GEOTECHNICAL INVESTIGATION REPORT

FOR:

PROPOSED MATRIX TOWER (B+G+9) CHAS Dist-BOKARO JHARKHAND

CLIENT:

M/s. AYUSH CONSTRUCTIONS

March 2021

PREPARED BY:

Vishesh Lab Pvt. Ltd.
MATERIAL AND GEOTECH LABORATORY

NABL Accredited Laboratory

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P0	Geotechnical Investigation Report	0028	AA	PSC	15.03.2021
REV.	DESCRIPTION	REPORT NO	PREPARED	APPROVED	ISSUE DATE

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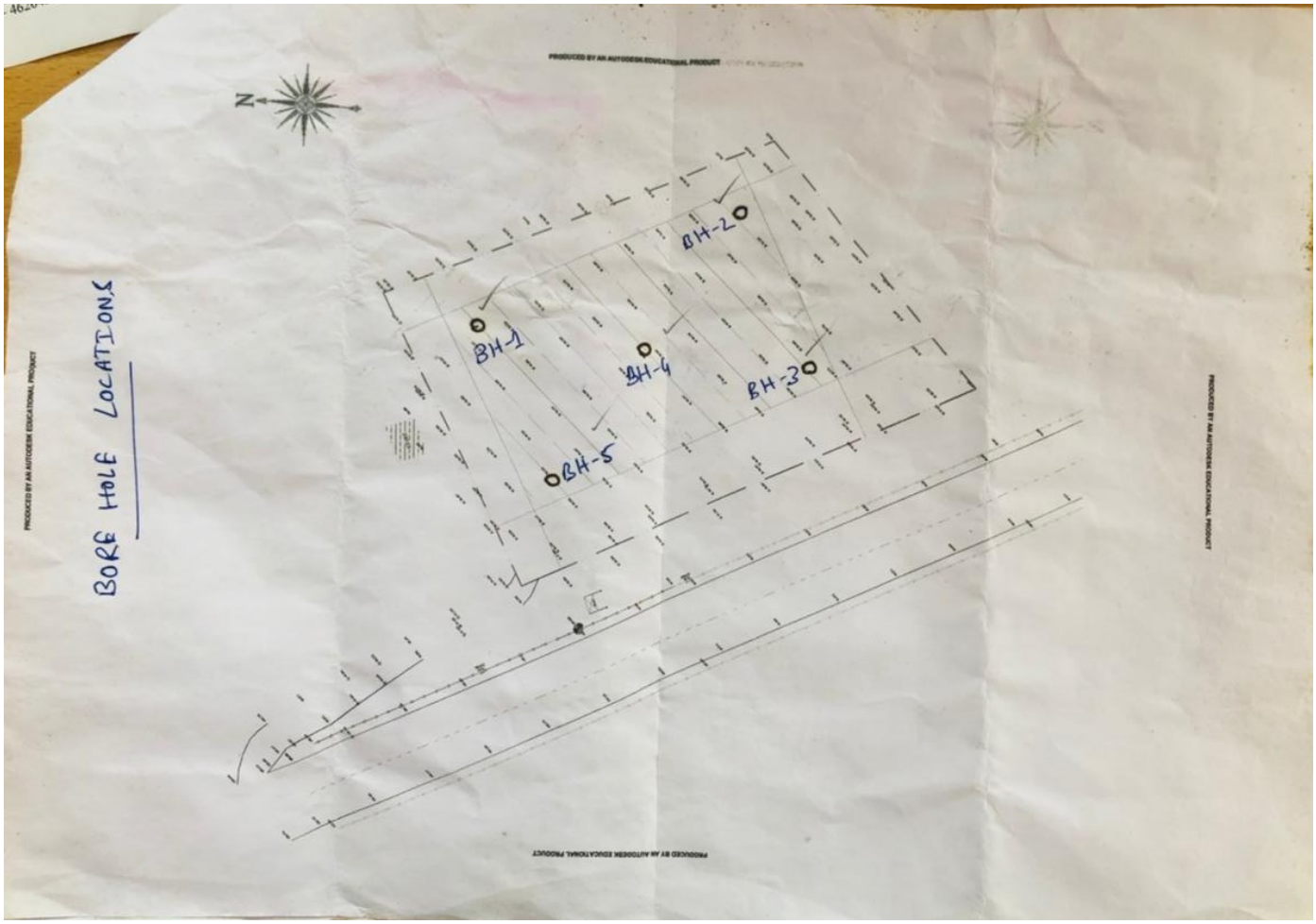
1.0 INTRODUCTION:

M/s. Ayush Constructions Proposed to construct a Proposed Matrix Tower (B+G+9) Chas Dist Bakaro Jharkhand. As a part of the project, in order to assess the sub soil profile and properties of the encountered strata M/s. Ayush Constructions entrusted the geotechnical investigation work to M/s. Vishesh Labs Pvt. Ltd. verbally communication.

1.1 SITE LOCATION:

The project site is Chas dist Bokaro, Jharkhand.



1.2 PROPOSED CONSTRUCTION:

It is proposed to Construct Matrix Tower (B+G+9) on Chas Dist - Bokaro, Jharkhand Ranchi. It is anticipated that the structures will be constructed mainly from RCC Structure.

1.3 SCOPE OF SERVICES:

"Scope of this contract covers geotechnical investigation for the proposed "Proposed Matrix Tower (B+G+9) Chas Dist - Bokaro" The overall purpose of this study is to investigate the general stratigraphy of the ground along the proposed pipeline and to verify the competency of the encountered strata to support the proposed structural elements. In this regard, the scope of includes as -

(i) Drilling of total 05 nos. of bore holes up to a maximum depth of 15m natural ground level or up to a depth of weathered or hard rock encountered with *RQD* (Rock Quality Designation)> 25%.

(ii) Conducting the standard penetration test at every 1.50m interval through soil as well as in weathered rock.

(iii) Collecting disturbed and Un-Disturbed soil samples.

(iv) Ground water table observation.

(v) Carrying out the relevant laboratory investigations on representative soil/rock samples.

(vi) Preparation of detailed geotechnical investigation report along with the suitable recommendations.

(vii) The Entire stretch of the pipe line is divided in different segment based on the location of region.

2.0 FIELD WORK:

Drilling and sampling in soil and rock was carried out using rotary drilling rig. Borehole in soil was advanced using rotary drilling method, while NX size core barrel with diamond bit was used to drill in rock. Water was circulated to cool the drilling bit. Ground water table was recorded after 24 hours of completion of drilling. On completion of drilling, soil samples were packed in plastic containers with proper identification tags. Rock cores were numbered and kept in core boxes.

Fieldwork was performed During Feb 2021. Representative of client indicated location of boreholes & details of coordinates. Following table summarizes the borehole location, its depth and other relevant information.

S. NO	BORE HOLE NO.	NORTHING (m)	EASTING (m)	R.L.	TOTAL DEPTH (m)
1.	BH-01	-	-	96.539	9.50
2.	BH-02	-	-	96.462	9.50
3.	BH-03	-	-	96.584	8.0
4.	BH-04	-	-	96.381	10.0
5.	BH-05	-	-	96.350	15.00

Table 1: Borehole Location Details

2.1 SUBSURFACE PROFILE:

Typically following type of stratum is encountered. It is possible that the stratum encountered may not be in the same order as tabulated. Details are furnished in the bore logs attached.

(i) **Stratum I**: clayey silty sand with gravel/ silty sand with gravel,

(ii) **Stratum II**: Completely to Highly weathered Rock

Thickness of each layer encountered along with SPT (Standard Penetration Test – *N* value) or *RQD* range as the case may be at the locations is tabulated below. It shall be noted that the stratum listed below may not be encountered is the same order as listed.

BH. NO.	LAYER I		LAYER II	
	THICK (m)	SPT N	THICK (m)	RQD %
BH-01	6.00	15 - <100	3.50	0
BH-02	4.50	<100	5.00	0
BH-03	4.50	<100	3.50	0
BH-04	1.50	<100	8.50	0-20
BH-05	6.00	35 - <100	9.00	0-25

Table 2: Subsurface Profile

(Above classification is based on driller's comments, our experience of the area and values of core recovery and Rock Quality Designation. They should not be considered for classifying rock from ease of excavation or payment point of view)

2.2 WATER LEVEL:

Water level was encountered in each boreholes . Correct method to determine ground water table is to install standpipe Piezometer and monitor over a long period. Following table show water level observed after 24hr.

BHNO.	WATER LEVEL (m)
BH-01	1.00
BH-02	1.00
BH-03	1.00
BH-04	1.00
BH-05	1.00

Table 3: Water Level in Boreholes

3.0 ENGINEERING ANALYSIS:

Engineering analysis of the subsoil was performed to determine net safe bearing capacity. Parameters obtained are based on various field and laboratory tests.

Engineering analysis of the subsoil was performed to determine net safe bearing capacity. Parameters obtained are based on various field and laboratory tests.

Rock is encountered at variable depth. It is considered that isolated pad foundation shall be used.

Two alternate foundations systems are considered.

Alternate I: Foundations placed on silty sandy clay

Alternate II: Foundations placed on rock

Following formula are used.

3.1 ALTERNATE I: FOUNDATIONS PLACED ON SILTY SAND/ CLAYEY SAND

3.1.1. BEARING CAPACITY CALCULATION FROM SHEAR FAILURE CONSIDERATION

Ultimate bearing capacity = $qu = C\ N\ C\ S\ C + q\ (Nq - 1)\ Sq + 0.5\ \gamma\ B\ N\ \gamma\ S\gamma$

Where, C = Cohesion and ϕ = angle of internal friction

Nq, Nγ bearing capacity factors based on ϕ

Sc, Sq, Sγ Shape factors based on ϕ

q = Overburden stress at the bottom of the foundation

γ = Unit weight of subsoil

B = Width of foundation.

3.1.2 SETTLEMENT FOR OPEN FOUNDATIONS

The magnitude of settlement, when foundation loads are applied, depends upon the compressibility of the underlying strata and rigidity of the substructure. In cohesive deposition, the post construction settlement is caused by dissipation of pore pressures and hence is time dependent so that consolidation settlement is computed for such soils using Terzaghi's one-dimensional consolidation theory. The immediate settlements in clays are estimated using the elastic theory considering the effect of a rigid stratum underlying the foundation soils (Reference: "Foundation Analysis and Design" by J.E.Bowles). The immediate settlements in cohesion-less soil are estimated using elastic theory as mentioned above or using SPT value as per IS: 8009 (Part 1).

Settlement analysis has been performed based on S.P.T values in accordance with Clause 9. 1. 4 of I.S 8009 (Part-1) – 1976 RA Fig.9.

3.2 FOUNDATIONS PLACED ON COMPLETELY WEATHERED ROCK/ HIGHLY WEATHERED ROCK

(i) Reference to "*IS 12070: Design and construction of shallow foundation on rocks*" and "*IS 13365 (Part I): Quantitative classification system of rock mass*". *RMR* (Rock Mass Rating) of the stratum at foundation depth is determined. Based on the *RMR*, *IS12070* recommends safe bearing capacity value. According to *IS 12070*, allowable pressure will result (in raft up to 6m thickness) in settlement less than 12mm.

Depth of influence of one width is considered for foundations placed on rock. Calculation might indicate that higher bearing capacity is possible but lower value is recommended since water loss is noticed in the boreholes and *RQD* is reducing with depth in few boreholes.

IS 12070 does not mention width or size and shape of foundation for calculating *NSBC*. Also, in the referred IS code there is no mention of immediate settlement.

Whenever foundations are placed on rock, it is sound engineering practice to embed foundations for minimum 50cm in rock.

(ii) Net safe bearing pressure as based on classification.

(iii) Net safe bearing pressure as based on uniaxial compression strength/ point load index strength.

4.0 CONCLUSIONS & RECOMMENDATIONS:

Net safe bearing capacity for foundations placed at different depth below the ground surface existing at the time of investigation is tabulated below.

BH NO	DEPTH (M)	STRATIFICATION AT FOUNDATION DEPTH	NET SAFE BEARINGCAPACITY (T/m^2)
BH-01	3.00	Yellowish Clayey silty Sand with gravel	29
	4.00	Yellowish Clayey silty Sand with gravel	30
BH-02	3.00	Yellowish Clayey silty Sand with gravel	29
	4.00	Yellowish Clayey silty Sand with gravel	30
BH-03	3.00	Yellowish Clayey silty Sand with gravel	29
	4.00	Yellowish Clayey silty Sand with gravel	30
BH-04	3.00	Yellowish Clayey silty Sand with gravel	29
	4.00	Yellowish Clayey silty Sand with gravel	30
BH-05	3.00	Yellowish Clayey silty Sand with gravel	29
	4.00	Yellowish Clayey silty Sand with gravel	30

Table 4: Net Safe Bearing Capacity

Conclusions and Recommendations are based on following accepted norms.

(i) Foundations should not fail in shear. Factor of safety of 3.0 is provided against bearing capacity failure for foundations placed on silty clay/ silty sand.

(ii) Anticipated settlements should be less than allowable value of 25mm for foundations placed on silty clay/ silty sand.

(iii) For foundations placed on rock, it is essential to ensure that there are no loose pockets on rock surface. In case of loose pockets or over excavation, it shall be filled by plain cement concrete.

(iv) **Estimate of Magnitude and Rate of Settlement of Proposed Foundations:** Since foundations are placed on rock, time dependant settlements are not anticipated. About 95% settlement is expected during initial loading.

(v) **Behaviour of Foundations under Seismic Conditions:** According to *IS 1893* Ranchi are located in zone II. Liquefaction is likely to happen in presence of high ground water table and sand. In case the stratification consists of silt / silty clay, liquefaction is not likely. In

zone III as per table 1 desirable minimum filed, SPT *N* should be >5 upto5m depth. Since foundations are placed on rock chances of liquefaction does not exist.

(vi) **Recommendations for Road:** In order to provide recommendations for road/ pavement it is necessary to collect bulk samples & perform relevant tests in the laboratory. This was not in present scope of work hence no recommendations are provided. However based on our experience at majority of the locations flexible pavement can be designed for CBR of 12 except locations where black cotton soil is encountered.

(vii) **Recommendations Regarding Any Special Construction Procedure:** Foundations shall be constructed as per relevant IS code.

(viii) **Recommended Side Slopes For Cutting And Embankment:** It is advisable to provide suitable slope protection method to keep sides of deep excavation from sloughing. Side slopes will depend on actual site condition & extent of ingress of water. Safe Slopes for excavated surfaces as below: -

a. Slightly weathered to Fresh Rock -0.25H to 1.0V
b. Highly to moderately weathered Rock -0.50 H to 1.0V
c. Completely disintegrated Rock as murrum -1.00 H to 1.0V
d. Silty Clay / sandy clayey silt -1.50 H to 1.0V

(ix) **Special Precautions:** It is essential to ensure that trees and other landscaped area will be about 3m away from the Pump house boundary.

(x) Modulus of subgrade reaction

This is determined by performing plate load test. Following values are recommended based on standard references. Values in Kg/cm3

Granular soil

CONSISTENCY	LOOSE	MEDIUM	DENSE
Dry or moist sand	1.3	4.2	16.0
Submerged sand	0.8	2.5	9.6

Recompressed clays

CONSISTENCY	STIFF	VERY STIFF	HARD
Modulus of subgrade reaction	2.4	4.8	9.6

5.0 TYPICAL CALCULATIONS FOR SAFE BEARING CAPACITY

SBC CALCULATION				
Name of project	Soil Investigation for Proposed to construct a Proposed Matrix Tower (B+G+6) Chas (Bokaro) Dhanbaad.			
Location	(Bokaro) Dhanbaad			
Design as per	IS :6403-1981 CLAUSE NO 5.2			
VOID RATIO:- Void ratio of a soil mass is defined as the ratio of volume of voids to the volume of solids.				
As per Fig.1 of IS: 6403-1981, the Ø value for N>50 is 41°00', As per classification, adapting Ø as 32°00' .				
In Case for SPT Sample	Qd = q*(Nq-1)*sq*dq*iq + 0.5*B*Y*Nr*sr*dr*ir*W'			
Qd =	**ULTIMATE BEARING CAPACITY IN (t/ m^2)**			
Ø =	Angle of internal friction of soil in (degree)			32.00
D_f =	Depth of foundation in (m)			3
ϒ =	Unit Weight of subsoil in submerged condition in (t/m^3)			0.8
q =	Effective Surcharge =(ϒ *df) in absence of external surcharge.df refers to depth of footing in (t/m^2) where ϒ			2.4
B =	Width/daimeter of footing in (m)			2
L =	Length of footing in (m)			2
N_q =	Bearing capacity factors due to cohesion, surcharge and weight of subsoil			24.36
N_r =	Bearing capacity factors due to cohesion, surcharge and weight of subsoil			32.652
s_q =	Shape factor for square footing =			1.2
s_r =	Shape factor for square footing =			0.60
DEPTH FACTORS CALCULATION				
√NQ =	$\sqrt{\tan^2(\pi/4+Ø/2)}$ =	tan(45 + Ø/2) =	tan(45 + Ø/2) =	1.8040
d_c =	(1+ (0.2)*(Df/B)*(√ NØ)			1.5412
d_q =	d_r =	1	FOR Ø < 10^0	1
d_q =	d_r =	1+ (0.1*D_f/B)*√ NØ	FOR Ø > 10^0	1.2706
i_c =	i_q =	$(1- a/90)^2$		1
i_r =		$(1 - a/Ø)^2$		1
W' =	Water table effect			0.5
q'd =q*(Nq-1)*sq*dq*iq + 0.5*B*Y*Nr*sr*dr*ir*W'				95.44
considering factor of safty (FOS)			3	
SAFE BEARING CAPACITY IN (t/ m^2) =			31.81	
Therefore Safe Bearing Capacity say,		**29**	**t/m2**	
Note: As per IS-1904-1986,The permissible Settlement for Isolated resting on sand and hard clay is 50mm, Fig 9 of IS 8009-Part I(checking for 25mm settlement), Considering above N Value 50 and width of the footing 2.00 m and depth factor 0.85 and water table effect 0.5, the foundation settlement per unit pressure i.e. 10 T/m2 is 4.9 mm. So for 29 t/m^2 bearing pressure, settlement would be about 24.16 mm (which is less than maximum permissible settlement 50mm)				

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APPENDIX A: LIST OF IS CODES REFERRED IN THE REPORT

A1. FIELD TESTS

Drilling and sampling in soil and rock	IS 1892
Standard Penetration test	IS 2131

A2. LABORATORY TESTS

Sample preparation	IS 2720 (Part I)
Moisture content	IS 2720 (Part II)
Sieve analysis	IS 2720 (Part IV)
Liquid and Plastic limit	IS 2720 (Part V)
Soil classification	IS 1498
Direct shear test	IS 2720 (Part XIII)
Consolidation test	IS 2720 (Part XV)
Unconfined compression on rock	IS 9143
Unit weight / density of rock	

APPENDIX B: BORE LOGS

DRILL HOLE # BH-01

Project No. 0028
Date: 11/03/2021

CLIENT **:** M/s Ayush Construction

PROJECT : Geotecnical Investigation for proposed Matrix Tower Chas (BOKARO)

Co-ordinates: ***Elevation:*** 96.539 ***Core:*** Nx ***Date Hole Started:*** 16/02/2021

Logged By: ***Water Level:*** 1M ***Drilling Method:*** Rotary ***Finished:*** 19/02/2021

Depth (m)	Run	Sample no.	Symbols	LITHOLOGIC DESCRIPTION	Elevation (RL)	SPT N Value	SPT GRAPH 0 20 60 100	Core Recovery %	RQD%	LABORATORY TEST RESULTS: Gravel %	Sand %	Silt + Clay %	Liquid Limit	Plastic Limit	Plasticity Index	Freeswell Index	C	Phi	Classification	UCS (Kg/cm2)
1		DS		***SC*** Clayey sands, sand-clay mixtures.																
		SPT-1				15				5.1	64.1	30.9	31.9	17.5	14.4				SC	
2		WS																		
3		SPT-2				>100				7.8	70.8	21.4	34.1	18.5	15.6				SC	
4		WS																		
		SPT-3				>100														
5		WS																		
6					90.54 6.00															
				W5 Completely Disintegrated weathered granitic gneiss				7.0													
7																				
8								13												
9								71												
					87.04 9.50															
10				End of Borehole																

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DRILL HOLE # BH-02

Project No. 0028
Date: 11/03/2021

CLIENT **:** M/s Ayush Construction

PROJECT : Geotecnical Investigation for proposed Matrix Tower Chas (BOKARO)

Co-ordinates: ***Elevation:*** 96.462 ***Core:*** Nx ***Date Hole Started:*** 20/02/2021

Logged By: ***Water Level:*** 1M ***Drilling Method:*** Rotary ***Finished:*** 21/02/2021

Depth (m)	Run	Sample no.	Symbols	LITHOLOGIC DESCRIPTION	Elevation (RL)	SPT N Value	SPT GRAPH 0 20 60 100	Core Recovery %	RQD%	LABORATORY TEST RESULTS										
										Gravel %	Sand %	Silt + Clay %	Liquid Limit	Plastic Limit	Plasticity Index	Freeswell Index	C	Phi	Classification	UCS (Kg/cm2)
1		DS		***SC*** Clayey sands, sand-clay mixtures.																
2		SPT-1				>100														
		WASH																		
3		SPT-2				>100				3.4	67.7	28.8	33.1	18.7	14.3				SC	
4		WASH			91.96 4.50															
5		SP		***W5*** Completely Disintegrated weathered granitic gneiss				5	0											
6		SP						7	0											
7																				
8		SP						10	0											
9		SP			86.96 9.50			28	0											
10				End of Borehole																

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DRILL HOLE # BH-03

Project No. 0028
Date: 11/03/2021

CLIENT **:** Krithika consultants

PROJECT : Geotecnical Investigation for proposed Matrix Tower Chas (BOKARO)

Co-ordinates: ***Elevation:*** 96.584 ***Core:*** Nx ***Date Hole Started:*** 22/02/2021

Logged By: ***Water Level:*** 1M ***Drilling Method: Rotary*** ***Finished:*** 23/02/2021

Depth (m)	Run	Sample no.	Symbols	LITHOLOGIC DESCRIPTION	Elevation (RL)	SPT N Value	SPT GRAPH 0 20 60 100	Core Recovery %	RQD%	LABORATORY TEST RESULTS: Gravel %	Sand %	Silt + Clay %	Liquid Limit	Plastic Limit	Plasticity Index	Freeswell Index	C	Phi	Classification	UCS (Kg/cm2)
1		DS		***SC*** Clayey sands, sand-clay mixtures.																
		SPT-1				>100														
2		WASH																		
3		SPT-2				>100				1.6	61.0	37.3	36	18.5	17.4				SC	
4		WASH			92.08															
					4.50															
5		SP		***W5*** Completely weathered granaitc Gneiss				6												
6		SP						10												
7		SP						34												
8					88.58															
				End of Borehole	8.00															
9																				
10																				

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DRILL HOLE # BH-04

Project No. 0028
Date: 11/03/2021

CLIENT **:** M/s Ayush Construction

PROJECT : Geotecnical Investigation for proposed Matrix Tower Chas (BOKARO)

Co-ordinates: ***Elevation:*** 96.381 ***Core:*** Nx ***Date Hole Started:*** 24/02/2021

Logged By: ***Water Level:*** 1M ***Drilling Method:*** Rotary ***Finished:*** 25/02/2021

Depth (m)	Run	Sample no.	Symbols	LITHOLOGIC DESCRIPTION	Elevation (RL)	SPT N Value	SPT GRAPH 0 20 60 100	Core Recovery %	RQD%	LABORATORY TEST RESULTS										
										Gravel %	Sand %	Silt + Clay %	Liquid Limit	Plastic Limit	Plasticity Index	Freeswell Index	C	Phi	Classification	UCS (Kg/cm2)
1		DS		***SC*** Clayey sands, sand-clay mixtures.	94.88															
					1.50															
2		SPT-1		***W5*** Completely weathered granatic gneiss		>100	•			0.9	69.3	29.9	34.1	18.6	15.6				SC	
		SP						19												
3																				
		SP						32												
4																				
5		1-6						20	0											
6																				
		7-14						50	12											
7																				
8		15-20						55	18											
9																				
		21-25						40	20											
10					86.38 10.00															

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DRILL HOLE # BH-05

Project No. 0028
Date: 11/03/2021

CLIENT **:** M/s Ayush Construction

PROJECT : Geotecnical Investigation for proposed Matrix Tower Chas (BOKARO)

Co-ordinates: ***Elevation:*** 96.350 ***Core:*** Nx ***Date Hole Started:*** 25/02/2021

Logged By: ***Water Level:*** 1M ***Drilling Method:*** Rotary ***Finished:*** 27/02/2021

Depth (m)	Run	Sample no.	Symbols	LITHOLOGIC DESCRIPTION	Elevation (RL)	SPT N Value	SPT GRAPH 0 20 60 100	Core Recovery %	RQD%	LABORATORY TEST RESULTS										
										Gravel %	Sand %	Silt + Clay %	Liquid Limit	Plastic Limit	Plasticity Index	Freeswell Index	C	Phi	Classification	UCS (Kg/cm2)
1		DS		***SC*** Clayey sands, sand-clay mixtures.																
2		SPT-1				35				3.1	54.7	42.2	34.2	18.6	15.6				SC	
		WASH																		
3		SPT-2				>100														
4																				
5		SPT-3				>100														
6		SPT-4		***W5*** Completely weathered grantic Gneiss	90.35 6.00	>100														
7								0												
8								5												
9								5												
10								10												
11																				
12								20												
13																				
14								25												
15					81.35 15.00															

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APPENDIX C: LABORATORY TEST RESULTS

Vishesh Lab Pvt. Ltd.
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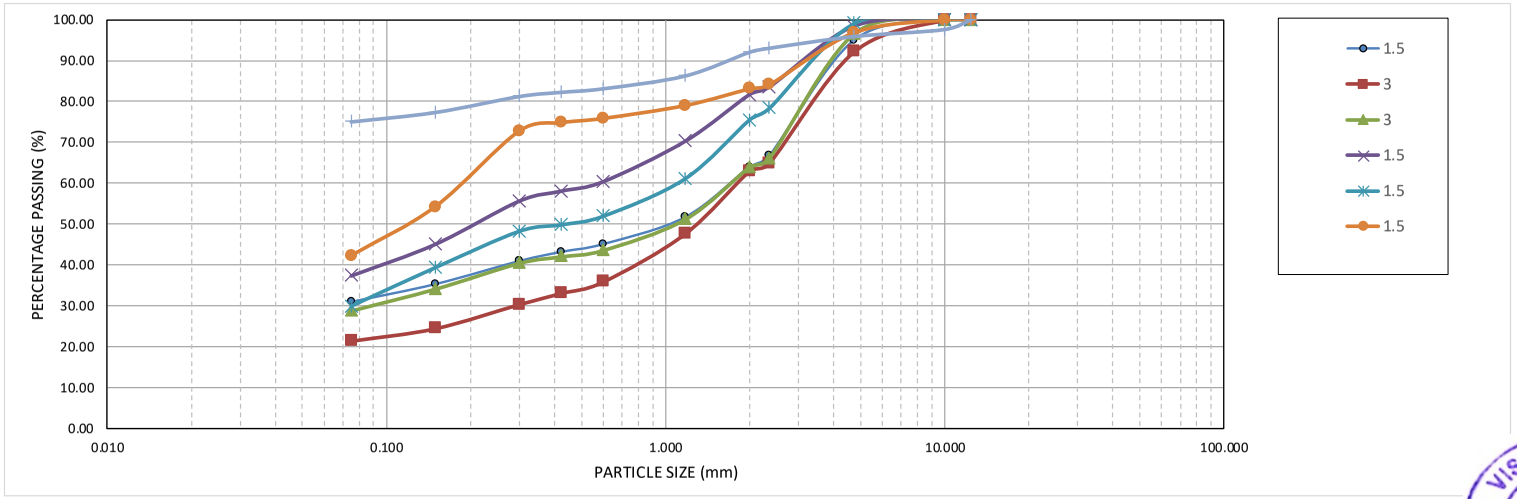
PROPOSED MATRIX TOWER (B+G+9) AT CHAS DIST – BOKARO JHARKHAND

Summary of Soil Test Results

Client:	**M/s. Ayush Constructions**	**Report No.**	**28**
Project:	**Geotechnical Investigation for Proposed construct a Matrix Tower (B+G+6) Chas (Bokaro) Dhanbaad.**		

			IS:2720(P29)		*IS:2720(P2)*	*IS:2720(P5)*			*IS:2720(P4)*			*IS:2720(P40)*	*IS:2720(P13)*		*IS:1498*
BH No.	**Sample Type**	**Depth (m)**	**Bulk Density**	**Dry Density**	**Moisture Content**	**Liquid Limit**	**Plastic Limit**	**Plasticity Index**	**Grain Size Analysis**			**Free Swell Index**	**Cohesion**	**Angle of Internal Friction**	**IS Classification**
			gm/cm^3	gm/cm^3	%	%	%	%	% Gravel	% Sand	% Silt/Clay	%	kg/cm^2	degree	-
1	SPT	1.5	-	-	-	31.9	17.5	14.4	5.1	64.1	30.9	-	-	-	SC
1	SPT	3	1.817	1.67	8.74	34.1	18.5	15.6	7.8	70.8	21.4	-	-	-	SC
2	SPT	3	-	-	-	33.1	18.7	14.3	3.4	67.7	28.8	-	-	-	SC
3	SPT	1.5	1.845	1.584	16.43	36.0	18.5	17.4	1.6	61.0	37.3	-	-	-	SC
4	SPT	1.5	-	-	-	34.1	18.6	15.6	0.9	69.3	29.9	-	-	-	SC
5	SPT	1.5	-	-	-	34.2	18.6	15.6	3.1	54.7	42.2	-	-	-	SC

PARTICLE SIZE DISTRIBUTION CURVE



For Vishish Lab

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