ENGINEERS WITHOUT BORDERS(EWB) -KNUST

GEOTECHNICAL ENGINEERING REPORT ON CLINIC PROJECT AT ULLO COMMUNITY, UPPER WEST REGION

January 7, 2021

GLOSSARY SYMBOLS AND ABBREVIATION

ABBREVIATION	NAME
AASHTO	American Association of State Highway and Transport Officials
AB	Auger Boring
ASTM	American Society for Testing and Materials
BS	British Standard
DCPT	Dynamic Cone Penetration Test
MC	Moisture Content
FS	Factor of Safety
LL	Liquid Limit
M/C	Moisture Content
PL	Plastic Limit
PI	Plasticity Index
Qall	Allowable Bearing Capacity
PL	Plastic limit
SG	Specific gravity
UCS	Unified classification system
TP	Trial pit
DH	Drill hole
Btn	Between

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1.0 INTRODUCTION

Engineers without Borders – Iowa State university (EWB-ISU) has committed to design and construct a new clinic facility for the Ullo Community in the Upper West region of Ghana. As part of the design a geotechnical investigation of the site for the project is required. Engineers without Borders - Kwame Nkrumah University of Science and Technology (EWB-KNUST), as part of their collaboration with EWB-ISU, undertook geotechnical investigations at the site for the clinic project at Ullo in the Upper West Region of Ghana. The aim of the investigation is to assess the general subsurface condition of the site and provide specific geotechnical parameters for the design of the foundations of the structure. This report presents the fieldwork and laboratory work undertaken as well as a discussion of the results and recommendations for the design.

2.0 FIELD WORK

The proposed site is a piece of a land at Ullo in the Upper West region of Ghana. The site is about 2km from the senior high school of the Ullo community. A simplified site investigation was designed which consisted of a combination of dynamic cone penetrometer (DCP) test, manual vibratory percussive drilling and trial pitting. The fieldwork was conducted on 7th of November 2020. A total of eleven (11) points were probed with the DCP, four (4) drill holes were sunk, and four trial pits were excavated. The location of the investigation points relative to the site is shown in Figure 1.

Figure 1: A google map image showing the points where all Trial pitting, DCPT and drilling took place

2.1 Field reconnaissance

Upon visit to the site, the clinic project team made a few key observations as follows:

- The topsoil was very dry
- The site slopes gently towards the road/path.
- The site has a vegetation cover in the form weeds and a few trees.

2.2 Trial pitting

Four trial pits were excavated at the site namely TP1, TP2, TP3 and TP4. The coordinates of the locations for the trial pits are given in table 1 at the appendix. The trial pits were about 0.3 m wide, 0.6m long, and depths varying between 0.3m to 0.6m. The depth of the trial pit depended on the hardness of the formation which made it difficult to excavate deeper. The trial pits were logged and samples were obtained from the different layers for Index property tests.

Figure 2: An image showing the trial pit being logged

Figure 3: An image showing trial pits being dug

2.2Vibratory Percussive Drilling

Drill holes were sunk at four locations on the proposed site to obtain a field log of the subsurface profile and to obtain samples for laboratory testing. The drill holes labelled DH1, DH2, DH3 and DH4 were made using a manual percussive drilling equipment with 60mm diameter split sampler with rod attachments. The test was terminated at a depth of 0.3m for DH1, 0.7m for DH2, 3.0m for DH3 and 1.0m for DH4 on account of the hardness of the formation. Some samples were retrieved and visually logged according to the Unified Soil Classification system. Figure 4 show the manual percussive drilling in progress. The samples were collected in plastic bags, labelled, and sealed for further analysis at the KNUST Soils laboratory. The results of the DCP blows-penetration plot are superimposed on the field logs of the drill holes in the appendix.

Figure 4: An image of an Auger drill in operation

Figure 5: An image of a sample obtained by Auger drilling

2.4Dynamic cone penetration testing

The Dynamic Cone Penetrometer (DCP) Test was conducted at eleven (11) locations. The test was conducted at the drilling points, trial pitting points and three (3) additional points. The DCP equipment used in this investigation consisted of a 10kg hammer dropping over a height of 460mm to strike an anvil that drove a 60^{o} cone into the ground. During the DCP test, at each DCP point the hammer was allowed to fall freely and the number of blows required to drive the cone 100mm into the ground (designated DCP n-value, (N_{DCP}) was recorded against the penetration. The details of the results of the number of blows against the penetration for the eleven (11) DCP points are given in the Appendix. Figure 6 shows the DCP test in progress.

Figure 6: An image showing DCPT test in progress

3.0 LABORATORY TESTING

The disturbed sample obtained by boring and trial pitting on site were tested. The tests provided information concerning the properties of soil found on site specific to the proposed Clinic site. For the Atterberg limits tests, the liquid limit and plastic limit tests of soil from the drill holes and trial pits were done in accordance with BS 1377 Part 2[1], (ASTM equivalent: ASTM D4318-00). The Cone Penetrometer method was used for the liquid limit tests. The grading tests were also performed in accordance with BS 1377 Part 2 (ASTM D422-63 (2002). The fine particles were determined using the hydrometer method with the dispersing agent being sodium hexametaphosphate. Table 2 in the appendix has the result of all laboratory test.

4.0 DISCUSSION OF RESULTS

4.1 Subsurface Description

The soil profile encountered at the site with respect to the trial pits shows a very dry, medium-dense topsoil of about 0.1m thick. Beneath this topsoil there exist a layer of dry, medium- dense, brownish-red, poorly graded sand with average thickness of about 0.3m. The final layer encountered beneath the aforementioned layer has an average thickness of about 0.2m and can be described as a, moist, dense, reddish-brown, poorly graded gravel. Digging deeper than a depth of about 0.8m either by means of trial pitting or auger drilling is difficult suggesting the presence of a stiff material perhaps a soft rock relatively very close to the surface of the ground. However, there was an exception for on the drill holes precisely DH3 which went deep to about 3m. The earth material sampled from that hole was inadequate to perform the classification test but by inspection from about 1.0m mark to about the 3m mark one can suggest it to be dense, damp, reddish –brown, clayey sand.

Groundwater was not encounter in any of the trial pits or the drill holes. Below is cross-section profile of classification and description information from only the trial pits.

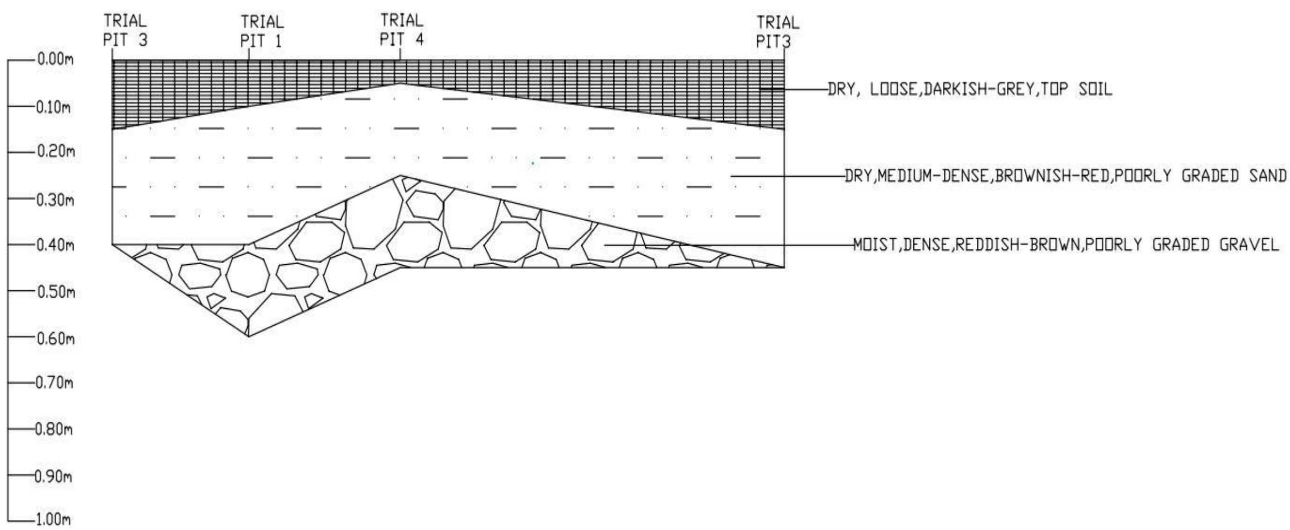


Figure 7:Cross-section Profile describing the proposed site with reference to only Trial pits.

4.2 Strength Profile

In the case of the strength determination of the soil the DCP test was used. The q_{allow} for each measured N_{DCP} was estimated from the equation ($q_{allow} = 44.9N_{DCP}$). This equation was obtained using the properties of the DCP equipment used for this investigation and utilizing an equation developed by Sanglerat (1972) for shallow foundations.

The profile shows that the removal of the top soil will immediately reveal the hard soil layer. Structural foundations may be placed at a minimum depth of 1.2m below ground surface. For a 1.2m wide footing at this depth, a minimum allowable bearing pressure of the order of about 500kN/m^2 (based on 25mm settlement) is recommended.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the fieldwork and subsequent analysis, the subsurface conditions at the site are considered suitable for the proposed development. Ground water was not encountered in any of the drill holes or trial pits investigated within the depths investigated.

The structural foundations of the proposed development may place at a depth of 1.2 m with an allowable bearing capacity of about 500 KN/m^2. Considering the nature of material encountered at the site, provision should be made for excavation in hard material.

6.0 APPENDIX

6.1 Table 1: Coordinates of the Test points (Trial pits, Drill Holes and DCPT)

ID	Longitude	Latitude	NOTES
DCP1(DH4)	2.56083333	10.68842500	
DCP 2	2.52722222	10.68838333	between DH4&TP4
DCP 3(TP4)	2.56027778	10.68829167	
DCP 4	2.56027778	10.68814722	betweenTP4&TP1
DCP5(DH2)	2.56055556	10.68818056	
DCP 6 (TP3)	2.56111111	DC	
DCP 7(DH3)	2.56083333	10.68801944	
DCP8(TP1)	2.56027778	10.68804167	
DCP 9(DH1)	2.56027778	10.68787778	between TP2 &TP1
DCP10	2.56055556	10.68786111	
DCP 11(TP2)	2.56055556	10.68774722	

6.2 Table 2: Summary Table of Laboratory results.

Sample ID	Depth (m)	Moisture Content (%)	SG	Atterberg limits			Grading				USCS
				PL	LL	PI	Gravel	Sand	Silt	Clay	
TP1	0.1-0.4	3.1	2.8	NP	20.1	NP	31	64	3	12	SP
	0.4-0.6	5.1	2.9	14	29	15	51	49	1	0	GP
TP 2	0.15-0.4	3.4	2.3	14	24	10	22	71	5	2	SP
TP 3	0.15-0.35	2.4	2.8	13	17	4	7	81	10	2	GP
	0.35-0.45	2.6	2.5	14	18	4	17	74	7	2	SP
TP4	0.05-0.25	3.6	2.2	7	14	7	35	59	3	3	SP
	0.25-0.45	4.2	2.5	16	24	8	57	37	6	0	GP
DH1	0-0.3	5	-	NP	30	NP	28	36	21	15	-
DH 2	0.0-0.2	5.7	1.6	16	24	8	21	74	2	3	SP
DH3	0.0-0.2	2.5	1.6	Not enough(Clayey sand)							
	0.2-1.0	10.9		24	43	19					-
	1.0-2.0	22.3		29	63	34	Not enough(silty clay)				SC
	2.0-3.0	23.2		26	60	34	Not enough(silty clay)				SC

DH4	0.0-0.4	4.4		Not-enough	48	49	2	1	SW
	0.4-1.0	8.8		Not-enough	51	49	0	0	GW

6.3 Drill hole Logs

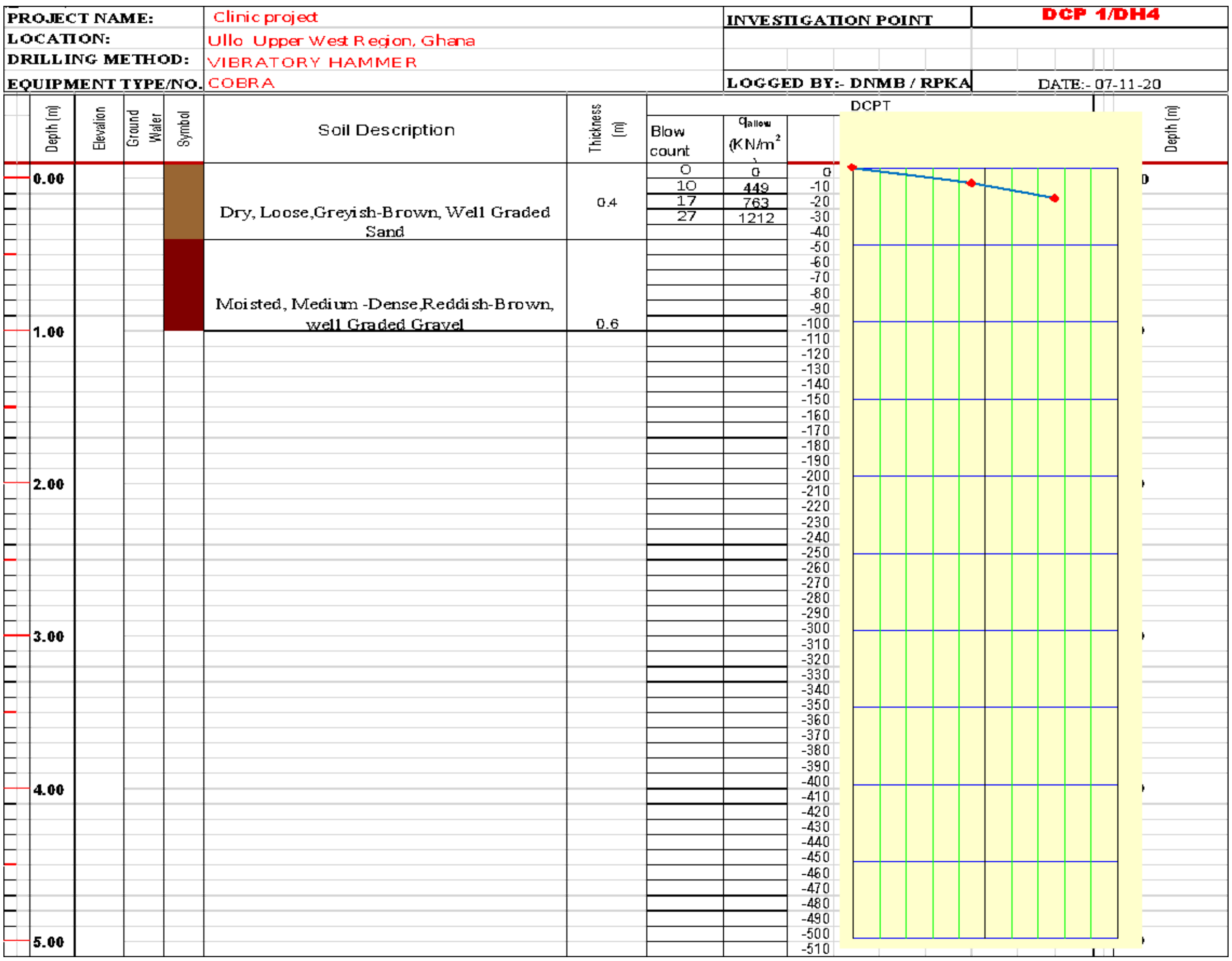


Figure 8:Drill hole Logs for DCP1/DH4

PROJECT NAME:	Clinic project	INVESTIGATION POINT	DCP 2(btn DH4&TP4)
LOCATION:	Ullo Upper West Region, Ghana		
DRILLING METHOD:	VIBRATORY HAMMER		
EQUIPMENT TYPE/NO.	COBRA	LOGGED BY:- DNMB / RPKA	DATE:- 07-11-20

Depth (m)	Elevation	Ground Water	Symbol	Soil Description	Thickness	Blow count	q_{blow} (KN/m^2)	DCPT
0.00						0	0	0
						3	135	-10
						15	674	-20
						24	1078	-30
						33	1482	-40
						43	1931	-50
						84	3772	-60
								-70
								-80
								-90
1.00								-100
								-110
								-120
								-130
								-140
								-150
								-160
								-170
								-180
								-190
2.00								-200
								-210
								-220
								-230
								-240
								-250
								-260
								-270
								-280
								-290
3.00								-300
								-310
								-320
								-330
								-340
								-350
								-360
								-370
								-380
								-390
4.00								-400
								-410
								-420
								-430
								-440
								-450
								-460
								-470
								-480
								-490
5.00								-500
								-510

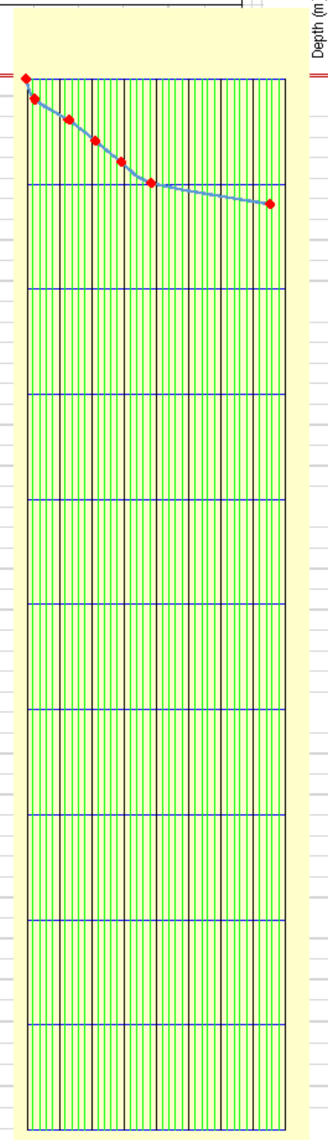


Figure 9:Drill hole Log for DCP(between DH4&TP4)

PROJECT NAME:	Clinic project	INVESTIGATION POINT	DCP 3(TP4)
LOCATION:	Ullo Upper West Region, Ghana		
DRILLING METHOD:	VIBRATORY HAMMER		
EQUIPMENT TYPE/NO.	COBRA	LOGGED BY:- DNMB / RPKA	DATE:- 07-11-20

Depth (m)	Elevation	Ground Water	Symbol	Soil Description	Thickness	Blow count	q_{allow} (KN/m^2)	DCPT
0.00				Dry,loose ,Darkish-Grey,Grading,(Topsoil with plant roots)	0.05	0	0	0
						8	359	-10
				Grey ,Dry,Medium-dense,Poorly Graded Sand	0.2	22	988	-20
						21	943	-30
						20	898	-40
				Dry,dense,Reddish-Brownish,grading,	0.2	86	3861	-50
1.00								
2.00								
3.00								
4.00								
5.00								

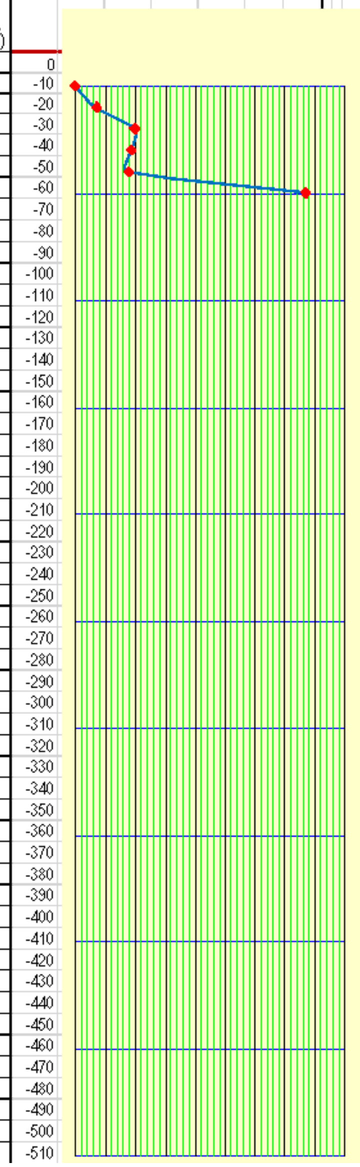


Figure 10:Trial pit Logs for DCP3(TP4)

PROJECT NAME:	Clinic project	INVESTIGATION POINT	DCP 4(btn TP4&TP1)
LOCATION:	Ullo Upper West Region, Ghana		
DRILLING METHOD:	VIBRATORY HAMMER		
EQUIPMENT TYPE/NO.	COBRA	LOGGED BY:- DNMB / RPKA	DATE:- 07-11-20

Depth (m)	Elevation	Ground Water	Symbol	Soil Description	Thickness	Blow count	q_{allow} (KN/m^2)
0.00						0	0
						3	135
						4	180
						25	1123
						34	1527
						40	1796
						47	2110
						40	1796
						26	1167
						36	1616
1.00						18	808
						14	629
						17	763
						15	674
						18	808
						20	898
						23	1033
						33	1482
						30	1347
						30	1347
2.00						27	1212
						35	1572
						36	1616
						34	1527
						35	1572
						40	1796
						83	3727
3.00							
4.00							
5.00							

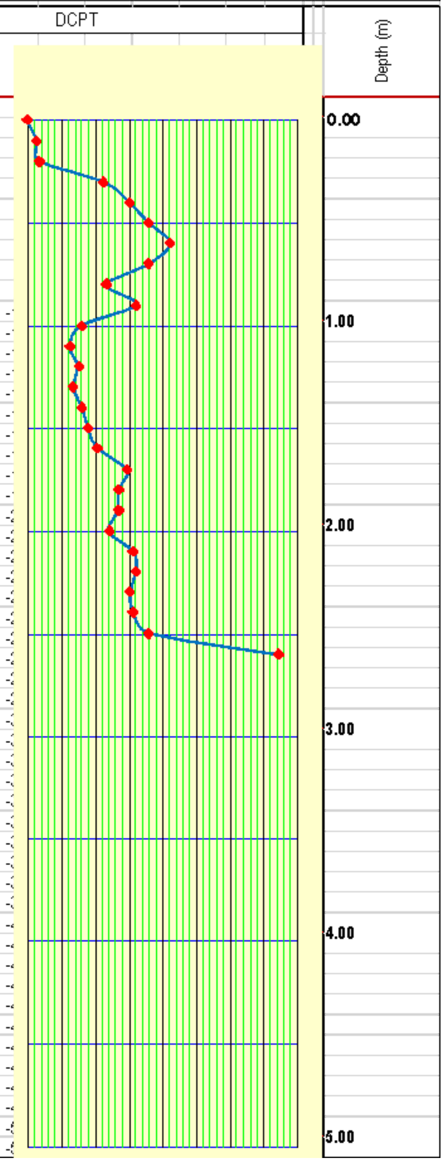


Figure 11:Drill Hole Logs for DCP4(between TP4&TP1)

PROJECT NAME:	Clinic project	INVESTIGATION POINT	DCP 5(DH2)
LOCATION:	Ullo Upper West Region, Ghana		
DRILLING METHOD:	VIBRATORY HAMMER		
EQUIPMENT TYPE/NO.	COBRA	LOGGED BY:- DNMB / RPKA	DATE:- 07-11-20

Depth (m)	Elevation	Ground Water	Symbol	Soil Description	Thickness	Blow count	q_{allow} (KN/m^2)	DCPT
0.00				Dry, loose, Brownish-Red, Poorly Graded Sand	0.2	0	0	0
						9	404	-10
						20	898	-20
						29	1302	-30
						31	1392	-40
						27	1212	-50
						29	1302	-60
						54	2425	-70
1.00								
2.00								
3.00								
4.00								
5.00								

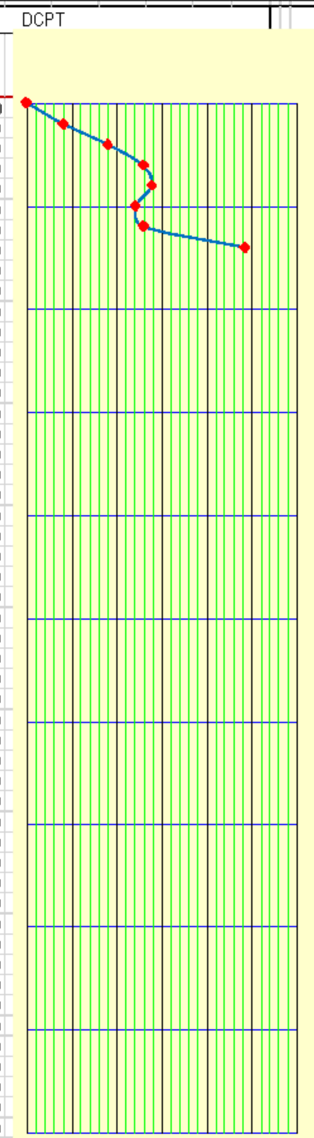


Figure 12: Drill Hole Logs for DCP5(DH2)

PROJECT NAME:	Clinic project	INVESTIGATION POINT	DCP 6(TP3)
LOCATION:	Ullo Upper West Region, Ghana		
DRILLING METHOD:	VIBRATORY HAMMER		
EQUIPMENT TYPE/NO.	COBRA	LOGGED BY:- DNMB / RPKA	DATE:- 07-11-20

Depth (m)	Elevation	Ground Water	Symbol	Soil Description	Thickness	Blow count	q_{allow} (KN/m^2)	DCPT
0.00						0	0	0
				Dry,Loose, Grey, Grading	0.15	85	3817	-10
						30	1347	-20
				Dry,Loose, Bronwish-Grey, Grading	0.2	62	2784	-30
				Dry, Medium-Dense Reddish-	0.1			-40
1.00								-100
2.00								-200
3.00								-300
4.00								-400
5.00								-500
								-510

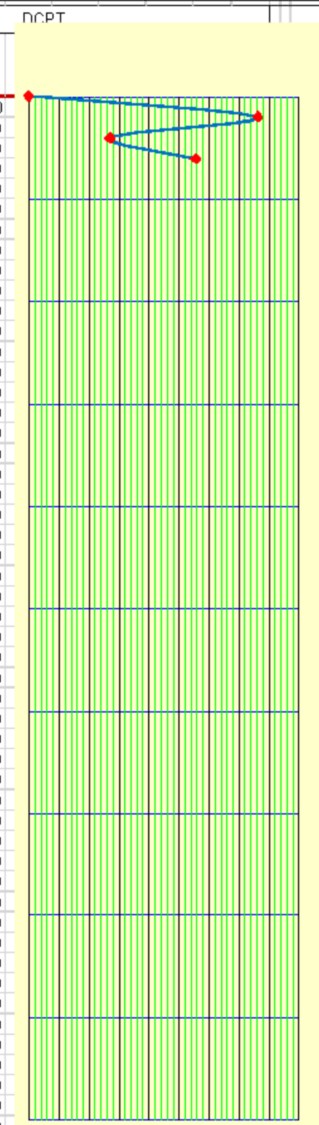


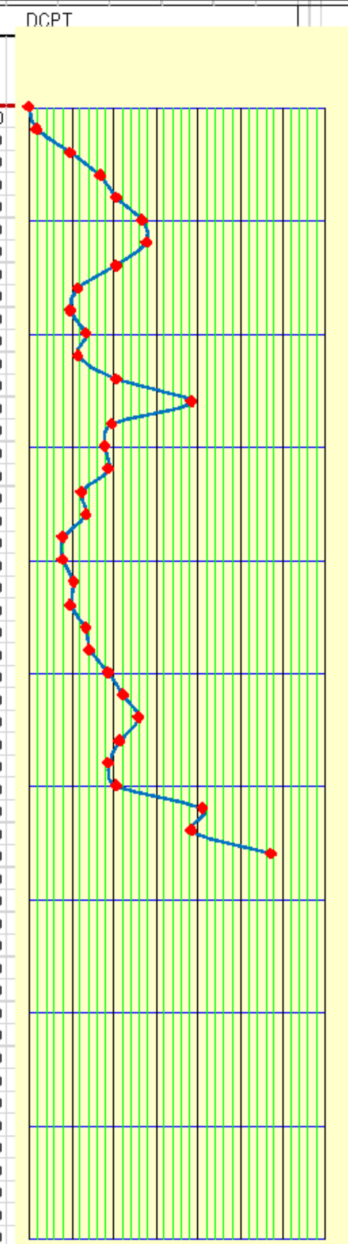
Figure 13: Trial Pit Log for DCP6(TP3)

PROJECT NAME:	Clinic project	**INVESTIGATION POINT**	**DCP7/Dh3**
LOCATION:	Ullo Upper West Region, Ghana		
DRILLING METHOD:	VIBRATORY HAMMER		
EQUIPMENT TYPE/NO.	COBRA	**LOGGED BY:- AKL / MO**	DATE:- 07-11-20

Depth (m)	Elevation	Ground Water	Symbol	Soil Description	Thickness (m)
0.00				Dry, Loose, Reddish brown, Poorly Graded sand.	0.2
				Dry, Loose, Brownish- Red,poorly Graded Sand	0.8
1.00				Moist,medium -dense, Reddish-Brown,Sandy clay	1
2.00				Moist,Dense, Reddish-Brown,sandy clay	
3.00					
4.00					
5.00					

DCPT

Blow count	q_{allow} (KN/m^2)	
0	0	0
2	90	-10
11	494	-20
19	853	-30
23	1033	-40
30	1347	-50
31	1392	-60
23	1033	-70
13	584	-80
11	494	-90
15	674	-100
13	584	-110
23	1033	-120
43	1931	-130
22	988	-140
20	898	-150
21	943	-160
14	629	-170
15	674	-180
9	404	-190
9	404	-200
12	539	-210
11	494	-220
15	674	-230
16	718	-240
21	943	-250
25	1123	-260
29	1302	-270
24	1078	-280
21	943	-290
23	1033	-300
46	2065	-310
43	1931	-320
64	2874	-330
		-340
		-350
		-360
		-370
		-380
		-390
		-400
		-410
		-420
		-430
		-440
		-450
		-460
		-470
		-480
		-490
		-500
		-510



Depth (m)

Figure 14:Drill Hole Logs for DCP7/DH3

PROJECT NAME:	Clinic project	INVESTIGATION POINT	DCP8 /TP1
LOCATION:	Ullo Upper West Region, Ghana		
DRILLING METHOD:	VIBRATORY HAMMER		
EQUIPMENT TYPE/NO.	COBRA	LOGGED BY:- AKL / MO	DATE:- 07-11-20

Depth (m)	Elevation	Ground Water	Symbol	Soil Description	Thickness
0.00				Dry,loose,Brownish-grey, Top soil	0.1
				Dry,Medium-Dense,Brownish-grey, Poorly Graded sand	0.3
				Moist,Dense, Reddish Brown Poorly Graded Gravel	0.2
1.00					
2.00					
3.00					
4.00					
5.00					

Blow count	q_{allow} (KN/m^2)	DCPT
0	0	0
4	180	-10
20	898	-20
29	1302	-30
50	2245	-40
38	1706	-50
3	135	-60
77	3457	-70

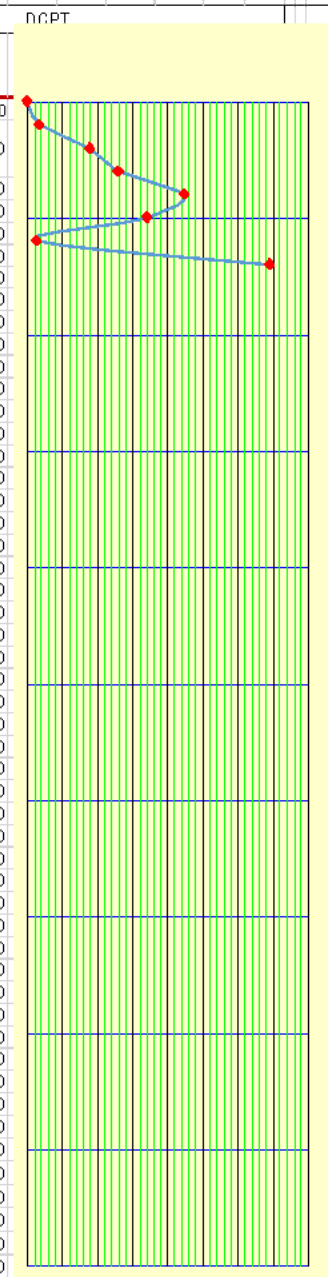


Figure 15:Trial Pit Logs for DCP8/TP1

PROJECT NAME:	Clinic project	INVESTIGATION POINT	DCP9 /DH1
LOCATION:	Ullo Upper West Region, Ghana		
DRILLING METHOD:	VIBRATORY HAMMER		
EQUIPMENT TYPE/NO.	COBRA	LOGGED BY:- AKL / MO	DATE:- 07-11-20

Depth (m)	Elevation	Ground Water	Symbol	Soil Description	Thickness	Blow count	q_{allow} (KN/m^2)
0.00				Dry,loose,Brownish-grey,Poorly Graded Sand	0.3	0	0
						14	629
						48	2155
						52	2335
1.00							
2.00							
3.00							
4.00							
5.00							

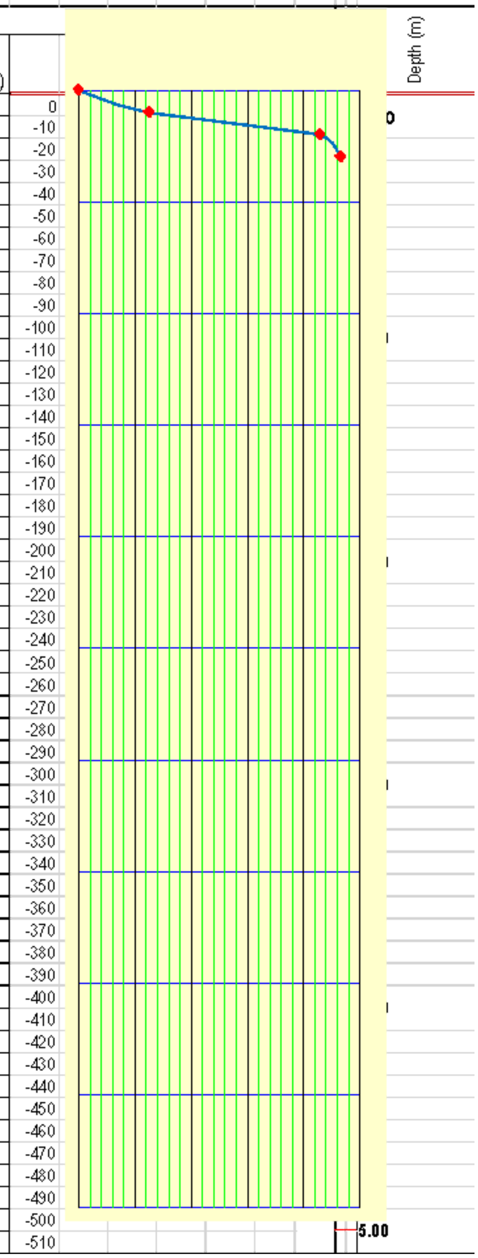


Figure 16:Drill Hole Logs for DCP8/DH1

PROJECT NAME:	Clinic project	INVESTIGATION POINT	DCP10(Btn TP2&TP1)
LOCATION:	Ullo Upper West Region, Ghana		
DRILLING METHOD:	VIBRATORY HAMMER		
EQUIPMENT TYPE/NO.	COBRA	LOGGED BY:- AKL / MO	DATE:- 07-11-20

Depth (m) | Elevation | Ground Water | Symbol | Soil Description | Thickness | DCPT | Depth (m)

Depth (m): 0.00, 1.00, 2.00, 3.00, 4.00, 5.00

Blow count	q_{allow} (KN/m^2)	
0	0	0
4	180	-10
16	718	-20
32	1437	-30
21	943	-40
17	763	-50
25	1123	-60
30	1347	-70
23	1033	-80
23	1033	-90
24	1078	-100
19	853	-110
25	1123	-120
43	1931	-130
67/3		-140
		-150
		-160
		-170
		-180
		-190
		-200
		-210
		-220
		-230
		-240
		-250
		-260
		-270
		-280
		-290
		-300
		-310
		-320
		-330
		-340
		-350
		-360
		-370
		-380
		-390
		-400
		-410
		-420
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		-480
		-490
		-500
		-510

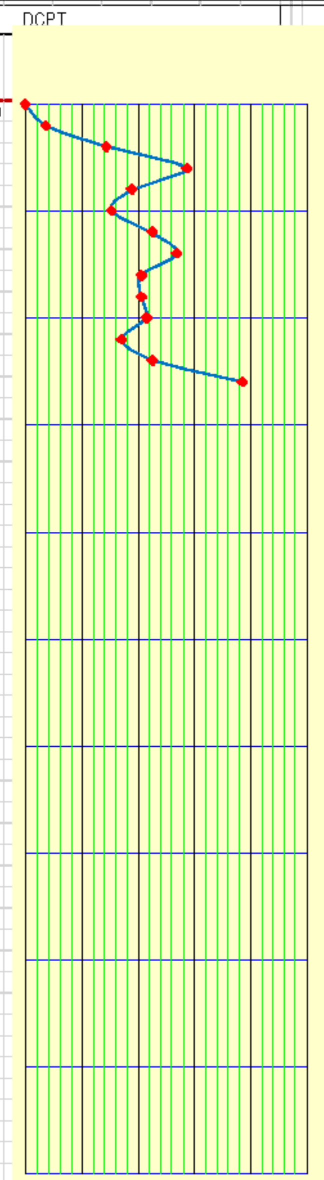

Figure 17: Drill Hole Logs for DCP10(Between TP2&TP1)

PROJECT NAME:	Clinic project	INVESTIGATION POINT	DCP11 (TP2)
LOCATION:	Ullo Upper West Region, Ghana		
DRILLING METHOD:	VIBRATORY HAMMER		
EQUIPMENT TYPE/NO.	COBRA	LOGGED BY:- AKL / MO	DATE:- 07-11-20

Depth (m)	Elevation	Ground Water	Symbol	Soil Description	Thickness
0.00				Dry, Loose,Darkish-Grey,(Topsoil with plant roots)	0.15
				Dry,Medium dense,Brownsih-Red,Poorly Graded sand	
1.00					
2.00					
3.00					
4.00					
5.00					

DCPT

Blow count	q_{allow} (KN/m^2)	Depth
0	0	0
3	135	-10
5	225	-20
20	898	-30
41	1841	-40
60/4	######	-50
		-60
		-70
		-80
		-90
		-100
		-110
		-120
		-130
		-140
		-150
		-160
		-170
		-180
		-190
		-200
		-210
		-220
		-230
		-240
		-250
		-260
		-270
		-280
		-290
		-300
		-310
		-320
		-330
		-340
		-350
		-360
		-370
		-380
		-390
		-400
		-410
		-420
		-430
		-440
		-450
		-460
		-470
		-480
		-490
		-500
		-510

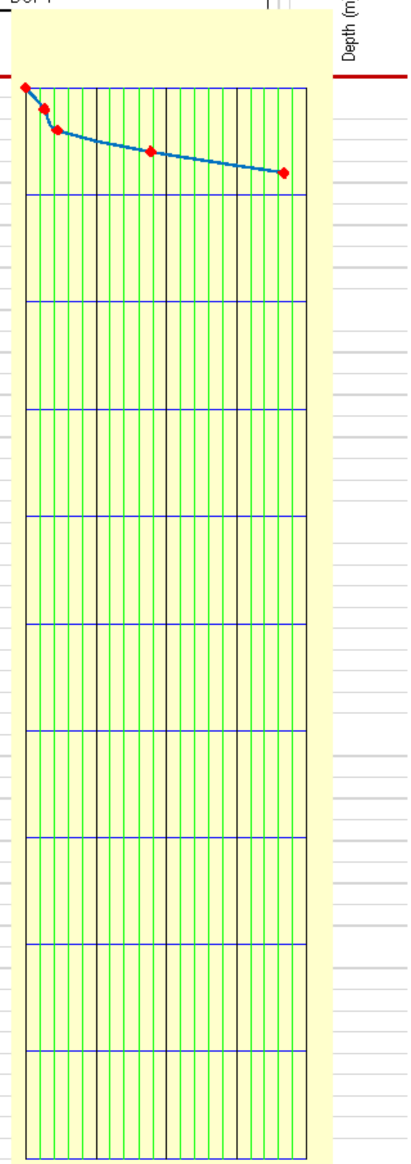

Figure 18:Trial pit Logs for DCP11(TP2)