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A
Report on
Subsoil investigation for Construction of
Residential Building
At
Ward No. – 02
Khata No.-172, Plot No.-773
(LAND – 10.5 DECIMAL)
Chanakyapuri, Chira Chas
Bokaro, Jharkhand

Submitted to: Smt Reeta Rana & Vinod Kumar Rabi

Executed by:

ELITE LABORATORY

SOIL & MATERIAL ANALYSIS CENTRE

A NABL ACCREDITATED LABORATORY
ISO/IEC 17025:2017, ISO 9001:2015

Laboratory Address:
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BITT)

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CHAPTER - 1
INTRODUCTION

1.1 In an attempt to facilitate the design of the proposed new construction of the foundation structure.

Subject: - Residential Building at Ward No. – 02 Khata No.-172, Plot No.-773 (LAND – 10.5 DECIMAL) Chanakyapuri, Chira Chas Bokaro, Jharkhand

A subsoil investigation work was programmed by the authority and for this work; the service is executed by ELITE LABORATORY, Ranchi

LAB Address: *Road no -05, Indrapuri, Ratu road, Ratu, Ranchi-834005, Jharkhand. (Near BITT)*

TO,
SMT REETA RANA & VINOD KUMAR RABI

1.2 The scope of the soil investigation consisted of making **03 nos**. of bore holes at this site.

1.3 The formation at the site is to be reported for various layers presented at their respective depth along with their thickness. This would also include the subsoil properties for each stratum so as to come up with the design parameters for designing foundations, the depth of foundation and the selection of type of foundation. As the ground water table location influences the bearing capacity of a foundation and the method of construction of a foundation at the site, its location has also to be found.

1.4 Soil samples in disturbed condition are collected. These samples would be taken to the laboratory for different laboratory tests to obtain various properties of sub-soil formation.

1.5 The exploration of the sub-soil formation being limited to **03 nos**. bore holes it is suggested that due weighted is given to the unexplored part of the area at the time of selecting design parameter.

CHAPTER – 2

PROJECT DETAILS

2.1 The fieldwork consisted of **03 nos**. of bore hole at pre-determined location. The detail of fieldwork like depth of bore hole, date of the fieldwork of site are presented below in tabular form.

Bore hole/Test no.	Depth of bore hole (m)	Date of commencement.	Date of completion.	Depth of water table.(m)
BH -1	4.0	22.12.2020	22.12.2020	NO WATER
BH -2	3.5	22.12.2020	22.12.2020	TABLE
BH -3	3.0	22.12.2020	22.12.2020	ENCOUNTERD

The fieldwork also included collection of disturbed and undisturbed soil samples and conducting standard penetration tests at regular intervals.

2.2 The bore holes of 150mm diameter (SX size) are initially sunk by auger boring up to the water table.

CHAPTER – 3

LABORATORY TESTING

The following tests were performed in the laboratory adopting standard practice. The tests were conducted as per relevant **IS Specifications**

SOIL

Sl no.	Description of test for Soil.	IS Code referred
1.	Natural moisture content.	IS:2720 (Part 2)-1973
2.	Grain size analysis.	IS:2720 (Part 4)-1985
3.	Atterberg's limit.	IS:2720 (Part 5)-1985
4.	Specific gravity.	IS:2720 (Part 3)-1980
5.	Direct Shear Test.	IS:2720 (Part 13)-1983

CHAPTER - 4

FOUNDATION DESIGN ASPECTS

A suitable foundation for any structure should have an adequate factor of safety exceeding the bearing capacity of the supporting soils. Also the vertical movements due to compression of the soil should be within tolerable limit for the structure. The foundations in accordance with the recommendations herein will satisfy these criteria.

4.1 FOUNDATION DESIGN CRITERIA

The maximum permissible total settlement and differential for the foundation settlement is governed by the technical requirements of the structure and is usually specified by the user.

4.2 BEARING CAPACITY OF SHALLOW FOUNDATION

Bearing capacity analysis for shallow foundations has been done in accordance with IS: 6403-1981. The following equation has been used for the analysis.

$$q_{net\ safe} = 1/F(CN_cS_cD_c + p(N_q-1)S_qD_q + 0.5B\,\gamma N_\gamma S_\gamma D_\gamma R_w)$$

Where

$q_{net\ safe}$ = Safe net bearing capacity of soil based on the shear failure criteria

C = Cohesion of clay

γ = Unit weight of soil

p = Overburden pressure

B = Width of foundation

R_w = Water table correction factor

F = Factor of safety

N_c, N_q, N_γ = Bearing capacity factors

S_c, S_q, S_γ = Shape factors

D_c, D_q, D_γ = Depth factors

All the Bearing capacity factors, Shape factors and depth factors have been considered as IS: 6403-1981, Table -1 clause - 5.1.1, 5.1.2.1 and 5.1.2.2 respectively.

CHAPTER – 5
GENERAL SITE CONDITIONS

5.1 GENERAL DESCRIPTION
The boring has been done as per the approved layout plan. The sub-soil formation has been investigated by sinking **03 nos.** of boreholes explored up to a suitable depth

5.2 GENERAL GEOLOGY
There are three well-defined seasons in region. The cold-weather season, from November to February, is the most pleasant part of the year. Lowest temperature in Jharkhand lies between -5°C to 0°C. High temperatures in December usually rise from about 50 °F (10 °C) into the low 70s F (low 20s C) daily. The hot-weather season lasts from March to mid-June. May, the hottest month, is characterized by daily high temperatures in the upper 90s F (about 37 °C) and low temperatures in the mid-70s F (mid-20s C). Maximum rainfall takes place during the months from July to September that accounts for more than 90% of total rainfall in the state.

5.3 SUB-SURFACE CONDITIONS
The field investigation data and the results of laboratory tests conducted on the samples collected from the **bore holes in general reveal similar stratification**.

The detailed soil profile and various soil layers have been provided in the soil profile attached. The soil strata are Sandy to very stiff to the depth explored.

The Bore logs in the annexure present the detailed Stratigraphy, cross sections and nature of soil at the borehole locations.

5.4 GROUND WATER CONDITIONS

During the current subsurface exploration ground water was not found up to the depth of exploration in the site. It should be noted that these observations reflect groundwater levels at the time of the field investigation and actual groundwater levels may fluctuate significantly in response to seasonal effects, regional rainfall, and other factors not observed during this investigation. There may be regional or perched water tables at greater depth. However, for the design purposes the ground water level has been considered at footing level as the ground water level may rise in peak rainy season/ due to unforeseen reasons.

5.5 REGIONAL SEISMICITY

The intensity of an earthquake at a place is a measure of the strength of shaking during the earthquake, and is indicated by a number according to the modified Mercalli Scale or M.S.K. Scale of seismic intensities

The Zone factors 'Z' for various Seismic zones as per IS: 1893 (P-1)-2002 is as follows:

Seismic Zone	II	III	IV	V
Seismic Intensity	LOW	MODERATE	SEVERE	**VERY SEVERE**
Z	**0.10**	**0.16**	**0.24**	**0.36**

The area falls under Zone-III as classified by Bureau of Indian Standards, Indicating low active zone.

5.6 LIQUEFACTION

Liquefaction is a state in saturated cohesion less soil wherein the effective shear strength is reduced to negligible value for all engineering purpose due to pore pressure caused by vibrations during an earthquake when they approach the total confining pressure. In this condition the soil tends to behave like a fluid mass.

Typically, cyclic loading of saturated soils leads to the buildup of excess pore-water pressure as a result of soil particles being rearranged with a tendency toward denser packing. Under undrained conditions (such as during earthquake shaking), loads are transferred from the soil skeleton to the pore-water with consequent reduction in the soils' shear strength.

Liquefaction-induced ground settlement and lateral spreading have been the primary cause for extensive damage to aboveground structures, foundations and pipelines during many

earthquakes.

CHAPTER - 6

SOIL PROFILE & RECOMMENDATION

From the exploratory bore holes at the site it is observed that sub soil formation at this site consists of cohesive soil at surface layer below. Details of the formations along with the "N" values are shown in the field bore log data sheets.

Since the sub soil formation below the founding level consists of decomposed rock product Bearing Capacity has been computed based on N value and in guidance with figure-1 and table -1 of IS: 6403-1981. However, based on calculation the following bearing capacities for **SQUARE** are recommended.

SOIL

LOCATION	SHAPE		DEPTH OF FOUNDATION	TYPE OF FOUNDATION	EGL OF BORE HOLE TOP TO BOTTOM(m)	EGL OF FOUNDATION LEVEL(m)	RECOMMENDED NET ALLOWABLE BEARING PRESSURE (t/m2)
	L	B					
CHANAKYAPURI, CHIRA CHAS BOKARO, (JHARKHAND)	**3**	**3**	**1.5**	**SQUARE**	**100**	**98.5**	**18.7**
	3	**3**	**2.0**		**100**	**98.0**	**21.2**
	3	**3**	**2.5**		**100**	**97.5**	**23.8**
	3	**3**	**3.0**		**100**	**97.0**	**26.4**

(Authorized Signatory)

Date:-

CHAPTER-7

SAMPLE CALCULATION OF BEARING CAPACITY OF SHALLOW FOUNDATION

The determination of the **net safe bearing capacity**, q_{ns}, is done first on the basis of the shear failure criterion after dividing the value of the **net ultimate bearing capacity qnf**, calculated as described below, by a suitable factor of safety. The **net soil pressure, q_s**, for a given permissible settlement is then calculated as explained in the next section. The lower of the two values, q_{ns} and q_s, thus determined is taken as the **allowable bearing capacity** of the soil.

1. Shear Failure Criterion. The **net ultimate bearing capacity qnf** (t/m^2) of a shallow foundation of breadth B (m) and depth D (m) is given as per IS: 6403-1981 (Sec.5.1.2) by the following equation:

$$q_{nf} = c\,N_c\,s_c\,d_c\,I_c + q\,(N_q - 1)\,s_q\,d_q\,I_q + 0.5\,\gamma\,B\,N_\gamma\,s_\gamma\,d_\gamma\,I_\gamma\,w$$

Where c = cohesion (t/m^2)

q = effective surcharge (t/m^2)

γ = unit weight of subsoil (t/m^3)

N_c, N_γ, N_q = bearing capacity factors, which are functions of ϕ, the angle of internal friction of the soil

s_c, s_q, s_γ = shape factors } related to cohesion, surcharge and density of subsoil respectively

d_c, d_q, d_γ = depth factors }

I_c, I_q, I_γ = inclination factors

w = water table factor (= 0.5 to 1.0) depending on the depth, D_w of water table- vide Table below.

The bearing capacity factors (N's) are functions of ϕ, the angle of internal friction of the soil. Their values are found for general shear failure by referring to standard tables. If subsoil conditions are such as to lead to local shear failure, the values of these factors are found for a reduced value of angle of internal friction (ϕ') given by the equation: $\tan \phi' = 0.67 \tan \phi$. The value of cohesion is also reduced to $c' = 0.67\,c$.

The values of the other factors for usual conditions are as tabulated below:

s_c =	1.3	1+0.2B/L	1	d_c =	$1+0.2\,(Nf)^{0.5}\,D/B$	D_w at G.L.	Fou'dn.Level
s_q =	1.2	1+0.2B/L	1	$d_q = d_\gamma$ =	1 for $f<10^o$	w = 0.5	1
s_g =	0.8//0.6	1-0.4B/L	1	$d_q = d_\gamma$ =	$1+0.1\,(Nf)^{0.5}\,D/B$ for $f>10^o$	Interpolation between these values	is linear.
FOR	sq.//	O Rect.	STRIP	I_c, I_q, I_γ = 1 for vertical load			

In the present case, the representative values of cohesion © and angle of internal friction

(ϕ) of the soil may be obtained from the soil data given earlier.

6.1 OPEN FOUNDATION

For satisfactory performance of a foundation, the following criteria must be satisfied:

(i) The foundation must not fail in shear.

(ii) The foundation must not settle by an amount more than the permissible settlement.

6.1.1 The allowable bearing capacity shall be taken as either of the following, whichever is less:

a) Net ultimate bearing capacity as obtained divided by suitable factor of safety, that is, net safe bearing capacity.

6.1.2 The net soil pressure that can be imposed on the base without the settlement exceeding the permissible values as given in IS: 1904-1978* to be determined for each structure of type of Soil, that is, safe bearing pressure.

Types of soil formations are specified in IS: 1904-1978. The methods for calculations of settlements for assumed pressure from standard penetration resistance are specified in IS : 8009 (Part I)- 1976; by calculating the settlements for two or three probable soil pressure and interpolating , the net soil pressure for permissible settlement may be estimated.

ALLOWABLE BEARING PRESSURE OF OPEN FOUNDATIONS FROM SHEAR FAILURE METHOD AS PER IS:6403-1981:

IS Code (IS:6403-1981), (Sec.5.1.2) recommends a bearing capacity equation which is similar in nature to those given by Meyerhof and Brinch Hansen . The **net ultimate bearing capacity** of a shallow foundation of breadth B (m) is given as per the IS code by the equation:

$$Qnf=cNc.\ Sc\ .dc.ic + q(Nq-1).sq.dq.iq + \tfrac{1}{2}.B.\gamma.N\gamma.s\gamma.d\gamma.i\gamma.W'$$

The net safe bearing capacity, qns = (qnf/factor of safety)

Where c= cohesion (t/m^2)

q= effective surcharge at the base level of foundation (t/m^2)

γw= Unit weight of subsoil (t/m^2)

B=breadth of footing:

L= length of footing

ϕ=angle of internal friction of soil

Df=depth of foundation

Nc, Nq, Nγ=Bearing capacity factors given in relevant tables for general shear failure.

for obtaining Nc', Nq', Nγ' corresponding to local shear failure a reduced value of $\phi'=\tan^{-1}(0.67 \text{ Tan } \phi)$ and corresponding values are taken for Nc, Nq, Nγ.

Sc, Sq,Sγ=Shape Factors

dc, dq, dγ=depth factors

ic,iq,iγ=inclination factors

W' water table factor (=0.5 for water table at the footing level & 1.0 for water table at depth B below the footing, to be obtained by linear interpolation).The values of the other factors are as tabulated below:

Shape factor	Sq./circ.	Rect.	Strip	dc=1+0.2(Df/B)(Nφ)0.5
Sc	1.3	1+0.2B/L	1.0	dq=dγ=1φ<10
Sq	1.2	1+0.2B/L	1.0	dq=dγ=1+0.1(Nφ)0.5 for φ>10
Sγ	0.8/0.6	1-0.4B/L	1.0	Ic=iq=iγ=1.0 for vertical loading

The net safe bearing capacity values calculated as above have to be checked for settlement in order to arrive at the net allowable bearing capacity values.

CHAPTER – 8
LABORATORY TEST RESULT

SOIL

MARK	DEPTH	PARTICLE SIZE DISTRIBUTION (%)			ATTERBERG'S LIMIT			NMC (%)	SPECIFIC GRAVITY	SHEAR STRENGTH	
		GRAVEL (%)	SAND (%)	SILT & CLAY (%)	LL (%)	PL (%)	PI (%)			C (Kg/cm^2)	Ø (degree)
BH 1	0.0 m to 4.0 m	9.25	40.36	50.39	19.58	10.23	9.35	12.54	2.610	0.12	23.8°
BH 2	0.0 m to 3.5 m	6.35	52.31	41.34	26.34	NP		17.85	2.534	0.03	27.5°
BH 3	0.0m to 3.0 m	11.54	51.52	36.94	24.87	NP		15.36	2.489	0.01	30.3°

DS – DISTURBED SAMPLE. C – COHESION Ø – ANGLE OF INTERNAL FRICTION
LL – LIQUID LIMIT PL – PLASTIC LIMIT PI – PLASTICITY INDEX
NP - NON PLASTIC

CHAPTER – 9
LIMITATION

This report presents recommendations pertaining to the proposed structures as represented to **ELITE LABORATORY**, as described herein. The findings and recommendations presented in this report are based upon soil conditions observed the available subsurface explorations, interpolation of the soil conditions between test pits, and extrapolation of these conditions throughout the proposed site area. They are further based on the assumption that the subsurface conditions do not deviate appreciably from those reported and those assumed. However, the possibility of different conditions cannot be discounted. In the event that changes in design loads or structural characteristics described in this report are made, **ELITE LABORATORY** should be retained to review our design recommendations and their applicability to the revised design plans. In this way, any required supplemental recommendations can be made in a timely manner.

This report has been prepared for the specific project, purpose, and customer stated in the report; the report may not be adequate for other uses. The use of the recommendations of this report for other projects or purposes or by other parties is not authorized.

Although **ELITE LABORATORY** has endeavored to characterize the surface and subsurface conditions at the site, **ELITE LABORATORY** is not as able to assess potential construction difficulties as is a contractor specializing in the work to be performed. Consequently, the Contractor is responsible, and **ELITE LABORATORY** is not, for final evaluation of potential construction difficulties.

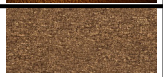
This report has been prepared in accordance with the care and skill generally exercised at the present time by reputable professionals in the field of geotechnical engineering, under similar circumstances, for projects in the project locality. No other warranty, either expressed or implied, is made as to the professional advice presented herein.

ANNEXTURE I

GEOTECHNICAL INVESTIGATION FOR THE CONSTRUCTION OF THE PROPOSED
FIELD BORE / DRILL LOG DATA SHEET

Location : - CHANAKYA PURI, CHIRACHAS (BOKARO)

BORE HOLE NO.	: 01	WATER LEVEL	: 00 m
METHOD OF BORING	: Auger drilling	Dia. OF THE BORE HOLE	: 150 mm
DATE OF COMMENCEMENT	: 22.12.2020	DATE OF COMPLETION	: 22.12.2020

DATE AND DEPTH	DESCRIPTION	SYMBOL	SAMPLE AND IN SITU TEST DEPTH /RUN(m) FROM	TO	LENGTH (m)	NO. OF BLOWS(SPT) 15cm	30cm	45cm	N VALUE / RECOVERY	TYPE OF SAMPLE	REMARKS
	GRAVEL & SILT		0	1.5	1.5	15	16	18	34	SPT	
	GRAVEL & CLAY		1.5	3.0	1.5	23	26	28	54	SPT	
	MOORUM & GRAVEL		3.0	4.0	1.0	29	34	38	72	SPT	REFUSAL
	TERMINATION DEPTH = 4.0 M										

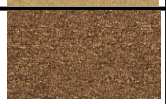
SPT – Standard Penetration Depth

GEOTECHNICAL INVESTIGATION FOR THE CONSTRUCTION OF THE PROPOSED

FIELD BORE / DRILL LOG DATA SHEET

Location : - CHANAKYA PURI, CHIRACHAS (BOKARO)

BORE HOLE NO.	: 02	WATER LEVEL	: 00 m
METHOD OF BORING	: Auger drilling	Dia. OF THE BORE HOLE	: 150 mm
DATE OF COMMENCEMENT	: 22.12.2020	DATE OF COMPLETION	: 22.12.2020

DATE AND DEPTH	DESCRIPTION	SYMBOL	SAMPLE AND IN SITU TEST DEPTH /RUN(m) FROM	TO	LENGTH (m)	NO. OF BLOWS(SPT) 15cm	30cm	45cm	N VALUE / RECOVERY	TYPE OF SAMPLE	REMARKS
	GRAVEL & SAND		0	1.5	1.5	6	9	12	21	SPT	
	GRAVEL & CLAY		1.5	3.0	1.5	15	18	22	40	SPT	
	SEDIMENTED ROCK		3.0	3.5	0.5	24	29	38	67	SPT	REFUSAL
	TERMINATION DEPTH = 3.5 M										

SPT – Standard Penetration Depth

GEOTECHNICAL INVESTIGATION FOR THE CONSTRUCTION OF THE PROPOSED

FIELD BORE / DRILL LOG DATA SHEET

Location : - CHANAKYA PURI, CHIRACHAS (BOKARO)

BORE HOLE NO.	: 03	WATER LEVEL	: 00 m
METHOD OF BORING	: Auger drilling	Dia. OF THE BORE HOLE	: 150 mm
DATE OF COMMENCEMENT	: 22.12.2020	DATE OF COMPLETION	: 22.12.2020

DATE AND DEPTH	DESCRIPTION	SYMBOL	SAMPLE AND IN SITU TEST DEPTH /RUN(m) FROM	TO	LENGTH (m)	NO. OF BLOWS(SPT) 15cm	30cm	45cm	N VALUE / RECOVERY	TYPE OF SAMPLE	REMARKS
	GRAVEL & SAND		0	1.5	1.5	11	19	26	45	SPT	
	SEDIMENTED ROCK		1.5	3.0	1.5	16	22	33	55	SPT	REFUSAL
	TERMINATION DEPTH = 3.0 M										

SPT – Standard Penetration Depth