill hole location plan of proposed "Sivok-Rongpo new BG railway line project" is given in plate no 1

The location (Co-ordinates) of drill holes, ground Elevations, total depth and water level are summarised in table 1 as below.

4. EXPLORATION METHODOLOGY

- NX size core drilling technique was adopted for the advancement of drill hole up to the explored depth. Drilling is done with standard mechanical feed rotary drilling machine as per IS: 6926-1973. In this method, the hole is advanced by rotating a system, consisting of a series of hollow drill rods to the bottom of which is attached a double/Triple tube core barrel with a diamond coring bit, by means of a diesel operated engine.
- When the rod with the coring bit is rotated, downward pressure is applied to the system to obtain penetration in the rocky strata and water under pressure was introduced into the bottom of the hole through the hollow drill rods. Water comes up through the annular space between the drill rods and the hole and is collected in the water sump, from where it is re-circulated. Water serves the dual function of cooling the bit as it enters the hole and carrying the cuttings from the bottom of the hole on its return journey to the surface as well as its colour also indicate a change in the layer during drilling.
- Seamless flush jointed steel casing of HX / NX sizes were used to prevent any caving and water loss from drill holes and those were inserted.
- Simultaneously with the advancement of drilling operations. Moreover, due to the collapsible nature of the subsurface formation, the holes were advanced by charging dense bentonite slurry to stabilize the walls of the drill holes.

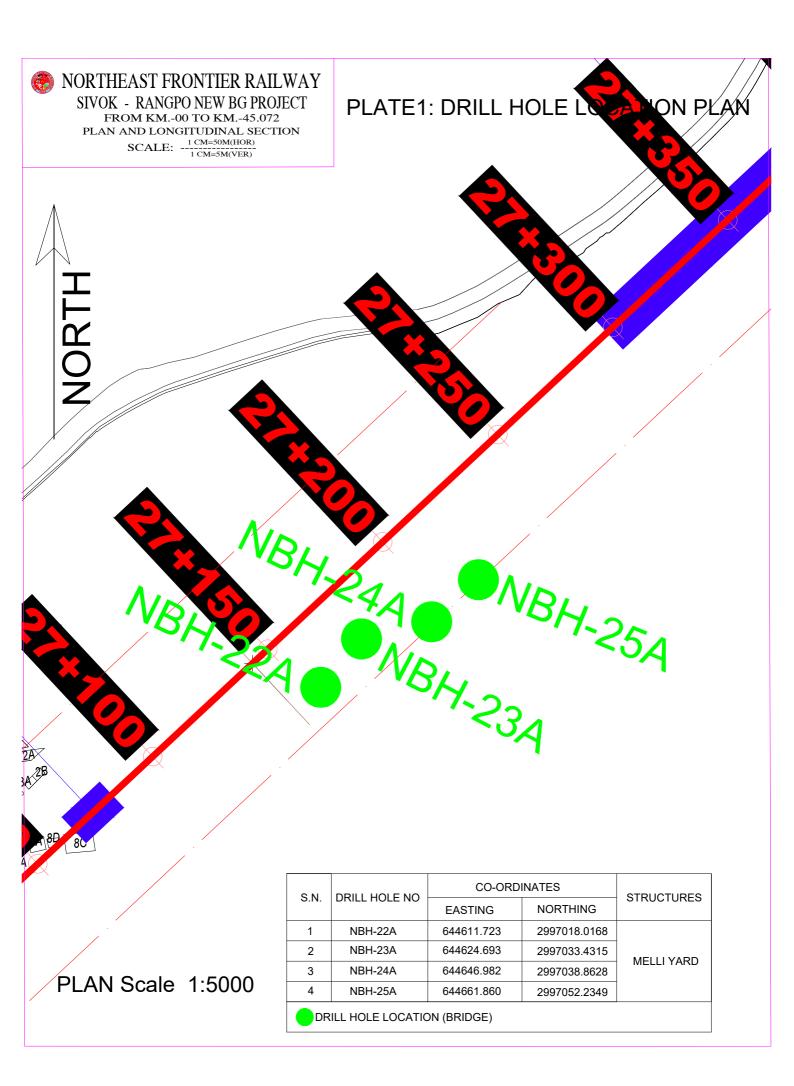
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- Standard Penetration Tests were conducted inside the holes wherever possible as per IS 2131-1981 "Method of standard penetration tests for soils". The split spoon sampler used is of standard design and dimension. The spoon is advanced by driving with a drop hammer weighing 63.5 kg falling freely through a height of 75 cm. A record of the number of blows required to penetrate every 15 cm. to a depth of 45cm is kept. The number of blows required for the last 30 cm penetration of the split spoon sampler is recorded as 'N'-value. On completion of the test, the sampler is lifted to the
- The ground opened and the specimen of the soil sample is stored in double polythene bags with the proper identification mark. The penetration number, 'N' has been shown against the corresponding depths in field bore/drill logs.
- Representative disturbed samples were collected regularly and wherever the stratum changed.
 These samples are taken from the split spoon samplers after standard penetration tests.
 These samples are labeled depth wise and used in the preparation of the bore/drill hole log and for general identification and classification purposes.
- Rock core samples were collected in standard NX size double/ triple tube core barrel and stored as per IS: 4464-1967 and IS: 4078-1967.

5. SUMMARY OF GEOLOGICAL AND GEOTECHNICAL BORE HOLES:

Based on core samples, drilling observations and in-situ tests performed in the drill holes, the subsurface geology, geotechnical conditions, Co-ordinates, ground Elevations, total depth and water level are summarised as below:

								SUMMARY OF BORE	HOLES			
SN	Structure	Borehole	Location C	coordinate	Ground Elevation	Depth Drilled	Overburden Encouneterd	Overburden Characterstics	Bedrock Encountered	Bedrock Characteristics	Ground water depth (m) below	Remarks
		no	Easting	Northing	(m)	(m)	From - to (depth) m		from - to (depth) m		ground level	
	1	2	3	4	5	6	7	8	6	7	8	9
1		NBH-22A	644611.723	2997018.0168	298.39	298.39 23 0.00 to 3.00	0.00 to 3.00	Brown colour top soil and pebbles of Quartzite.	3.00 to 23.00	weak to medium strong, Quartzitic Phyllite with irregular interbands of white coloured Quartzite,	N.E.	slightly weathered, intensely to moderately fractured
2	MELLI YARD	NBH-23A	644624.693	2997033.4315	311.02		0.00 to 8.00	Top soil,Boulders,cobbles, Pebbles and granules with clayl material (6 to 8.30m) of Greenish grey to brown coloured,Quartzitic Phyllite and Quartzite.	8.00 to 35.00	weak to medium, strongQuartzitic Phyllite with irregular interbands of white coloured Quartzite	16.50	Highly to moderately weathered, highly to moderately fractured. Sheared mass encountered from 13.50 to 16.50m & 33.50 to 35.00 m
3		NBH-24A	644646.982	2997038.8628	309.67	15	0.00 to 2.50	Top soil, Pebbles and granules of Quartzitic Phyllite	2.50 to 15.00	Weak to medium strong, Quartzitic Phyllite with irregular interbands of white coloured Quartzite,	N.E.	Slightly to moderately & highly weathered, intensely to moderately fractured, highly fractured
4		NBH-25A	644661.860	2997052.2349	304.40	15	0.00 to 4.00	Top soil, Pebbles & granules of Quartzitic phyllite	4.00 to 15.00	Weak to medium strong rock, Quartzitic Phyllite with irregular interbands of white coloured Quartzite	N.E.	Intensely to very intensely & moderately fractured, fresh to slightly & moderatey to highly weathered



ANNEXURE -1

STRUCTURE: MELLI YARD

GEOLOGICAL LOG, PHOTOGRAPHS AND PERMEABILITY TEST RESULTS OF DRILL HOLES: NBH-22A, NBH-23A, NBH-24A, NBH-25A AND LAB TEST REPORT OF CORE SAMPLES

							G	EC	DLOGICAL L	O	G (OF	D	RI	LL	Н	OLI	Ε										NO : NBH-22A NO : 1 of 1
PROJEC	Г			: SIVO	K-RA	NGF	O NE	W BO	G RAILWAY LINE PRO	JECT							CO-O	RDINA	ТТ	ES				: <u>N</u>	29970	18.01	68, E644	611.7225
LOCATI	ON			: MELI	LI												ANGI	E WIT	НΙ	IORI	ZON	TAL		: <u>90</u>	0			
STRUCT	URE			: YARI	<u>D</u>												BEAR	ING O	FΗ	OLE				: <u>V</u> є	ertical	<u>l</u>		
CLIENT				: <u>IRCO</u>	N IN	ΓER	VATIO	ONA	L LTD.								DEPT	H OF I	IOI	Æ				: <u>23</u>	.00m			
DRILLIN						DRI	LLING	GS PV	VT.LTD.									DD OF I									13.03.201	
GROUN				: 298.39														OF CO		BAR	REL						RIPLE TU	<u>UBE</u>
COLLER	ELEVA	TION		: 298.5		ar c	F 60	n=	GTDLIGTIN IN LI								LOGC	ED BY				D	RILI		K.TOI	MAK		
[(m)	DEPT	H (m)	LITHOLOGY		SI		F CO	RE	STRUCTURAL CONDITIONS				COL				~				m)	W	ATE .OSS	R			ABILITY	
ELEVATION (m)	FROM	OI	DESCRIPTION	LOG	< 10mm	10 to 25 mm	25 to 75 mm 75 to 150 mm	> 150 mm	DESCRIPTION	0-20	20-40	40-60	08-09	80-100	IN FIG	RQD %	FRACTURE INDEX	SIZE OF CASING SIZE OF HOLE		SIZE OF BIT	DEPTH OF GWT (m)	NIL	PARTIAL	COMPLETE PENETRATION R	cm/min	IEST SECTION (m)	LUGEON VALUE	SPECIAL OBESERVATIONS AND INTERPRETATIONS
297.89	0.00	0.50		∇			CVIII					7		8	34						_ 	_		3.1				
297.39	0.50	1.00	Brown coloured top soil.												40			00m)		jamc	Ì			2.5	50			
296.89	1.00	1.50		1 0										•	36	rden	rden	HX (2.00m)	(NX Diamond				2.0	00			
296.39	1.50	2.00		0		Over	burde	en	Overburden						44	Overburden	Overburden	I	F	<u></u>	-			1.7	78			
295.89	2.00	2.50	Pebbles of Quartzitic Phyllite.	∇										•	48	Ó	ð-	^ ^		i l	-			1.6	57			
295.39	2.50	3.00		∇										•	36					1	İ			1.6	7	3	1621	SPT:3.00-3.14m=60 blows
294.39	3.00	4.00		\sim	Т		9 1	1		-	-	-	- 1		82	15	8	<u>-</u> -	-	-{	-		-	2.3	8			Rock encountered from 3m
293.39	4.00	5.00			>10	<10	3 1	1	FJ=40º/ Sm U, clay filled (Brownish due					-	80	13	>15	(8.00m)			-			2.5	60			
292.39	5.00	6.00		>			9 3		to weathering) with							Nil	9	ž ¦			-			2.2		6	1143	
291.39	6.00	7.00				<10	5		iron stained walls					-	96	10	12			1	-			1.6	+			
290.39	7.00		Greenish grey coloured, fine	\sim	-	<10	9 2		Discontinuity did not	-						Nil	>10	Ш			-			1.6				
289.39	8.00		grainedQuartzitic Phyllite with irregular interbands of white		-	5	5 5		distinct	-						11	>10	۲						2.0				
288.39	9.00		coloured Quartzite, slightly to	\sim	-	_	11 2		FJ=20-30°/Sm U					-	98	11	>10	-		i				_				
200.39	9.00	10.00	moderate weathered, weak to medium strong rock, intensely	\sim	-	3	11 2		FY 20 (C. 11	-					97		>10	-			pə.			2.0	18			
287.39	10.00		fractured ocassionally very intensely and moderately		>10	<10	7 3 3 1		FJ=20/SmU, J=70°/RU,Iron stained						99 96	Nil	>10	'		Bit	Not Encountered			2.0				
286.39	11.00		fractured.	\sim	>10	-	_										NA			Core Bit	ot En			1.8	-			
285.39	12.00	13.00		\sim		-	7 2									31	6	N2	K	CC	Ż			1.9	-			
284.39	13.00	14.00				<10	12								92		NA			NMLC	1			2.0	_			
283.39	14.00	15.00		\sim	<10	_	7 1									Nil					-			2.0	+			Mechanical breakage also
282.39	15.00	16.00		1.	<10		11 2		FJ=20-30°/Sm U,						95		>10			1	-			1.8	2			obsereved
281.39	16.00	17.00	Greenish grey coloured, fine grainedQuartzitic Phyllite with	~	>10	5	3 1	1	J=60/RU						100	28	>10			 - -	-			2.2		5-18	7.67	
280.39	17.00		irregular interbands of white coloured Quartzite, slightly	~			6 2	2						-		55	5			i				2.				
279.39	18.00		weathered, weak to medium strong rock, intensely to moderately fractured	\sim	>10	-	7 1										NA			İ	-			1.				
278.39	19.00	20.00	,	-	>10		2 1	2	FJ=40°/ Sm U, clay filled					-		35	>10			 	-			1.7	9			
277.39	20.00	21.00	Greenish grey coloured, fine grainedQuartzitic Phyllite,	~	>10	<20	5		with iron stained						94					 	i			1.8	2			
276.39	21.00		highly weathered, weak to medium strong rock, very	\sim	>20	>10	1 1		Discontinuity did not distinct							Nil	NA							2.0	10			
275.39	22.00	23.00	intensely to intensely fractured.	~	>20	>20	1								88			i		Ļ	¥			1.8	2			
			Overburden	XX				ear Z					i join	t						=Gro							SPT.=St	andard Penetration Test
No	tation	:-	Quartzitic Phyllite					uarta		J=O										nooth	1		R=R	ough				
0			Slightly fractured:Core recovered m							_																		
			Moderately fra:Core recovered mostly										_						stly	as cl	nips a	and f	ragr	nents w	ith a f	tew so	cattered	short core lengths.
			Intensely fractured : Lengths average	ge trom (3 to 1	U cm	with	rragn	nented intervals. Core i	ecove	ered	mo	stiy i	n ler	ngths !	ess t	tnan 10	cm.										

NBH-22A, DEPTH 0.00 to 7.15m



NBH-22A, DEPTH 7.15 to 12.30m



NBH-22A, DEPTH 12.30 to 17.65m



NBH-22A, DEPTH 17.65 to 23.00m



			IN-	SITU CO	NSTAN	T HEA	D PER	MEABI	LITY (WATER	PERCO	LATION)	TESTS D	ATA			DRILL HOL SHEET	E: NBH-22A: 1 of 1
	DJECT			: SIVOK – I		O NEW B	G RAILW	AY LINI	E PROJEC	CT		5. COORDI				18.0168, E64461	1.7225	
2. LOC 3. CLI	CATION/F	EATURE	:	: MELLI / : IRCON IN		TIONAL	I TID						DEPTH FRO D LEVEL EI		: 23.00m : 298.39m			
	EN I LLING A	GENCY		: ARIHANT								8. COLLAR		_	: 298.59III : 298.51m			
	st	e		-	ne			Water Int	ake(L/5m	nin)				il e	1	COEF PERMEAB		
Test No.	Depth of Test Section (m)	Dia. of Hole		vaule of C1	Average Time (min.)	" ii	in in	_ ii	_ ifi	_ ii	ge of Γwo ings	Q=Average Constant Intake of Water(L/min.)	Depth of Ground Water Level(m)	Water Level Height above GL(m)	Differential Head(H) (m)	AS PER IS 55	. ,	REMARKS
Ţ	Depi	Dia	ž	\and \and \and \and \and \and \and \and	Aver (1 st 5 min	2 nd 5 min	3 rd 5 min	4th 5 min	sth 5 min	Average of Last Two Readings	Q=, Const of Wa	Depth	Wat Heig	Dif	cm/sec.	Lugeon	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	3.00	НХ	0.00606	6.06 x 10 ⁻³	5	42.00	38.00	40.00	39.00	45.00	42.00	8.40	N.E.	0.14	3.14	16.2115 x 10 ⁻³	1621.15	i) The H for test below W.T. = Depth of water in
2	6.00	NX	0.00795	7.95 x 10 ⁻³	5	32.00	41.00	42.00	48.00	40.00	44.00	8.80	N.E.	0.12	6.12	11.4314 x 10 ⁻³	1143.14	casing – Depth of GW Table.
									ļ	i					i		-	
																		ii) The H for test above W.T. = WL in casing –
																		Depth of test sec.
																		iii) The expression K=C ₁ x O/H where
																		K= Permeability in cm/sec.
																		Q= Constant rate of flow into hole in litre/min.

SIVOK - RANGPO NEW BG RAILWAY LINE PROJECT WATER PERMEABILITY TEST CLIENT : IRCON INTERNATIONAL LTD. DRILLING AGENCY : ARIHANT DRILLING PVT LTD. PACKER TYPE : Double LOCATION / FEATURE : MELLI YARD DIAMETER OF HOLE : NX(76 mm) BOREHOLE : NBH-22A TYPE OF DRILLING : Diamond Core ANGLE OF THE HOLE : 90° (Vertical) PERIOD : 13.03.2018 TOTAL DEPTH OF THE HOLE GROUND ELEVATION : 298.39m : 23.00m COLLAR ELEVATION : 298.51m SHEET : 1/1 GUAGE **DEPTH OF HEIGHT OF** *ACTUAL Meter Reading of Water Intake(Litres) Water Intake Litres/Minute PERMEABILITY Water Intake **PRESSUR** GROUND WATER PRESSURE WATER SWIVEL Ε INTERPRETATION FLOW CHART Third After After After First IN LUGEON'S INITIAL Sec. 5min. Lt./ min /m kg/cm2 (m) (m) kg/cm2 Avg. 5min. 10min. 15min. 5min. 1-Test Section 15.00m to 18.00 M Permeability in Lugeon 1280.00 1308.00 1338.00 1371.00 28.00 30.00 33.00 31.50 2.10 1.00 2.64 7.95 Laminar Actual Pressure(kg/cm²) 7.95 2.64 1380.00 1420.00 1459.00 1499.00 40.00 39.00 40.00 39.50 2.00 7.23 2.63 3.64 7.23 3.64 N.E 1.40 1510.00 1568.00 1625.00 57.00 58.00 3.00 1684.00 58.00 59.00 3.87 4.64 8.33 8.33 4.64 7.67 7.51 3.64 1690.00 1727.00 1769.00 1809.00 37.00 42.00 40.00 41.00 2.73 2.00 3.64 7.51 7.32 2.64

2.64

7.32

29.00

30.00

1815.00 1844.00 1874.00 1902.00

29.00

1.93

28.00

1.00

								01.0616:-	<u> </u>	,					\										HOLE NO : NBH-23A
							GE(OLOGICAL L	UG	i O	F I	JK.	ılL	HC)LE										SHEET NO:1 of 1
PROJEC	T			: SIVO	K-RA	NGPO	NEW BO	G RAILWAY LINE PROJE	CT						CO-C	ORDIN	JATTE	ŝ				: <u>N29</u>	97033.43	15,E6446	24.6930
LOCAT	ON			: MELI	LI										ANG	LE W	тн н	ORIZO	NTAI	_		: <u>90°</u>			
STRUCT	URE			: YARI	D										BEAF	RING	OF HC	LE				: Vert	ical		
CLIENT				: IRCC	N IN	TERNA	ATIONA	L LTD.							DEPT	TH OF	HOLE	3				: 35.0	0m		
DRILLIN	NG AGE	NCY		: ARIH	IANT	DRILL	INGS PV	/T.LTD.							PERI	OD OI	F EXEC	CUTIO	N			: 02.0	3.2018 - 1	10.03.2018	3
GROUN			I	: 311.0													ORE B	ARRE	L			: DOI	UBLE/TE	RIPLE TU	<u>BE</u>
COLLE	R ELEVA	ATION		: 311.1	4m			I	1						LOG	GED B	BY		- 1	DD	ILL	: AK.	TOMAR		Γ
	DEPT	H (m)	LITHOLOGY		SIZ	ZE OF O		STRUCTURAL CONDITIONS			OF C	ORE								WA	TER		PERME	EABILITY	
ELEVATION (m)				1	<u> </u>	1		CONDITIONS	<u> </u>	112	1		1	-	×				m)	LC	OSS	RATE		I	
IOI															FRACTURE INDEX	ING	щ		DEPTH OF GWT (m)			N	EST SECTION (m)		SPECIAL OBESERVATIONS AND
EVA	FROM	IO	DESCRIPTION	LOG		E E	um c	DESCRIPTION							REI	SIZE OF CASING	SIZE OF HOLE	BIT)FG		, E	PENETRATION I	OLL	_	INTERPRETATIONS
뮵	FR	1			< 10mm	10 to 25 mm 25 to 75 mm	75 to 150 mm > 150 mm					. 0	2	% (LC.	OF	OF	SIZE OF BIT	TH		COMPLETE	min TETR	SEC.	LUGEON VALUE	
					< 101	10 to 25 to	75 to > 15		0-20	20-40	40-60	80-100	IN FIG	RQD %	FRA	SIZI	SIZI	SIZI	DEF	F S	SOLA	PEN/	ITEST	LUG	
310.52	0.00	0.50	Brown coloured top soil	∇									30			HX 0.5	1					2.50			
310.02	0.50	1.00		0									40			1	1	puc				2.27			
309.52	1.00	1.50	Pebbles of Quartzitic Phyllite										44			İ		iam				2.50			SPT:1.50-1.62m=60blows
309.02	1.50	2.00		∀									60	1 _	_	1		NX Diamond				2.00			
308.02	2.00	3.00											55	Overburden	Overburden		H	I				2.63	3	1127	SPT:3.00 - 3.14m=55blows
307.02	3.00	4.00	Boulders,cobbles, Pebbles and	▽	С	verbu	rden	Overburden					60	erbu	erbu	'		A				2.50		l	
306.02	4.00	5.00	granules with clayl material (6 to 8.30m) of Greenish grey to brown	0									75	Ó	ð	.50)	ļ					2.22			
305.02	5.00	6.00	coloured,Quartzitic Phyllite and	U									65	1		NX (10.50)	li					2.08			
304.02	6.00	7.00	Quartzite.	0									68	_		Ż	1					2.50	6	673	SPT:6.00-6.00m=60blows
303.02	7.00	8.00		▽									56	-		1	ļ	-				2.22		073	Rock encountered from 8.30m
302.02	8.00	9.00			>10	1	2			-	-	-	75	45	8	4-						2.13			
301.02	9.00	10.00		\sim	>20 <	1 10 4							82	43	0		ļ					2.13			SPT:9.00-9.09m=50blows
300.02	10.00	11.00		\sim	\pm	10 2							85	Nil		H	İ					2.50			
					720	-10 2								-		Ÿ	-	-				_			
299.52	11.00	11.50		\sim	<10	1 1 1	1						58 70	26			H	-				2.00			
299.02	11.50	12.00											_				H	i				1.67			
298.52	12.00	12.50		\sim	+	2 1	1						76	Nil			H					2.50			
298.02	12.50	13.00			<10	1 1							62	l								2.00			
297.52	13.00	13.50		$\tilde{\propto}$		3	2	FJ=55º/ Smooth,					80	22	ele .		ļ					1.67			
297.02	13.50	14.00	Greenish grey coloured, fine grained-	X	>20			undulating, clay filled					40	-	licak			-				1.43			
296.52	14.00	14.50	-Quartzitic Phyllite with irregular interbands of white coloured	\times	-	<10 1		(Brownish due to weathering) with iron					58	_	Not Applicable		ļ					1.67			
296.02	14.50	15.00	Quartzite, moderate to highly weathered, weak to medium strong,	\approx	-	<10		stained walls					50	-	Not		H					1.56			Rock mass is highly
295.52	15.00	15.50	very intensely to intensely fractured	∞	>30								38				1	-				1.79			fractured , weak to medium strong and Moderately to
295.02	15.50	16.00	and sometimes moderately fractured.	XX	>30	1							42	Nil			NX	'	仆			1.67			highly weathered from 9.00 to 24.00m
294.52	16.00	16.50		\sim	>20	1							48	_				Bit	16.50			1.43			
294.02	16.50	17.00			>20	2							66				li	Core I				1.67			
293.02	17.00	18.00		\sim	>20 <	<10 5	Ш						82				i i	Q				1.54			
292.02	18.00	19.00			>20 <	<10 3	1						84					NMI				1.61			
291.02	19.00	20.00		٥.	>20 <	<10 1	2						90					1				1.54			
290.02	20.00	21.00			<	<10 1	3 1]				88	34	9							1.67			
289.02	21.00	22.00			>10 >	10 6	2						84		ĺ				_			1.82			
288.02	22.00	23.00			>10 <	<10 4	1	J=30º/ Smooth -					85	Nil	NA				_			1.72			
287.02	23.00	24.00			_ <	<10 8	1	Slightly rough, plane,					94]		i	_			1.82			
286.02	24.00	25.00			<10	1	2 2	iron stained walls					96	44	8							1.61			
285.02	25.00	26.00			l L	4	6						98]	10							1.67			
284.02	26.00	27.00		\sim	<	<10 7	1						95	Nil	14				=			1.54			
283.02	27.00	28.00	Greenish grey coloured, fine grained-		_	<10 6							81	1411	14				_			1.61			
282.02	28.00	29.00	-Quartzitic Phyllite with irregular interbands of white coloured	\sim	>10 <	<10 5	2						85	L	12			i	_			1.54			
281.02	29.00	30.00	Quartzite, moderate weathered,	\sim	<	<10 4	1						82	11	13			i				1.67			
280.02	30.00	31.00	weak to medium strong, intensely fractured, sometimes very intensely		<10 >	10 4	1	FJ=55º/ Smooth,					86	13	14							1.54			
279.02	31.00	32.00	and moderately fractured.	\sim	<	<10 6	1	undulating, clay filled					84		13				=			1.54	1		
278.52	32.00	32.50		\sim	>10	5		(Brownish due to weathering) with iron				ſ	70	1		1			_			1.67	1		
278.02	32.50	33.00			>10	2	1	stained walls					72	1	ĺ				_			1.56			
277.52	33.00	33.50		\sim	>10	5 3							76	Nil				i	_			1.43			Sheared rock mass from
277.02	33.50	34.00		XX	>20 <	<10							66	1	>15							1.67			13.50 to 16.50m and 33.50 to 35.00m
276.52	34.00	34.50	Greenish coloured Sheared rock	XX	>20 <	<10							62	1	ĺ				=			1.56			55.00III
276.02	34.50	35.00	mass of Phyllite Quartzite	$\langle \! \rangle \! \langle$	>20	1 1							70	1			j	 	_			1.43			
			Overburden	\approx	,	Sh	near /W/	eak Zone	FI=I	oliati	ion ic	oin+	1.0	<u> </u>	l	1	GWT	.=Gro	ind W	ater T	able	1.10	l	SPT =S+~	Indard Penetration Test
				MV M	<u>. </u>	JII														T				J. 1Jid	
No	tation	:-	Quartzitic Phyllite	~			Quar	tzite	J=O	ther Jo	oint						Sm=S	mooth	1	R	=Rou	ıgh			
140	011	-	Slightly fractured:Core recovered mostly						_				_												
			Moderately fractured:Core recovered mostl	_												red m	ostly a	s chips	and f	ragme	ents w	rith a fe	w scatte	red short	core lengths.
			Intensely fractured: Lengths average fro	m 3 to 1	10 cm	with fr	agmente	ed intervals. Core recover	ed me	ostly i	in ler	gths	Iess th	nan 10	cm.										

NBH-23A, DEPTH 0.00 to 8.25m



NBH-23A, DEPTH 8.25 to 16.10m



NBH-23A, DEPTH 16.10 to 22.25m



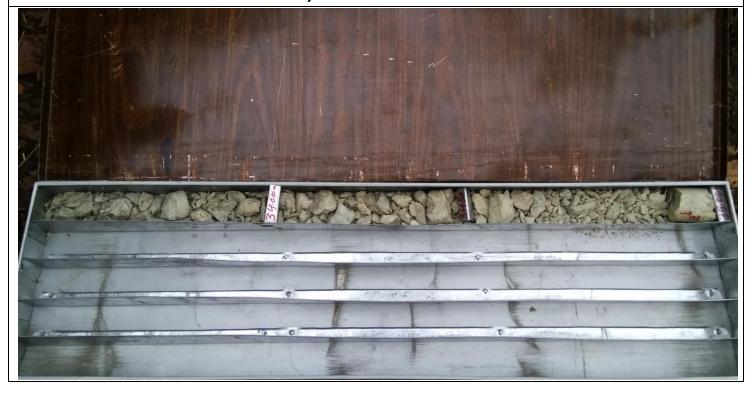
NBH-23A, DEPTH 22.25 to 27.45m



NBH-23A, DEPTH 27.45 to 33.50m

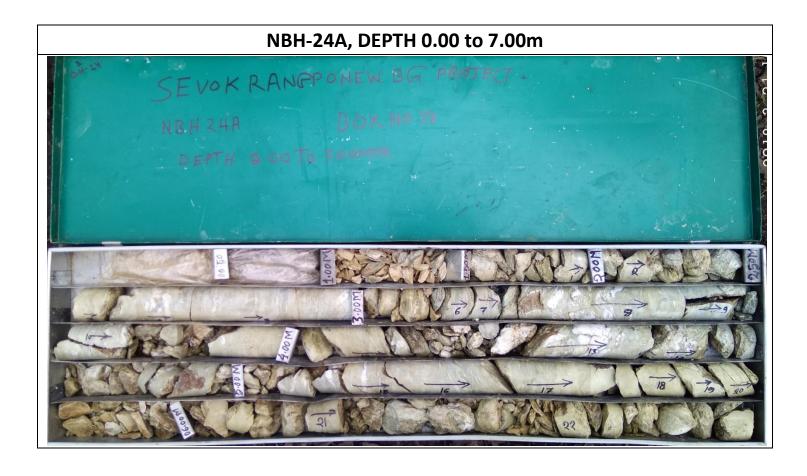


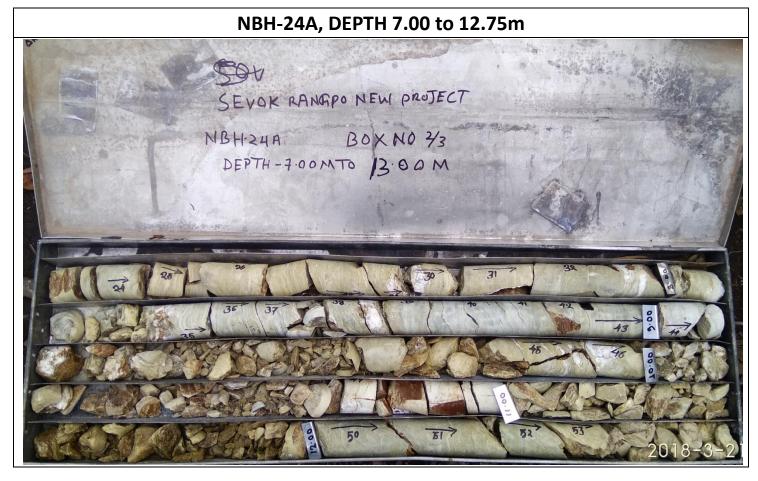
NBH-23A, DEPTH 33.50 to 35.00m



			IN-	SITU CO	NSTAN	T HEA	D PER	MEABI	LITY (WATER	PERCO	LATION)	TESTS D	ATA			DRILL HOL SHEET	E: NBH-23A: 1 of 1
1. PRC	DJECT			: SIVOK – I	RANGPO	O NEW B	G RAILW	AY LINI	E PROJEC	CT		5. COORDI	NATES		: N299703	3.4315,E644624	.6930	
2. LOC	CATION/F	EATURE	:	: MELLI/	YARD							6. TOTAL I	DEPTH FRO	M ESL	: 30.00m			
3. CLI	ENT			: IRCON IN	TERNA	TIONAL	LTD.					7. GROUNI	D LEVEL EI	_	: 311.02m			
4. DRI	LLING A	GENCY		: ARIHANT	DRILL	ING PVT.	LTD.					8. COLLAR	EL		: 311.14m			
	est n)	ole		2	ime			Water Int	ake(L/5m	nin)		ge take min.)	ound l(m)	vel	ial)	COEFI PERMEAB		
Test No.	Depth of Test Section (m)	Dia. of Hole		vaule of C1	Average Time (min.)	1 st 5 min	2 nd 5 min	3 rd 5 min	4th 5 min	sth 5 min	Average of Last Two Readings	Q=Average Constant Intake of Water(L/min.)	Depth of Ground Water Level(m)	Water Level Height above GL(m)	Differential Head(H) (m)	AS PER IS 55	29-(PART-I)	REMARKS
T	Dep Sec	Dia	2	S S	Ave	1 5 n	2' 5 n	3. 5 n	4 5 n	s 5 n	Average o Last Two Readings	Q= Cons of Wa	Depth	Wa Hei	DI H	cm/sec.	Lugeon	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	3.00	НХ	0.00606	6.06 x 10 ⁻³	5	31.00	28.00	30.00	26.00	32.00	29.00	5.80	N.E.	0.12	3.12	11.2654 x 10 ⁻³	1126.54	i) The H for test below W.T. = Depth of water in
2	6.00	NX	0.00795	7.95 x 10 ⁻³	5	26.00	24.00	25.00	27.00	25.00	26.00	5.20	N.E.	0.14	6.14	6.7329 x 10 ⁻³	673.29	casing – Depth of GW Table.
																		ii) The H for test above W.T. = WL in casing –
																		Depth of test sec.
																		iii) The expression K=C ₁ x O/H where
																		K= Permeability in
																		cm/sec. Q= Constant rate of flow into hole in litre/min.

									G	EOLOGICAL	LO	OC	G C	F	DI	RIL	L l	НО	LE										O: NBH-24A
PROJE	СТ			: SIVC	K-F	RAN	IGPC	NE	W B	G RAILWAY LINE PROJE	СТ							CO-C	ORDII	NATT	ES					: <u>N299</u>	7038.8	628,E6446	
LOCA	TION			: MEL	LI													ANC	GLE W	TTH I	IORIZ	ONT	AL			: <u>90°</u>			
STRUG	CTURE	3		: YAR	D													BEA	RING	OF H	OLE					: VER	ΓICAL		
CLIEN	IT			: IRCC	ON I	NTI	ERN	ATIC	ONA	L LTD.								DEP	TH O	F HOI	.E					: 15.00	m		
DRILL	ING A	GENC	Ϋ́Y	: ARIF	IAN	VI D	DRILI	INC	GS P	VT.LTD.								PERI	OD C	F EXI	CUTI	ON				: 15.03	.2018	- 17.03.20	18
GROU	ND EL	LEVAT	ION	: 309.6	57m													TYPI	E OF (CORE	BARF	EL				: DOU	BLE/T	RIPLE TU	JBE
COLL	ER ELI	EVATI	ON	: 309.8	31m													LOG	GED	BY	1		-	DII.	. 1	: <u>AK.</u> T	OMA	2	
(u	DEPI	ΓH (m)	LITHOLOGY		5				RE	STRUCTURAL CONDITIONS													W	ATE	ER	Ħ	PERM	EABILITY	
ELEVATION (m)						1												ΕX	(1			(m)			_	RAI	-	ш	SPECIAL
ATIC	Ļ							u										IND	SINC	J.E		GWI				ION	<u>a</u>	ALU	AND
ELEV	RON	OI	DESCRIPTION	LOG	_	mm	mm	0 mr	ш	DESCRIPTION								URE	FCA	FHC	F BIJ	I OF		\L	ETE	TRAT	CTIC	N N	INTERPRETATIONS
I	Н.				0mn	to 25	to 75	to 15	50 n		0:	40	09-	-80	100	FIG	ур %	ACI	ŒO	Œ O	Œ O	PTF	ر	RTI/	MPI	NET /mj	STSE	GEC	
					V	10	52	33	^		0-2	50-	40	-09	-08		RC	FR	ΊS	SE		DI	Z	ΡA	S		Ĕ	27	
309.17			Brown coloured top soil														r	υ	m)		NX								
308.67				V		_											ırdeı	ırdeı	(2.00	НХ	Ä								
308.17			Pebbles and granules of	⊽		Ove	erbu	rdei	1	Overburden							verb	verbı	НХ										
307.67			Quartzitic Phyllite	▽													Ó	Ó		^	i								
306.67			Greenish grey coloured, fine	\sim			1	1	1			-		-		-	72	6		+	Ť	-		-			3	1177	
			grainedQuartzitic Phyllite with		-1/	2 47/	0 2			FJ=35º/ Smooth,										İ								11,7	
305.67			coloured Quartzite, slightly to moderately weathered, weak to	\sim		-	+		1	(Brownish due to																			
304.67	DESCRIPTION LOC																												
303.67	5.00	6.00			>20	<10	0 5	2								90	21	>15	8.00m		İ					2.32	6	1065	
			Overteitie Dhydlite with innerview																NX (i	q							
302.67	6.00	7.00	interbands of white coloured	\sim	~20	2-10	0 2			Discontinuity did not						0.1	NT:1	NIA		ij	±.	ıntere				2.04			
302.67	6.00	7.00	weathered, weak to medium		>30) <10	0 2			distinct						64	NII	NA		'	ore B	ncon				2.04			
			strong, very intensely fractured.	\sim																	O O	Not E							
									İ	FT 250/6 4										NX	NM	I							
301.67	7.00	8.00	interbands of white coloured	\sim		<10	0 7	4		undulating, clay filled						90	10	>10								1.92			
300.67	8.00	9.00	weak to medium strong,	\sim			12	2		weathering) with iron						96	10	11		į						1.85			
299.67	9.00	10.00			>20	0 -10	0 2	2		sunce wans						01				ļ						2.04			
298.67						+	+	-												li									
297.67			Quartzitic Phyllite with irregular	\sim		+-				distinct																			
297.07	11.00	12.00	interbands of white coloured Quartzite,moderately to highly		-20	J - 20	0			FI 250 / C th						73					li					1.90			
296.67	12.00	13.00	weathered, weak to medium strong, very intensely to	\sim	>20	>10	0 1	3		undulating, clay filled						91	Nil	NA			İ					1.78			
295.67	13.00	14.00	intensely fractured.		>20) >10	0 3	1								82					l					1.92			
294.67	14.00	15.00		\sim	>10) <10	0 5	3		distinct						93				 	 - 					1.82			
			Overburden	\otimes	{			Sl	hear	Zone	FJ=	Foli	atior	ı joir	ıt					GWI	:=Gro	und \	Wate	r Ta	ıble.			SPT.=S	tandard Penetration Test
			Quartzitic Phyllite	~ ~	,			Ç	Quar	tzite	J=C	Othe	r Joii	nt						Sm=5	Smoot	h		R=R	Roug	h			
No	7 12.00 13.00 weathered, weak to medium strong, very intensely to intensely fractured. 7 13.00 14.00 15.00 Verburden Shear Zone FJ=Foliation joint Shear Zone FJ=Foliation joint Shear Zone SPT.=Standard Penetration Test																												
1				mostly i	in ler	ngths	s fron	10 t	о 30с	m with most lengths about	Ve	ry in	itens	ely f	ractu	ıred :	Core	recov	ered:	mostly	as ch	ips a	nd fr	agn	nents	s with a	a few s	cattered s	hort core lengths.
1			Intensely fractured : Lengths average	age fro	om 3	to 1	10 cm	wit	th fra	agmented intervals. Core	reco	vere	ed m	ostly	in l	ength	ıs less	s than	10 cr	n.									





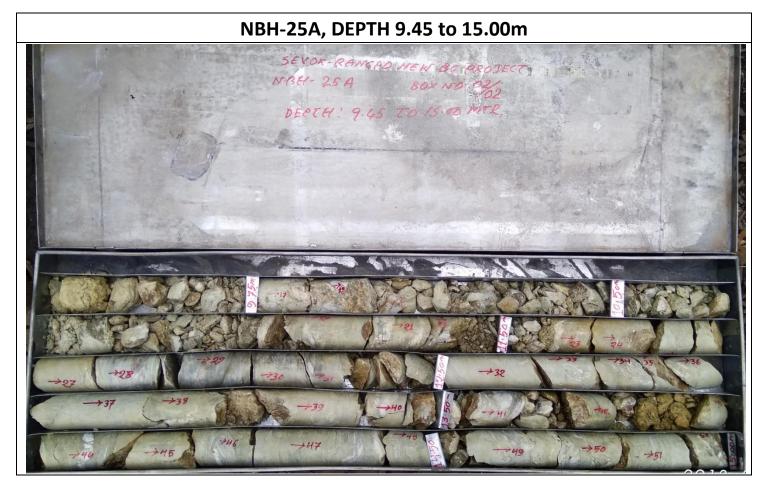
NBH-24A, DEPTH 12.75 to 15.00m

			IN-	SITU CO	NSTAN	NT HEA	D PER	MEABI	LITY (WATER	R PERCO	LATION)	TESTS D	ATA			DRILL HOL SHEET	E: NBH-24A: 1 of 1
1. PRC	DJECT			: SIVOK – I	RANGPO	O NEW B	G RAILW	AY LINI	E PROJEC	CT		5. COORDI	NATES		: N299703	8.8628,E644646	5.9823	
2. LO	CATION/F	EATURE		: MELLI /	YARD							6. TOTAL I	DEPTH FRO	M ESL	: 15.00m			
3. CLI	ENT			: IRCON IN	TERNA	TIONAL	LTD.					7. GROUNI	D LEVEL EI	_	: 309.67m			
4. DRI	LLING A	GENCY		: ARIHANT	DRILL	ING PVT.	LTD.					8. COLLAR	EL		: 309.81m			
	est n)	ole	(5	ime			Water Int	ake(L/5n	nin)		ge take min.)	(m)I	/el	al	COEF PERMEAB		
Test No.	Depth of Test Section (m)	Dia. of Hole	4	Vaule of C1	Average Time (min.)	1 st 5 min	2 nd 5 min	3 rd 5 min	4th 5 min	5th 5 min	Average of Last Two Readings	Q=Average Constant Intake of Water(L/min.)	Depth of Ground Water Level(m)	Water Level Height above GL(m)	Differential Head(H) (m)	AS PER IS 55	29-(PART-I)	REMARKS
L	Dep	Dia		\ a	Ave	1 5 n	2' 5 n	3, 12	4 5 n	s 5 n	Avera Last Read	Q= Cons of Wa	Deptl	Wa Hei	ΞŒ	cm/sec.	Lugeon	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	3.00	нх	0.00606	6.06 x 10 ⁻³	5	32.00	27.00	29.00	30.00	31.00	30.50	6.10	N.E.	0.14	3.14	11.7726 x 10 ⁻³	1177.26	i) The H for test below W.T. = Depth of water in
2	6.00	NX	0.00795	7.95 x 10 ⁻³	5	38.00	42.00	47.00	40.00	42.00	41.00	8.20	N.E.	0.12	6.12	10.6520 x 10 ⁻³	1065.20	casing – Depth of GW Table.
									-	-	-							
																		ii) The H for test above W.T. = WL in casing –
																		Depth of test sec.
																		iii) The expression K=C ₁ x Q/H where
																		K= Permeability in
																		cm/sec. Q= Constant rate of flow
																		into hole in litre/min.

							GEO	DLOGICAL	LC	G	o	F D	RI	LL	HC	LE									HOLE NO: NBH-25A SHEET NO: 1 of 1
PROJEC	Γ			: SIVO	K-RAN	NGPO	NEW BO	G RAILWAY LINE PRO	DIEC	Γ_					CO-	ORDI	NATT	ES				: <u>N299</u>	97052.234	9,E644661	.8595
LOCATI	NC			: MELI	<u>I</u>										AN	GLE V	VITH I	HORI	ZONT	AL		: <u>90°</u>			
STRUCT	URE			: YARI	<u>)</u>										BEA	ARING	OF H	OLE				: Verti	ical		
CLIENT				: IRCO	N INT	ERNA	TIONAL	LLTD.							DEF	TH C	F HOI	LE				: 15 <u>.00</u>	<u>)m</u>		
DRILLIN				: ARIH	ANT	DRILL	INGS PV	/T.LTD.								NOD C								5.03.2018	
GROUN				: 304.40												PE OF		BARI	REL					IPLE TUB	<u>E</u>
COLLER	ELEVA	TION		: 304.50				1							LOC	GGED	BY			DR	II.I.	: <u>AK.T</u>	OMAR		
	DEPT	H (m)	LITHOLOGY		SIZ	ZE OF PIEC	CORE ES	STRUCTURAL CONDITIONS	% C	OF CO	ORE	RECO	OVEF	Υ						WA	TER		PERME	ABILITY	
ELEVATION (m)								_					Т		×				(m)	LC	255	RATE	_		SPECIAL
OTTV															<u>N</u>	SING	LE		3WT			NO	E)		OBESERVATIONS AND
CEV/	FROM	TO	DESCRIPTION	LOG		H H	m (DESCRIPTION							URE	S.	HO	BIT	OF(7	RATI	CTIO	z	INTERPRETATIONS
E	Ш				< 10mm	10 to 25 mm 25 to 75 mm	75 to 150 mm > 150 mm		0	40	40-60	90-80	001-08	RQD %	FRACTURE INDEX	SIZE OF CASING	SIZE OF HOLE	SIZE OF BIT	DEPTH OF GWT (m)	NIL	CANTENE	PENETRATION Cm/min	EST SECTION (m)	LUGEON	
				1000000000	, ,	25	75		0-20	20-40	40-	-09	2	ĭ	Ħ	SIZ	SIZ	SI	ΞĞ	Ę ż	¥ 8	3 2 5	Ħ	ΠA	
303.90	0.00	0.50	Brown coloured top soil	0									3	2				puot				2.50			
303.40	0.50	1.00											4	2				NX Diamond				2.00			
302.90	1.00	1.50		0									4	2 =	_	(3.00m)	НХ	ž				2.00			SSPT:1.50-1.66m=10, 42 blows
302.40	1.50	2.00					,						4	orrde	urde	HX (3	117	Ŷ				2.50			·
301.90	2.00	2.50	Pebbles & granules of Quartzitic	∇	U	verbu	raen	Overburden					3	— 및	Overburden	1		Ì				2.00			
301.40	2.50	3.00	phyllite	0									5		0			ļ				1.85	3	1427	SPT:3.00-3.20m = 18, 38 blows
300.90	3.00	3.50											5	-		↑	个					2.00		1427	,,,,,,
300.40	3.50	4.00		0									5	-			1					1.78			
299.90	4.00	4.50		\sim	<10	1	1			-			-	0 22	10	+ <u> </u> -		۱			-	1.67			Rock encountered from 4.0m
					~10										-	I i	l i					-	_		Nock cheduncted from 4.0m
299.40	4.50	5.00				1	3						8	-	8	-		İ				2.00	_		
298.90	5.00	5.50		\sim	>10	1							5	8		H	H	İ				1.78		1	
298.40	5.50	6.00			>10	2							6	0		1	l	'				2.00	6	989	
297.90	6.00	6.50	Greenish grey coloured, fine	\sim	>10	1							4	8		'	H		tered			1.78			
297.40	6.50	7.00	grainedQuartzitic Phyllite with irregular interbands of white										4	4		(m0(unoou			1.67			
296.90	7.00	7.50	coloured Quartzite, moderatey to highly weathered, weak to	\sim	>20			Discontinuity did not distinct					5	2 Nil		NX (12.00m)	'	Sore B	Not Encountered			1.42			
296.40	7.50	8.00	medium strong rock,intensely to very intensely fractured.										5		NA	Z		NMLC Core Bit				1.78			
295.90	8.00	8.50	very intensely flactured.	<u> </u>	>20	1							5	4			NX	Z				1.67			
295.40	8.50	9.00			<10	5 2							6	8		ļį						1.67			
294.65	9.00	9.75		٥.	>20	5 2							6	6				ļ				1.87			
293.90	9.75	10.50			>30	2							7	2			li	İ				1.67			Almost rock mass is
292.90	10.50	11.50		<u> </u>	>20	5 1	2						8	3 11		▋┆	İ					2.00			moderately to highly weathered and fractured
291.90	11.50	12.50			<	10 4	5						9	0 24	10	j						2.08			from 5.0 to 11.50m
290.90	12.50	13.50	Greenish grey coloured, fine grainedQuartzitic Phyllite with irregular interbands of white	\sim		5 3	5	FJ=35-40°/Slightly RU/ clay filled					9	5 32	8							2.22			
289.90	13.50	14.50	coloured Quartzite,frsh to slightly weathered, weak to medium	~	>10 <	10 5	1 1	(Brownish due to weathering) with					9	5 30	6	1						2.08			
			strong rock, intensely to moderately fractured.	\sim				iron stained walls					-			1							-		
289.40	14.50	15.00				1	3						9	0 10	7		¥	ţ				1.67		1	
			Overburden	XX			Shear Z	one	FJ=	Folia	tion	joint					GWT	.=Gro	und V	Vater 1	Γable	e.		SPT.=Sta	ndard Penetration Test
No	tation	:-	Phyllite	ς >			Quartz	ite	J=C	ther	Join	t					Sm=9	Smoot	h	R	=Ro	ugh			
			Slightly fractured:Core recovered m																						-
			Moderately fractured:Core recovered															as ch	ips an	d frag	men	ts with a	few scatt	ered short	core lengths.
1			Intensely fractured : Lengths averag	e from 3	to 10	cm wi	th fragm	ented intervals. Core re	2COV	ered	mos	tly in	lengtl	is less	than ?	10 cm.									

NBH-25A, DEPTH 0.00 to 9.45m





			IN	SITH CO	NCTAN	JT HEA	D DED	MEARI	ITV	WATEL	DEDCO	LATION)	TESTS D	АТА			DRILL HOL	E: NBH-25A
											TERCO						SHEET	: 1 of 1
1	DJECT			: SIVOK – I		O NEW B	G RAILW	VAY LINI	E PROJEC	CT		5. COORDI	NATES			2.2349,E644661	.8595	
1	CATION/F	EATURE		: MELLI /								6. TOTAL I		252	: 15.00m			
3. CL				: IRCON IN								7. GROUNI			: 304.40m			
4. DR	LLING A	GENCY		: ARIHANT	DRILL	ING PVT.	LTD.					8. COLLAR			: 309.50m			
_	rest m)	əle	(5	ime			Water Int	ake(L/5m	nin)		ge ıtake min.)	ound d(m)	vel	lai (COEF PERMEAB		
Test No.	Depth of Test Section (m)	Dia. of Hole		Vaule of C	Average Time (min.)	ii.	ıd nin	e nin	ч ii	sth 5 min	ge of Two ings	Q=Average Constant Intake of Water(L/min.)	of Gr	Water Level Height above GL(m)	Differential Head(H) (m)	AS PER IS 55	29-(PART-I)	REMARKS
Т	Dep	Dia	2	\ \	Ave	1 st 5 min	2 nd 5 min	3 rd 5 min	4th 5 min	sth 5 mi	Average of Last Two Readings	Cons	Depth of Ground Water Level(m)	Wa Hei	Di.H	cm/sec.	Lugeon	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	3.00	НХ	0.00606	6.06 x 10 ⁻³	5	18.00	25.00	31.00	34.00	39.00	36.50	7.30	N.E.	0.10	3.10	14.2703 x 10 ⁻³	1427.03	i) The H for test below W.T. = Depth of water in
2	6.00	НХ	0.00606	6.06 x 10 ⁻³	5	22.00	25.00	42.00	48.00	52.00	50.00	10.00	N.E.	0.13	6.13	9.8858 x 10 ⁻³	988.58	casing – Depth of GW Table.
																		ii) The H for test above W.T. = WL in casing –
																		Depth of test sec.
																		iii) The expression K=C ₁ x Q/H where
																		K= Permeability in
																		cm/sec. Q= Constant rate of flow
																		into hole in litre/min.

TEST REPORT

A. Density, Porosity, Water Absorption and Specific gravity as per IS 13030:1991

Sl. No.	Sample ID	Depth (m)	Bulk Density (g/cm³)	Dry Density (g/cm³)	Specific gravity	Water Absorption (%)
1	NBH-22A	03.00-04.00	2.694	2.674	2.73	0.72
2	NBH-23A	20.00-21.00	2.683	2.650	2.74	1.23
3	NBH-24A	12.00-13.00	2.661	2.628	2.72	1.26
4	NBH-25A	11.50-12.50	2.638	2.631	2.65	0.26

B. Uniaxial Compressive Strength(Natural Condition) as per IS: 9143-1979 (Reaffirmed 2016)

Sample No.	Source of Sample	Location	Depth (m)	Type of Machine Used	No. of Specimens Tested	Stress Rate (MPa/s)	Specimen No.	Lithological Description of Rock As per Client / Laboratory Observation (Visual Examination)	Orientation of Loading Axis	Mode of Failure	Duration of Test (min)	Diameter (mm)	Height (mm)	UCS (MPa)
NBH-22A		Melli Yard	16.00-17.00		1		104	Greenish grey colour. fine grain Quartzitic Phyllite with irregular inter band of white color quartzite		Wedge Shear	1.0	51.82	99.95	30.020
NBH-23A	Sevoke-Rangpo New BG Project	Melli Yard	20.00-21.00	500 kN CTM	1	0.5	55	Greenish grey colour. fine grain highly weathered Quartzitic Phyllite with irregular inter band of white color quartzite	Vertical	Wedge Shear	0.3	51.64	100.41	9.363
NBH-24A	Sevoke-Rangp	Melli Yard	5.00-6.00		1		16	Greenish grey colour. fine grain Quartzitic Phyllite with irregular inter band of white colour quartzite	'n	Wedge Shear	0.8	51.59	88.89	23.397
NBH-25A		Melli Yard	12.50-13.50		1		37	Greenish grey colour. fine grain Quartzitic Phyllite with irregular inter band of white color quartzite		Wedge Shear	1.6	51.72	95.89	48.564

C. Modulus of Elasticity & Poisson's Ratio(Natural Condition) as per IS:9221-1979

Sample No.	Source of Sample	Location	Depth (m)	Type of Machine Used	No. of Specimens Tested	Stress Rate (MPa/s)	Specimen No.	Lithological Description of Rock As per Client / Laboratory Observation (Visual Examination)	Orientation of Loading Axis	Mode of Failure	Duration of Test (min)	Diameter (mm)	Height (mm)	Modulus of Elasticity(Gpa)	Poisson's Ratio
NBH-22A	Project	Melli Yard	16.00-17.00		1		104	Greenish grey colour. fine grain Quartzitic Phyllitic with irregular inter band of white color quartzite		Wedge Shear	1.0	51.82	99.95	27.2	0.24
NBH-23A	Sevoke-Rangpo New BG Project	Melli Yard	20.00-21.00	500 kN CTM	1	0.5	55	Greenish grey colour. fine grain highly weathered Quartzitic Phyllitic with irregular inter band of white color quartzite	Vertical	Wedge Shear	0.3	51.64	100.41	8.5	0.26
NBH-24A	Sevok	Melli Yard	5.00-6.00	500	1		16	Greenish grey colour. fine grain Quartzitic Phyllitic with irregular inter band of white colour quartzite		Wedge Shear	8.0	51.59	88.89	21.2	0.25
NBH-25A		Melli Yard	12.50-13.50		1		37	Greenish grey colour. fine grain Quartzitic Phyllitic with irregular inter band of white color quartzite		Wedge Shear	1.6	51.72	95.89	33.5	0.23

D. Point Load Index Strength as per IS: 8764-1998 (Reaffirmed 2014)

SLNo.	Sample ID	Depth (m)	Source of Sample	Location	Specimen No.	Orientation of Loading Axis with respect to bedding planes	Rock Type As per Client / Lab (Visual Examination)	Width Perpendicular to the Loading Direction (W) (mm) (D) (mm)	Distance between Platen Contact Points (D) (mm)	Point Load Index Strength I _{s(50)} (MPa)	Remarks
14	NBH-22A	03.00	sct		8			78.35	51.77	2.85	
15	NBH-23A	20.00-	w BG Proje	rd	57	<u></u>		80.13	51.66	0.67	al
16	NBH-24A	12.00-	ce-Rangpo New BG Project	Melli Yard	51	Horizontal	Quartzitic Phyllite	75.8	51.6	1.6	Diametrical
17	NBH-25A	11.50-	Sevoke-		29			81.7	51.8	1.1	

E. Brazilian Tensile Strength (Natural Condition) as per IS:10082-1981 (Reaffirmed 1996)

Sample ID	Depth (m)	Source of sample	Location	Specimen No.	Rock Type (As per Client)	Diameter (mm)	Thickness (mm)	Tensile Strength (MPa)
NBH-22A	17.00-18.00			110	Quartetic Phyllite	51.79	29.85	3.45
NBH-23A	24.00-25.00	lew BG Project	/ard	83	Quartetic Phyllite	51.12	27.61	1.02
NBH-24A	12.00-13.00	Sevoke-Rangpo New	Melli Yard	50	Quartetic Phyllite	51.74	29.52	2.10
NBH-25A	12.50-13.00	Se		32	Quartetic Phyllite	51.74	27.47	4.30

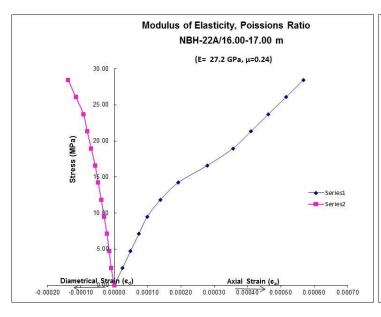
F. Triaxial Shear Strength (Natural Condition) as per IS: 13047-1991 (Reaffirmed 2016)

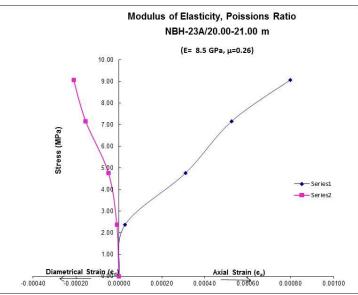
e No.	Sample	tion	Depth (m)	Moisture Content (%)	Specific Gravity	Porosity	Type of Machine Used	of Specimens Tested	Specimen No.	Lithological Description of Rock Client / Laboratory Observation (Visual Examination)	Orientation of Loading Axis	Failure	Diameter (mm)	Height (mm)	Confining Pressure (MPa)	Pressure		(6
Sample No.	Source of Sample	Location	Q	-	-	-	pe of Mac	of Specin	2		tation of	Mode of Failure	51.87	77.45	7.845	58.45	c (MPa)	φ (°)
			27.00	1	1	ı	Ty	No.	3		Orien		51.90	78.01	9.807	66.94		
	gpo	_	0	-	1	ı	rame		1	Greenish grey colour. fine grain		ailure	51.94	76.26	5.884	30.04		
DH-22A	Sevoke-Rangpo New BG Project	Melli Yard	17.00-18.00	-	1	ı	500 kN Load frame	03	2	quartetic Phyllite with irregular	Vertical	Wedge Shear Failure	51.79	79.88	7.845	39.04	2.21	35.35
	Sev	_	1.	ı	1	1	500 k		3	interband of white color quartzite		Wedg	51.75	78.35	9.807	44.73		
	gpo ject	75	00	-	1	ı	rame		1	Greenish grey colour. fine grain		ailure	50.61	64.38	5.884	17.93		
NBH-23A	Sevoke-Rangpo New BG Project	Melli Yard	24.00-25.00	-	-	-	500 kN Load frame	03	2	highly weathered quartetic Phyllite with irregular		e Shear Failure	50.86	62.15	7.845	21.15	1.20	23.68
	Sev	_	2.	-	-	-	100s		3	interband of white color quartzite		Wedge	51.38	64.74	9.807	27.11		

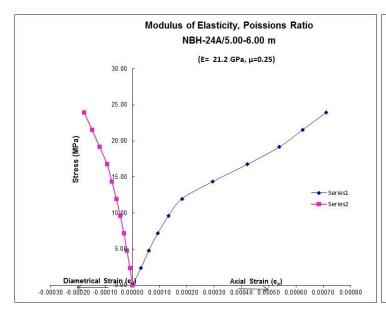
Sample No.	Source of Sample	Location	Depth (m)	Moisture Content (%)	Specific Gravity	Porosity	Type of Machine Used	No. of Specimens Tested	Specimen No.	Lithological Description of Rock Client / Laboratory Observation (Visual Examination)	Orientation of Loading Axis	Mode of Failure	Diameter (mm)	Height (mm)	Confining Pressure (MPa)	Pressure	c (MPa)	φ (_°)
		rd	2.50-3.00	-	-	1			τ	Greenish grey colour. fine grain		ailure	51.83	78.76	5.884	32.77		
NBH-24A		Melli Yard	2.50-	-	-	1		03	7	quartetic Phyllite with irregular	Vertical	Wedge Shear Failure	51.67	98'62	7.845	43.17	1.37	40.19
			8.00-	-	ı	ı			8	interband of white colour quartzite		Wedg	51.81	78.53	9.807	50.97		
	Rangpo Project		13.00-14.50	-	ı	ı	500 kN Load frame		τ				51.61	73.12	5.884	37.89		
	Sevoke-Rangpo New BG Project		13.00	-	-	ı	00 kN Lo		7	Greenish grey colour. fine grain		ailure	51.62	77.50	7.845	46.56		
NBH-25A		Melli Yard	12.00-	-	-	-	, u,	03	3	quartetic Phyllite with irregular	Vertical	Wedge Shear Failure	51.66	26.09	9.807	55.41	2.74	39.36
		-		-	-	-			2	interband of white color quartzite		Wedg	51.64	96.81	7.845	38.80		
				-	-	1			3				51.63	90.76	9.807	47.89		

- A. For Modulus of elasticity & Poisson's Ratio plots please see Annexure -A.
- B. For Triaxial strength test plots please see Annexure -B.
- C. For UCS, Modulus of elasticity & Poisson's ratio, tested samples photographs please see Annexure-C.
- D. For Point Load tested samples photographs please see Annexure-D.
- E. For Triaxial tested samples photographs please see Annexure-E.
- F. For Tensile tested samples photographs please see Annexure-F.
- G. For Petrography Analysis please see Annexure-G.

ANNEXURE-A Modulus of elasticity & Poisson's ratio Plots







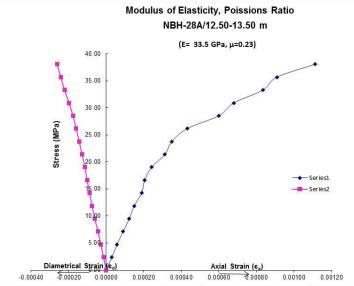
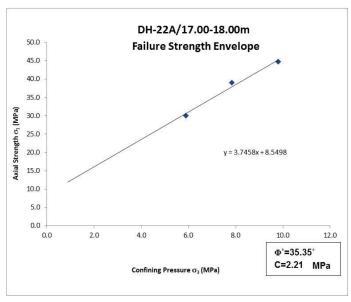
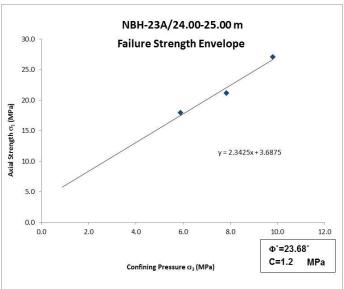
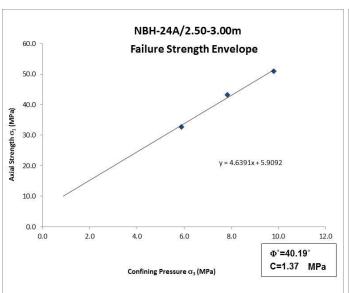


Fig. 1 Plots between Axial Stress and Axial Strain (ϵ_a) and Diametrical Strain (ϵ_d) for modulus of elasticity & Poisson's ratio

ANNEXURE-B Triaxial Strength Plots







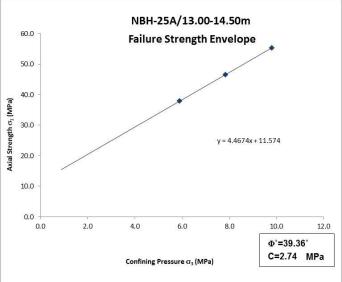


Fig. 2 Plots between Axial Strength and Confining Pressure for Triaxial strength of rock Core samples

ANNEXURE-C UCS with Modulus of elasticity & Poisson's ratio Tested Sample

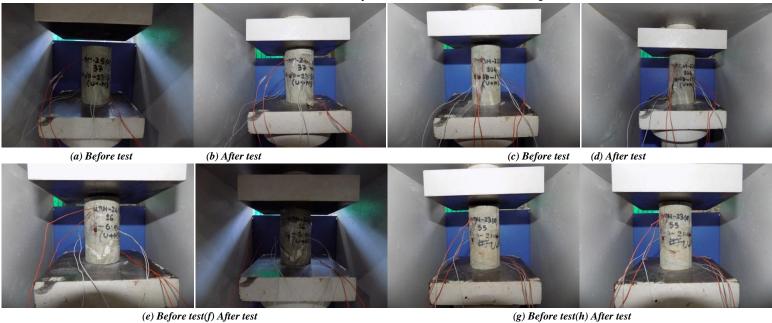


Fig:-3 UCS with modulus of elasticity and Poisson's ratio Tested Samples

ANNEXURE-D Point Load Index Strength Tested Samples



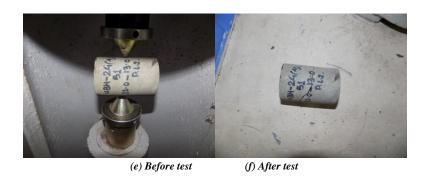


Fig:4 -Point Load Strength Index Tested Samples Photograph

ANNEXURE-E Triaxial Shear Strength Tested Samples



(a) Before test(b) After test

(c) Before test(d) After test

(d) Before test(d) After test

(e) Before test(d) After test

(f) Before test(d) After test

(g) Before test(d) After test

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(g) Before test(d) After test

(e) Before test(f) After test (g) Before test(h) After test

Fig:-5Triaxial Shear Strength Tested Samples

ANNEXURE-F Tensile (Brazilian) Tested Samples



(a) Before test(b) After test

(c) Before test(d) After test

Fig: 6 -Brazilian Tensile Tested Samples Photograph

(g) Before test(h) After test

(e) Before test(f) After test

Annexure-G (Petrography Analysis)

INTRODUCTION:

This report incorporates petrographic study of rock samples from Sevoke-Rangpo New BG Project. The rock sample was submitted by M/s Arihant Drillings Pvt. Ltd. on 09/07/2018 at the Aimil testing Laboratory, New Delhi office.

Petrography of rock sample has been carried out as per standard IS: 2386 (Pt-8)-1963 (Reaffirmed-1997)-"
"Petrographic Examination".

Thin sections of the given sample were examined megascopically as well as under polarizing microscope with an aim to identify different mineral constituents, detrimental minerals, if any and photo-micrographed for documentation. The microscopic examination also includes study of micro-textures and alterations which have been observed between minerals grain boundaries.

The rock description given hereunder solely pertains to megascopic and microscopic study of two thin sections only without any feedback of the field description and name, keeping this in view it is suggested that given name of the rock type by laboratory studies should preferably not be matched with text book description of the rock. But it should be viewed in conjunction with alterations identified, if any, of the rock.

PETROGRAPHIC OBSERVATIONS AND INTERPRETATIONS

1. PETROGRAPHIC STUDY OF SAMPLE NO-1:

Senders sample ID : MELLI YARD/NBH-22A

Field name of sample, if any

(assigned by the sender)

: Not specified by the sender

Nature of the sample : Rock core Location/ Depth of the sample : 16.00-17.00m

Sample ID (ATES Lab) : RC-842

Laboratory name of the sample : Quartzitic Phyllite

(assigned by the present study)

Megascopic Study of the Sample (Study aid –naked eye & hand lens):

The given rock sample is light dark grey in colour with intercalation of secondary white quartz. The rock is fine grained foliated, hard and compact and has medium specific gravity. The rock has thin encrustation on its outer surface.



Fig.-: Rock sample

Microscopic study of the sample (Study aids – Computer interfaced high resolution polarizing microscope with photographic attachment)

A. Mineralogical Content (V. E.):

			Mineralogi	cal Content %		
SI. No.	Quartz	Muscovite/ Sericite	Chlorite	Ferruginous Material	Strained quartz of total quartz present	Undulose Extinction angle
1	45-47	18-20	28-30	5-7	*8-10	*10-12
2	47-49	17-19	26-28	6-8	*8-10	*10-12

^{*}observations are recorded only on the grains which are relatively better developed.

B. Textures and Microstructures:

It is a fine to medium grained rock in which hazy individual mineral boundaries are identifiable under high magnification of x100 mgf. Most of the muscovite is altered to sericite and green coloured chlorite occurs as distributed throughout the rock. Grains of secondary quartz are present as irregular haphazard grains. Quartz grains in general occupy the foliation planes and are probably responsible for the strength of the rock. Foliation which is discernible in the hand specimen is more prominent in the thin section.



Fig.- Mgf: X100

Fig.- Mgf: X100

2. PETROGRAPHIC STUDY OF SAMPLE NO-2:

Senders sample ID : MELLI YARD/NBH-23 A

Field name of sample, if any

: Not specified by the sender

(assigned by the sender)

Nature of the sample : Rock core Location/ Depth of the sample : 24.00-25.00m

Sample ID (ATES Lab) : RC-847

Laboratory name of the sample (assigned by the present study)

: Phyllitic Quartzite

Megascopic Study of the Sample (Study aid -naked eye & hand lens):

The given rock sample is off-white in colour with intercalation of secondary white quartz. The rock is medium to coarse grained, hard and compact and has medium specific gravity. The rock also show thin and crude foliation.



Fig.-: Rock sample

Microscopic study of the sample (Study aids – Computer interfaced high resolution polarizing microscope with photographic attachment)

A. Mineralogical Content (V. E.):

			Minera	alogical Content	t %	
SI. No.	Quartz	Muscovite/ Sericite	Chlorite	Ferruginous Material	Strained quartz of total quartz present	Undulose Extinction angle
1	59-61	12-14	22-24	3-5	*8-10	*10-12
2	58-60	14-16	20-22	4-6	*8-10	*10-12

^{*}observations are recorded only on the grains which are relatively better developed.

B. Textures and Microstructures:

It is a fine to medium grained rock in which foliation is defined by preferred orientation of muscovite and chlorite. At places quartz grains are stressed and occupy the parallelism with flaky minerals. Some quartz grains as well as flakes of mica are lying oblique to foliation of the rock. Quartz rich portions have some of the grains of quartz as secondary also and by and large the shape and size of the quartz grains varies. Grains of ferruginous material are randomly oriented and localized.



Fig.- Mgf: X100

Fig.- Mgf: X100

3. PETROGRAPHIC STUDY OF SAMPLE NO-3:

Senders sample ID MELLI YARD/NBH-24 A

Field name of sample, if any

(assigned by the sender)

Not specified by the sender

Nature of the sample : Rock core Location/ Depth of the sample : 12.00-13.00m

Sample ID (ATES Lab) : RC-855

Laboratory name of the sample

(assigned by the present study)

: Quartzitic Phyllite

Megascopic Study of the Sample (Study aid –naked eye & hand lens):

The given rock sample is light dark grey in colour with intercalation of secondary white quartz. The rock is fine grained foliated, hard and compact and has medium specific gravity. The rock has thin encrustation on its outer surface.



Fig.-: Rock sample

Microscopic study of the sample (Study aids – Computer interfaced high resolution polarizing microscope with photographic attachment)

A. Mineralogical Content (V. E.):

			Mineralog	gical Content %		
SI. No.	Quartz	Muscovite/ Sericite	Chlorite	Ferruginous Material	Strained quartz of total quartz present	Undulose Extinction angle
1	47-49	18-20	28-30	3-5	*8-10	*10-12
2	46-48	16-18	30-32	4-6	*8-10	*10-12

^{*}observations are recorded only on the grains which are relatively better developed.

B. Textures and Microstructures:

It is a fine to medium grained rock in which hazy individual mineral boundaries are identifiable under high magnification of x100 mgf. Most of the muscovite is altered to sericite and green coloured chlorite occurs as distributed throughout the rock. Foliation which is discernible in the hand specimen is more prominent in the thin section. Grains of secondary quartz are present as irregular haphazard grains. Quartz grains in general occupy the foliation planes and are probably responsible for the strength of the rock.



Fig.- Mgf: X100

Fig.- Mgf: X100

4. PETROGRAPHIC STUDY OF SAMPLE NO-4:

Senders sample ID : MELLI YARD/NBH-25 A
Field name of sample, if any : Not specified by the sender

(assigned by the sender)

Nature of the sample : Rock core Location/ Depth of the sample : 12.50-13.50m

Sample ID (ATES Lab) : RC-858

Laboratory name of the sample

(assigned by the present study)

Megascopic Study of the Sample (Study aid –naked eye & hand lens):

It is a fine grained rock, grey in colour with greenish tinge, characterized by thin phyllitic cleavage/foliation. The outer surface of the specimen has a sheen which may be occupied by fine grained mica/ sericite. It has a massive thin band of fine grained quartz, overall thinly foliated rock which has thin bands of quartz. The rock has medium specific gravity. The rock is so fine grained that no individual mineral grain is identified.



Fig.-: Rock sample

Microscopic study of the sample (Study aids – Computer interfaced high resolution polarizing microscope with photographic attachment)

A. Mineralogical Content (V. E.):

SI.		Mineralogical Content %													
No.	Quartz	Muscovite/ Sericite	Chlorite	Ferruginous Material	Strained quartz of total quartz present	Undulose Extinction angle									
1	47-49	20-22	26-28	3-5	*8-10	*10-12									
2	43-45	21-23	28-30	4-6	*8-10	*10-12									

^{*}observations are recorded only on the grains which are relatively better developed.

B. Textures and Microstructures:

It is a fine grained rock in which foliation is defined by preferred orientation of muscovite and chlorite. At places quartz grains are stressed and occupy the parallelism with flaky minerals. Some quartz grains as well as flakes of mica are lying oblique to foliation of the rock. The grains of secondary quartz are also seen at places, by and large the shape and size of the quartz grains varies. Grains of ferruginous material are randomly oriented and localized.



Fig.- Mgf: X100

Fig.- Mgf: X100