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Engineering Properties of Construction Soils in a Basement Complex Terrain. A Case Study of School of Engineering Itakpe Campus, Kogi State Polytechnic, North Central Nigeria

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Abstract
The aim of this study is to investigate the Engineering properties of soil at the school of Engineering, Itakpe Campus and its effects on constriction activities in the area. Soil samples were collected at locations adjacent to failing buildings between the depths of 0.8 m to 2.0 m below the subsurface *into the dry polyethylene bags. The Global Positioning System (GPS) readings of the sampling locations were recorded, and the samples were taken to the Civil Engineering Department of Kogi State Polytechnic for analysis. The objectives of the study is to determine the following index properties of the soil: natural moisture content, particle size distribution, Atterberg limits, proctor compaction, and specific gravity. The results of the tests show that the site was dominated with poorly graded soil of sandy gravel in composition with specific gravity (2.2 - 2.7), liquid limit (25.8 % - 39.0 %), plastic limit (18.8 % - 35.1 %), Natural moisture content (3.89 % - 27.91 %) and maximum dry density (620 kg/m^3 - 825kg/m^3).*
KEY WORDS: Engineering, Properties, Construction, Soil, Basement Complex.

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I. Introduction

Soil and Earth are synonymous when used in relation to building construction. From the soil profile, top soils are generally being removed before any engineering works are carried out or before soils are excavated for use as construction materials. Soils are directly used to make building materials such as cement, bricks and concretes. Strength and stability of soils are related to its physical properties. Soils with good structures are more stable and reliable as construction materials. Building on wrong soils or without footing on unstable clays or sands can leads to foundation failures and cracks which will eventually affect the stability of the buildings. Soils are classified in several different ways but generally include: gravels, sands, clays, silts and peats. Good soils should have the right proportions of clay, sands and gravel. Some buildings in the study area are already showing signs of failure in form of cracks which necessitate this study. This research is to investigate if the physical properties of the soils is the major cause responsible for these failures or cracks.

Location and Access of the study area

The study area is Kogi State Polytechnic Itakpe Campus which is located in Okehi Local Government Area of Kogi State in North Central Nigeria. It lies within latitudes 7^{0}36'N to 7^{0}39'N and Longitudes 6^{0}17'E to 6^{0}22'E. Itakpe is located northeast of Okene and is about 10 km along the Okene – Lokoja road. Fig.1. shows the location map of Kogi state showing Itakpe and important towns.

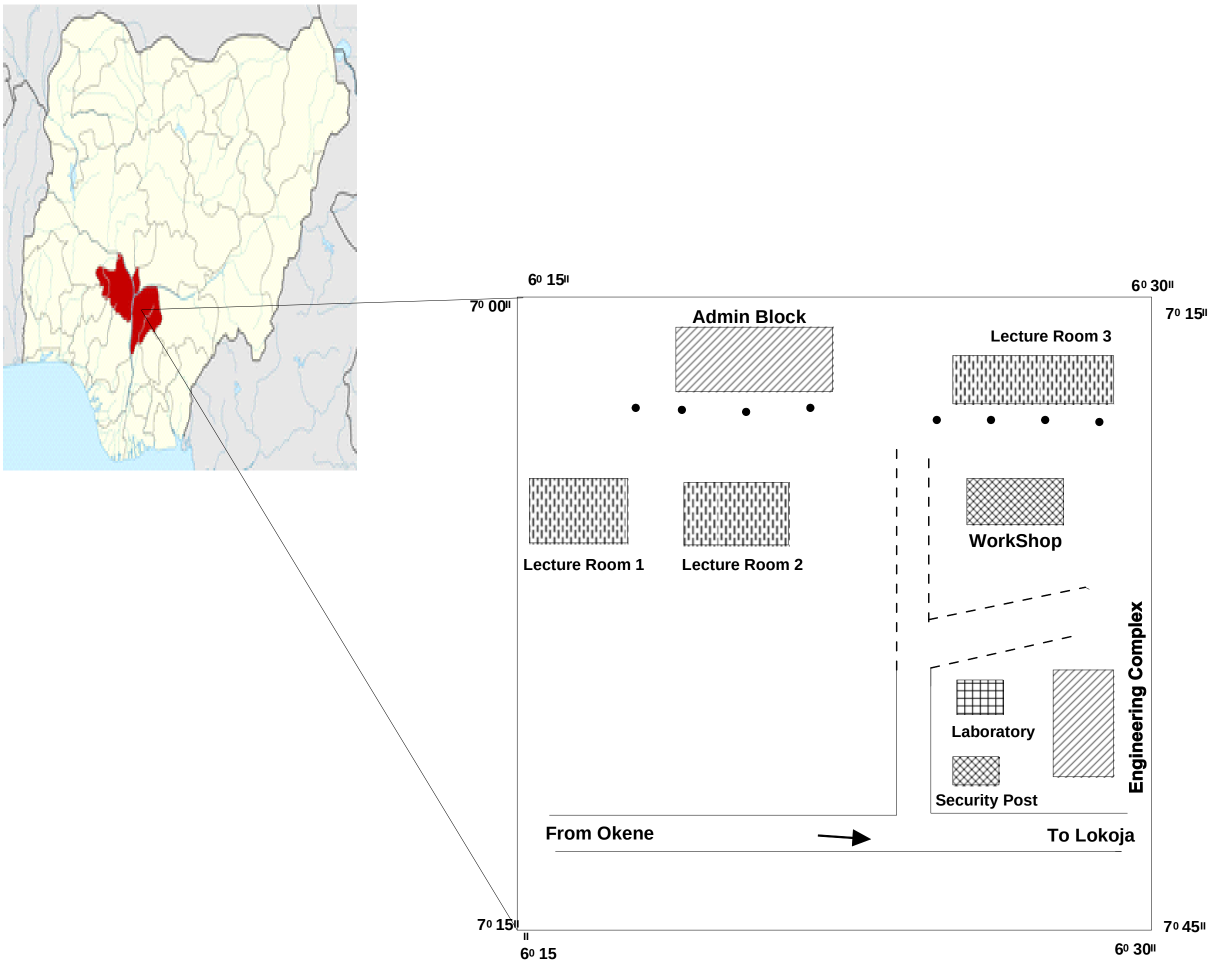

Figure 2: An Inset map of the study area in Nigeria

Geology of the Study Area

The study area, Itakpe lies within the Crystalline Basement Complex. The Nigerian Basement Complex is a part of the Pan – African mobile belt and lies between the West African and Congo Cratons and lies within south of the Tuareg (Black, 1980). The geologic setting of the study area is made up of two distinct complexes of rocks (Wright, 1976); (a) Pre - Cambrian rocks which have undergone intensive tectonic and metamorphic changes and are commonly referred to as the Basement complex and (b) Mesocenozoic deposits which are only slightly affected by the same processes. The Basement Complex of Nigeria includes those of the North Central Nigeria, the Southwestern Nigeria and the Eastern province. The three broad lithological groups within the Nigerian Basement Complex are the Migmatite Gneiss Complex made up largely of Migmatite and Gneisses of various compositions, the low grade sediment dominated Schist belt and the Granitic rocks which cut both the Migmatite Gneiss Complex and the Schists belt (Ajibade and Woakes, in Kogbe 1980).

Itakpe is endowed with Iron Ore deposit, and the deposit is localized within the Gneiss – Migmatite – Quartzite unit of Nigerian basement complex. Annor and Freeth (1985). Olade (1979) describe the geology of Okene as made up of Granodiorite – tonalite – gneiss lithologic unit, overlain by sequences of low grade Metasediments and intruded by Granodioritic and Granite rocks. The major rock types that occurred in the area includes Granite Gneiss, Granites, Quartzites, Schists,, Amphibolites and Pegmatites but in this particular area Amphibolites was not visible. Olade (1979) gave a vivid description of the geology of the ore deposit to be made up of two types of Quartzites: the ferruginous quartzite and non ferruginous quartzite. The ferruginous quartzites occur as Magnetites – rich and Hematite – rich bands and lenses in alternation with gneiss. The non ferruginous quartzites are rear in Itakpe hill but are localized at the southern fridges.

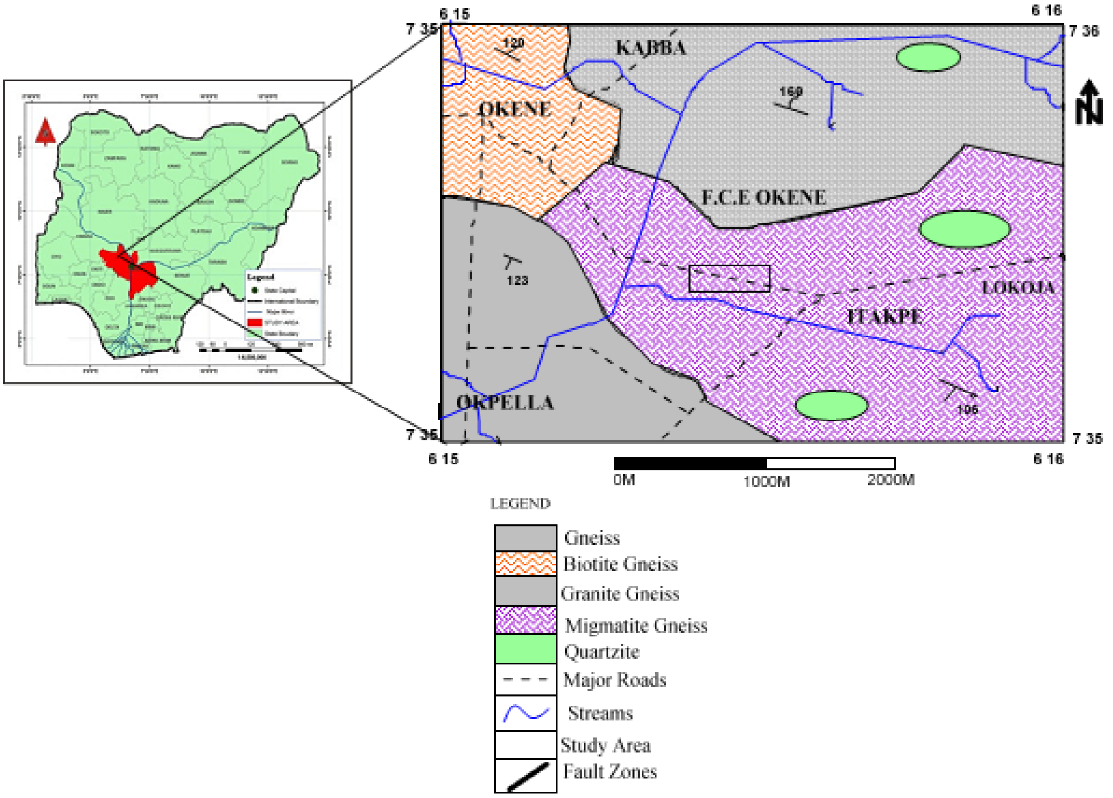

Figure 3: Geological Map of the Study Area.

II. Materials and Method

The materials used for the study are as follows:

Geographical position system (GPS), Sampling bag, Marker, Spatula, Masking tape, Measuring tape, Proctor rammer, Scoopels, Desiccators, Sieve, Mortal, Pestle, Density bottle, Measuring cylinder, Weighing balance, Oven, Shovel and Digger. The method involves removing the top soil using shovel and digging between 0.5 to 1.5 m before taking samples which is up to 2 kg per location. The GPS of each sampling points were taken and recorded. The samples were taken by using shovel into the sampling bag for onward transfer to the Department of Civil Engineering for washing, drying and analysis for engineering properties of the soil.

Tables 1: The result of the various field's observations.

S/N	Name of building	Longitude (E)	Latitude (N)	Elevation above sea level (M)	Observation
1	Old admin block	006°21′577″	07°39'469″	469	The crack is as wide as 0.8cm, sample at about 1.5m depth and above contain high organic matter.
2	R .A. C Block	006°21′546″	07°39′469″	512	The cracks are less than 0.5cm wide, Sample at about 1.5m depth and above have no organic matter but contains medium grain size of laterite.
3	Hall A Block	006°21′651″	07°39′453″	559	The cracks in this location are about 0.5-1cm wide, the soil is rich in brown clay.
4	New ongoing construction laboratory block	006°21′661″	07°21′766″	564	No crack is observe, sample at about 1.5m depth and above contain about 1.5cm large grain size also rich in laterite
5	Engineering complex	006°21′661″	07°39′409′	568	The crack is less than 0.5cm, sample at about 1.5m depth and above contain large grain size solid formation

Table 2: Summary of the grain sizes distribution of the study area

S/N	Name of building	% of Clay	% of Sand	% of Gravel	Soil Description
L1	Old Admin Block	4 %	64 %	32 %	Sandy gravel
L2	R .A. C Block	6 %	58 %	36 %	Sandy gravel
L3	Hall A Block	4 %	64 %	32 %	Sandy gravel
L4	New ongoing construction laboratory block	4 %	38 %	58 %	Sandy gravel
L5	Engineering complex	32 %	33 %	35 %	Clayey Sand

Table 3: Values for Maximum Dry Densities of cohesive Soils. (Department of Scientific Industrial Research (1956).

Average values of		Maximum |Dry Density as obtained from standard compaction test kg/m^3	Suitability of soil for construction of embankments
Liquid Limit	Plastic Limit		
>65	>22	<1600	Not suitable to very poor
65 – 50	22 – 19	1600 – 1730	Poor
50 – 32	19 – 16	1730 – 1920	Fair
32 – 24	16 – 14	1920 – 2060	Good
<24	<14	>2060	Excellent

Table 4: Summary of Atterberg and Compaction Test Result

Samples No	**Liquid Limit (%)**	**Plastic Limit (%)**	**Plasticity Index**	**Plasticity**	**Optimum Water content (OWC)**	**Max. Dry Desnsity (kg/m3)**	**Suitability of soil for construction/ embankments**
L1	22.8	15.5	5.2	Slightly plastic	**13.0**	**620**	Good
L2	23.0	12.1	2.8	Slightly plastic	**12.6**	**749**	Good
L3	39.0	12.3	3.9	Slightly plastic	**16.1**	**728**	Good
L4	30.7	26.3	4.4	Slightly plastic	**14.3**	**825**	Good
L5	34.8	18.8	16.0	Medium plastic	**9.4**	**818**	Good

III. Discussion

The result of the research are presented in tables 2,3 and 4.

Particle Sizes Distribution: The distribution of particles in the soil are presented I table 2 with more than 95% of samples fall within sand to gravel with 5 % clay.

Natural Moisture Content: The natural moisture content of the soil sample as shown in table 3 ranges from 3.89 % - 27.9 %. These results suggested that the soil has high ability to hold water during wet season which when losses during the dry season could cause serious shrinkage.

The Atterberg Limit Test: The summary of the plasticity index result in table 4 which range from 2.8 % to 16 %, soil sample in this study area have low to medium plasticity and will not posses problem when use in any engineering construction as stated by Burnister (1947). This indicated that the soil can be further classified as sandy gravel soil of low to medium plasticity

Liquid limit is the minimum water that a soil will contain before it begin to flow as a liquid. The liquild limit as shown in table 2 range from 25.8 % to 39 % which are not suitable for any engineering construction

The plastic limit of the soil sample is range from 18.8 % to 35.1 % which are not suitable for any engineering construction.

Specific Gravity: Specific gravity is the ratio of density of a substance to the density of reference substance. This reference substance is always water. The specific gravity of soil sample obtain from the study are range from 2.2 to 2.7

Maximum Dry Density: The maximum dry density of the sample collected from the study ranges from 620 kg/m^3 to 825 kg/m^3 on average, they are less than 1000 kg/m^3 as reported by Department of indusrial Scientific research (1956) and are not good to be used as construction material.

IV. Conclusion

The following characteristic of the soil are obtained after the analysis:

- The top soil are compose of silt, clay and decaying organic materia.l
- The sub soil are compose of 95 % of sand and gravel with 5 % clay.
- The platicity Index ranges from 2.8 % to 16 %.
- The pasticity limit varies from 18.8 % to 35.1 %
- The liquid limit is 22.8 % – 34.8 %.
- The optimum water contnt is 9.4% to 16.1 %.
- The maximum dry density is 620 to 825 (kg/m^3) .

In term of grain sizes distribution, with more than 95 % of the soil composed of sand and gravel with 5 % clay as a binding material, the soil is good for construction purpose specially in line with Baker (1999).The plasticity limit of 18.8 % to 35.1 % is good as a construction material e.g block molding. The plasticity Index of 5.2, 2.8, 3.9. 4.4, and 16 are within limits for good construction materials as reported by Danso (2018).The liquidity limit (22.8 % – 34.8 %.) is supportd by Houben and Guillaud (2018) that liquidity limit should range from 25% to 50 %..

The soil on the site at the school of Engineeering, Itakpe campus may be use as construction material based on the above analysis,

V. Recommendation

Based on the above analysis of physical properties, the subsoil at the school of Engineering, Itakpe Campus is good as construction material with the following recommendations

1. The design of subsequent buildings should include more colum base at the DPC level up to a minimum depth of 5m or more.
2. The foundation soil may require significant improvement through engineering reinforcement in the form of raft/pile foundation to enhance their bearing capacities.
3. A good drainage system should be constructed around the buildings to prevent continuous washing away of the building's foundation foot.
4. A detail combine geotechnical and geophysical invetigation should be carried out on the other zones of the soil profiles.

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