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DOI: https://doi.org/10.64388/IREV9I10-1717102

Foundation Quality Assessment of Sub Soils in Parts of Nonwa-Gbam, Tai LGA, Rivers State, Nigeria

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Abstract - An assessment of the quality of sub soils which form the foundation of structures in parts of Nonwa-Gbam communities in Tai Local Government Area of Rivers State, was carried out to determine the suitability of the soils for ongoing construction of structures in the communities. A total of six geotechnical boreholes were drilled to 10m each .Three boreholes each in Nonwa and Gbam communities. Soil samples (disturbed) retrieved at 1m intervals in both locations, described and classified according to their depths on the field to determine the subsurface stratigraphy of the soils. Laboratory tests were carried out to determine the quality of the soils by identifying and classifying the soils using the particle size distribution (wet and dry sieve analysis) and moisture content of the soils. The subsurface stratigraphy in Nonwa consists of dark brown silty sand fom 0-4m, underlain by light brown sandy clay from 4-8m and fine to medium to coarse sand from 8-10m. While in Gbam, the stratigraphy consists of dark to light brown silty, sandy clay from 0-6m, sandy clay from 6-8m and sand from 8-10m Results of the wet sieve (hydrometer) analysis show the occurrence of 80% sand. These sands are poorly graded, with a high percentage of the fine to medium fraction from the dry sieve analysis of the soils with moisture content percentages below 50%. These results are indicative of the ability of the soils to transmit fluids thus, low water retention capacity of the soils which makes them good foundation materials for construction. Although, further analysis of the soils is recommended to determine their bearing capacities, before the construction of the structures in Nonwa-Gbam.

Key Words: Subsurface soil stratigraphy, Particle size distribution, poorly graded sand and Moisture content

I. INTRODUCTION

Nonwa-Gbam, a two-settlement community in Tai Local government area, is one of the rural communities in Rivers State, where fast and extensive infrastructural development is taking place. However, some of the recurrent foundation failures, differential settlements, cracks in buildings and in extreme cases, complete structural collapse of the building after construction which have occurred in different parts of Nigeria, have also been observed in Rivers state. These failures are often linked to the lack of comprehensive geotechnical evaluations prior to construction, which has led to poor foundation designs based on inaccurate or assumed soil parameters. The safety of any engineering structure largely depends on the quality of sub soils underlying them and the ability of these soils to support applied loads without undergoing shear failure or excessive settlement. This study therefore aims to assess the quality of sub soils in Nonwa-Gbam communities by identifying, classifying and analyzing some key soil parameters such as the subsurface soil stratigraphy, moisture content and particle size distribution of the soils thus providing information on the quality of sub soils for construction purposes. Although different studies of the quality of foundation materials have been carried out in the Niger Delta including[1], [2], [3], [4] and [5], emphasizing the subsurface stratigraphy, geotechnical properties and bearing capacity of the soils as vital tools for determining the quality of sub soils and ensuring the safety and durability of structures, more data is needed from localised areas within this region which this study provides.

II. LOCATION

Nonwa-Gbam are two communities located in Tai Local Government Area (L.G.A) of Rivers State, Southern Nigeria. Tai L.G.A forms part of the larger Ogoni region within the south eastern part of the Niger Delta. It is characterized by humid tropical climate, dense vegetation, and high rainfall intensity. Geologically, the soils in Nonwa-Gbam consists of Quarternary to Recent sand deposits which are underlain by the Akata, Agbada and Benin formations respectively from oldest to youngest in age [6], [7] . Geographical co-ordinates of Nonwa-Gbam Figure 1, show that the communities lie approximately between latitude 4°40'N and 4°50'N and longitude 7°15'E and 7°25'E and is accessible via several major and minor roads linking it to neighboring communities such as Bori, Eleme, and Port Harcourt. The East-West Road, one of the key federal roads in the region, which provides access from Port Harcourt to parts of Tai L.G.A, while rural roads and footpaths link the various settlements and borehole locations within Nonwa-Gbam. The study locations are accessible by vehicles and on foot. For the purpose of this research, sampling sites were selected to represent the varying terrain and sections undergoing infrastructural development within the community.

III. MATERIALS AND METHODS

The field study involved the drilling of Six (6) geotechnical boreholes to a depth of 10m each at six different locations (Table 1) by Percussion drilling method. Collection of soil samples at 1m intervals,

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identification and description of the soil's lithology and laboratory determination of the moisture content, bulk density and particle size distribution in accordance with the standards of ASTM-D2216 and ASTM D422/ D7928.

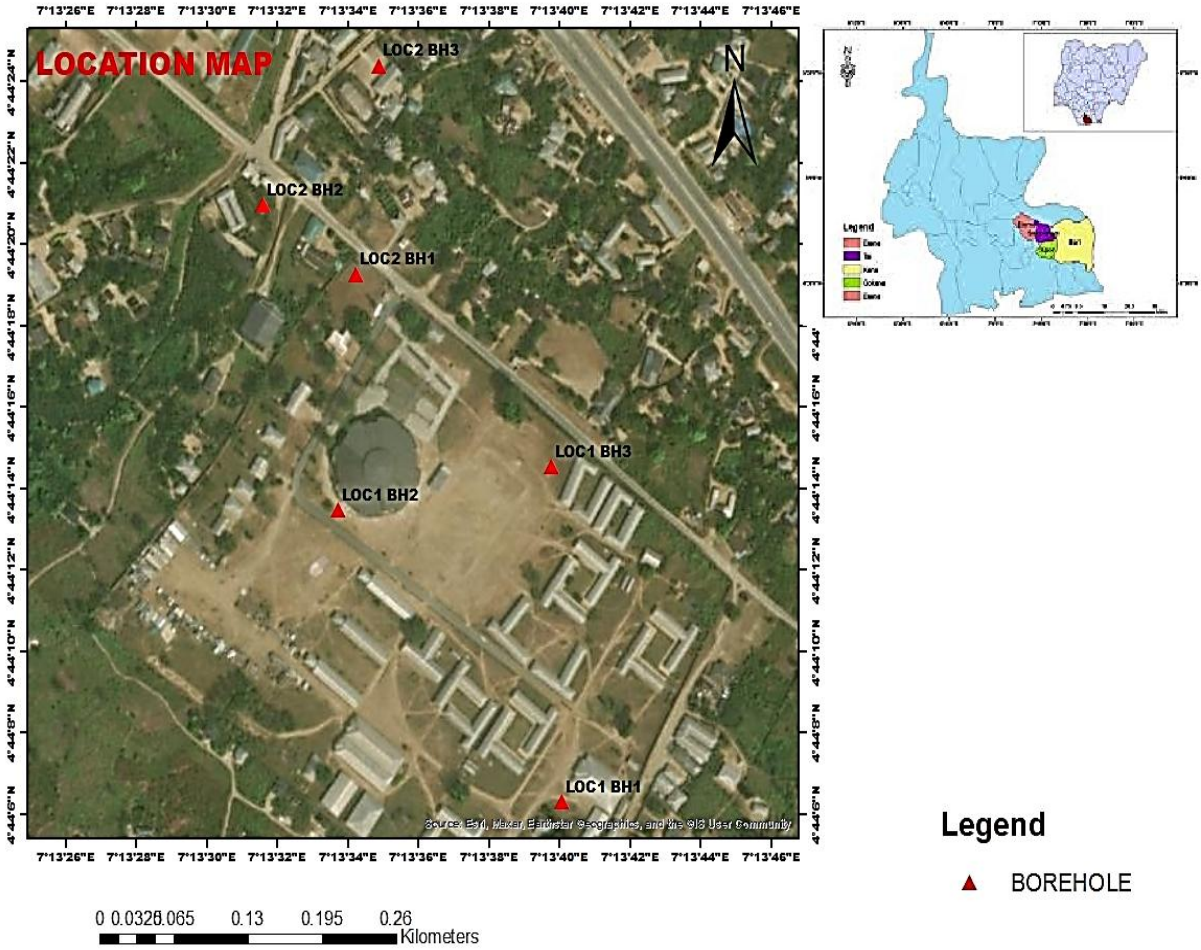

Figure 1: Google Earth Map of Tai L.G.A showing borehole locations in Nonwa-Gbam.

Table 1: Geographical coordinates of Borehole locations in Nonwa-Gbam

LOCATIONS	BOREHOLE	LATITUDE (°)	LONGITUDE (°)
LOCATION 1 (GBAM)	BH1	N 4^0 44' 6.306"	E7^0 13' 40.068"
	BH2	N 4^0 44' 13.473"	E 7^0 13' 33.730"
	BH3	N 4^0 44' 14.561"	E 7^0 13' 39.903"
LOCATION 2 (NONWA)	BH1	N 4^0 44' 19.266"	E 7^0 13' 34.248"
	BH2	N 4^0 44' 21.036"	E 7^0 13' 31.595"
	BH3	N 4^0 44' 24.419"	E 7^0 13' 34.870"

III. RESULTS AND DISCUSSIONS

STRATIGRAPHY

The subsurface stratigraphy in Nonwa figure 2 consists generally of a dark brown, silty sand at 0-4m, light brown sandy clay at 4-8m and light brown fine to medium to coarse sand from 8-10m. Intercalations of Grey clayey sand occur at 1-4m in BH2 and 6-8m in BH3. While, intercalations of silty clays occur at 1-4m in BH3. In Gbam community, the subsurface stratigraphy figure 3 comprises of a dark brown silty sand from 0-1m in all the boreholes. A light brown silty clay underlies this soil at 4-8m in BH1, 5-7m in BH2 and 6-8m in BH3. This strata if underlain by fine to medium to coarse sand from 8-10m in BH1, 7-10m inBH2 and 8-10m in BH3 where the drilling and collection of soil samples was terminated. Similar results have been found by [2] and [5] on the stratigraphy of sub soils in parts of the Niger delta.

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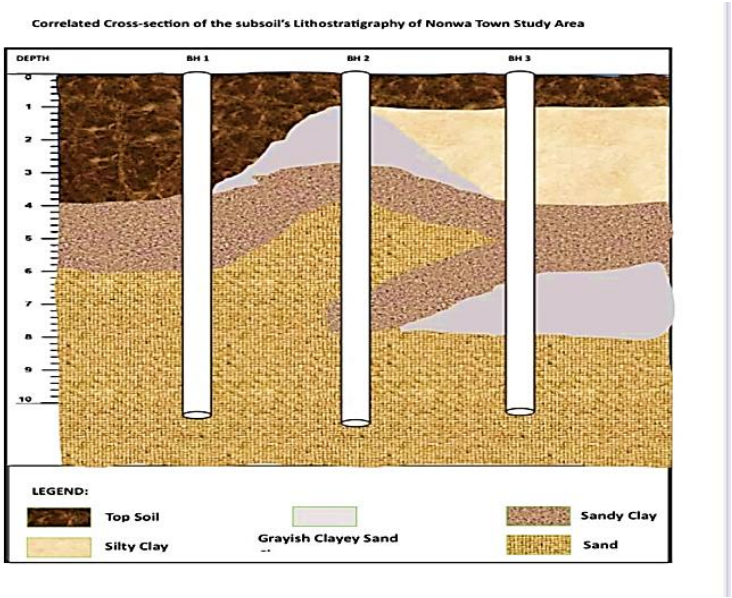

Figure 2: Cross-section of the Lithostratigraphy of Nonwa Town

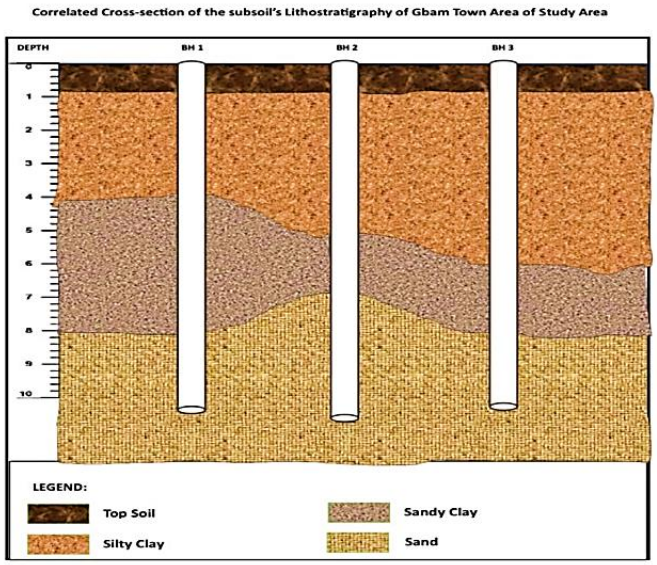

Figure 3: Cross-section of the Lithostratigraphy of Gbam Town

PARTICLE SIZE DISTRIBUTION AND MOISTURE CONTENT OF THE SOILS

Dry sieve analysis plots of the particle size distribution in figures 4 and 5 display poorly graded (PG) fine to medium to coarse sand fractions with a higher percentage of the fine to medium sand fractions in Nonwa and Gbam communities as shown in Table 3. While the wet sieve analysis plot in figures 6 and 7 show a high percentage of sand 50% and above over the clays and silts which are less than 30% as shown in Table 2. These results are indicative of the low water retention ability of the sands and high permeability as shown by their moisture content percentages which are generally below 50% as shown in Table 3. The moisture content percentages of the soils display an increase in water (moisture) content percentage with depth in borehole BH1 from 1-5m and a decrease in water content percentage with depth in BH2 and BH3 from 1-5m in both Nonwa and Gbam communities. These results may be attributed to the lithology of the soils at these depths which generally range from silty sand at 0-4m to silty, sandy clays at 4-8m in both locations. Similar poorly graded sands with low high permeability have been found by [1], [8], [9] and [10] on the characterization of sub soils in the Niger delta.

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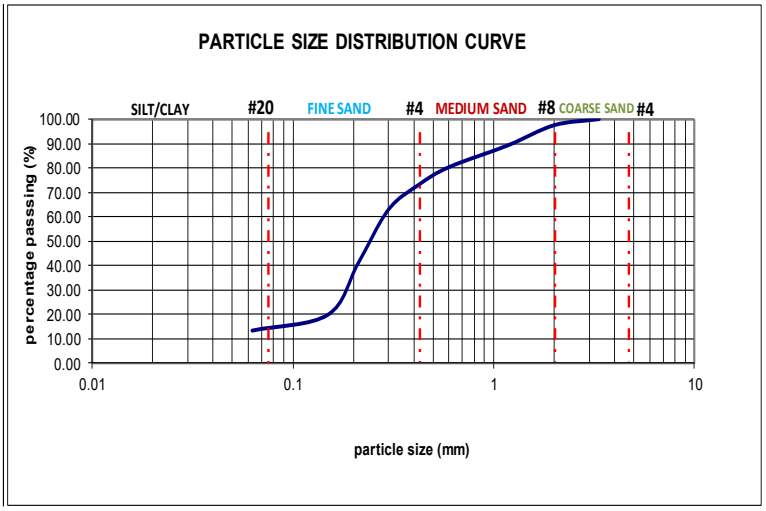

Figure 4: Typical plot of the particle size distribution of soils in BH2 -7m in Gbam, showing the poorly graded fine-medium-coarse sand curve.

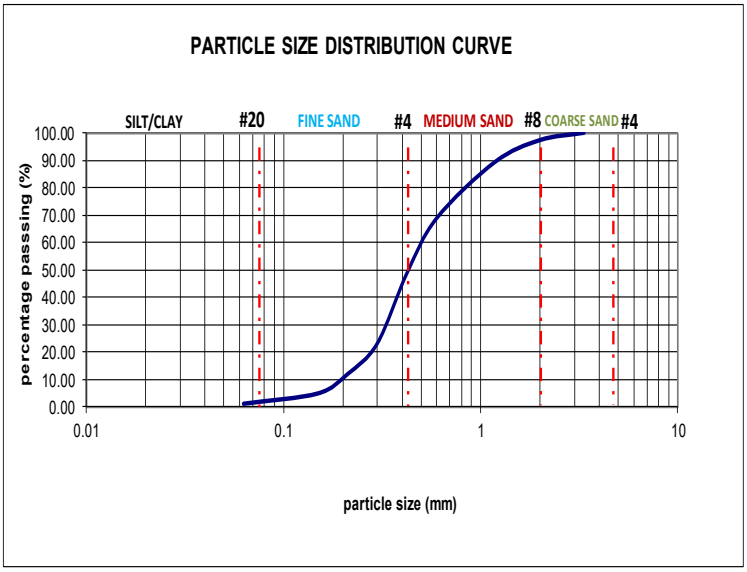

Figure 5: Typical plot of the particle size distribution of soils in BH2 -9m in Nonwa, showing the poorly graded fine-medium-coarse sand curve.

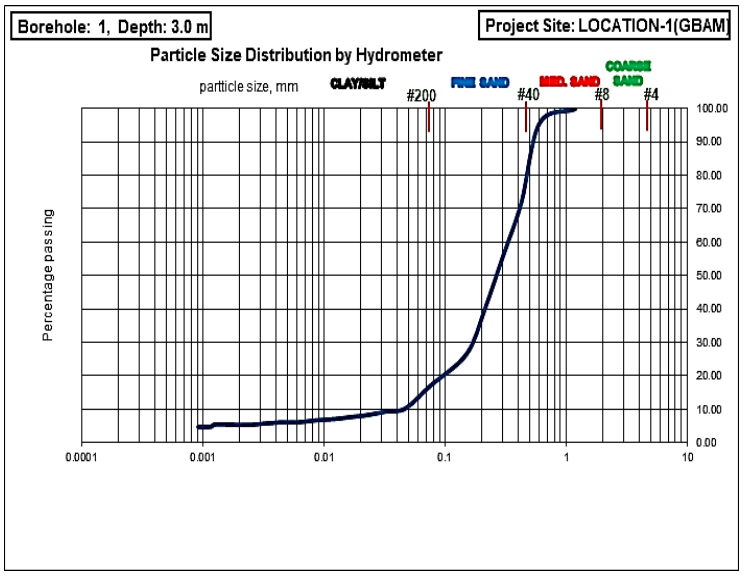

Figure 6: Particle size distribution plot by hydrometer BH1, 3.0m in Gbam.

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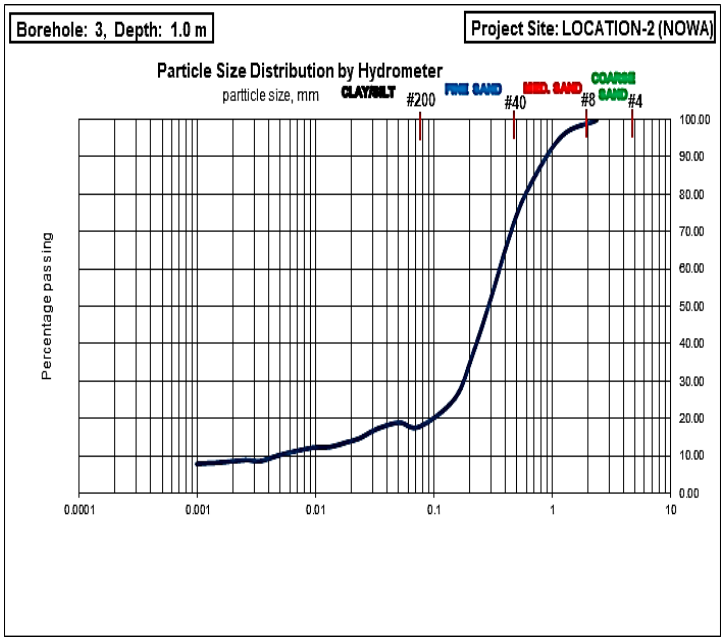

Figure 7: Particle size distribution plot by hydrometer BH2, 1.0m in Nonwa.

Table 2: Particle size distribution by Hydrometer (wet sieve analysis) of soils in Nonwa-Gbam

Location/Depth (m)	% Clay	% Silt	%Sand	% Gravel
GBAM				
BH1-3m	5.2	11.7	83.1	0
BH2- 2m	7.9	9.3	82.8	0
BH3- 1m	8.2	10.3	81.5	0
NONWA				
BH1-3m	11.1	9.0	80.0	0
BH2-2m	28.0	16.9	55.7	0
BH3-1m	8.2	9.6	82.2	0

BH-Borehole

Table 3: Particle size distribution by dry sieve analysis of soils in Nonwa-Gbam

Location	Coarse Sand %	Medium Sand %	Fine Sand %	D_{50} (mm)	D_{60} (mm)	D_{10} (mm)	CU/Description
GBAM							
BH1-9m	20	40	40	0.5	0.6	0.2	3.0 / PG
BH2-7m	2	24	58	0.25	0.3	0.1	3.0 / PG
BH2-8m	15	45	40	0.5	0.6	0.2	3.0 / PG
NONWA							
BH1-6m	20	30	42	0.7	0.4	0.2	2.0 / PG
BH2-1m	2	40	28	0.3	0.3	0.1	3.0 / PG
BH2-9m		53	44	0.3	0.3	0.1	3.0 / PG

BH- Borehole CU- Coefficient of Uniformity, PG- Poorly Graded

Table 4: Moisture content percentages of soils in Nonwa-Gbam

Location/Depth (m)	Moisture Content (%)
GBAM	
BH1- 1m	18.1
BH1- 5m	19.3
BH2- 1m	30.2
BH2- 5m	20.1
BH3- 1m	49.2
BH3- 5m	18.0
NONWA	
BH1- 1m	16.6
BH1- 5m	22.9
BH2- 1m	30.2
BH2- 5m	21.9
BH3- 1m	25.5
BH3- 5m	16.3

BH-Borehole

IV.CONCLUSION

The Stratigraphy, particle size distribution and moisture content percentages of the soils in Nonwa-Gbam show poorly graded fine to medium to coarse silty, clayey sands with moisture content percentages below 50%. The sands exhibit high permeability thus, they do not retain water. These qualities classify the soils as good foundation materials for construction.

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