GEO-TECHNICAL INVESTIGATION REPORT

Name Of Work

Construction of Building G+4 Chas, Bokaro

SH:- Soil Investigation

BRIEF DESCRIPTION

AGENCY	M/S. SARJU CONSTRUCTION
NAME OF WORK	Construction of G+4 building at plot no 7393
LOCATION	Chas, Bokaro
TESTING AGENCY	GEO GLOBE CONSULTANTS (ISO : 9001-2015) PlotNo.777, JLPL Industrial Area, Sector 82, Mohali, Punjab-160062. Contact: 9888608424 Gmail: ggconsultants2010@gmail.com Website: www.geoglobeconsultant.com
TESTING	GEO-TECHNICAL INVESTIGATION

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Auth. Signatory

CONSTRUCTION OF
G+4 BUILDING AT
CHAS, BOKARO

SH- SOIL INVESTIGATION

श्री अखिलान यादव
Akhilesh K. Yadav

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1.0 Introductions

1.01 The report presented herein deals with result of field and laboratory investigation carried out to assess the nature of sub-soil strata and to evaluate the bearing capacity and other parameters **at plot no-7393, Chas, Bokaro.**

1.02 The work of soil investigations was assigned to M/s Geo Globe Consultants , Mohali. (Pb)

2.00 Scope of work

The soil investigation covers the following: -

2.01 Conducting Standard Penetration Test (SPT) in 4 Nos. bore holes up to a depth of 6m or refusal (where N. Value >100) which ever comes earlier.

2.02 Collecting soil samples at various depths as per requirement of the Client from the bore holes as feasible, for laboratory tests.

2.03 Analyzing the field and laboratory observations.

2.04 Submitting one copies of the soil investigations report and recommending safe Bearing capacity of soil.

3.00 Site

3.01 The Site of Investigation is at Chas, Bokaro.

There is no special features which affected the explorations.

3.02 The location of bore holes was given by the client's representative who was with the investigating team till the investigations were over.

4.0 Ground Water table.

Sr.No.	B.H Location	Water Table Depth From NGL (m)
1	BH-1	Nil
2	BH-2	Nil
3	BH-3	Nil
4	BH-4	Nil

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5. Field Investigations

The field investigations were conducted to cover the entire scope of the job.

Boring – operations (IS 1892-1979)

The exploratory bore holes were made by shell and auger by pushing the casing pipe and removing material within the casing. To avoid excessive disturbance to the in-situ deposits, the casing was not driven but was rotated frequently with slow motion. The samples were taken from below the bottom of the casing after completely cleaning the bore holes of any loose material at all depths wherever the samples had to be taken. The undisturbed soil samples were taken by pushing thin walled tubes into the bore holes. Immediately after taking these, they were logged, labeled, sealed in polythene bag and sent to the laboratory for testing.

5.02 Standard Penetration Test (SPT) (IS: 2131)

The Standard Penetration Tests were conducted at various depths in the bore holes. These tests were conducted by driving into the soil a standard split spoon sampler. This sampler was driven with the help of a hammer weighing 63.5 kg. Which was vertically guided to fall through a free height of 75cm on the driving head. This driving head was attached to a drill rod, to the other end of which the sampler was fitted. The number of blows required to penetrate the first, second and third 15 cm lengths of the sampler were noted. The number of blow(i.e.N value), as given in the data sheets of bore holes, is the numerical value for the number of blows counted during the second and third stages i.e. for a depth of 30 cms. The procedure adopted for conducting this test was as per IS: 2131. The observed N values for all the boreholes have been noted down in tables. These values were corrected for over burden pressure.

6.00   Laboratory Investigations

6.01   The laboratory tests were conducted on selected soil samples recovered from the test bore holes. The results obtained have been given in the various tables at the end of the report.

6.02:   Grain Size Analysis: (IS 2720 part 4)

Grain Size analysis was carried out on Disturbed and undisturbed Samples obtained during boring operation. Percentage of sand and combined Silt and Clay were determined from this analysis. The test was carried out as per IS: 2720 (Part IV).

6.03:   Liquid Limits and Plastic Limits(IS 2720 part 5)

To obtain an idea about the consistency characteristics of materials met with at various elevations, the liquid limits and plastic limits of fine fractions were evaluated as per procedure laid down in IS : 2720 (Part-V). These values have been recorded only in the case of plastic samples (cohesive soils), on the bore hole data.

6.04   To obtain an idea about the consistency characteristics of materials met with at various elevations, the liquid limits and plastic limits of fine fractions were evaluated as per procedure laid down in IS : 2720 (Part-V). These values have been recorded only in the case of plastic samples (cohesive soils), on the bore hole data.

6.05   The wet density and grain size analysis was done for the samples taken as per IS : 2720 (Part IV).

6.06   Direct Shear Test (IS 2720 part 13):1986

This test was performed in a shear-box apparatus. The apparatus consisted of two-piece shear box of square cross-section. The lower half of the box was rigidly held in positions in a container which rested over rollers and which was pushed forward at a constant rate by a geared jack, driven by an electric motor. The upper half of the box butted against a proving ring. The soil sample was compacted in the shear box and was held between metal grids and porous stones. Normal load was

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applied on the pressure pad. The shearing strain was made to increase at constant rate. The shear force at failure corresponding to the applied normal load was measured with the help of the proving ring. A number of identical specimens were tested under increasing normal loads and the required maximum shear force was recorded and a graph was plotted between shear force as the ordinate and normal load as the abscissa to get the failure envelops and the value of c & ϕ

6.07 Unconfined Compression Test : **(IS : 2720 Part 10)** is carried out on cylindrical sample of cohesive soil of dia 3.8 cm as per guidelines given in code.

6.08 **Triaxial Compression Test (IS 2720 part 11)**

A triaxial compression test is the most versatile test available for the shear testing of soil. In this test a soil specimen , cylindrical in shape was subjected to direct stresses acting in three mutually perpendicular directions by means of triaxial apparatus comprises of triaxial cell and loading frame. The major principal stress was applied in the vertical direction and the other two principal stresses were applied in the horizontal directions by the fluid pressure all around the specimen . the test was performed on cylindrical specimen of dia 38 mm. The height of the specimen was twice the dia. Shearing processes were started immediately without any consolidation and without allowing any drainage of water. In this way no drainage or dissipation of pore water pressure from soil specimen took place during the entire testing time.

7.0 CONSOLIDATION TESTS (IS 2720 part 15)

The consolidation tests were carried out on undisturbed soil specimen in order to determine the settlement characteristics of soil at different depths. The tests is conducted in accordance to IS : 2720 (Pt-XV).

An undisturbed soil specimen was extruded to the consolidation ring of 60mm dia. The edge was trimmed carefully such that the sample was flushed with the top and bottom edges of the ring. The thickness of the specimen was measured and the weight was recorded. The bottom porous stone was then centered on the base of the

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consolidation cell. The specimen was then placed centrally between the bottom porous stone and the upper porous stone. A filter paper was provided in between specimen and porous stones. Then the loading cap was placed on the top. The consolidometer was placed in position in the loading device and suitably adjusted. The dial gauge is then clamped into position for recording the relative movement between the base of the cell and the loading cap. A seating pressure of 0.05 kg/cm2 was applied to the specimen. The cell was kept filled with water. After 24 hr. the test was continued further using a loading sequence on the soil specimen of 0.25, 0.5, 1.0, 2.0, 4.0, & 8.0 kg/cm2. For each loading increment after application of load, readings of the dial gauge was taken using time sequence 0, 0.25, 1, 2.25, 2, 6.25, 9, 16, 25, 36, 49 ... up to 24 hrs. From the observations of all incremental pressures, void ratio versus log (pressure) curve was obtained. The slope of the straight line portion was designated as

compression index cc.

7.1 Interpretation of Soil Strata

i) On perusal of the strata chart (Table-1 to 4) indicates the sub-soil strata at the site is heterogeneous in nature

ii) Bore hole location No.1 the majority of soil strata from NGL to 2m silty sand was found following with refusal at 2m (N Value >100).

iii) Bore hole location No.2 the majority of soil strata from NGL to 1m silty sand was found following with refusal at 1m (N Value >100).

iv) Bore hole location No.3 the majority of soil strata from NGL to 2m silty sand was found following with refusal at 2m (N Value >100).

v) Bore hole location No.4 the majority of soil strata from NGL to 1m silty sand was found following with refusal at 1m (N Value >100)

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NOTATIONS USED

NSL	-	Natural Surface Level
SSWL	-	Sub-soil Water Level
B	-	Width of Footing
L	-	Length of Footing
D	-	Depth of Footing
P	-	Effective Pressure
P_0	-	Initial Effective Pressure at mid height of layer
ΔP	-	Pressure Increment
q	-	Effective Surcharge at Base Level of foundation
P_n	-	Net Loading Intensity
q_{nf}	-	Net Ultimate Bearing capacity
q_a	-	Allowable b.c.
q_{ns}	-	Net safe b.c. against Shear Failure
N	-	SPT Value
N_n	-	Normalised SPT Value
C_N	-	Correction Factor for N-Value
N_C	-	Corrected SPT Value
CL	-	Clay of low plasticity
ML	-	Silt of low plasticity
SP	-	Poorly Graded Sand with no fines
SM	-	Silty Sand, Poorly Graded Sand-Silt Mixture
SW	-	Well Graded Sand with no fines
GW	-	Well Graded Gravels
GP	-	Poorly Graded Gravels
GM	-	Silty Gravels
GSF	-	General Shear Failure
LSF	-	Local Shear Failure
GC	-	Clayey Gravels
SC	-	Clayey Sands
MI	-	Silt of Medium Plasticity
CI	-	Clay of Medium Plasticity
MH	-	Silt of High Plasticity
CH	-	Clay of High Plasticity

$M_{(NP)}$	-	Non Plastic Silt
ML-CL	-	Mixture of ML and CL
ϕ	-	Angle of Internal Friction
ϕ'	-	Effective Angle of Internal Friction
ϕ_m	-	Mobilised Angle of Internal Friction
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
w'	-	Moisture Content
γ	-	Bulk Unit Weight
γ_{sat}	-	Saturated Bulk Unit Weight
γ_d	-	Dry Bulk Density
γ'	-	Submerged Unit Weight
q_u	-	Unconfined Compressive Strength
C_u	-	Undrained Shear Strength
C'	-	Effective Cohesion
G	-	Specific Gravity
H	-	Thickness of Soil Layer
H_t	-	Thickness of sandy layer
B_t	-	Top width of sandy layer
ΔP_t	-	Stress increment at top of sandy layer
D_f	-	Depth factor
L_{yf}	-	Lateral yield factor
R_f	-	Rigidity factor
S_o	-	Settlement due to net unit foundation loading intensity (1 Kg/Cm^2)
S_{ob}	-	Settlement due to net unit foundation loading intensity under submerged conditions (1Kg/Cm^2)
S_t	-	Total settlement
e_0	-	Void Ratio
FOS	-	Factor of Safety
LL	-	Liquid Limit
PL	-	Plastic Limit
C_C	-	Compression Index
PI	-	Plasticity Index

DETERMINATION OF THE CORRECTED N-VALUES

BH – 1

Depth below NGL (m)	Observed N-value (N)	Overburden pressure t/m^2	Correction factor C_N	Corrected N-value N_C
2.0	>100	1.96	2.01	-

BH – 2

Depth below NGL (m)	Observed N-value (N)	Overburden pressure t/m^2	Correction factor C_N	Corrected N-value N_C
1.0	>100	1.75	1.62	-

BH – 3

Depth below NGL (m)	Observed N-value (N)	Overburden pressure t/m^2	Correction factor C_N	Corrected N-value N_C
1.0	23	1.74	1.59	-
2.0	>100	2.60	1.68	-

BH – 4

Depth below NGL (m)	Observed N-value (N)	Overburden pressure t/m^2	Correction factor C_N	Corrected N-value N_C
1.0	>100	1.85	1.90	-

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FOUNDATION ANALYSIS:-

Bearing capacity has been evaluated keeping in view of the foundation will be safe against local or general shear failure.

The shear value determined in the laboratory with the help of Shear Test on the collected samples from the Location The actual lowest shear value determined in the laboratory worked out to C-value 0.00 Kg/cm2 and ϕ value as between 33°-37°.Using these values the net bearing capacity is calculated from the following formula as per IS 6403-1981 for local shear failure. For calculation purpose the type of foundation is assumed as 1.5 m wide isolated foundation is considered.

Determination of Bearing Capacity

Mode of computation

As per shear failure consideration, Type of foundation = isolated Footing

Width of foundation be considered as 1.5 m,

Depth of foundation =1.5 m,

Governing Soil Parameters, c=0, ϕ=36.5°,

(A) Shear failure Considerations:

(B) General shear faluire

N_q = 39.40, S_q = 1.2, d_q = 1.20
N_γ = 60.56, S_γ = 0.8 , d_γ = 1.20

$$d_q = d_\gamma = 1 + 0.1 \frac{D_f}{B} \tan(45 + \phi/2)$$

γ_d= 1.94, γ_b=2.12

Net Ultimate b.c: $q_{nf}=q(N_q-1) S_q d_q + 0.5 B\gamma N_y S_y d_y W'$.
=170.92 t/m^2
Net Safe b.c 'q_{ns}' = 68.37 T/m^2 (f.o.s = 2.5)

Where: q_{nf} - = Net ultimate bearing capacity

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q_{ns}' = Net Safe bearing capacity

ϕ = angle of shear resistance

q   = Effective surcharge

B   = Width of footing

γ = density

Sc, Sq, Sy   = Bearing capacity factors, Shape factors

dc, dq, dy   = Depth factors

ic, io, iy   =   = inclination factors

pressure has been calculated as code IS: 8009 (Part 1)1976

For N ≥ 50, corresponding settlement=5.0mm

Permissible settlement chosen as 12 mm

Allowable Bearing pressure works out to be ==24 t/m2

From among both calculations, least value is adopted

Therefore, Allowable Safe Bearing Capacity = 24 t/m2

Applying disturbance factor 0.8*24=19.2 t/m2

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Conclusions and Recommendations

❖   On the basis of field & laboratory investigation & calculation for bearing capacity values following reference have been drawn.

❖   The value of allowable b.c to be adopted for design consideration at different depths are as follows

❖   This is the general recommendation. The designer may change the recommendation & he may decide the depth of the foundation & type of foundation as per the structural details of structure.

SUMMARY

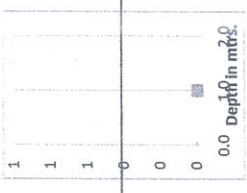| S. No.	Width/size of fdn (B) m	Depth from NGL m	Type of Foundation	$(q_a)_{Net}$ t/m^2
BH 1 to BH 4	1.5	1.5	Isolated Footing	19.2

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Bibliography:-

1) (IS 1892-1979)   : Code of practice for subsurface investigation for foundations

2) (IS: 2131)   : Code of practice for Standard Penetration test

3) (IS 2720 part 4) : Methods os test for soils part 4 ,grain size analysis

4) (IS 2720 part 5) : Methods os test for soils part 5 Determination of liquid and plastic limits

5) (IS 2720 part 10) : Methods os test for soils part 10, determination of unconfined compression test.

6) (IS 2720 part 11) : Methods os test for soils part 10, determination of unconfined compression test, determination of shear strength parameters of soil specimen tested in unconsolidated undrained triaxial compression without the measurement of pore water pressure (amendment 3) Reaffirmed 1990 CED 23

7) (IS 2720 part 15) : Methods os test for soils part 15, Determination of consolidation properties.

8) (IS 2720 part 13)   : Methods of test for soils part 13, Direct Shear Test.

9)   (IS 6403 -1981)   : Code of practice for determination of bearing capacity of shallow foundations .

10) Settlement Consideration :   (IS: 8009 (Part-I)-1976 Reaffirmed 2003),

PROJECT:- Soil Investigation for Construction of proposed structure.
LOCATION:- (CHAS), BOKARO
BH NO.:- 1

REFERENCE POINT (RL):- NGL
DATE OF BORING :-
DIA OF CASING=150 mm

LABORATORY TEST RESULTS

DEPTH FROM NGL (m)	SPT (N) BLOWS 30cm OBSERVED SPT	SPT (N) BLOWS 30cm CORRECTED	STANDARD PENETRATION RESISTANCE CURVE	SYMBOLIC REPRESENTATION	I.S.C. GROUP	Level Of Water Table	% MOISTURE	% GRAVEL MODULES (-80 MM FRACTION)	SAND %	% SILT + CLAY (-75 MICRON)	LL	PI	FIELD Density gm/cc	DRY Density gm/cc	SP. GRAVITY	VOID RATIO	UNCONFINED COMP. STRN Kg/cm² (Cu)	C' Kg/Cm²	φ° DIRECT SHEAR TRIAXIAL COMPRESSION TEST	COMPRESSION INDEX Cc	REMARKS	TYPE OF SAMPLE DS OR UDS
1.0	>100	>100			SM		8.00	0.00	71.00	29.00	N	P	2.120	1.945	2.64	0.357	-	-	36	-	silty sand	DS
2.0	>100	>100					8.05	0.01	72.00	30.00	N	P	2.22	2.036	2.68	0.316	-	-	37	-	silty sand	::

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PROJECT:-Soil Investigation for Construction of proposed structure.
LOCATION: - BOKARO (CHAS)
BH NO.:- 2

REFERENCE POINT (RL) :- NGL
DATE OF BORING :-
DIA OF CASING=150 mm

LABORATORY TEST RESULTS

DEPTH FROM NGL (m)	SPT (N) BLOWS 30cm OBSERVED SPT	SPT (N) BLOWS 30cm CORRECTED	STANDARD PENETRATION RESISTANCE CURVE	SYMBOLIC	I.S.C. GROUP	Level Of Water Table	% MOISTURE	% GRAVEL MODULES (-80 MM FRACTION)	% SAND	% SILT + CLAY (-75 MICRON)	LL	PI	DENSITY (gm/cc) FIELD Density gm/cc	DENSITY (gm/cc) DRY Density gm/cc	SP. GRAVITY	VOID RATIO	UNCONFINED COMP. STRN Kg/Cm² (C_u)	C' Kg/C m²	ϕ^0 DIRECT SHEAR TRIAXIAL COMPRESSION TEST	C_c COMPRESSION INDEX	REMARKS	TYPE OF SAMPLE DS OR UDS
1.0	RF	RF		(hatched)	SM		4.31	0.00	70.00	30.00	N	P	1.658	1.574	2.64	0.677	-	-	24	-	Silty sand	DS

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PROJECT:-Soil Investigation for Construction of proposed structure.
LOCATION:- BOKARO (CHAS)
BH NO.:- 3

REFERENCE POINT (RL) :- NGL
DATE OF BORING :-
DIA OF CASING=150 mm

LABORATORY TEST RESULTS

DEPTH FROM NGL (m)	SPT (N) BLOWS 30cm OBSERVED SPT	SPT (N) BLOWS 30cm CORRECTED	STANDARD PENETRATION RESISTANCE CURVE	SYMBOLIC REPRESENTATION	I.S.C. GROUP	Level Of Water Table	% MOISTURE	% GRAVEL MODULES (-80 MM FRACTION)	% SAND	% SILT + CLAY (-75 MICRON)	LL	PI	DENSITY (gm/cc) FIELD Density gm/cc	DENSITY (gm/cc) DRY Density gm/cc	SP. GRAVITY	VOID RATIO	UNCONFINED COMP. STRN Kg/Cm² (C_u)	DIRECT SHEAR TRIAXIAL COMPRESSION TEST C' Kg/C m²	DIRECT SHEAR TRIAXIAL COMPRESSION TEST Φ°	COMPRESSION INDEX C_c	REMARKS	TYPE OF SAMPLE DS OR UDS
1.0	23	19			SM		14.00	0.00	59.00	41.00	N	P	1.868	1.624	2.65	0.63	-		22		Silty sand	DS
2.0	RF	RF			SM		4.31	0.00	51.00	49.00	N	P	1.828	1.736	2.64	0.521	-	-	28	-	Silty sand	DS

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PROJECT:-Soil Investigation for Construction of proposed structure.
LOCATION:- BOKARO (CHAS)
BH NO.: 4

REFERENCE POINT (RL) :: NGL
DATE OF BORING :-
DIA OF CASING=150 mm

LABORATORY TEST RESULTS

DEPTH FROM NGL (m)	SPT (N) BLOWS 30cm OBSERVED SPT	CORRECTED RF	STANDARD PENETRATION RESISTANCE CURVE	SYMBOLIC	I.S.C. GROUP	Level Of Water Table	% MOISTURE	% GRAVEL MODULES (-80 MM FRACTION)	% SAND	% SILT + CLAY (-75 MICRON)	LL	PI	DENSITY (gm/cc) FIELD Density gm/cc	DRY Density gm/cc	SP. GRAVITY	VOID RATIO	UNCONFINED COMP. STRN Kg/Cm² (Cᵤ)	C' Kg/Cm²	Φ° DIRECT SHEAR TRIAXIAL	COMPRESSION TEST COMPRESSION INDEX Cc	REMARKS	TYPE OF SAMPLE DS OR UDS
1.0	RF	RF			SM		6.10	0.00	76.00	24.00	N	P	1.680	1.569	2.64	0.683	-	-	25	-	Silty sand	DS

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