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Geotechnical Indications Of Eastern Bypass Area In Port Harcourt, Niger Delta

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***Abstract*— With increased urbanization within this area, the reclamation of existing water ways for habitation are on the increased. The study intends to profile such areas geotechnically, thereby providing relevant information for the purpose of foundation design. The area under study depicts three stratigraphy layers. This includes top refilled loosed to medium dense sandy layer overlying a soft clay region with average Cu of 9KN/m^2 and Average CPT value of 5kg/cm^2. Beneath this layer is a loosed to medium densed sandy layer, with the Medium Densed layer indicating Phi value > 31^o. Due to the Poor Settlement Characteristics (compression Index > 0.4) beneath the refilled layer, it is highly recommended that deep foundation(Piles) be considered for structures greater than two floors within this area**

Keywords—component; Deep Foundation; Bearing Capacity ; Easternbypass; Niger Delta; settlement.

I INTRODUCTION

Increased Urbanization in this part of the Niger Delta has resulted to an increased in reclamation of waterways. This is as a result of insufficient land mass for habitation and the high rate of urbanization. This trend has now led to continues development of infrastructure on existing waterways through land reclamation process.

Thus the need to profile the relevant subsoil engineering characteristics, to enable structural engineers carry out appropriate design for foundation within the area.

II SITE DESCRIPTION AND GEOLOGY.

Geologically, the site is underlain by the Coastal Plain sands of the Benin formation (short and stauble, 1967), which in this area is overlain by soft-firm silty clay sediments belonging to the Pleistocenic Formation. The general geology of the area essentially reflects the influence of movements of rivers, in the Niger delta and their search for lines of flow to the sea with consequent deposition of transported sediments.

The surface deposits in this area comprises silty-clays. The near surface silty clays are subjected to mild desiccation during the dry season. Substantial seasonal variations in moisture are expected in the area. This could result in some false enhancement of strength in the dry season. The sandy layers underlying the top clay are predominantly medium to coarse in grain sizes. Port Harcourt is within the dry flat land unit of the Morphological Division of the Niger Delta. (Nwankwola *et al,2014*), but the study Area which is situated in the Eastern Bypass Area(Location, N04^{o}46'39" , E07^{o}01'15") of Port Harcourt, is depicted as a reclaimed waterway.

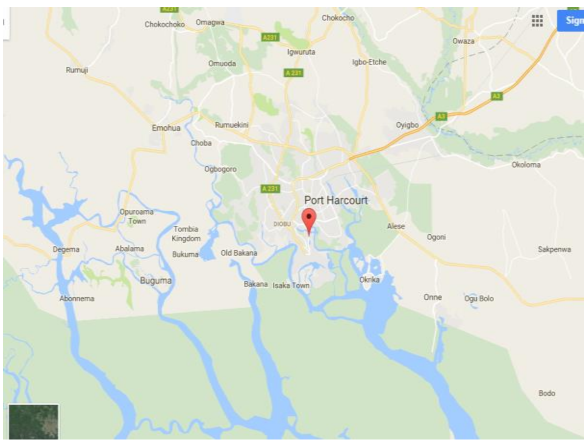

Fig 1. Showing Location of Area

III Methods of Investigation

A Soil Borings

Conventional boring method which consists of the use of the light shell and auger hand rig was used in the boring operation. During the boring operations, disturbed samples were regularly collected at depths of 0.75m intervals and also when change of soil type is noticed. Undisturbed cohesive soil samples was retrieved from the boreholes with conventional open-tube sampler 100mm in diameter and 450mm in length. The open-tube sampler consists essentially of a lower end and upper end screwed into a drive head which is attached to the rods of the rig. The head has an overdrive space and incorporates a non-return valve to permit the escape of air or water as the samples enters the tube. The sampler is driven into the soil by dynamic means using a drop hammer. On withdrawal of the sampler, the non-return valve assists in retaining the sample in the tube. All samples recovered from the boreholes were examined, identified and roughly classified in the field.

Standard Penetration Tests (SPT) was performed every 1.5m advance through cohesionless soils. The main objective of this test is to assess the relative densities of the cohesionless soils penetrated. In this test, a 50mm diameter split spoon sampler is driven 450mm into the soil with a 63.5kg hammer falling freely a distance of 760mm. The sampler is driven into the soil in two stages. The initial 150mm penetration of the sampler is the seating drive and the last 300mm penetration, the test drive. The number of blows required to effect the last 300mm penetration below the seating drive provide an indication of the relative density of the cohesionless soil stratum tested. This is also referred to as the N-value. The penetration resistance in blow counts with depth are indicated on the borehole logs.

B Bearing Capacity

The conventional method of foundation design is based on the concept of bearing capacity or allowable bearing pressure of the soil. The bearing capacity is defined as the load or pressure developed under the foundation without introducing damaging movements in the foundation and in the superstructure supported on the foundation.

Damaging movements may result from foundation failure or excessive settlement. The two criteria used in the design of foundation are therefore:

(a) Determination of bearing capacity of soil and the selection of adequate factor of safety, usually not less than 2.5

(b) Estimating the settlement under the expected load and comparison with the permissible settlement

Modified Terrzerghi Bearing Capacity equation (Murthy, 2007) was used in the calculation of the ultimate bearing capacity of the soil for rectangular foundations.

$$q_u = CN_c\,[1 + 0.3BL] + \gamma D_f N_q + 12\gamma B N_\gamma\,[1 - 0.2BL]\ 1$$

IV Results and Discussion

A Soil Stratigraphy

The data from the soil sampling and laboratory tests were carefully evaluated for the determination of the stratification of the underlying soils . The evaluation uncovered three primary zones .

Table 1, Showing Lithology

Layers	Depth(m)	Lithology
1	0-3	Top Soil/refilled Sandy Layer
2	3-11	Clay ,Grayish
3	11-25	Sand, Brownish

Classification Test was done within Procedure Prescribe by BS 1377, Part 2, 1990 for Classification Test.

B Engineering Properties of The Soils

The investigation disclosed that the soil deposits within the depths explored are characterized by near-surface deposit of loosed to Medium Densed poorly graded refilled sandy layer (about 3m thick) overlying a Normally Consolidated soft clay of High compressibility (about 8m thick). Beneath this layer is a well graded loosed to medium densed Sandy Layer .

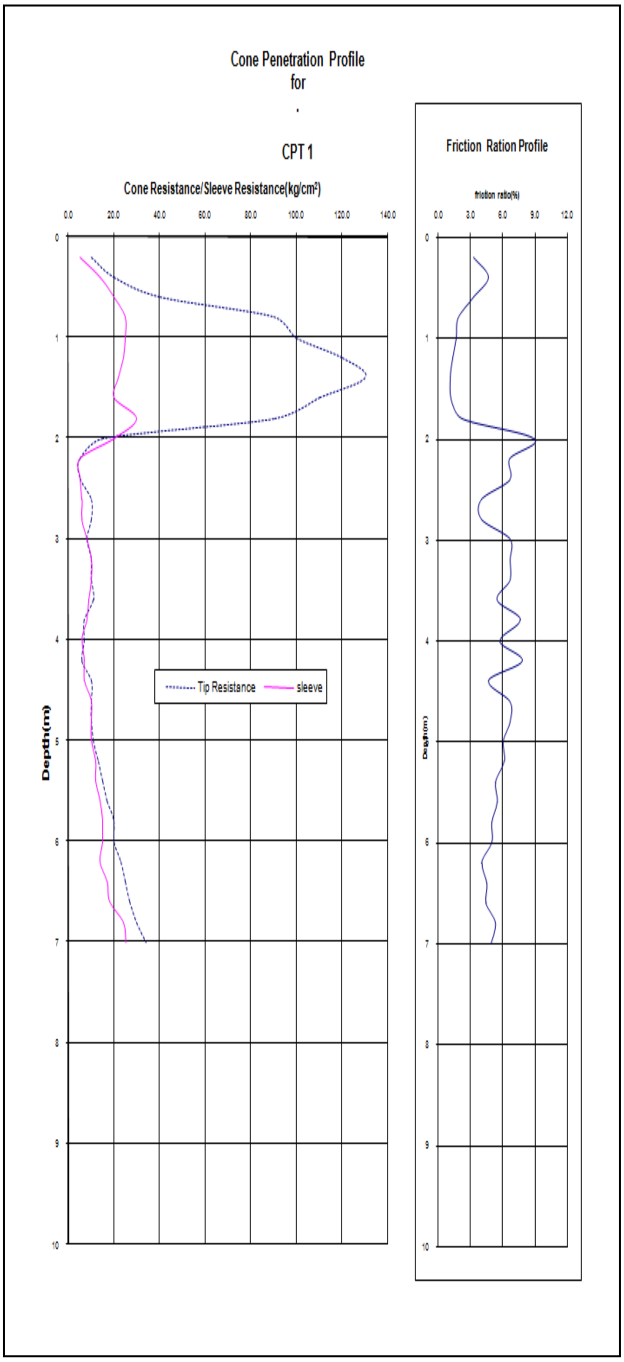

Fig. 2 CPT Profile

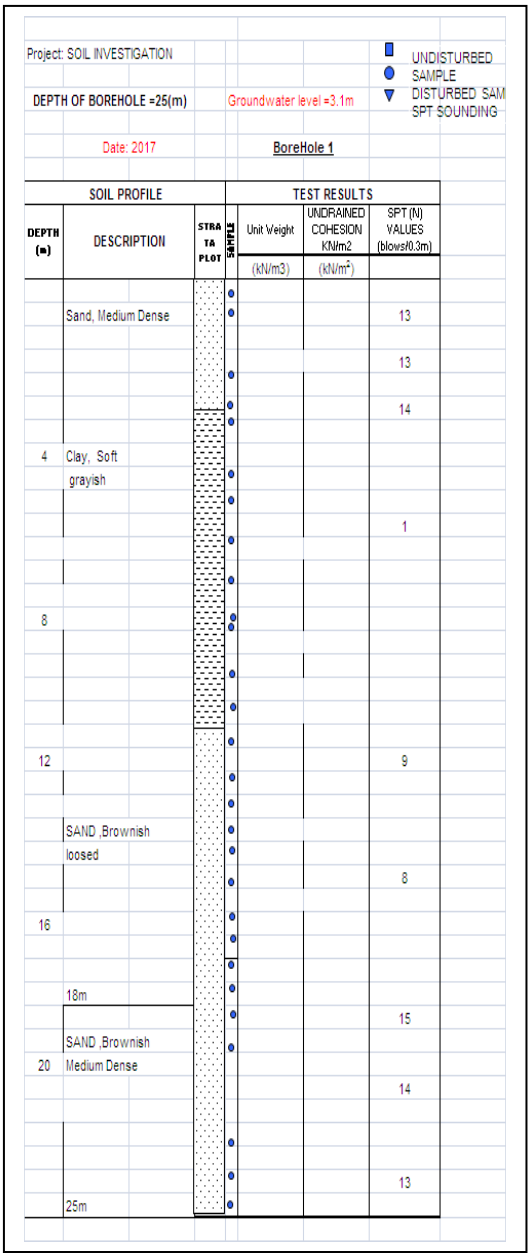

Fig. 3 Soil Lithology

Table 2. CLASSIFICATION TEST

Borehole No.	Depth (m)	Moisture Content	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Unit Weight γ (KN/m^3)	USCS
1	6	23	36	19	17	18.1	CI
1	9	22	35	18	17	18.3	CI

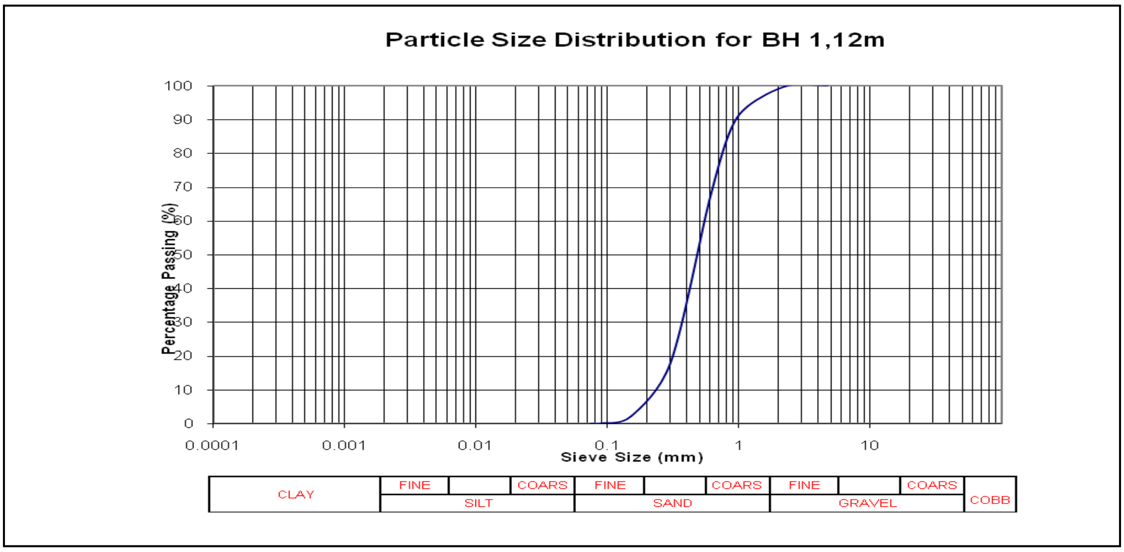

Fig. 4 Mohr Circle Plot

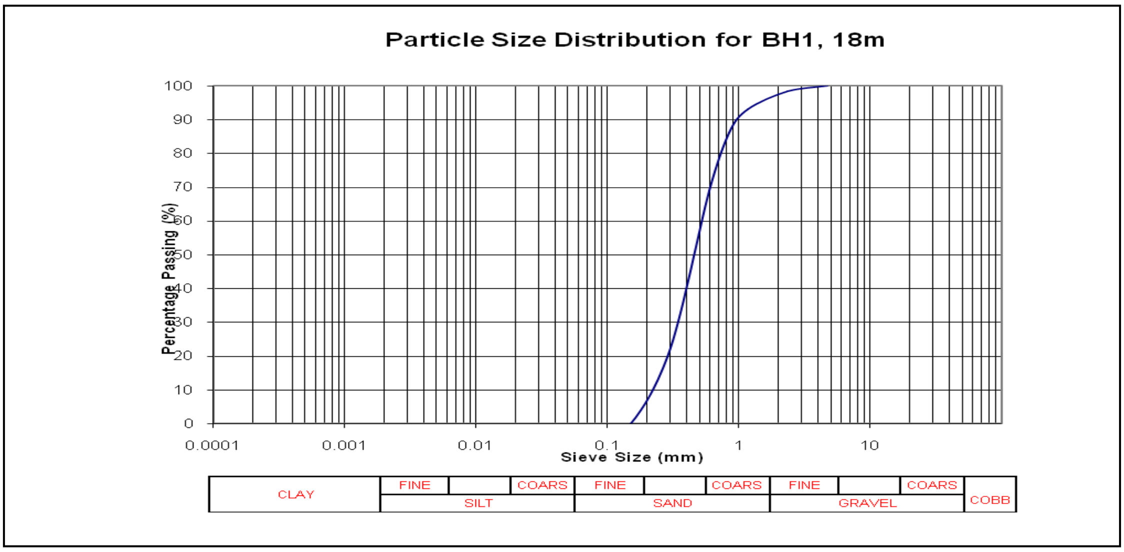

Fig. 5 Mohr Circle Plot

Table 3: Triaxial, UU BH 1, 3.5m

Minor Principal Stress	$100KN/m^2$	$300KN/m^2$	Cohesion	Phi
Deviator Stress	$19KN/m^2$	$21KN/m^2$	9	0.3
Major Principal Stress	$119KN/m^2$	$321KN/m^2$		

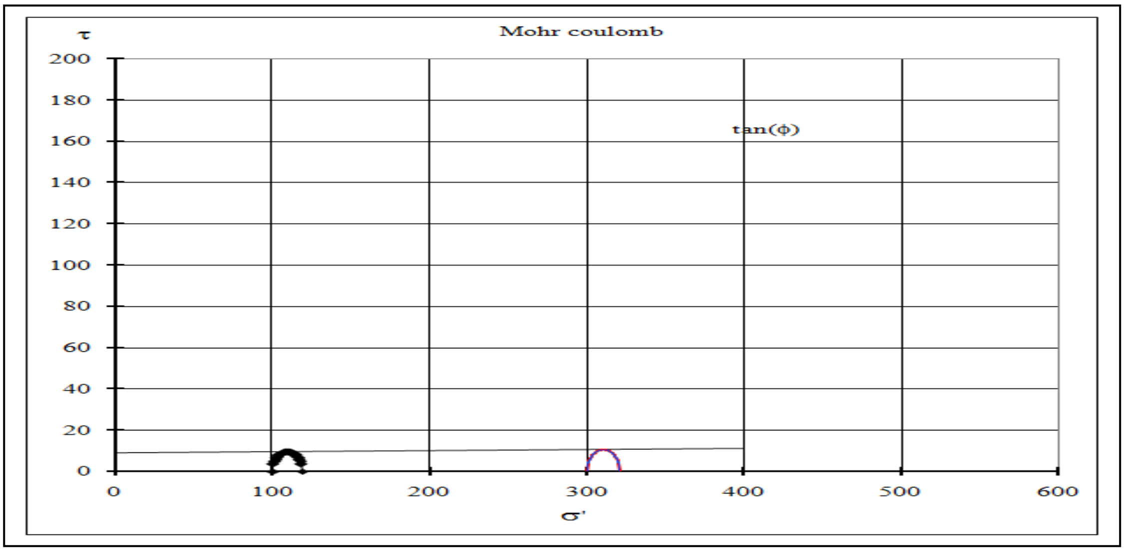

Fig. 6 Mohr Circle Plot

Table 4.Triaxial, UU BH 1, 5m

Minor Principal Stress	$100KN/m^2$	$300KN/m^2$	Cohesion	Phi
Deviator Stress	$21KN/m^2$	$24KN/m^2$	10	0.4
Major Principal Stress	$121KN/m^2$	$324KN/m^2$		

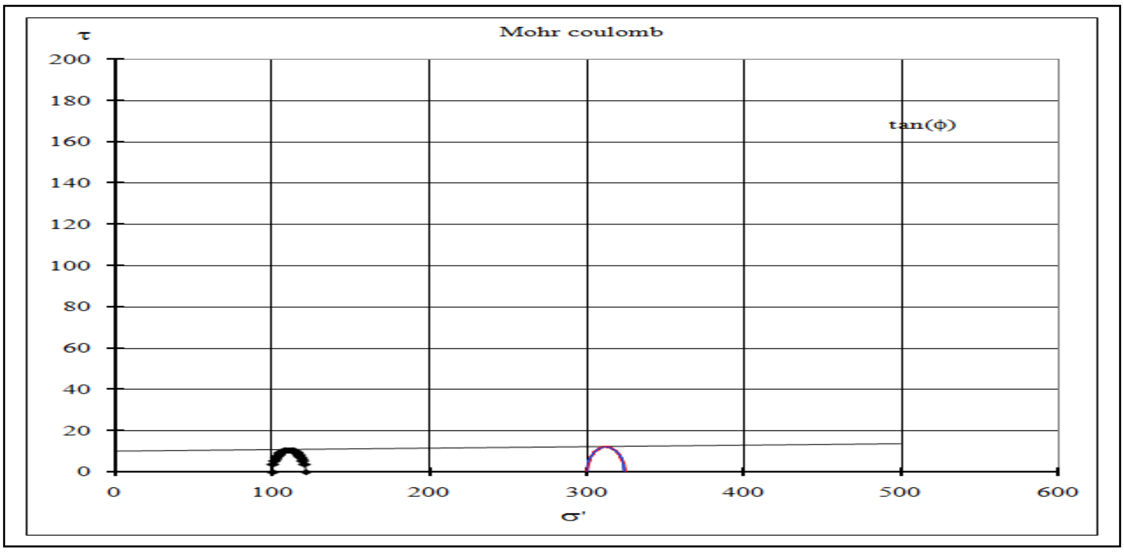

Fig. 7 Mohr Circle Plot

Table 5. DIRECT SHEAR TESTS

Bore-Hole No	**Depth Sample(m)**	**Normal Stress KN/m²**	**50**	**100**	
1	1.5	**Shear Stress KN/m²**	27	50	
		Phi	25^0		
		unit weight	19.4		
		Specific Gravity	2.62		

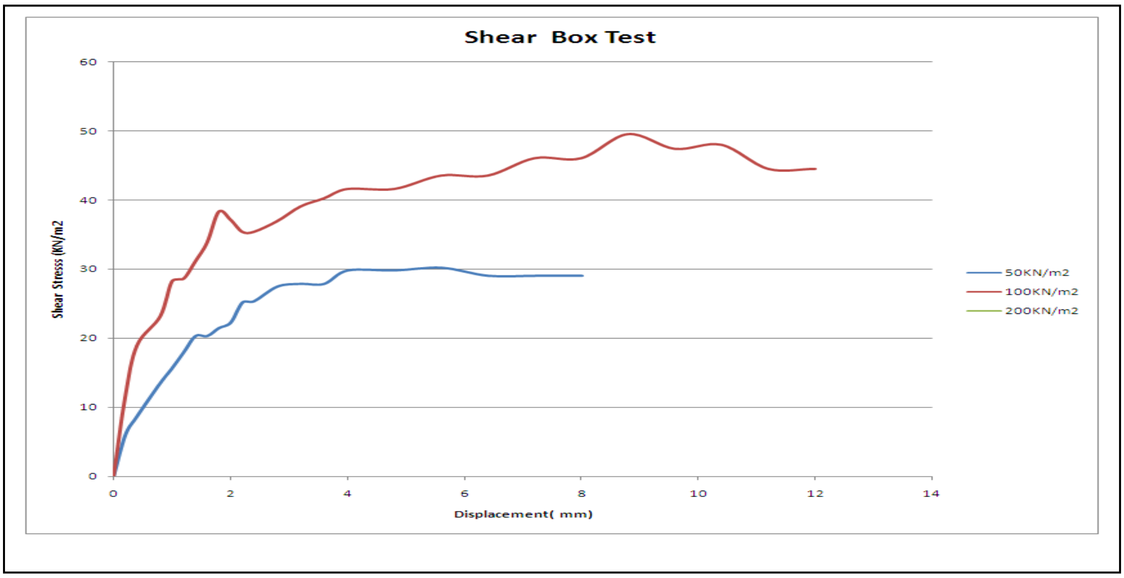

Fig 8 . Plot of Shear Strength and Displacement

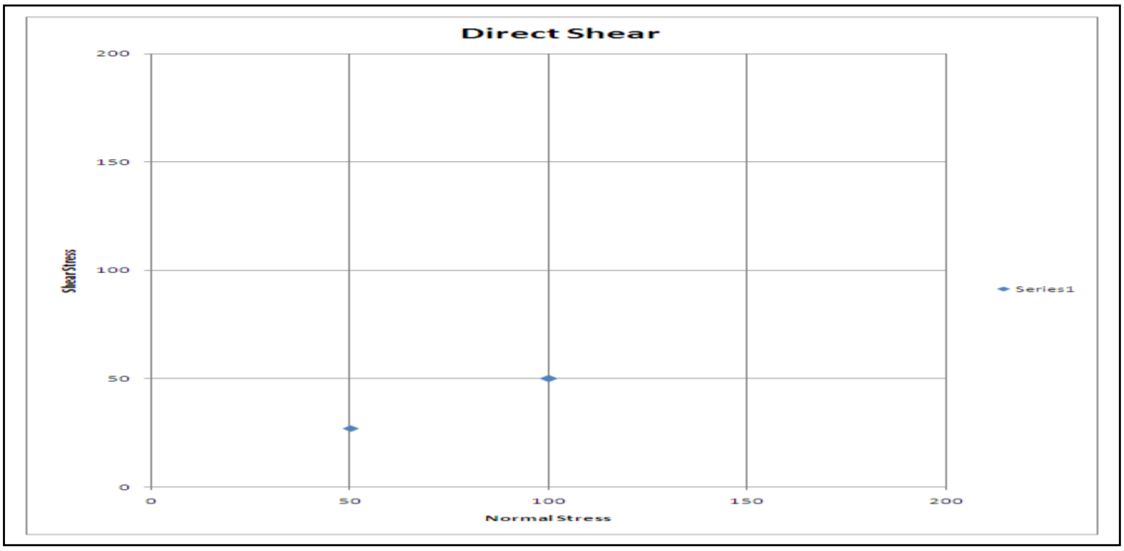

Fig 9 . Plot of Shear and Normal Stress

Table 6. PARTICLE SIZE DISTRIBUTION

Borehole No	Depth(m)	Effective particle	d_{30}	Mean particle size d_{50}(mm)	d_{60}	Coefficient of uniformity	Coefficient of curvature
1	1.5	0.2	0.35	0.53	0.67	3.35	0.914179104
1	2	0.26	0.4	0.55	0.63	2.42307692	0.976800977
1	12	0.12	0.35	0.48	0.52	4.33333333	1.963141026
1	18	0.12	0.33	0.45	0.51	4.25	1.779411765

C Bearing Capacity Calculations for Shallow Foundation.

Undrained cohesion of 0 kPa , Unit weight of 18kN/m^3 and angle of **internal friction of 25** were adopted for the bearing capacity analysis, adopting methods from BS 1377, Part 7 1990: 8 . Table 10., indicates low values of allowable bearing capacities with different L/B ratios. Cu values of the clayey (depth 3m-11m) beneath the top sandy layer , indicates very low average value of Cu=9KN/m^2 , indicating an unstable region.

D Settlement of Shallow Foundation

Laboratory Consolidation Test was performed on selected Cohesive sample to determine the compressibility Parameter. The Test was carried out in accordance with Procedure Recommended in BS 1377, Part 5, 1990:3. Method proposed by Pacheco Silva (1970) was used to determine the Preconsolidation Pressure graphically. Settlement Analysis based on Normally consolidated soils are stated as follows (Coduto D.P, 2007)

$$s = \Sigma c_c 1 + e_o H log\,[\sigma_{zf}/\sigma_{zo}] \qquad (2)$$

Where:
s= settlement
e_o= void ratio
H= height of Clay
σ_{zf} =final vertical effective stress
σ_{zo}= Initial vertical effective stress
c_c= compression index

Results of Primary Settlement in table 9 , indicates high intolerable values

Table 7. COMPRESSIBILITY PARAMETER.

Bore-Hole Nos	Depth (m)	Pressure Range (Kpa)	Coefficient of Consolidation Cv(m^2/yr)	Coefficient of Volume Compressibility Mv(m^2/MN)	Coefficient of Permeability K cm/s
1	**3.75m**	0-12.5	0.44676	6.008000	8.34E-8
		12.5-50	0.4964	2.132122	3.29E-8
		25-50	0.55845	1.184116	2.06E-8
		50-100	0.638228	1.610577	3.19E-8
		100-200	0.7446	0.798631	1.85E-8
		200-400	0.89352	0.470166	1.31E-8

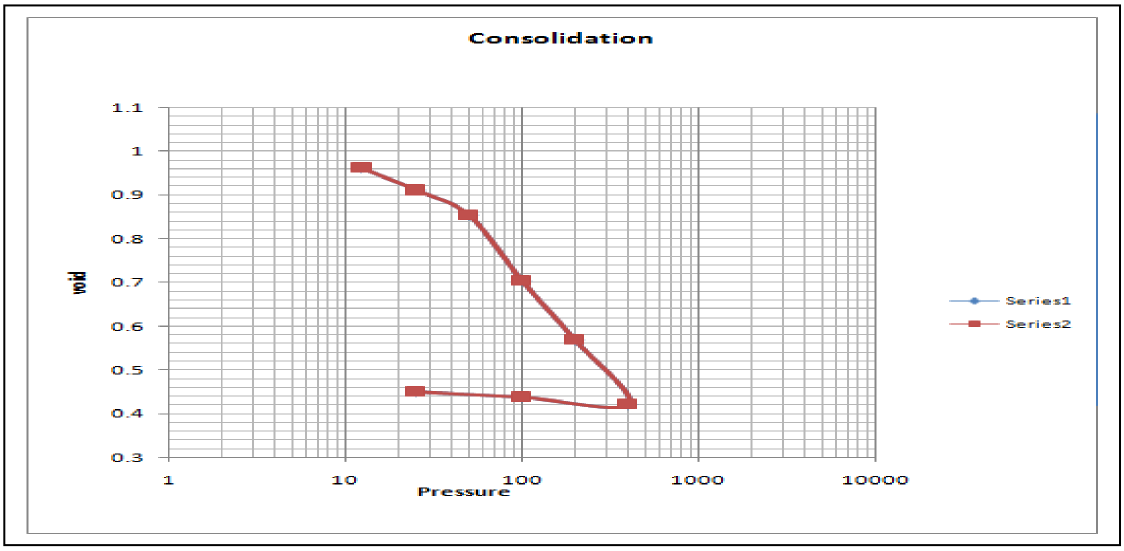

Fig 10 . Void Ratio / Pressure Plot

Table 8. Settlements Parameter

clay	**Normally consolidated., OCR <1**
e_o	**0.96**
Preconsolidation Pressure	**45KPa**
C_c	**0.47**
P_o	**27**
Soil Compressibility based on CC and e_o	**0.2**
P_i (elastic)	
P_c (Primary)	

Computed Rate of Settlements

Rate of Settlements	**Years**
T50	**0.6**
T90	**2.4**

Table 9. Showing Settlement variation

Pressure (KPA)	**50**	**100**	**150**	**200**	**250**	**400**	**600**
Settlement (mm)	110.6579311	208.326582	295.7375	374.8421	447.0829	632.4381	828.9156

Table 10. Showing Bearing Capacity

Depth (m)	Width (m)	Undrained Shear Strength (KN/m²)	Ultimate Bearing Pressure (KN/m²)			Allowable Bearing Pressure (KN/m²), F.S=3		
			L/B =1	L/B= 1.5	L/B = 5	L/B=1	L/B=1.5	L/B=5
1	1	0	127.836	130.539	134.3232	42.61	43.51	44.77
1	1.5	0	144.054	148.1085	153.7848	48.02	49.37	51.26
1	2	0	160.272	165.678	173.2464	53.42	55.23	57.75
1	2.5	0	176.49	183.2475	192.708	58.83	61.08	64.24
1	5	0	257.58	271.095	290.016	85.86	90.37	96.67
1	10	0	419.76	446.79	484.632	139.92	148.93	161.54
1.5	1	0	175.536	178.239	182.0232	58.51	59.41	60.67
1.5	1.5	0	191.754	195.8085	201.4848	63.92	65.27	67.16
1.5	2	0	207.972	213.378	220.9464	69.32	71.13	73.65
1.5	2.5	0	224.19	230.9475	240.408	74.73	76.98	80.14
1.5	5	0	305.28	318.795	337.716	101.76	106.27	112.57
1.5	10	0	467.46	494.49	532.332	155.82	164.83	177.44
2	1	0	223.236	225.939	229.7232	74.41	75.31	76.57
2	1.5	0	239.454	243.5085	249.1848	79.82	81.17	83.06
2	2	0	255.672	261.078	268.6464	85.22	87.03	89.55
2	2.5	0	271.89	278.6475	288.108	90.63	92.88	96.04
2	5	0	352.98	366.495	385.416	117.66	122.17	128.47
2	10	0	515.16	542.19	580.032	171.72	180.73	193.34

Allowable Bearing Capacities for shallow foundations (Water depth > foundation Depth)

V Conclusion

The Study Reveals that the surface within these area are underlain by a loosed to Medium Dense Poorly Graded refilled sandy layer (about 3m thick) overlying a Normally Consolidated soft clay of High compressibility (about 8m thick) . Beneath this layer is a loose sandy layer (about 7m thick and Phi value < 30°) overlying a medium dense, well graded Sandy Layer(with Phi value > 31°) .

Moisture Content , Liquid Limit , Recompessional Index and Plasticity Index Shows Moderate Values, indicating Moderate Compressibility. Drainage Characteristics is expected to be low at the site as indicated by the K values .

An average Cu=9KN/m² and Phi =0 was considered within depth of 3m-5m An average CPT of 5kg/cm² was indicated within depth of 3m-5m The allowable bearing capacity profile of the sub-surface shows Low bearing Capacities characteristics (1.5m: 57KN/m²,). Settlement predictions based on a loading of 100KN/m² indicated a settlement 208 mm within the clay layer. The differential and total settlement is expected to be within intolerable limits. Due to the highly anticipated settlement values , Deep (Pile) foundation within these areas of the Niger delta is recommended for more than two floors . Due to the loosed layer beneath the clayey layer(with phi values < 30°), Piles toes should be situated within Medium dense layer. The Final Dimension/depth of the Footing Should be determined by the Structural Engineer..

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