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GEOTECHNICAL PROPERTIES OF LATERITIC SOIL STABILIZED WITH CORN COB ASH

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Abstract: This study assesses geotechnical properties of lateritic soil using corn cob ash (CCA). Preliminary tests were carried out on the soil sample for classification purposes. California Bearing Ratio (CBR), Unconfined Compressive Strength (UCS) and compaction tests were performed on both the soil sample and the stabilized lateritic soil, which was stabilized by adding CCA in percentages of 2, 4, 6, 8 and 10 respectively by weight of the soil. The results showed that the addition of CCA reduced the values of Maximum Dry Density (MDD) from 1345kg/m^3 at 0% CCA to 1284kg/m^3, the Optimum Moisture Content (OMC) increased from 14.95% to 20.20%, both at 10% CCA. The unsoaked CBR values increased from 9.25% at 0% CCA to 28.20%, the UCS values increased from 495kN/m^2 to 560kN/m^2, for both CBR and UCS, the peak values were at 8% CCA. It was therefore concluded that CCA performs satisfactorily as a cheap stabilizing agent for stabilizing lateritic soil especially for subgrade purposes.
Keywords: Atterberg limits, corn cob ash, lateritic soil, stabilization, strength tests

INTRODUCTION

Many researchers have come up with various definitions of laterites, of note to this study is as posited by Ola (1983), where laterites is defined as the product of tropical weathering with red, reddish brown and dark brown colour, with or without nodules or concreting and generally (but not exclusively) found below hardened ferruginous crust or hard pan. Fundamentally, soils having a ratio of silica to sesquioxide (SiO_2/Fe O_3 + Al_2 O_3) which are less than 1.33 are regarded as laterites, between 1.33 and 2.00 are as regarded as lateritic soil and those above 2.00 are as non-lateritic soils. Though, this definition is not convenient from the engineering point of view especially where there is a lack of adequate laboratory facilities. According to Maignien (1966) and Gidigasu (1976) have three stages have been identified in the process of laterization. The first stage, decomposition is characterized by physico-chemical breakdown of primary mineral and the release of constituent elements. The second stage involves leaching under appropriate drainage condition of combined silica and bases and the relative accumulation and enrichment from outside sources (absolute accumulation) of oxides and hydroxides of sesquioxides (mainly Al_2O_3 and Fe_2O_3), the most resistant to leaching. The third stage which is the hydration or desiccation involves partial or complete dehydration (sometimes involving hardening) of the sesquioxide rich materials or secondary materials. There are five major factors that influence the formation of soils and they are: parental material, climate, topography, vegetation and time, of these primary factors, climate in considered to be the most important factor (Ola, 1978).

Laterite, a sedimentary rock deposit arising from the weathering of rocks, is one of the most common and readily available road building materials that can be sourced locally in Nigeria (Joel and Edeh, 2015). According to Bello et al. (2015), lateritic soils are generally used for road construction in Nigeria. Lateritic soil in its natural state more often, have low bearing capacity and low strength as a result of high content of clay. If lateritic soil contains a substantial amount of clay materials, its strength and stability cannot be guaranteed under load especially in the presence of moisture. The presence of high plastic clay in lateritic soil, causes soil cracks and damage on pavement, road ways, building foundations or any civil engineering construction projects. The need to improve the strength and durability of lateritic soil in recent time has become imperative, consequently, this has led researchers towards using stabilizing materials that can be sourced locally at very a cheap cost. These local materials can be categorized as either agricultural or industrial wastes. The capability to blend the naturally occurring lateritic soil with some chemical additives to give it better engineering properties in both strength and water proofing is very important.

Stabilization, according to Ogundipe (2013), is the process of blending and mixing materials with a soil to improve certain properties of the soil. The process may include the blending of soils to achieve a desired gradation or the mixing of commercially available additives that may alter the gradation, texture or plasticity or act as a binder for cementation of the soil. There are three purposes of stabilization, these include; strength improvement, dust control and soil water proofing (Amu and Adetuberu, 2010).

According to Mujedu et al.,(2014), corncob is the hard thick cylindrical central core of the maize, it is also described as the agricultural waste product obtained from corn or maize which is the most important cereal crop in Sub-Sahara Africa, 589 million tons of maize was produced worldwide in the year 2000 and the United States was reported to be the largest maize producer having 52 % of world production. Africa produced 7% of the world maize. Corn cob ash can be obtained by drying the cobs thoroughly and burning them intensively using open air burning. Thereafter, the product would be sieved using sieve number 200.

Figure 1: Corn Cob

LOCATION AND GEOLOGY OF THE STUDY AREA

According to Ogunribido (2011), the study area Akure lies within longitude 7^0 18^1 N and 7^0 16^1 N North of Equator and between latitude 5^0 09^1 E and 5^0 11.5^1 E of Green Winch meridian. The study area occurred within the Precambrian Crystalline rocks of the basement complex of Southwestern Nigeria. The predominant rock types in the study area are charnockites, granite, gneiss and migmatitic rocks. In some places in the study are these rocks have undergone deep weathering.

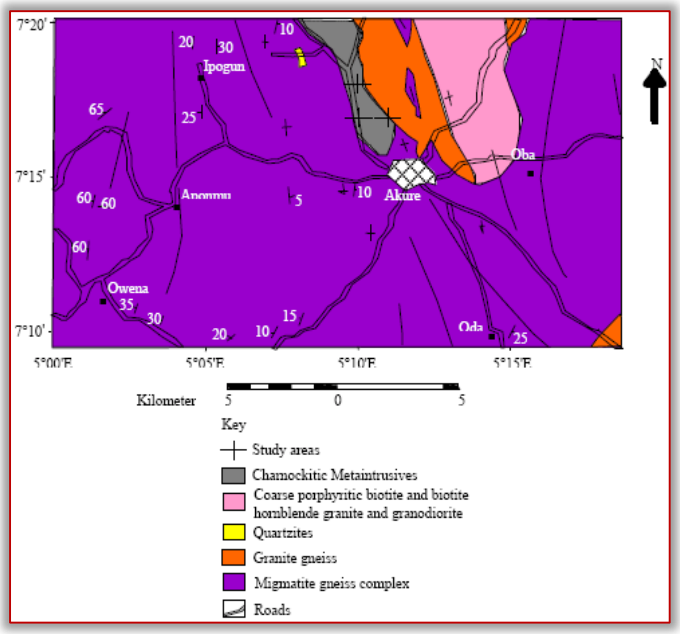

Figure 2: Geological map of Akure showing study area. Source: Ademeso (2009).

MATERIALS

The materials used for this research work were lateritic soil, Corn Cob Ash (CCA) and potable water.

The lateritic soil was collected from at burrow pit in Akure, Ondo State at depths representative of the soil stratum and not less than 1.2m below the natural ground level.

The corncob was collected from a large corn farmland. The cobs were dried thoroughly, cut into smaller sizes and burnt for about ten hours using open air burning at 600^0C. Finally the product was sieved through BS Sieve 75µm Sieve.

Potable water was gotten from the running taps in the laboratory.

METHODS

The soil sample was air-dried for two weeks at the Geotechnical Laboratory of Federal University of Technology, Akure before analyzing the soil sample. The Corn Cob Ash (CCA) was added to the natural soil sample at varying proportion of 2,4,6,8 and 10% by weight of soil, the following tests were carried out on the mixes: Atterberg limits test, compaction tests, unconfined compressive strength and the California Bearing ratio tests. The procedures for the various tests were carried out in accordance with BS 1377 (1990) and BS 1924 (1990).

DISCUSSIONS

The sum of SiO_2, Al_2O_3 and Fe_2O_3 for Corn Cob Ash gives 80.44%, which is greater than 70% recommended by ASTM C618 (2003), for the classification of pozolanic materials.

Table 1. The chemical composition test results of Corn Cob Ash

Elemental oxides	Weight percentages
CaO	10.24
SiO_2	64.90
MgO	2.08
Na_2O	0.43
Al_2O_3	10.79
Fe_2O_3	4.75
SO_3	2.53
K_2O	4.23

Source: Owolabi et al., (2015)

Table 2. The preliminary test results of lateritic soil

Property	Amount
Natural moisture content (%)	13.20
Percentage passing BS No 200 Sieve	52
Liquid limit (%)	53
Plastic Limit (%)	18
Plasticity Index (%)	35
Specific gravity	2.70
Maximum Dry Density (kg/m^3)	1345
Optimum moisture content (%)	14.95
California bearing ratio (Unsoaked) (%)	9.5
Unconfined Compressive Strength (kN/m^2)	495
AASHTO Classification	A-7-6

Preliminary tests (such as Atterberg limits, specific gravity and particle size analysis) were carried out on the soil sample. According to Garber and Hoel (2009), for a soil to be classified into A-7 group, it must have a minimum liquid limit value of 41%, percentage passing through BS No 200 sieve must be greater than 35% and the Plasticity Index must be greater than 11%, all these conditions were met by the Soil Sample. Also for a soil to be classified into the A-7-6 subgroup, it must satisfy the following requirement, P.I > L.L -30, therefore 35 > 53-30 = 23.

Table 3: Strength test results

CCA (%)	MDD (kg/m³)	OMC (%)	UCS (kN/m²)	CBR (Unsoaked) (%)
2	1340	15.80	510	11.10
4	1335	16.70	525	18.05
6	1320	18.10	542	24.64
8	1301	19.10	560	28.20
10	1284	20.20	550	26.10

— Compaction

With the increased addition of CCA, the Maximum Dry Density (MDD) reduced. This reduction may be attributable to the replacement of soils by the CCA in the mixture which has lower specific gravity of 1.05, this is less than that of the lateritic soil (2.70). The CCA therefore fills the voids in the lateritic soil. The reduction in MDD may also be attributed to coating of the soil by the CCA which result to large particles with larger voids and hence less density (Fattah et al., 2013).

With the increased addition of CCA to the lateritic soil sample, the Optimum Moisture Content increased in value this may be attributed to the addition of CCA, which decreases the quantity of free silt and clay fraction and coarser materials with larger surface areas were formed, these process need water to take place. This implies also that more water is needed in order to compact soil-CCA mixtures (Fattah et al., 2013).

— California Bearing Ratio (CBR) tests

It was observed that the gradual increase in addition of CCA led to increase in value of Unsoaked CBR till it got to its optimum value of 28.20% at 8% CCA.

With the further addition of CCA that is at 10% the value in CBR reduced. The increase in CBR may be because of the gradual formation of cementitious compounds in the soil by reaction between CCA and some amounts of Calcium hydroxide present in the soil. The decrease in CBR at 10% CCA may be due to extra CCA that could not be mobilized for the reaction which occupies spaces within the sample. This reduces the bond in the soil-CCA mixture (Okafor and Okonkwo, 2009).

— Unconfined Compressive Strength (UCS) tests

As more CCA ash was being added to the soil, the values of Unconfined Compressive Strength (UCS) increased to its optimum value at 8% CCA by weight of soil. Thereafter, it reduced at 8% CCA. Increase in values of UCS and decrease at 10% CCA can be explained as it was in the case of California bearing ratio.

— Atterberg limit

Figure 3, shows the relationship between the addition of CCA to the lateritic soil and its effects on the Atterberg limits (Liquid limit, Plastic limit and Plasticity Index). It was observed that there was a general reduction in values of liquid limit, and Plasticity Index. While the plastic limit values increased. According to Fattah et al., (2013), decrease in liquid limit and plasticity index is an indication of improvement of the soil, since CCA reaction forms compound possessing cementitious properties calcium silicate cement with soil particles.

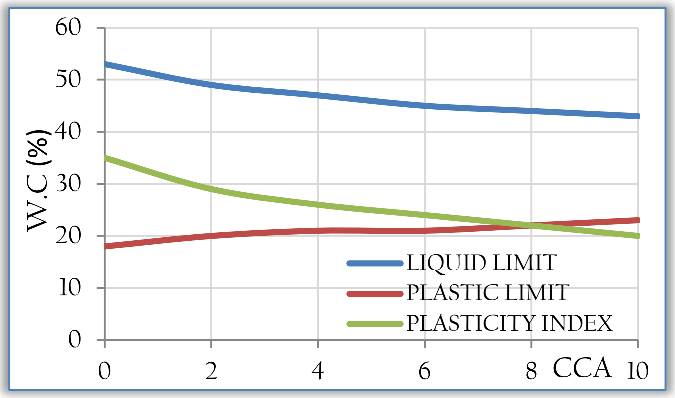

Figure 3: Graph showing effects of CCA on Water Content (W.C.)

CONCLUSIONS

From the results of the investigation carried out in this study, the following conclusions can be drawn:

— The lateritic soil was classified under A-7-6 group.
— Liquid Limit and Plasticity Index values reduced considerable from 53% at 0% CCA to 43% at 10% CCA and from 35% at 0% CCA to 20% at 10% CCA respectively.
— The treatment of the lateritic soil resulted to the decrease in Maximum Dry Density (MDD) and increase in Optimum Moisture Content (OMC) with the addition of CCA.
— The Unsoaked CBR values increased with the addition of CCA to the lateritic soil sample to an optimum value of 28.20% at 8% CCA by weight of soil from 9.25% at 0% CCA.
— The UCS values increased with the addition of CCA to the lateritic soil sample to an optimum value of 560kN/m² at 8% CCA by weight of soil.

As a consequence, one can conclude that the Corn Cob Ash (CCA) performs satisfactorily as a cheap agent for stabilizing lateritic soil especially for sub-grade purposes in road construction.

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