



## Textural Characteristics of subsoils in the main campus of Akwa Ibom State University, Ikot Akpaden, Akwa Ibom State, Southern Nigeria

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### Abstract

The textural characteristics of soils are very useful indices of the potential mechanical behaviour of the soil. These properties are used to identify and classify soils, prior to construction. Soils in nature usually contain varying proportions of gravel, sand, silt, clay or organic matter, they rarely exist separately. The aim of this study is to evaluate the textural properties of shallow subsurface soils, in six different locations within the main campus of Akwa Ibom State University, which serve as foundations for office buildings and roads. Field investigations including the drilling of six geotechnical boreholes to a depth of three meters each and laboratory analysis of the Moisture content, Particle size distribution, Atterberg limit and Compaction properties of the disturbed soil samples were performed.

The stratification of Sub soils from 0-3 meters in the six locations in the main campus of the University consist of reddish brown, clayey, silty, fine to medium grained sand in locations L1, L2 and L3, while a light to dark brown, clayey, silty, fine to medium grained sand underlies locations L4, L5 and L6. Laboratory analysis of the sub soils reveal low natural moisture content percentages of the soils which are generally below 30%. The clay have average liquid limit and plasticity index values between 34% to 50% and 16% to 25% respectively and are of low to intermediate plasticity with a low swelling potential. Particle size distribution of the soils, show they are poorly graded sand. Optimum moisture content and maximum dry density values of the soil show location 4 has the lowest percentage of fines (40%), the lowest optimum moisture (8.3%) and highest maximum dry density ( $1830 \text{ kg/m}^3$ ), while location 5 has the highest percentage of fines (48%) the highest optimum moisture content (11.8%) and lowest maximum dry density ( $1740 \text{ kg/m}^3$ ). The

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maximum dry density values and optimum moisture content percentages of the soils in all locations fall within the recommended range for good back fill materials. Although the textural properties of the subsoils show that the soils are all suitable for construction purposes, an increase in the density of the soils is recommended to improve its stability, using a suitable soil improvement method.

**Keywords:** Textural properties; Shallow subsoils; Subsurface stratification; Compaction; Soil improvement

## 1.0 Introduction

Soils usually consist of varying proportions of gravel, sand, silt, clay or organic matter; it rarely exists separately in nature (Murthy, 2009). Soil texture considers the size, shape and arrangement of the component minerals (Pettijohn, 2004). The component minerals amongst other factors influence the size, shape of particles and the consistency of the soil. Soils are classified based on these qualities. The textural characteristics of soil referred to as the index properties of soils, are very useful indices of the potential mechanical behaviour of the soil. These properties which are used to identify and classify soils prior to construction are determined in the laboratory from soil samples. The particle size distribution and the plasticity of soils are the two most important textural properties of soils (Akpokodje, 2001). The student population in Akwa Ibom State University is increasing rapidly every year, thus the need for the expansion of infrastructures within the main campus of the University. In this study, focus is on examining the textural properties of the shallow subsurface soils in six different locations within the main campus, which serve as foundation for the construction of office buildings and roads.

## 2.0 Description of Study Location

The University main campus lies between latitude  $4^{\circ}32^{\text{I}}\text{N}$  and  $4^{\circ}42^{\text{I}}\text{N}$  and longitude  $7^{\circ}40^{\text{I}}$

E and  $7^{\circ}50^{\text{I}}$  E (Fig. 1). The study area, Ikot Akpaden, Mkpato Enin Local Government Area, Akwa Ibom State is located in the Tertiary Niger Delta sedimentary basin, formed as a complex regressive offlap sequence of clastic sediments, ranging in thickness from 9,000 meters to 12,000 meters (Etu-Efeotor, 1997). Three main depositional environments (marine, mixed and continental) are present in the Niger Delta and are represented by the Akata, Agbada and Benin Formations respectively (Short and Stauble, 1967; Etu-Efeotor (1997). Geomorphologically, Mkpato Enin has a flat, low lying terrain that overlies the younger Benin Coastal Plain sand (Pliocene to Peistocene) and terminates in the Coastal brackish water, Mangrove swamp zone, lying southward (Peters, 1989).

## 3.0 Materials and Methods

### Materials

A hand Auger was used to drill six boreholes (Table 1) to a depth of three meters each. Disturbed soil samples were collected at every one meter interval. All soil samples were described on the field and transported to the laboratory for different subsoil tests including, Natural moisture content, Atterberg limit, Particle size distribution and Compaction.

### Method

All tests were performed according to British Standard BS 1377 (1990) and American Society for Testing and Materials, ASTM (1975). The test procedures are discussed below:

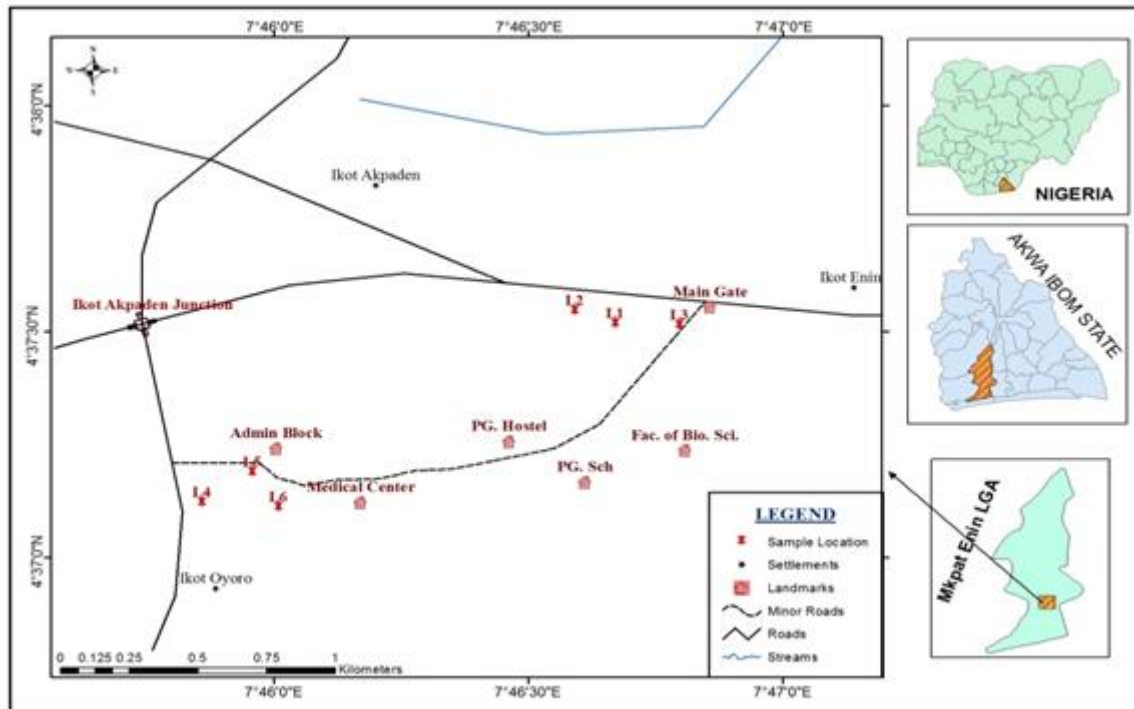
### Natural moisture content

20g of wet soil from each of the soil samples were oven dried overnight immediately the soil samples arrived from the field to determine the amount of moisture (water) content present in the soil.

## Sieve Analysis

Representative soil samples were washed, oven dried and 200g of dried soil passed through a

set of sieves on a sieve shaker using the mechanical sieve analysis method.



**Fig. 1:** Map of the main campus of Akwa Ibom State University, showing the borehole locations

**Table 1:** Coordinates of Sample Locations

| Sample location | Longitude     | Latitude       |
|-----------------|---------------|----------------|
| L1              | 7°37'30.894"E | 4° 37'30.894"N |
| L2              | 7°46'40.752"E | 4°37'30.6"N    |
| L3              | 7°46'40.122"E | 4°37'30.99"N   |
| L4              | 7°45'44.154"E | 4°37'23.04"N   |
| L5              | 7°45'56.79"E  | 4°37'23.25"N   |
| L6              | 7°45'57.102"E | 4°37'23.316"N  |

## Liquid Limit Determination

Samples weighing 200g were passed through sieve 0.425mm and mixed with distilled water to form a paste, which was put into the Casagrande apparatus cup and a groove created. The number of blows to close the groove was recorded and the moisture content at each phase determined. A graph of the moisture content

against the number of blows was plotted and the moisture content at 25 blows recorded as the liquid limit.

## Plastic limit Determination

20g of dry soil sample used during the liquid limit test was mixed to form a paste. A portion of the paste was rolled on a glass plate to form

a thread until it cracked at approximately 3mm in diameter. The moisture content of the cracked thread was determined.

### Compaction

Compaction tests were performed on soil samples to determine the dry density of the soil through the process of packing soil particles closely together and expelling air by mechanical means to obtain the optimum moisture content and maximum dry density of the soil.

## 4.0 Results and Discussions

### Sample Description

Soil samples from locations L1 to L3 consist of reddish brown silty, fine to medium grained sand, while soils from locations L4 to L5 are dark brown to light brown, silty, fine to medium grained sand.

### Textural Characteristics of Sub soils

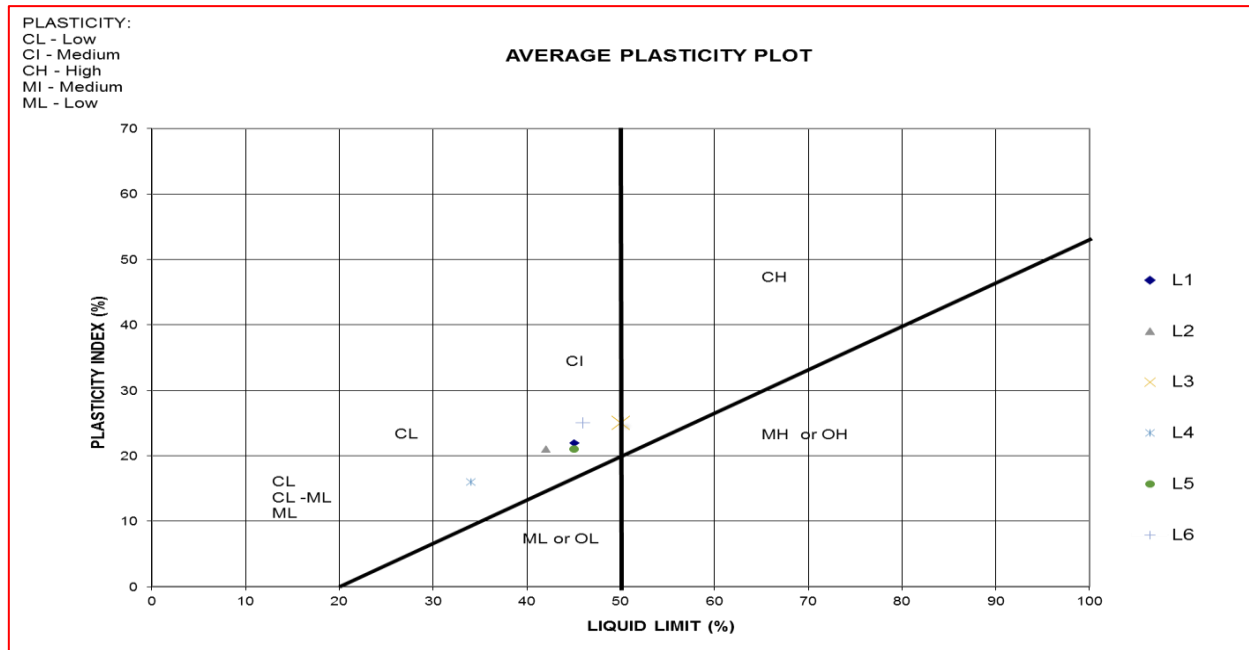
The textural characteristics of the Sub soils are presented in Table 2. Moisture content of the soils are generally below 30%. Location 4 has the lowest moisture content value (19.8%),

lowest percentage of fines (40%) and highest percentage of sand fraction (60%). While location 5, has the highest moisture content value (29.5%), highest percentage of fines (48%) and lowest sand fraction (52%). The higher the percentage of fine fractions (silt and clays) and lower the sand fraction, the higher the ability of the soil to absorb and retain water. The liquid limit and plasticity index values range between 34% to 50% and 16% to 25% respectively. All the clays are of intermediate plasticity (CI) except the clay soil in location 4, which is of low plasticity (CL) (Fig. 2). This can be attributed to the low percentage of fines (silts and clays) and high percentage of sand fraction of this soil indicating its low ability to retain moisture thus, the low swelling potential of the clay. Particle size distribution graphs display poorly graded soils (Fig.3) consisting of 40% - 48% fines and 52% - 60% sand. The poorly graded sands are indicative of the free draining nature of the sand. Similar moisture content and Atterberg limit values in the Niger delta have been obtained by Tse and Akpokodje (2010), Nwankwoala *et al.* (2015) and Ehibor *et al.* (2019).

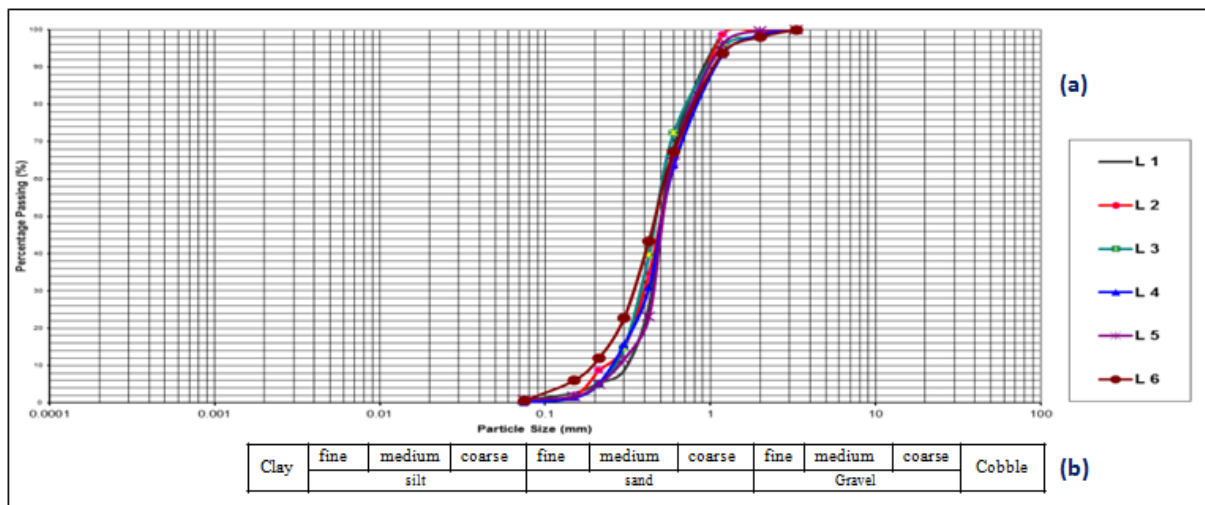
**Table 2:** Textural characteristics of Sub soils

| Sample Location          | L1   | L2   | L3   | L4   | L5   | L6   |
|--------------------------|------|------|------|------|------|------|
| Moisture content (%)     | 25.3 | 23.3 | 24.7 | 19.8 | 29.5 | 26.2 |
| % Fines                  | 42   | 44   | 45   | 40   | 48   | 42   |
| % Sand                   | 58   | 56   | 55   | 60   | 52   | 58   |
| Liquid limit (%)         | 45   | 42   | 50   | 34   | 45   | 47   |
| Plastic limit (%)        | 23   | 21   | 25   | 18   | 24   | 25   |
| Plasticity index (%)     | 22   | 21   | 25   | 16   | 21   | 22   |
| USCS                     | CI   | CI   | CI   | CL   | CI   | CI   |
| OMC (%)                  | 11.4 | 11.0 | 11.2 | 8.3  | 11.8 | 11.7 |
| MDD (KG/m <sup>3</sup> ) | 1760 | 1761 | 1763 | 1830 | 1740 | 1744 |

NB: USCS- Unified Soil Classification System, OMC- Optimum Moisture Content  
MDD- Maximum Dry Density, CI- Clays of Low Plasticity (Liquid limit value below 35%),  
CI- Clays of Intermediate plasticity (Liquid limit value 35-50%)



**Fig. 3:** A Plot of the Plasticity index versus Liquid limit showing the low to intermediate plasticity of the Clays in Locations L1-L6



**Fig.4:** A plot of the percentage of soil passing through the sieves versus Particle Sizes of the different soil fractions L1- L6, (a) Poorly graded Particle size distribution curves, (b) Particle Sizes of the different soil fractions

**Compaction Characteristics**

Compaction analysis of the soils reveal optimum moisture content percentages range from 8.3% to 11.8% and the maximum dry density from 1760 kg/m<sup>3</sup> to 1830 kg/m<sup>3</sup> (Table 2). From Table 2, Location four (L4) has the lowest percentage of fines, lowest optimum moisture content and highest maximum dry density. The low moisture content, low percentage of fines and high

percentage of sand fraction in Location 4 accounts for the high maximum dry density value in this location. While Location five (L5) with the highest percentage of fines, and lowest sand percentage, has the highest optimum moisture content and lowest maximum dry density value. The high percentage of fines (silt and clays) in a soil increases the inter particle water present and reduces the dry density of the soil. These results are similar to the findings of

Ehibor *et al.* (2019) on the compaction characteristics of soils in Uyo, Eastern Niger Delta but differ from studies in Warri, Western Niger Delta by Ugbe (2011) and Avwenagha *et al.* (2014). Although the maximum dry density and optimum moisture content of the soils in the different locations fall within the

recommended range for good back fill materials, the low maximum dry densities values in all the locations excluding location four, indicates the need for an increase in the density of the soil in order to increase its stability.

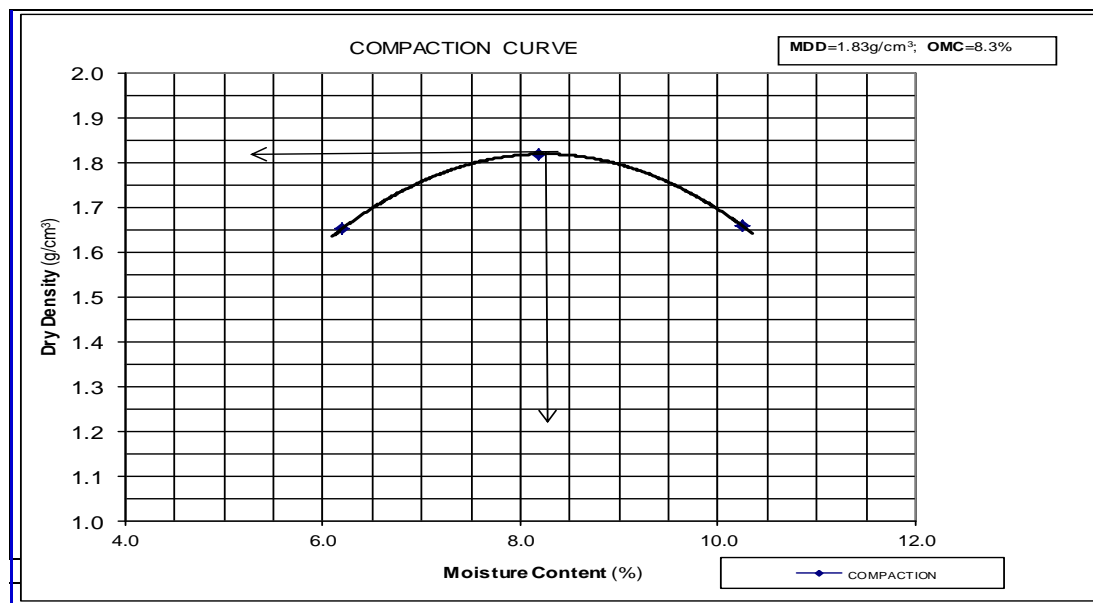


Fig.5: A Compaction plot of Clay in L4 showing the maximum dry density vs optimum moisture content

## 5.0 Conclusion

This study analyzes shallow subsurface soils in six different locations within the permanent site of Akwa Ibom State University, which serve as foundation for office buildings and roads. The stratification of Sub soils from 0-3 meters consists of reddish brown, clayey, silty, fine to medium grained sand in locations L1, L2 and L3, while a light to dark brown, clayey, silty, fine to medium grained sand underlies locations L4, L5 and L6. Laboratory analysis of the sub soils reveal that the clay which are of low to intermediate plasticity have a low swelling potential. Particle size distribution of the soils, present a dominance of poorly graded, medium grained, free draining sand. Optimum moisture content and maximum dry density values depict location four with the lowest percentage of fines, lowest optimum moisture and highest

maximum dry density; location five with the highest percentage of fines, highest optimum moisture content and lowest maximum dry density. These values fall within the recommended range for good back fill materials. Although the textural properties of the soils in all locations show that the soils are suitable for construction purposes, an increase the density of the soils using a suitable soil improvement method is recommended.

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