Foundation Evaluation of Subsoils in Parts of Finima, Bonny Island, Eastern Niger Delta.

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Abstract- Foundation evaluation of sub soils was carried out in Finima Bonny Island, Eastern Niger Delta to assess the particle size distribution and bearing capacity of the soils for shallow foundation designs using strip and square footings. The investigation involved the drilling of eight boreholes to a maximum depth of 30m each and the retrieval of soil samples at 1m interval, in situ cone penetration tests and laboratory analysis of the particle size distribution of the soil. The stratigraphy of the soil consists of fine to medium to coarse dense sand with intercalations of soft, dark grey clays at various depths between 11-14m and 25-28m. Particle size distribution of the soils show uniformly graded soils in all boreholes except BH06 and BH07 which are poorly graded. Analysis of the bearing capacities of the soils for strip and square footings showed that the soils in BH06 and BH08 had the highest ultimate and allowable bearing capacities at 1.5m depth, while BH02 and BH08 had the highest values at a depth of 3.0m. For the square footing, the ultimate and allowable bearing capacity values of the soil are highest in BH06 (Qu-4304KN/m, Qallow-1722KN/m) at 1.5m depth. While BH02 (Qu-9669KN/m, Qallow-3868KN/m) is highest at 3.0m depth. The results of the particle size distribution and bearing capacity reveal that the soils are suitable foundations for light and medium load structures like bungalows and one-storey building.

Keywords: Bearing Capacity, Particle Size Distribution, Shallow Foundation Design Stratigraphy.

I. INTRODUCTION

In recent years, the need for geotechnical investigations has grown rapidly in response to urbanization, infrastructural development and industrial expansion. As cities and towns become increasingly populated on daily basis, the need for bigger buildings and more complex infrastructure even in areas with unsuitable soils conditions to accommodate this expansion has also increased. An understanding of the subsurface soil conditions prior to construction is needed for the safety of structures. Unfortunately, geotechnical studies are still undervalued due to ignorance or mere negligence often leading to avoidable structural failure .

In coastal regions, geotechnical investigation assumes even greater importance due to the unique challenges posed by soft, saturated soils, high groundwater tables, saline intrusion, and geomorphological instability [1]. The engineering challenges associated with coastal zones are amplified by climate change, sea-level rise, and increasing human settlement. Some of the most severe geotechnical problems occur in deltaic regions, areas formed by sediment deposition at river mouths because the soils tend to be young, unconsolidated, organic-rich, and highly compressible. These conditions predispose structures to differential settlement, low of bearing capacity, and long-term deformation underscoring the necessity of localized geotechnical studies tailored to the peculiarities of each environment. Bonny Local Government Area LGA Rivers State, Nigeria, located within the Niger Delta, is one of such coastal regions in the world.

The Niger Delta is composed of Quaternary deposits characterized by fine-grained sediments, organic matter, and weakly consolidated strata [2].The socio-economic importance of Bonny Island amplifies the urgency of understanding its geotechnical conditions. Bonny Island is not only a residential and cultural hub but also home to some of Nigeria's most significant industrial facilities, including the Nigeria Liquefied Natural Gas (NLNG) complex. The island also accommodates oil and gas pipelines, export terminals and supporting infrastructure critical to Nigeria's economy. Failure of any these structures in this region could have dire consequences, not only for the local communities but also for nation at large.
Finima town, Bonny Island is of strategic importance due to its proximity to these facilities. This area is

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characterized by soft cohesive soils with low bearing capacity, significant variability in soil stratification, and a shallow groundwater table [1], [3]. Given the complexity of these interrelated parameters, site-specific geotechnical studies are necessary to characterize the soils in Finima to generate data for shallow foundation design. Previous studies in Bonny Island such as [1],[3], [4] and [5] and in other parts of the Niger Delta [6], [7], [8], [9], [10] etc have highlighted significant spatial variability in soil properties, even within localized areas . This variability has profound implications for foundation design and structural performance. Against this backdrop, this research aims to provide an empirical assessment of the particle size distribution and bearing capacity analysis of the foundation soils in Finima, Bonny Island Eastern Niger Delta thereby bridging the data gap and enabling safe, efficient and economically viable foundation designs in the area.

11.Geology / Hydrogeology Of The Study Location
Bonny Island falls within the Beach ridges on-shore geomorphic sub-environment of the Niger Delta. Geologically these comprise Pleistocene and Recent sediments deposited by fluvial and shallow continental shelf hydrodynamic processes. The area is characterized by strong wave and tidal action, which further compacts the sediments. Plant growth over beach ridges over the years has resulted in the formation of extensive primary tropical freshwater forest. Energy conditions decrease from shore face to outer edge. The litho facies include the delta tip, mainly evenly laminated fine to medium sand. The hydrogeology of the area is highly influenced by the presence of ferruginous sandy formation due to high oxidation condition of the near surface aquifers and predominant saline water intrusion. The sand forms the major aquifer in the area while the clay forms the aquitards. The water table in the area varies with season. The area has a declining water table during the dry season. Generally, water table ranges between 0.1m (surface)- 3m depending on the season [1]. According to [11] both confined and unconfined aquifers are encountered at varying depths and they contain highly saline groundwater. The water table in the area generally fluctuates around 2.0m inland from the coast. The maximum elevation of the Island ranges between 2.0m-4.5m above mean sea level. There is a subsection of clay at the top, preceding a column of coarse and pebbly sands [12] and [13]. The geology of the area is characterized by three formations, namely Akata (oldest), Agbada and Benin(youngest). These formations consist primarily of regressive Tertiary sediments as detailed in the geology of the Niger delta formation by [14] and [15].

Finima town is situated near the coast in Bonny Local Government Area of Rivers State, Nigeria. Geographically, it's positioned in the Niger Delta region, with coordinates which lie between Latitude: 4023'35"N and 4023'40"N and Longitude: 7010'40"E and 7010'45"E Figure 1.

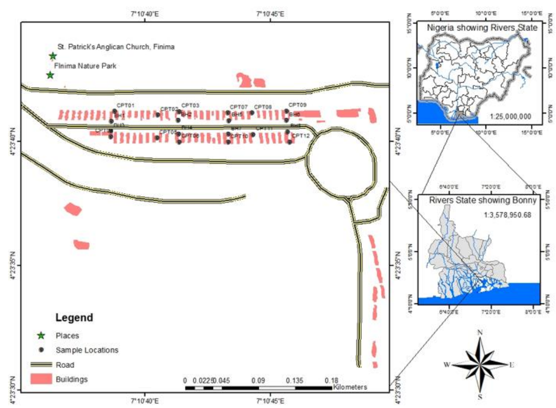

Figure 1: Map of Bonny LGA showing the sample locations in Finima town.

111. MATERIALS AND METHODS
This study focuses on Finima town in Bonny Island Eastern Niger Delta and involves field investigation and laboratory testing to determine the particle size distribution and design suitable shallow foundations. The field investigation involved the drilling of eight (8) boreholes to a maximum depth of 30m each using both the manual and motorized rigs and in situ cone penetration test. Retrieval, sampling and description of soil samples at 1m interval, and laboratory determination of the particle size distribution.

II. DATA ANALYSIS FOR SHALLOW FOUNDATION DESIGN

The ultimate bearing capacity (Qu) for Strip footing on soils was determined using: [16] bearing capacity equation. Thus, Terzhaghi's ultimate bearing capacity equation for strip footing is as follows:

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$$Qu = 0.67\,cNc + \gamma DfNq + 0.5\gamma BNy$$

The ultimate bearing capacity (Qu) for square pad footing on soils was determined using Terzhaghi's 1943 bearing capacity equation mordified from the Strip footing equation by applying the shape factor. Thus, Terzhaghi's ultimate bearing capacity equation for square footing is as follows:

$$Qu = 1.3cNc + \gamma DfNq + 0.4\gamma BNy$$

Qu - Ultimate bearing capacity of soil
C - Cohesion of soil= 0
γ - Unit weight of soil
Df - Depth of Foundation
B - Width of the footing
Ø = Angle of internal friction
N_c, N_q, N_y - Bearing Capacity factors (depend on the angle of internal friction [Ø]
F.S - Factor of safety (2.5)

III. RESULTS

Soil Stratigraphy

The stratigraphic profile across all eight borings consists generally of fine to medium to coarse dense, sand with intercalations of soft, dark grey clays at various depths between 11-14m and 25-28m as shown in figures 2 and 3. Similar results have been obtained by Nwankwoala (2012), Alaminiokuma and Omigie, (2018) and Ebikeme and Tamuno, (2024) in Bonny Eastern Niger delta.

Particle Size Distribution

Average values of the particle size distribution of the soils in Table 1 show a high percentage of the fine and medium sand fractions of the soil. The grain size curves in figures 4 and 5 also display fine to medium to coarse grained sands. These soils are uniformly graded (UG) in all the boreholes excluding BH06 and BH07 where the soils are poorly graded soils (PG) according to the unified soil classification system. The soils depict high porosity and permeability thus a low water retention capacity which makes them suitable as foundation materials.

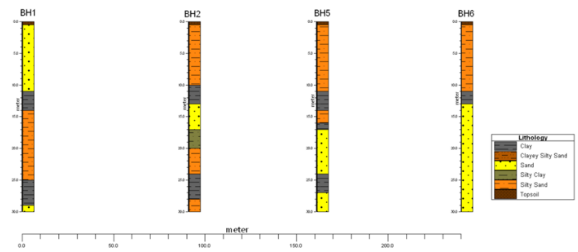

Figure 2: Litholog of boreholes BH1, BH2, BH5 and BH6 showing the different lithologies at various depths in the study area

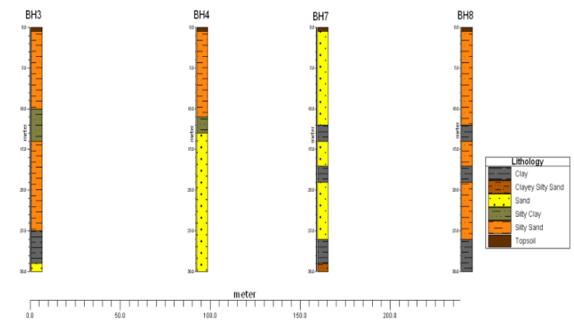

Figure 3: Litholog of boreholes BH3, BH4, BH7 and BH8 showng the different litologies at various depths in the study area

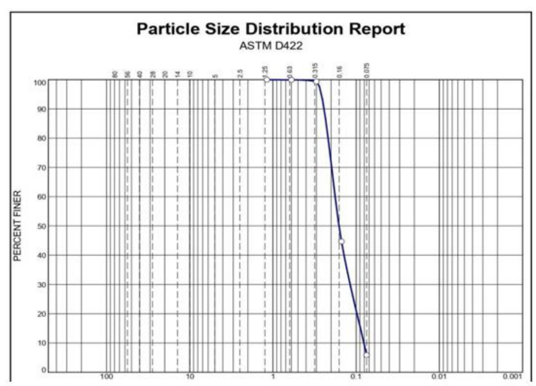

Figure 4: Particle size distribution curve BH03 at a depth of 3.0m showing the uniformly graded soil.

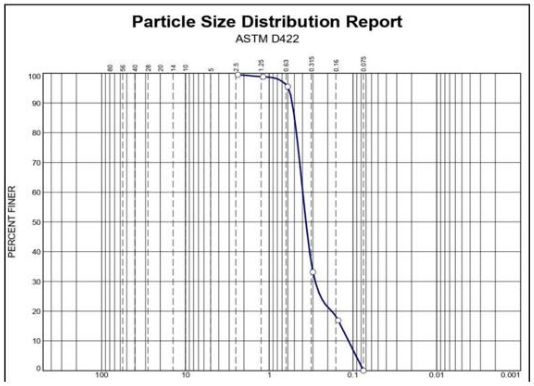

Figure 5: Particle size distribution curve BH06 at a depth of 2.0m showing the poorly graded soil.

Table 1: Particle size Distribution Parameters

BORING	WATER TABLE DEPTH	% FINES SILT	% FINE SAND	% MED SAND	% COARSE SAND	D_{10} (mm)	D_{50} (mm)	D_{60} (mm)	CU	USCS
BH01	0.5	3.1	75.5	42.3	0.9	0.20	0.28	0.31	1.55	UG
BH02	0.4	0.2	85.7	14.6	0.0	0.16	0.25	027	1.69	UG
BH03	0.4	0.2	73.6	24.9	0.5	0.18	0.29	0.31	1.72	UG
BH04	0.5	4.0	95.8	0.0	0.0	0.08	0.12	0.13	1.63	UG
BH05	0.3	0.5	81.1	29.9	1.6	0.17	0.30	0.31	1.82	UG
BH06	0.3	0.2	68.2	31.1	0.0	0.13	0.40	0.39	3.00	PG
BH07	0.3	4.0	75.3	21.4	0.0	0.13	0.23	0.26	2.00	PG
BH08	0.3	9.7	87.2	5.9	0.0	0.13	0.20	0.22	1.70	UG

CU- Coefficient of Uniformity, USCS- Unified soil classification system,
UG- Uniformly graded soil, PG- Poorly graded soil

Table 2: Bearing Capacity Values For Strip Footing At 1.5m and 3.0m Depth

	Df -1.5m B -1.5m		Df -3.0m B -3.0m	
BORINGS	Qu (KN/m^2)	Qallow (KN/m^2)	Qu (KN/m^2)	Qallow (KN/m^2)
BH01	4346	1739	9661	3844
BH02	5229	2092	10697	4279
BH03	3126	1251	5963	2385
BH04	4839	1936	4289	1716
BH05	4618	1847	8735	3494
BH06	21662	8665	3264	1306
BH07	4346	1738	8159	3264
BH08	21662	8665	10697	4279

Qu- Ultimate Bearing Capacity of soil, Qallow- Allowable Bearing Capacity of soil
Df- Depth of foundation, B- width of footing

Table 3: Bearing Capacity Values For Square Footing At 1.5m and 3.0m Depth

	Df -1.5m B - 3.0m		Df - 3.0m B - 4.5m	
BORINGS	Qu (KN/m^2)	Qallow (KN/m^2)	Qu (KN/m^2)	Qallow (KN/m^2)
BH01	3866	1546	8687	3475
BH02	3651	1460	9669	3868
BH03	2799	1119	5427	2171
BH04	4303	1721	6063	2425
BH05	3866	1546	8687	3475
BH06	4304	1722	2949	1179
BH07	3866	1546	7395	2958
BH08	1309	524	2999	1199

Qu- Ultimate Bearing Capacity of soil, Qallow- Allowable Bearing Capacity of soil
Df- Depth of foundation, B- width of footing

Bearing Capacity of the Soils

Analysis of the bearing capacity values of the soil for shallow foundation design using strip and square footings at 1.5m and 3.0m depth are shown in Tables 2 and 3 respectively. The results show ultimate and allowable bearing capacity values of the strip footing ranging from (Qu- 3126KN/m2 – 21662KN/m2, Qallow-1251KN/m2-8665KN/m2) at 1.5m and (Qu-

3264KN/m2-10697KN/m2, Qallow- 1716KN/m2-4279KN/m2) at 3.0m. BH06 and BH08 have the highest ultimate and allowable bearing capacity values of the soil at 1.5m depth while BH02 and BH08 have the highest ultimate and allowable bearing capacity at 3.0m depth. For the square footing, the ultimate and allowable bearing capacity values of the soil are highest in BH06 (Qu-4304KN/m2, Qallow-1722KN/m2) at 1.5m depth and BH02 (Qu- 9669KN/m2, Qallow-3868KN/m2) at 3.0m depth. Ultimate and allowable bearing capacity values of the soil are suitable for both strip and square footing shallow foundation designs.

IV. CONCLUSION

The subsurface stratigraphy between 0-5m in all the boreholes, the particle size distribution and bearing capacity of the soils show that the fine to medium to coarse grained sand are dense, uniformly graded and free draining. This makes them are suitable for shallow foundation designs for light and medium load structures using strip and square footings. Further analysis of the sub soils at greater depths should be carried out to determine their suitability for larger structures and design suitable foundations at these depths.

REFERENCES

[1] H. O. Nwankwoala- Hydrochemical and Sustainability Evaluation of Groundwater in Bonny Island, Eastern Niger delta. African Journal of Basic and Applied Sciences. 3(6), 2011, pp. 271-277.

[2] H. O. Nwankwoala & A. N. Amadi-Geotechnical properties and subsurface characterization of soils in the Niger delta, Nigeria. International Journal of Engineering and Technology. 3(2), 2013, pp. 193-200.

[3] H.O. Nwankwoala – Investigation of Geotechnical Engineering properties of subsurface soils in Bonny Island, Eastern Niger delta. Nature Environment and Pollution Technology. An International Quarterly Scientific Journal. 11(4), 2012, pp.527-534.

[4] G.1. Alaminiokuma & J.I. Omigie-Geotechnical properties of soils for Civil Engineering construction in Nyuene, Bonny Island Nigeria. Canadian Journal of Pure and Applied Sciences. 12(3), 2018, pp. 4593-4600.

[5] S. C. Ebikeme & J. A. Tamuno- Geotechnical insights on shallow foundations in sedimentary terrains: Findings from Bonny Island. Research Journal of Engineering and Allied Sciences. 12(2), 2024, pp. 1-14.

[6] A. C. Tse & E.G. Akpokodje- Geotechnical evaluation of some sand deposits in parts of the eastern Niger delta. Nigeria Journal of mining and geology. 38 (2) 2016, pp. 135-141.

[7] T. K. S. Abam- Engineering Geology of the Niger delta. 2016, 6(3) pp. 65-89.

[8] I.U. Ehibor & E. G. Akpokodje- The subsurface soil stratigraphy and foundation quality of soils underlying Uyo Town, Eastern Niger delta, Nigeria. Journal of Earth Sciences and Geotechnical Engineering. 9 (2) 2019, pp.1-12.

[9] I. U. Ehibor & A. C. Tse- Bearing Capacity Analysis of subsoils for shallow and deep foundation in Uyo Town, eastern Niger delta, Nigeria. International Journal of Engineering Science Technologies. 6(4) 2022, pp.20-35.

[10] N. D. Miracle, I. U. Ehibor & A. C. Udoh-Bearing capacity and foundation quality of subs oils in parts of the main campus of Akwa Ibom State University, Ikot Akpaden, Akwa Ibom State, Nigeria. 9(2) 2025, pp. 80-96.

[11] F. D. Giadom, T. K. S Abam & C.U. Nebo-The hydrogeological Regimen and saltwater Intrusion in parts of Boony Island, Rivers State. International Journal of Science and Engineering Research. 13(3). 2022, Pp. 141-152.

[12] J. O. Etu-Efeotor 7 E. G. Akpokodje- Acquifer systems in the Niger delta. Journal of mining and Geology. 26(2), pp 279-285.

[13] M. U. Osakuni & T. K. S Abam- Shallow Resistivity measurements for Cathodic protectiob of piplines in the Niger delta. Environmental Geology.45(6), pp. 747-751.

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DOI: https://doi.org/10.64388/IREV9I10-1716933

[14] R. A. Reyment-Aspects of Geology of Nigeria. University of Ibaden press. 1965, p.145

[15] K. C. Short & A.J. Stauble- Outline of the Geology of the Niger delta. American Association of Petroleum Geologists. 5(1),1967, pp. 761-779.

[16] K. Terzaghi- Theoretical Soil Mechanics. John Wiley and sons Inc.1960 p.258.