Geotechnical Investigation Report for Design and Construction of Proposed ACECOR Building at University of Cape Coast

Prepared for:
FAS Consult Limited

Prepared by:
E. N. Bonne Acquah
P. O. Box KA 9709
Airport - Accra

February, 2021

TABLE OF CONTENTS

1.0 INTRODUCTION

A geotechnical investigation has been conducted on a parcel of land at the University of Cape Coast. The geotechnical investigation forms part of engineering studies for the design and construction of the ACECOR Building.

The objective of the investigation was to obtain information about the geological conditions at the site and assess the subsurface soil conditions so as to determine the soil parameters and soil bearing capacity to be considered for the design and construction of the foundations.

The subsurface conditions revealed by the investigation are discussed in this report. The report discusses the activities carried out as part of the investigations, presents the results and makes recommendations for the design of the foundations.

2.0 SITE DESCRIPTION

2.1 The Site

The location of the site is shown in Figure 1.

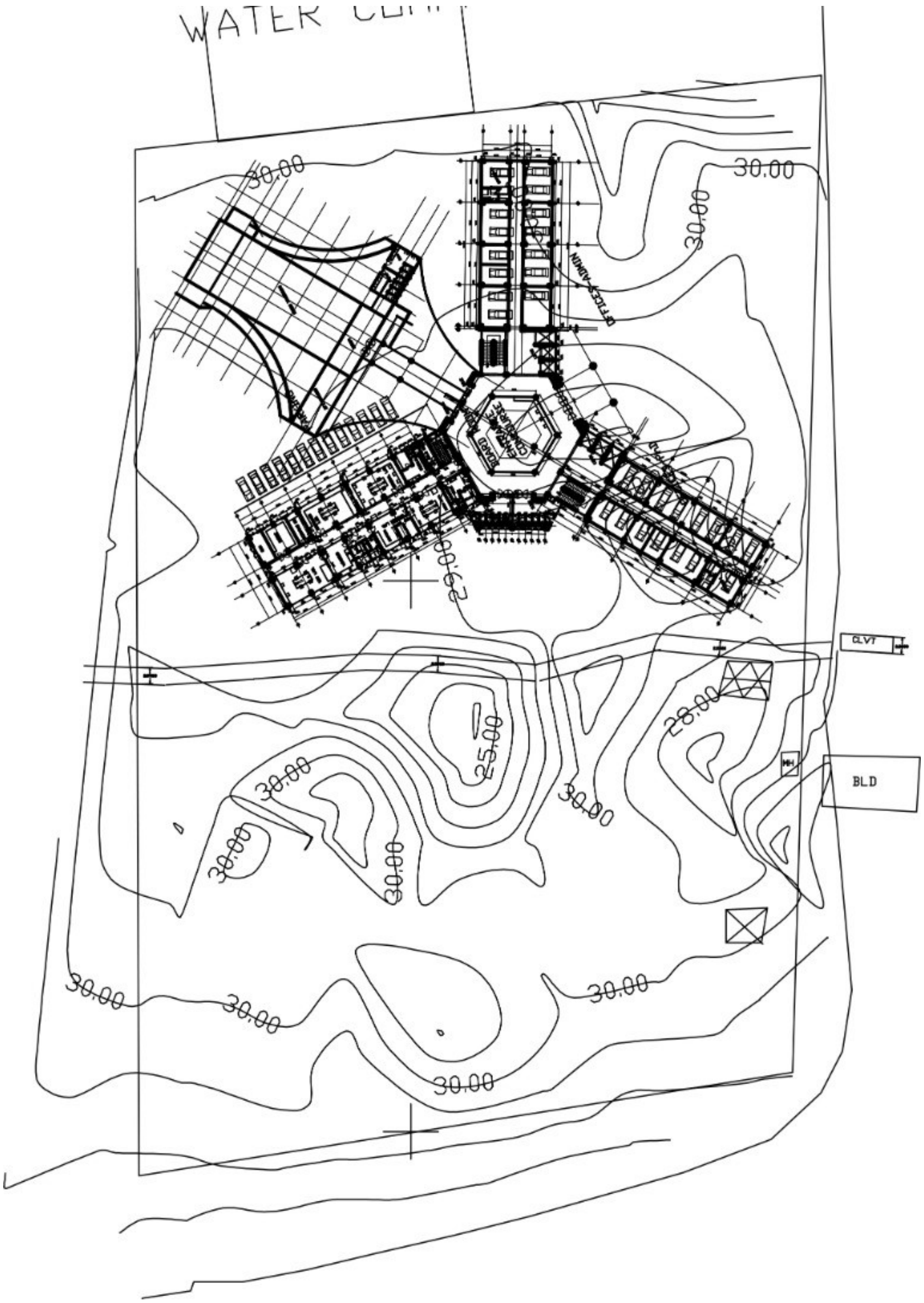


Figure 1: Location of the Site

2.2 Climate

The Cape Coast area lies within the zone of heavy seasonal rainfall. The area generally experiences two main rainy seasons. The seasons are however not distinct. There is a major rainy season that reaches its peak in May-June and a minor season between September and November. The average annual rainfall is about 1250mm. The degree of saturation of surface soils is very high in May–June, i.e during the peak of the first rainy season. The period between January to April is relatively dry and maximum desiccation of surface soils takes place.

2.3 Geology of the Area

The area of the site is underlain by rocks of the Sekondian formation which consists of sandstones, grits, shales and mudstones, nodules of limestone and siderite. The superficial soils are silty sands and clays. (Ref. 1)

2.4 Seismic Considerations

Ghana cannot be considered as a major earthquake prone area of the world. The coastal areas are however subjected to earthquakes of relatively low intensities.

A detailed seismic hazard assessment study is yet to be conducted for Ghana. A Global Seismic Hazard Assessment study conducted on a macro-scale hazard for the African region provided the Southern Ghana region with a rock peak ground acceleration of 0.16g for an annual exceedance probability (AEP) of 10% in 50 years.

Based on records of the seismic hazard, the geologic setting of Southern Ghana and ground motion estimates from other similar locations in the world with similar seismo- tectonic features, a deep rock PGA (i.e., zero-period spectral acceleration) with an annual exceedance probabilities of 10% in 50 years of 0.15 - 0.2g could be assumed for the area.

The project area is located within zone 3 of the seismic risk map of Ghana as shown in Figure 2. Definition for the Seismic Zones is shown in Table 1. It is recommended that engineering structures in zone 3 should be analysed with an assigned horizontal ground acceleration of 0.35g.

(Ref. 2). The recommended ground acceleration of 0.35g represents the average for the range 0.14 - 0.57g.   A deep rock PGA of 0.2g is recommended to be used for design.

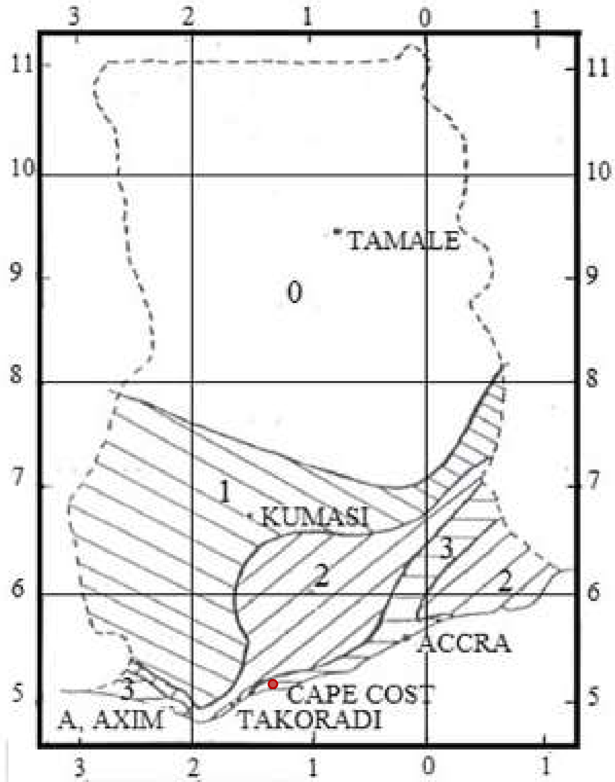


Figure 2. Seismic Risk Map of Ghana

Table 1. Definition of Seismic Zones

Seismic Zone	Assigned Horizontal Design Ground Acceleration: g
0	0
1	0.15
2	0.25
3	0.35

3.0 THE INVESTIGATION

The investigation included fieldwork and laboratory testing.

3.1 Field Work

The field work consisted of Dynamic Cone Penetrometer (DCP) Test and drilling boreholes. The field work was started on 15^{th} February 2021 and completed on 20^{th} February 2021.

3.2 Borehole drilling

Three (3) boreholes were drilled to establish the soil profile. The borehole drilling was conducted in accordance with BS 5930 – Site Investigations for Civil Engineering Projects.

The boreholes were drilled to a maximum depth of 9m using the FLYDISC DRILLING RIG XUL – 100 drilling equipment. Bulk disturbed samples of the soils were recovered, preserved in airtight containers and labelled as the holes were advanced.

3.3 Dynamic Cone Penetrometer Test

The in-situ strength (Bearing Capacity) of the ground medium was tested using a Dynamic Cone Penetrometer (DCP). The equipment has the following characteristics:

Weight of hammer	10kg
Weight of anvil	6kg
Height of fall of hammer	50.0cm
Cone Diameter	2.4cm
Cone Surface Area	$5cm^2$
Apex Angle of Cone	60°

This equipment also has a slotted open drive sampler capable of retrieving samples of the formation being penetrated.

Five (5) DCP tests were performed across the proposed area for the building. Additional five (5) DCP tests were performed across the area for future development. The test were done at the points as shown in Figure 3. The DCP tests were done to estimate the variation of the bearing capacity of the ground medium with depth. The number of blows required for the cone to penetrate 10cm into the ground medium was noted for various depths. The test was terminated when the number of blows required for the cone to penetrate 10cm exceeded 50 or when there was an obvious 'refusal' as indicated by a rebounding of the hammer when dropped on the anvil.

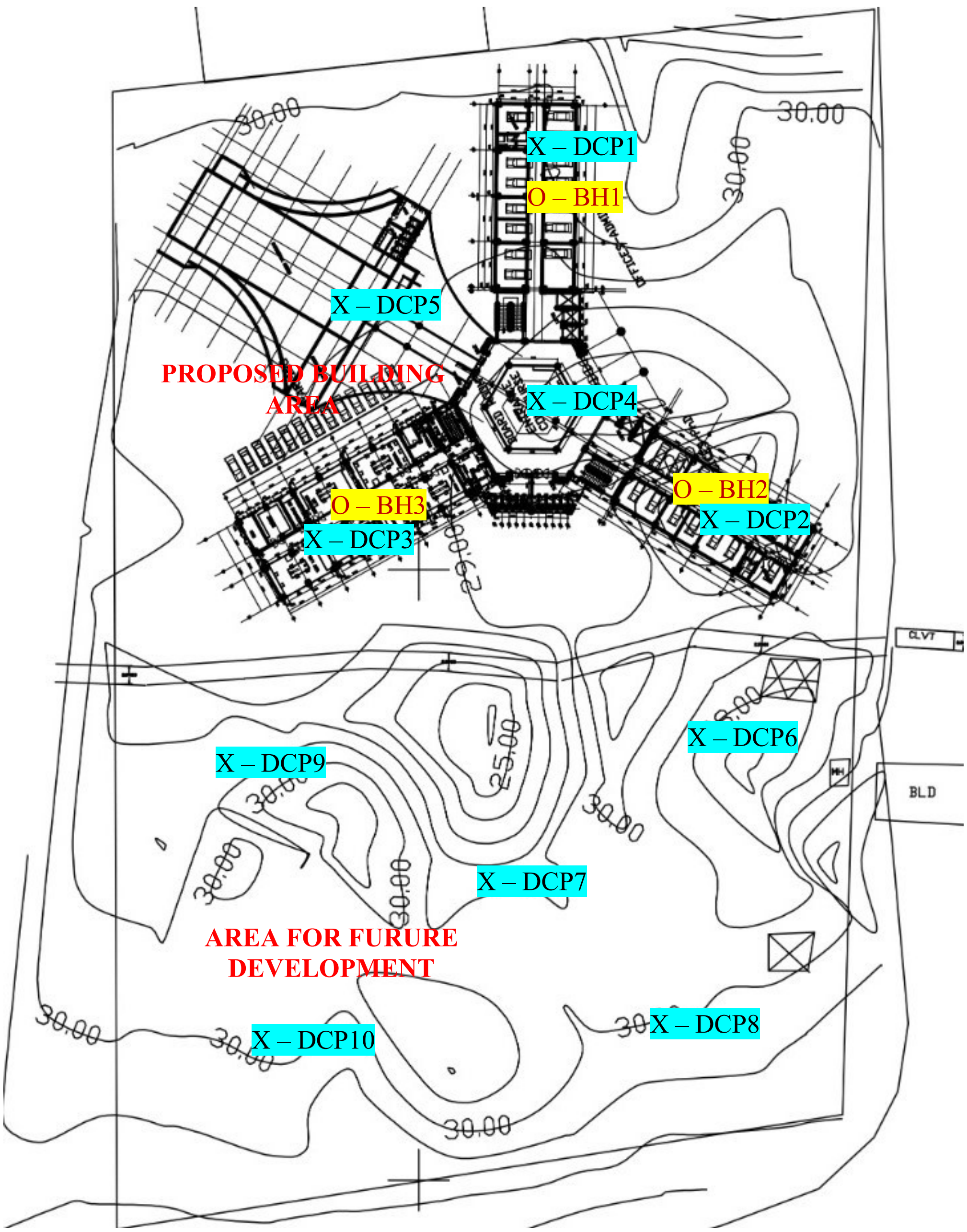


Figure 3. Location of Test Points

3.4 Laboratory Tests

The following standard engineering tests shall be performed on the soil samples retrieved from the boreholes:

- Moisture Content
- Particle Size Distribution (by Wet Sieving)
- Atterberg Limits

The tests were done in accordance with the following test methods/standard.

BS1377: Methods of Test for Soils for Civil Engineering Purposes.
ASTM D2217/GHA S7 - Sieve Analysis of Granular Soils,
ASTM D4318/GHA S6 - Determination of Atterberg Limits of Soil Fines.

Differential Free Swell (DFS) Test was also carried out on samples of the soils. The DFS test consists of the following process. Two samples of the dried soil passing the 0.425mm sieve and weighing 10g each were taken. One sample was put in a 50cc graduated glass cylinder containing distilled water and the other containing kerosene. Both samples were left for at least 24 hours and their volumes noted.

The DFS is expressed as:

$$\frac{\text{Volume of soil in water} - \text{Volume of soil in kerosene}}{\text{Volume of soil in kerosene}} \times 100\ \%$$

The DFS values were used to assess the compressibility of the soils.

3.5 Soil Profile and Soil Properties

The test pit revealed that the site has a soil profile of loose brown clayey SAND topsoil lying over loose to medium dense yellowish brown gravelly clayey SAND to a depth of about 6m The soil gradually changed into dense to very dense mottled yellow/reddish brown decomposed/weathered SANDSTONE.

The soil profile and the properties of the soil obtained from the laboratory tests are shown in Appendix A.

Water was encountered in all the boreholes. The water was encountered at depth between 1.2 – 1.8m. The water levels stabilised at 1.0 after 24 hours.

The laboratory test results on the soil samples are summarised in Table 2.

Table 2: Summary of Laboratory Test Results for Borehole Soil Samples

Sample Identification		Grading			Atterberg Limits			Swell Potential
	Moisture Content (%)	Gravel Content (%)	Sand Content (%)	Silt/Clay Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plastic Index (%)	DFS (%)
BH1 ds1 0.2 – 1.3m	4.5	3	70	27	13	10	3	0
BH1 ds2 1.3 – 3.4m	14.9	0	56	44	34	11	23	12
BH1 ds3 3.4 – 3.8m	16.2	57	25	18	38	12	26	18
BH1 ds4 3.8 – 6.3m	22.6	0	40	60	40	16	24	37
BH1 ds5 6.3 – 8.8m	16.7	0	69	31	29	17	12	0
BH2 ds1 0.4 – 2.1m	17.2	3	37	60	18	8	10	36
BH2 ds2 2.1 – 5.5m	17.8	0	62	38	35	12	23	36
BH2 ds3 5.5 – 8.7m	17.7	0	72	28	29	18	11	0
BH3 ds1 0 – 1.6m	12.0	1	62	37	Non-Plastic			0
BH3 ds2 1.6 – 6.6m	17.0	0	55	45	41	12	29	24
BH3 ds3 6.6 – 9.0m	15.3	0	73	27	24	18	6	36

The liquid limits and the plasticity indexes of the clayey SAND upper soil layers fall within Zone 4 of the Plasticity Chart (Figure 4). The highly decomposed/weathered SANSTONE fall within Zone 2 of the Plasticity Chart. The results indicate that the clayey SAND has medium plasticity and the weathered SANDSTONE has low plasticity.

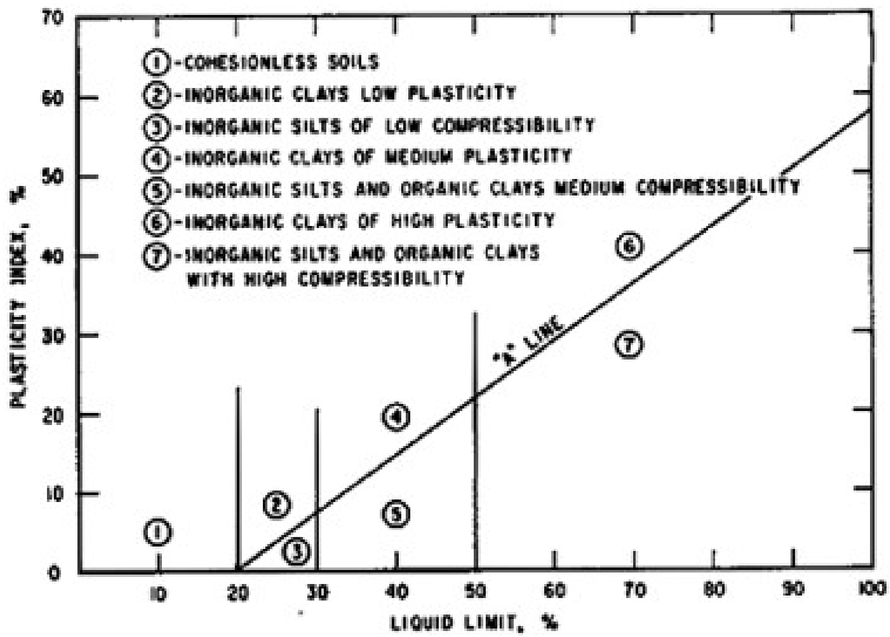


Figure 4. Casagrande Plasticity Chart.

Peck, Hansen and Thorburn (1974) related the plasticity index to the swelling potential of soils in a simple relation shown in Table 3. (Ref. 3)

Table 3. Relationship between Plasticity Index and swelling potential

Swelling Potential	Plasticity Index (%)
Low	0-10
Medium	10-20
High	20-35
Very high	35 and above

The degree of expansiveness of soils and the possible damage to light loaded structures may be quantitatively assessed from Table 4.

Table 4. Relationship between Differential Free Swell and Degree of Expansiveness

Differential Free Swell (%)	Degree of Expansiveness
Less than 20	Low
20-35	Moderate
35-50	High
Greater than 50	Very High

The clayey SAND has moderate to high potential to undergo volume change with variation in soil moisture. When the moisture within the clayey SAND vary between the dry and wet seasons, it is likely to cause alternate shrinkage and swelling of the soil. This could result in differential ground movement if the moisture distribution is not uniform.

The decomposed/highly weathered SANDSTONE has no potential to undergo volume change with variation in soil moisture.

A sample of the water collected from borehole 3 was tested to determine pH value, Sulphate Content and Chloride ion concentration in order to establish whether there is considerable amount of salts in the soil that may be aggressive to buried concrete and steel. The results of the chemical test on the water sample are presented in Table 5 and in Appendix B.

Table 5: Chemical Test Results on Water Samples

Borehole No.	PH	CI (mg/l)	SO4 (mg/l)
3	5.1	8730	928
Limits	6.85	400	300

The levels of chlorides and sulphate in the water are higher than the prescribed limits of BRE Digest Standard of maximum 400mg/l and 300mg/l respectively. The buried concrete and reinforcement steel are highly susceptible to attack by the salts. The use of admixtures that will counteract the adverse effects of the salts, during production of concrete for the substructure is recommended. A dense concrete mix is therefore recommended for construction of the structures.

The site is close to the Gulf of Guinea and the air is likely to be saline and aggressive. Reinforcement steel should not be exposed to the environment for long periods.

3.6 Estimation of Bearing Capacity of Ground Medium

The strength characteristics of the overburden granular soils may be evaluated by converting the unit resistance of the ground into either allowable bearing capacity or standard penetration (N) blow- counts.

The dynamic cone penetration r, defined as the number of blows required for advancing the cone by 10cm may be converted into unit resistance R_D of the ground in kN/m^2 or kPa using the formula

$$R_D = \frac{m^2 H}{Ae(m+P)}$$

Where 'e' is the penetration per blow in cm (i.e **e=10/r**)

Using the above parameters for the dynamic cone penetrometer used, it can be shown that

$$R_D = \frac{6250}{e}\left(kN/m^2\right)$$

Substituting 10/r for 'e'

$$R_D = 625r$$

For shallow foundations, the ultimate bearing capacity $\mathbf{q_{ult}}$ may be obtained from the unit R_D by the following relationship (Ref. 4)

$$q_{ult} = \frac{R_D}{20}\left(kN/m^2\right)$$

The ultimate bearing capacity may be obtained from the approximate relationship:

$$q_{ult} = 30\ r\ \ (kN/m^2)$$

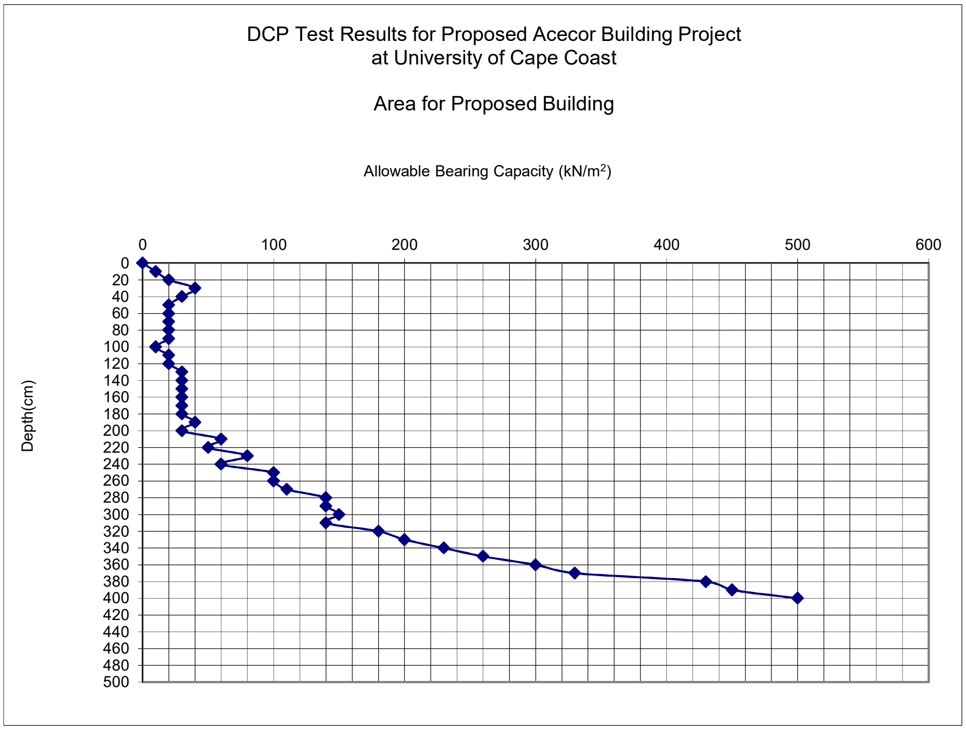
The ultimate bearing capacity (q_{ult}) is the estimated load limit at which failure is expected to occur. This value is lowered by a safety factor to arrive at the allowable bearing capacity ($\mathbf{q_{all}}$) to be used for the design of the foundations. The choice of safety factor should be based on the extent of subsurface investigation, reliability of the estimated loads, importance of the structure and consequences of failure. The choice of safety factor should be based on the extent of subsurface investigation, reliability of the estimated loads, importance of the structure and consequences of failure. The designer may consider a safety factor in the range 2.0 to 4.0. A safety factor of 3.0 has been applied to the minimum ultimate bearing capacity values. The estimated bearing capacities are presented in Tables 6 and 7 for the area for the proposed building and the area for future development respectively. Variation of the bearing capacities with depth has been presented in the Graphs in Figure 6 and 7. The depths has not been referenced to a specific datum.

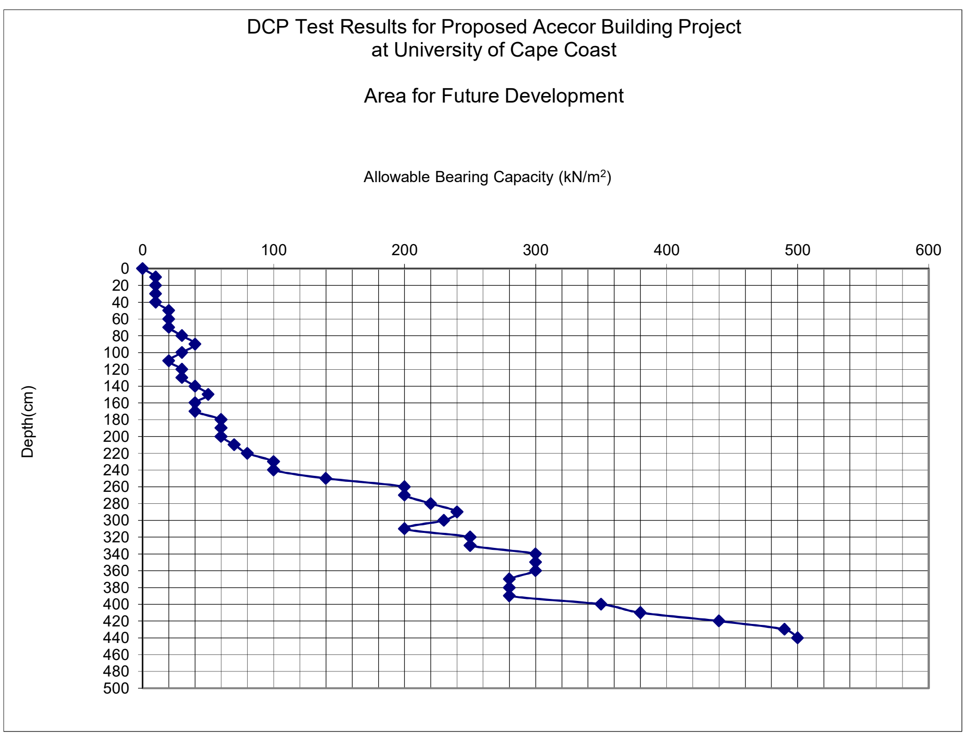
Table 6. Bearing Capacity for Proposed Building Area

Depth (m)	Ultimate Bearing Capacity q_{ult} (kN/m^2)						q_{all} (kN/m^2)
	Test 1	Test 2	Test 3	Test 4	Test 5	Minimum	
0.10	30	30	150	90	60	30	10
0.20	120	60	300	120	120	60	20
0.30	120	120	360	120	180	120	40
0.40	120	90	330	120	180	90	30
0.50	60	120	330	90	120	60	20
0.60	60	90	270	60	60	60	20
0.70	90	120	270	60	90	60	20
0.80	60	120	180	90	60	60	20
0.90	60	60	180	60	60	60	20
1.00	90	90	150	30	90	30	10
1.10	90	120	180	60	90	60	20
1.20	60	90	240	60	90	60	20
1.30	90	150	240	240	120	90	30
1.40	90	120	300	240	120	90	30
1.50	90	120	300	180	120	90	30
1.60	90	120	210	120	150	90	30
1.70	90	120	180	120	90	90	30
1.80	150	150	210	90	120	90	30
1.90	120	150	210	120	120	120	40
2.00	150	180	240	90	120	90	30
2.10	180	390	360	180	240	180	60
2.20	150	450	360	150	270	150	50
2.30	240	450	360	240	330	240	80
2.40	180	480	420	330	270	180	60
2.50	300	540	540	330	330	300	100
2.60	420	570	600	300	360	300	100
2.70	360	630	510	330	510	330	110
2.80	420	810	600	450	450	420	140
2.90	420	900	660	450	510	420	140
3.00	570	1200	690	450	450	450	150
3.10	540	1110	690	420	540	420	140
3.20	540	1200	750	660	540	540	180
3.30	750	1260	750	900	600	600	200
3.40	900	1350	1350	900	690	690	230
3.50	990	1380	1470	780	870	780	260
3.60	1020	1500	1290	900	960	900	300
3.70	1320		1290	990	1260	990	330
3.80	1410		1440	1290	1470	1290	430
3.90	1440		1380	1350	1500	1350	450
4.00	1500		1500	1500		1500	500

Table 7. Bearing Capacity for Area for Future Development

Depth (m)	Ultimate Bearing Capacity q_{ult} (kN/m^2)						q_{all} (kN/m^2)
	Test 1	Test 2	Test 3	Test 4	Test 5	Minimum	
0.10	60	30	90	30	30	30	10
0.20	30	30	60	60	30	30	10
0.30	60	30	60	90	30	30	10
0.40	180	120	60	90	30	30	10
0.50	240	120	120	120	60	60	20
0.60	180	210	180	240	60	60	20
0.70	120	180	150	240	60	60	20
0.80	90	240	150	270	120	90	30
0.90	120	300	150	270	180	120	40
1.00	150	270	90	240	150	90	30
1.10	90	270	60	390	270	60	20
1.20	90	270	90	180	270	90	30
1.30	90	210	150	180	300	90	30
1.40	120	210	210	210	390	120	40
1.50	150	210	240	210	420	150	50
1.60	120	270	330	210	450	120	40
1.70	120	270	390	240	510	120	40
1.80	180	210	390	180	450	180	60
1.90	180	240	390	300	480	180	60
2.00	180	240	330	300	510	180	60
2.10	300	210	420	450	480	210	70
2.20	360	240	390	450	450	240	80
2.30	450	360	360	510	300	300	100
2.40	540	420	420	690	300	300	100
2.50	600	660	510	750	420	420	140
2.60	600	660	750	900	630	600	200
2.70	600	750	780	1200	630	600	200
2.80	660	1050	750	1320	750	660	220
2.90	720	1050	750	870	720	720	240
3.00	690	1050	780	1020	720	690	230
3.10	810	1140	690	1050	600	600	200
3.20	750	1350	750	1080	840	750	250
3.30	900	1350	750	1050	900	750	250
3.40	990	1440	900	1140	990	900	300
3.50	990	1440	900	1320	960	900	300
3.60	960	1260	900	1380	900	900	300
3.70	960	1260	840	1380	840	840	280
3.80	990	1410	840	1470	900	840	280
3.90	1050	1350	840	1500	1020	840	280
4.00	1170	1470	1050		1080	1050	350
4.10	1260	1500	1140		1200	1140	380
4.20	1440		1320		1440	1320	440
4.30	1500		1470		1500	1470	490
4.40			1500			1500	500


DCP Test Results for Proposed Acecor Building Project
at University of Cape Coast
Area for Proposed Building
Allowable Bearing Capacity (kN/m2)
0
100
200
300
400
500
600
Depth(cm)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500


DCP Test Results for Proposed Acecor Building Project
at University of Cape Coast
Area for Future Development
Allowable Bearing Capacity (kN/m2)
0
100
200
300
400
500
600
Depth(cm)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500

3.7 Foundations

The nature of the sub-soils is such that shallow foundations could be considered for the proposed structures. Pad or spread footings placed at a minimum depth of 2.5m may be considered. A bearing capacity of $100kN/m^2$ may be adopted for the design.

Due to the moderate to high potential to undergo volume change with variation in soil moisture, it is advised that the columns should be tied with ground beams to limit the adverse effect of any uneven ground movement that may occur.

Adoption of the low bearing capacity of $100kN/m^2$ will require very wide footings. A raft foundation or strip foundation designed as inverted T-beams may be considered as other options. A modulus of sub-grade reaction of $1.2 \times 10^4 kN/m^3$ is recommended for design of the raft foundation and strip foundation.

Alternatively, it is advised that short bored piles or caissons should be constructed to transmit the loads to the firm strata at depths greater than 4.0m. An end bearing capacity of $500kN/m^2$ may be considered for the caissons. The caps for the caissons should be tied with beams.

Due to the presence of water at a shallow depth of 1.0m, it would be expedient for a pump to be provided at the site during excavation.

The soils are likely to cave in during open excavation and hinder the construction of the substructure. Measures should be taken to minimize the effect of the collapsing sides of the excavation on the works.

4.0 DISCLAIMER

The designer has the final choice of type of foundation to adopt and how deep to place the foundations after considering all factors that are likely to affect the building during the service life.

These findings are based on the conditions as revealed by the investigation. There may however be some special conditions at the site, though unlikely, which may not have been discovered through the investigation. Any special conditions observed during construction may be brought to our notice for redress.

E. N Bonne Acquah (7/3/2021)

REFERENCES:

(1) Geological Survey Dept.	Geological map of Ghana with mineral deposits. 1988.
(2) BRRI	The Seismic Design of Reinforced Concrete Structures. 2012
(3) Gopal Ranjan and Rao. A.S.R	Basic and Applied Soil Mechanics
(4) Sanglerat, G	The Penetrometer and Soil Exploration. 2^{nd} Edition 1972

APPENDIX A – BOREHOLE LOGS

BOREHOLE LOG

GEOTECHNICAL INVESTIGATION FOR ACECOR BUILDING PROJECT AT UNIVERSITY OF CAPE COAST

CLIENT: FAS CONSULT LIMITED

BORING METHOD: PERCUSSION | **LOGGED BY: E Koranteng**

Hole Diameter: 150mm | **START DATE : 15th February, 2021**

Borehole No.: 1 (Page 1 of 2) | Latitude 5.10227, Longitude -1.28471 | **END DATE : 16th February, 2021**

Depth (m)	Assumed Elevation (m)	Sample Type	Soil/Rock Description	SPT Test: N-Value	SPT Test: Material Recovery (mm)	Rotary Core drilling: Core Run (m)	Rotary Core drilling: Water Return (%)	Rotary Core drilling: Total Core Recovery (%)	Rotary Core drilling: RQD (%)	Moisture Content (%)	Consistency Limits: Liquid Limit (%)	Consistency Limits: Plastic Limit (%)	Consistency Limits: Plastic Index (%)	Grading: Gravel (%)	Grading: Sand (%)	Grading: Fines (%)	DFS (%)
0.0																	
0.1			Loose blackish SAND (Topsoil)														
0.2																	
0.3																	
0.4																	
0.5																	
0.6																	
0.7		ds1	Loose yellowish brown fine to medium grained							4.5	13	10	3	3	70	27	0
0.8			SAND														
0.9																	
1		SPT1		N=3	150												
1.1																	
1.2																	
1.3																	
1.4																	
1.5																	
1.6		ds2								14.9	34	11	23	0	56	44	12
1.7																	
1.8		▼															
1.9																	
2		SPT2		N=6	400												
2.1																	
2.2																	
2.3			Firm to stiff mottled yellow, green, grey, white,														
2.4			brown fine to medium grained clayey SAND														
2.5			with pockets of gravel														
2.6																	
2.7																	
2.8																	
2.9																	
3		SPT3		N=21	325												
3.1																	
3.2																	
3.3																	
3.4																	
3.5																	
3.6		ds3	Medium dense to dense mottled red, brown,							16.2	38	12	26	57	25	18	18
3.7			yellow, green, grey sandy, clayey GRAVEL														
3.8																	
3.9																	
4		SPT4		N=14	225												
4.1																	
4.2																	
4.3			Stiff to hard mottled yellow, green, grey, light														
4.4			brown, dark brown clayey SAND														
4.5																	
4.6																	
4.7																	
4.8																	
4.9																	
5		SPT5		N=16	380												

LEGEND

ds - disturbed sample	LL - Liquid Limit	▼ Ground Water level	**Notes** Refusal recorded at 7m
ud - undisturbed sample	PL - Plastic Limit		
SPT - Standard Penetration Test Sample	PI - Plasticity Index		
nmc - natural moisture content	DFS - Differential Free Swell		

BOREHOLE LOG

GEOTECHNICAL INVESTIGATION FOR ACECOR BUILDING PROJECT AT UNIVERSITY OF CAPE COAST

CLIENT: FAS CONSULT LIMITED

BORING METHOD: PERCUSSION — **LOGGED BY: E Koranteng**

Hole Diameter: 150mm — **START DATE: 15th February, 2021**

Borehole No.: 1 (Page 2 of 2) — Latitude 5.10227, Longitude -1.28471 — **END DATE: 16th February, 2021**

Depth (m)	Assumed Elevation (m)	Sample Type	Soil/Rock Description		SPT Test: N-Value	SPT Test: Material Recovery (mm)	Rotary Core drilling: Core Run (m)	Rotary Core drilling: Water Return (%)	Rotary Core drilling: Total Core Recovery (%)	Rotary Core drilling: RQD (%)	Moisture Content (%)	Consistency Limits: Liquid Limit (%)	Consistency Limits: Plastic Limit (%)	Consistency Limits: Plastic Index (%)	Grading: Gravel (%)	Grading: Sand (%)	Grading: Fines (%)	DFS (%)
5.0																		
5.1																		
5.2																		
5.3																		
5.4																		
5.5		ds4	Stiff to hard mottled yellow, green, grey, light								22.6	40	16	24	0	40	60	37
5.6			brown, dark brown clayey SAND															
5.7																		
5.8																		
5.9																		
6		SPT6			N=22	390												
6.1																		
6.2																		
6.3																		
6.4																		
6.5																		
6.6																		
6.7																		
6.8																		
6.9																		
7		SPT7			N=62	260												
7.1																		
7.2																		
7.3																		
7.4		ds5	Dense to very dense mottled yellow, green,								16.7	29	17	12	0	69	31	0
7.5			grey, black, brown highly weathered															
7.6			SANDSTONE															
7.7																		
7.8																		
7.9																		
8		SPT8			N=60	180												
8.1																		
8.2																		
8.3																		
8.4																		
8.5																		
8.6																		
8.7																		
8.8		SPT9			N=60	0												
8.9			End of hole															
9																		
9.1																		
9.2																		
9.3																		
9.4																		
9.5																		
9.6																		
9.7																		
9.8																		
9.9																		
10																		

LEGEND

ds - disturbed sample — LL - Liquid Limit — ▼ Ground Water level

ud - undisturbed sample — PL - Plastic Limit

SPT - Standard Penetration Test Sample — PI - Plasticity Index

nmc - natural moisture content — DFS - Differential Free Swell

Notes

Refusal recorded at 7m

BOREHOLE LOG

GEOTECHNICAL INVESTIGATION FOR ACECOR BUILDING PROJECT AT UNIVERSITY OF CAPE COAST

CLIENT: FAS CONSULT LIMITED

BORING METHOD: PERCUSSION | **LOGGED BY: E Koranteng**

Hole Diameter: 150mm | **START DATE: 18th February, 2021**

Borehole No.: 2 (Page 1 of 2) | Latitude 5.10187, Longitude -1.28440 | **END DATE: 19th February, 2021**

Depth (m)	Assumed Elevation (m)	Sample Type	Soil/Rock Description		SPT Test: N-Value	SPT Test: Material Recovery (mm)	Rotary Core drilling: Core Run (m)	Rotary Core drilling: Water Return (%)	Rotary Core drilling: Total Core Recovery (%)	Rotary Core drilling: RQD (%)	Moisture Content (%)	Consistency Limits: Liquid Limit (%)	Consistency Limits: Plastic Limit (%)	Consistency Limits: Plastic Index (%)	Grading: Gravel (%)	Grading: Sand (%)	Grading: Fines (%)	DFS (%)
0.0																		
0.1																		
0.2			Loose mottled black, yellow, green, grey															
0.3			clayey SAND															
0.4																		
0.5																		
0.6																		
0.7																		
0.8		ds1									17.2	18	8	10	3	37	60	36
0.9																		
1		SPT1	Soft mottled yellow, green, grey		N=2	0												
1.1			sandy CLAY with pockets of gravel															
1.2		▼																
1.3																		
1.4																		
1.5																		
1.6																		
1.7																		
1.8																		
1.9																		
2		SPT2			N=9	450												
2.1																		
2.2																		
2.3																		
2.4																		
2.5																		
2.6																		
2.7		ds2									17.8	35	12	23	0	62	38	36
2.8																		
2.9																		
3		SPT3			N=8	450												
3.1																		
3.2																		
3.3			Stiff to hard mottled yellow, green, grey															
3.4			brown, sandy CLAY with pockets of gravel															
3.5																		
3.6																		
3.7																		
3.8																		
3.9																		
4		SPT4			N=20	340												
4.1																		
4.2																		
4.3																		
4.4																		
4.5																		
4.6																		
4.7																		
4.8																		
4.9																		
5		SPT5			N=22	400												

End of hole

LEGEND

ds - disturbed sample | LL - Liquid Limit | ▼ Ground Water level

ud - undisturbed sample | PL - Plastic Limit

SPT - Standard Penetration Test Sample | PI - Plasticity Index

nmc - natural moisture content | DFS - Differential Free Swell

Notes

Refusal recorded at 8.7m

BOREHOLE LOG

GEOTECHNICAL INVESTIGATION FOR ACECOR BUILDING PROJECT AT UNIVERSITY OF CAPE COAST

CLIENT: FAS CONSULT LIMITED

BORING METHOD: PERCUSSION | **LOGGED BY: E Koranteng**

Hole Diameter: 150mm | **START DATE : 18th February, 2021**

Borehole No.: 2 (Page 2 of 2) | Latitude 5.10187, Longitude -1.28440 | **END DATE : 19th February, 2021**

Depth (m)	Assumed Elevation (m)	Sample Type	Soil/Rock Description	SPT Test: N-Value	SPT Test: Material Recovery (mm)	Rotary Core drilling: Core Run (m)	Rotary Core drilling: Water Return (%)	Rotary Core drilling: Total Core Recovery (%)	Rotary Core drilling: RQD (%)	Moisture Content (%)	Consistency Limits: Liquid Limit (%)	Consistency Limits: Plastic Limit (%)	Consistency Limits: Plastic Index (%)	Grading: Gravel (%)	Grading: Sand (%)	Grading: Fines (%)	DFS (%)
5.0																	
5.1																	
5.2			Stiff to hard mottled yellow, green, grey														
5.3			brown, sandy CLAY with pockets of gravel														
5.4																	
5.5																	
5.6																	
5.7																	
5.8																	
5.9																	
6		SPT6		N=22	380												
6.1																	
6.2																	
6.3																	
6.4																	
6.5																	
6.6																	
6.7																	
6.8																	
6.9																	
7		SPT7	Medium dense to very dense mottled yellow,	N=48	340												
7.1			green, grey, black, brown highly weathered														
7.2			SANDSTONE														
7.3																	
7.4																	
7.5																	
7.6																	
7.7		ds3								17.7	29	18	11	0	72	28	0
7.8																	
7.9																	
8		SPT8		N=48	370												
8.1																	
8.2																	
8.3																	
8.4																	
8.5																	
8.6																	
8.7																	
8.8		SPT9		N=50	30												
8.9			End of hole														
9																	
9.1																	
9.2																	
9.3																	
9.4																	
9.5																	
9.6																	
9.7																	
9.8																	
9.9																	
10																	

End of hole

LEGEND

- ds - disturbed sample
- ud - undisturbed sample
- SPT - Standard Penetration Test Sample
- nmc - natural moisture content
- LL - Liquid Limit
- PL - Plastic Limit
- PI - Plasticity Index
- DFS - Differential Free Swell
- ▼ Ground Water level

Notes

Refusal recorded at 8.7m

BOREHOLE LOG

GEOTECHNICAL INVESTIGATION FOR ACECOR BUILDING PROJECT AT UNIVERSITY OF CAPE COAST

CLIENT: FAS CONSULT LIMITED

BORING METHOD: PERCUSSION | **LOGGED BY: E Koranteng**

Hole Diameter: 150mm | **START DATE: 16th February, 2021**

Borehole No.: 3 (Page 1 of 2) | Latitude 5.10191, Longitude -1.28489 | **END DATE: 17th February, 2021**

Depth		Sample			SPT Test		Rotary Core drilling					Consistency Limits			Grading			
(m)	Assumed Elevation (m)	Type	Soil/Rock Description		N-Value	Material Recovery (mm)	Core Run (m)	Water Return (%)	Total Core Recovery (%)	RQD (%)	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plastic Index (%)	Gravel (%)	Sand (%)	Fines (%)	DFS (%)
0.0																		
0.1																		
0.2																		
0.3																		
0.4																		
0.5																		
0.6		ds1									12.0		Non-Plastic		1	62	37	0
0.7			Loose mpttled black, brown, yellow, green															
0.8			fine to medium grained clayey SAND															
0.9																		
1		SPT1			N=2	0												
1.1																		
1.2																		
1.3																		
1.4																		
1.5		ds2									10.9	42	20	22	8	71	21	79
1.6																		
1.7		▼																
1.8																		
1.9																		
2		SPT2			N=6	450												
2.1																		
2.2																		
2.3																		
2.4																		
2.5		ds2									17.0	41	12	29	0	55	45	24
2.6																		
2.7			Stiff to hard mottled yellow, green, grey															
2.8			brown, clayey SAND with pockets of gravel															
2.9																		
3		SPT3			N=7	410												
3.1																		
3.2																		
3.3																		
3.4																		
3.5																		
3.6																		
3.7																		
3.8																		
3.9																		
4		SPT4			N=16	450												
4.1																		
4.2																		
4.3																		
4.4																		
4.5																		
4.6																		
4.7																		
4.8																		
4.9																		
5		SPT5			N=25	420												

End of hole

LEGEND

- ds - disturbed sample
- ud - undisturbed sample
- SPT - Standard Penetration Test Sample
- nmc - natural moisture content
- LL - Liquid Limit
- PL - Plastic Limit
- PI - Plasticity Index
- DFS - Differential Free Swell
- ▼ Ground Water level

Notes

Refusal recorded at 7m

BOREHOLE LOG

GEOTECHNICAL INVESTIGATION FOR ACECOR BUILDING PROJECT AT UNIVERSITY OF CAPE COAST

CLIENT: FAS CONSULT LIMITED

BORING METHOD: PERCUSSION | **LOGGED BY: E Koranteng**

Hole Diameter: 150mm | **START DATE: 16th February, 2021**

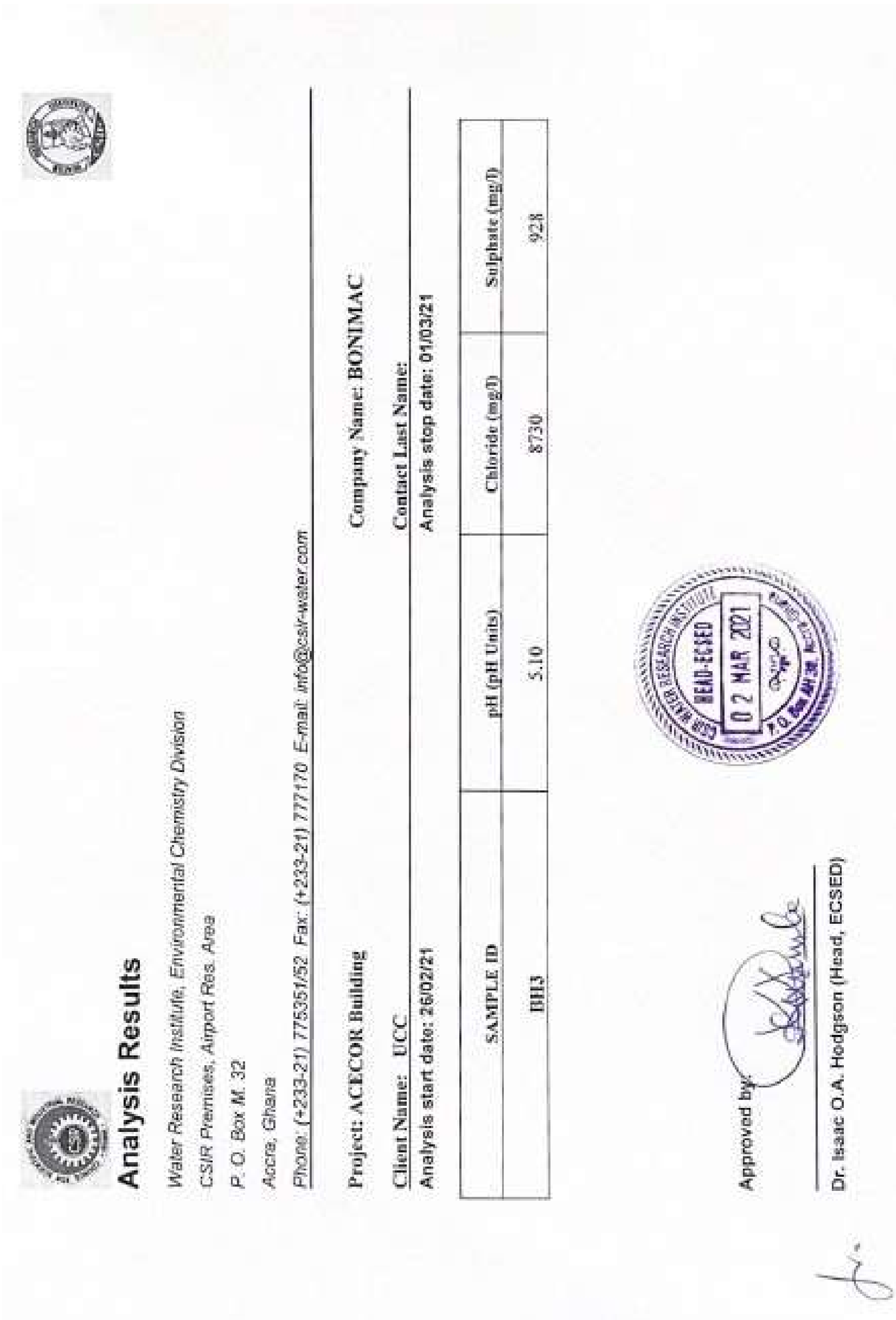
Borehole No.: 3 (Page 2 of 2) Latitude 5.10191, Longitude -1.28489 | **END DATE: 17th February, 2021**

Depth (m)	Assumed Elevation (m)	Sample Type	Soil/Rock Description	SPT Test: N-Value	SPT Test: Material Recovery (mm)	Rotary Core drilling: Core Run (m)	Rotary Core drilling: Water Return (%)	Rotary Core drilling: Total Core Recovery (%)	Rotary Core drilling: RQD (%)	Moisture Content (%)	Consistency Limits: Liquid Limit (%)	Consistency Limits: Plastic Limit (%)	Consistency Limits: Plastic Index (%)	Grading: Gravel (%)	Grading: Sand (%)	Grading: Fines (%)	DFS (%)
5.0																	
5.1																	
5.2																	
5.3																	
5.4																	
5.5																	
5.6																	
5.7			Stiff to hard mottled yellow, green, grey														
5.8			brown, clayey SAND with pockets of gravel														
5.9																	
6		SPT6		N=33	370												
6.1																	
6.2																	
6.3																	
6.4																	
6.5																	
6.6																	
6.7																	
6.8																	
6.9																	
7		SPT7		N=55	270												
7.1																	
7.2																	
7.3																	
7.4																	
7.5		ds3	Very dense mottled yellow, green, grey, black							15.3	24	18	6	0	73	27	36
7.6			brown highly weathered SANDSTONE														
7.7																	
7.8																	
7.9																	
8		SPT8		N=60	270												
8.1																	
8.2																	
8.3																	
8.4																	
8.5																	
8.6																	
8.7																	
8.8																	
8.9																	
9		SPT9		N=60	240												
9.1			End of hole														
9.2																	
9.3																	
9.4																	
9.5																	
9.6																	
9.7																	
9.8																	
9.9																	
10																	

End of hole

LEGEND			Notes
ds - disturbed sample	LL - Liquid Limit	▼ Ground Water level	Refusal recorded at 7m
ud - undisturbed sample	PL - Plastic Limit		
SPT - Standard Penetration Test Sample	PI - Plasticity Index		
nmc - natural moisture content	DFS - Differential Free Swell		

APPENDIX B – CHEMICAL TEST ON WATER SAMPLE



Analysis Results

Water Research Institute, Environmental Chemistry Division
CSIR Premises, Airport Res. Area
P. O. Box M. 32
Accra, Ghana
Phone: (+233-21) 775351/52 Fax: (+233-21) 777170 E-mail: info@csir-water.com

Project: ACECOR Building **Company Name: BONIMAC**

Client Name: UCC **Contact Last Name:**

Analysis start date: 26/02/21 Analysis stop date: 01/03/21

SAMPLE ID	pH (pH Units)	Chloride (mg/l)	Sulphate (mg/l)
BH3	5.10	8730	928

Approved by:

Dr. Isaac O.A. Hodgson (Head, ECSED)