Potentials of Groundnut Shell Ash for Stabilization of Ekiti State Soil, Nigeria.

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***Abstract*—Some laboratory tests (i.e. Particle Size Analysis, Atterberg limits, Compaction and California Bearing Ratio (CBR) tests) were conducted on Soil sample collected from Ido – Ekiti, Southwestern part of Nigeria stabilized with 2% to 10% (by proportion of soil) Groundnut Shell Ash (GSA) content. The results indicated that the soil is silt – clayey with high plasticity and it belongs to A – 7 – 6 soil group. It has general rating of fair to poor for subgrade materials. These properties however changed after stabilization as the soil's Maximum Dry Density (MDD) value decreases while Optimum Moisture Content (OMC) and CBR values increase with increase in the GSA content. It portrayed that the soil stabilization with GSA content brought about increase in the coarse particles of the soil through cementation. The mechanical strength of the soil also improved.**

Keywords—Groundnut Shell Ash (GSA); Atterberg limits; Optimum Moisture Content (OMC); Maximum Dry Density (MDD); California Bearing Ratio (CBR).

I. INTRODUCTION

Foundation is of utmost significant in any Civil Engineering construction. It must be firm enough to carry the whole structure. For any foundation to be able to perform its function effectively, the soil underneath and surrounding it must play essential role. Thus, there is need to acquire knowledge about the soils' properties and their behavioural factors. Expansive or problem soils (i.e. soils with poor properties) always make cost of Civil Engineering construction to be expensive. But to improve on the properties of the expansive soil (thus reduce cost of construction), soil stabilization process is best engaged. From time immemorial and presently, different methods of soil stabilization have always been utilized from ancient times till date and are very efficient, cost - effective and popular method for soil improvement in construction work ([3], [15]).

[13] expressed that "*the construction of highways are capital-intensive because of its materials demand. Due to the excessive cost of removing problem soils and its replacement, there is need to look for alternative means which involves stabilization of the problematic soil using locally available additives".* Many industrially manufactured additives such as cement, lime etc., agricultural and solid wastes (as locally available additives) such as palm kernel shell, groundnut shell, sawdust, locust beans etc have been used for soil stabilization and were found to be effective by past research works of ([3], [8], [9], [10], [11], [12], [13], [14], [15] and others.

The cost of construction of stabilized road using industrial additives is still high which is constantly discouraging the third world and destitute nations from providing necessary infrastructure (e.g. roads) for their people. Though, World Bank has been spending considerable capital on research work directed at tackling industrial waste products for more and better use ([9], [11], [13], [14]).

The use of locally available additives (like Groundnut Shell Ash – GSA) for soil stabilization helps environment in many ways such as proper disposal and management of wastes. As Waste improper disposal and management always lead to unfavourable consequences on environmental ecosystem which usually leads to diseases and epidemics spate. It also strengthens local industries growth ([9], [11], [13]).

Groundnut Shell is an agricultural waste acquired from groundnut milling with more than 20 million hectares of groundnut cultivated per year all over the world. Nigeria is one of its major producers. Groundnut Shell Ash (GSA) as shown in table 1 has pozzolanic material which makes it a better replacement of industrial additives in soil stabilization.

Table 1: Composition of Groundnut Shel Ash - GSA ([16]).

PARAMETERS	GSA SAMPLE (%)
SiO_2	26.96
Al_2O_3	5.82
Fe_2O_3	0.50
CaO	9.5
MgO	5.60
SO_3	1.86
K_2O	20.02
Na_2O	1.15
P_2O_5	2.0
MnO_2	0.32
TiO_2	0.69
LOI	22.00
TOTAL	97.47

In this study, potentials of using GSA for stabilization of the study area soil are investigated. This will help in having technical information / data concerning the Engineering properties of the study area soil. It will also help in assessment of GSA as better (or otherwise) locally available additive.

STUDY AREA - Ido - Ekiti is located in Ido/Osi Local Government Area of Ekiti State, Nigeria as shown in fig. 1. It is situated on Latitude 7^{O}45'23"N and Longitude 5^{O}15'27"E in the northern part of the state where the routes from Oyo, Osun and Kwara states respectively converge. Ido-Ekiti is the headquarters of Ido/Osi local council. It is bounded in the east by Ipere and Iludun, in the south by Igbole and Ifinsin axis and in the north and northwest by Usi and Ilogbo – Ekiti. It is in the tropical part of South-western, Nigeria ([1], [2]).

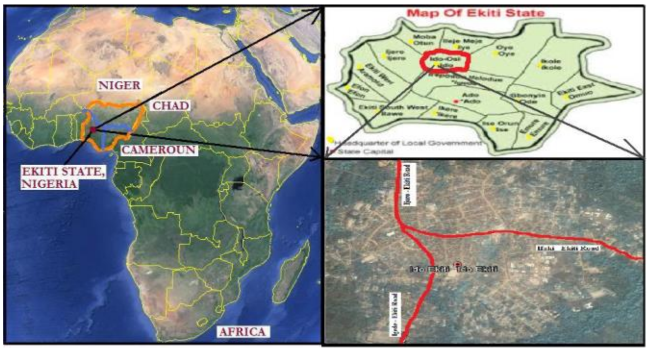

Fig. 1: Location of the Study area – Ido Ekiti [4]

II. MATERIALS AND METHODS

Groundnut Shell Ash (GSA) used is produced by subjecting some cleaned quantities of groundnut shells obtained from the study area to laboratory furnace at the Federal University of Technology, Akure, Nigeria. GSA passing through sieve no. 75μmm was used for this study.

Soil sample is collected from trial pit at a depth between 0.5m to 1.2m in the study area using method of disturbed sampling. After collection, soil sample was stored in polythene bags to prevent loss of moisture content. The sample was then taken to the laboratory where the deleterious materials such as roots were removed. The sample was air dried, broken down with mortar and pestle and passed through a set of sieve (i.e. from Sieve No. 10 (18.75mm) to Sieve No. 1 (0.075mm)) to remove large particles. Moulding of test specimens was started as soon as possible after completion of identification.

The GSA additive was mixed with the soil sample in the proportion of 0 – 10%. All tests were performed according to standard methods contained in [5]. Their properties were studied and determined to ensure that all relevant factors would be available for establishment of correlations among them. The tests carried out on the soil sample are Particle size distribution, Atterberg limits, Compaction and California Bearing Ratio (CBR). The results were compared to the standard specified values and grouped in accordance with [6] and [7].

PARTICLE SIZE DISTRIBUTION - This test is used in analyzing the particles, group the particles into different ranges of sizes and to ascertain the relative proportion by mass of the soil sample(s). The results of this test on the soil sample were classified according to AASHTO in [6].

ATTERBERG LIMITS - These tests (i.e. Liquid Limits (LL), Plastic Limit (PL) and Plasticity Index (PI)) were carried out on the soil sample(s) and help in assessing the samples natural reactions to water. The results were compared to the standard specified values in accordance with [6] and [7] as earlier stated.

COMPACTION - The importance of this test is to establish the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of the soil sample(s) ([6], [7]).

CALIFORNIA BEARING RATIO (CBR) - is a penetration test used in acquiring relative value(s) of shearing resistance of road pavement layers materials. It is a dimensionless index conducted in a standard laboratory or on the field during construction. It is commonly used method of soil evaluation for pavement design especially in tropical and subtropical countries ([6], [7]).

III. RESULTS AND DISCUSSION

Table 2 showed results of particle size distribution test for the natural soil sample and fig. 2 showed graph plotted from it.

Table 2: Summary of Particle Size distribution Test Results for the Natural Soil Sample

SIEVE SIZE(mm)	20	12.5	9.5	4.25	2.36	1.18	0.6	0.3	0.15	0.075
SOIL SAMPLE (%)	100	96.8	88.5	75.9	67.1	61.7	57.8	48.4	41.5	36.9
LOWER LIMIT(%)	100	87	80	65	50	36	26	18	13	7
UPPER LIMIT(%)	100	97	94	82	65	51	40	30	24	14

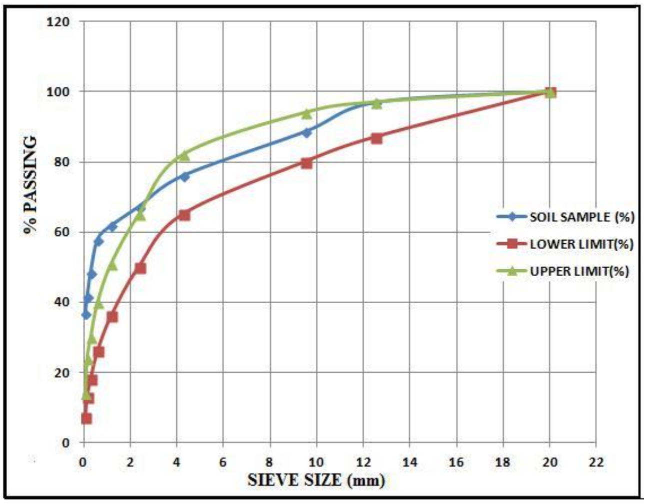

Fig. 2: Graph of the Particle Size distribution Test for the natural Soil Sample.

From Table 2 and Fig. 2, the results showed that the natural soil sample has very high percentages finer than 0.0075 fractions (i.e. >35%), which is average of 36.9%. The average percentages of sand and gravel were 30.2% and 21.4% respectively. These results imply that the soil has large clay contents.

Table 3 showed Geotechnical Index properties of the natural soil sample before stabilization process of the locally available additive (i.e. addition of GSA additive). With reference to Table 3 and [6], the natural soil sample could be generally classified as Silt – Clayey soil and fell under group classification of A - 7 - 6 with significant clayey material constituents, though there were presence of some sand and gravel materials constituents in the soil.

Table 3: Properties of the Natural Soil before Stabilization

CHARACTERISTICS	DESCRIPTION
Natural Moisture Content (%)	21.37
Specific Gravity	2.7
Colour	Reddish Brown
% Passing B.S. Sieve No. 1	36.9
Liquid Limit (%)	47.5
Plastic Limit (%)	27.4
Plasticity Index (%)	20.1
Group Index	2.7
AASHTO Classification	A-7-6
Max'm Dry Density (MDD - Kg/m^3)	1480
Optimum Moisture Content (OMC - %)	1.38
California Bearing Ratio (CBR - %)	6.0

Its general rating as sub-grade materials is fair to poor. They have significant constituent materials of mainly clayey soils. The soil also appeared to have low moisture content. It did not met the required specification for subgrade (i.e. LL ≤ 80%, PI ≤ 55% and MDD > 1760kg/m^3), base and subbase course materials (i.e. LL ≤ 35%, PI ≤ 12% and MDD > 2000kg/m^3). This portrayed that it fell below the required standard(s) recommended for most construction works, thus not suitable and requires stabilization.

Table 4: Summary of Compaction and CBR Tests Results for the Treated Soil Sample

GSA (%)	MDD (Kg/m3)	OMC (%)	CBR (%)
0	1480	1.38	6
2	1470	1.42	8
4	1460	1.43	16
6	1440	1.44	17
8	1430	1.45	14
10	1400	1.47	18

Table 4 showed results of Compaction and CBR tests for the treated soil sample (i.e. tests on variation of soil sample with additive (GSA) contents) and Figs. 3 - 5 showed graphs plotted from it.

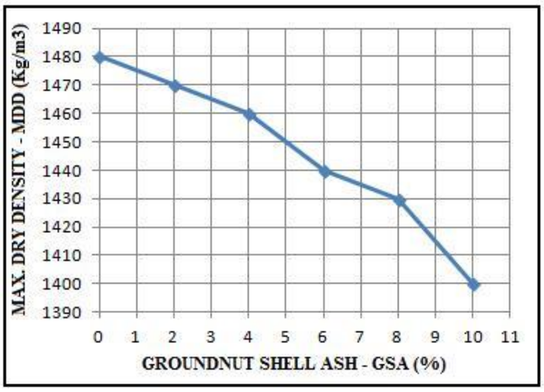

Fig. 3: Graph of the Maximum Dry Density (MDD) Test for the Treated Soil Sample.

From Fig. 3, it can be observed that the MDD value decreased with increase in the GSA content. This can be attributed to the replacement of soil by the GSA in the mixture which have relatively lower Specific Gravity of 2.4 compared to that of the soil which 2.7. It could also be attributed to coating of the soil by GSA which resulted in large particles with larger voids and density.

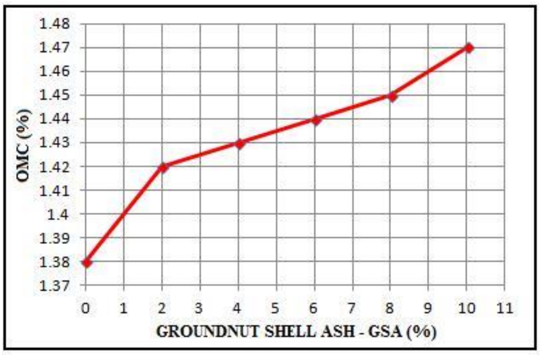

Fig. 4: Graph of the Optimum Moisture Content (OMC) Test for the Treated Soil Sample.

From Fig. 4, it can be observed that the OMC value increased with increase in the GSA content. This can be attributed to the addition of the additive (i.e. GSA) which decreased the quality of free silt, clay fraction and coarse materials with large surface areas formed. This also portrays that there is need for more water in order to compact the soil – GSA mixture.

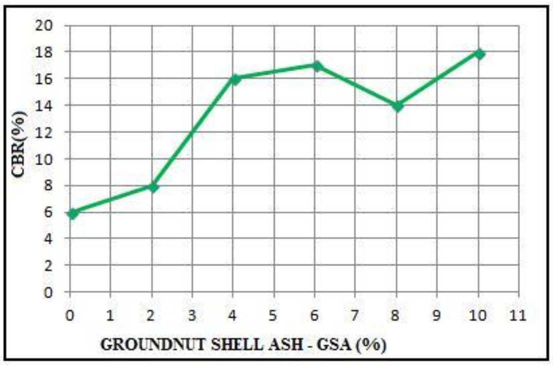

Fig. 5: Graph of the California Bearing Ratio (CBR) Test for the Treated Soil Sample.

From Fig. 5, it can be observed that the CBR (Unsoaked) value initially dropped with the addition of 2% GSA content, but the value later rise to almost its peak at 6% GSA content. However, it slightly dropped at 8% GSA content and rise up again to reach its peak at 10% GSA content. The initial decrease in the CBR value is due to the reduction in silt and clay content of the soil which reduced its cohesion. The increment in the CBR value after 2% GSA content could be attributed to gradual formation of cementitious compound between the GSA and Calcium Hydroxide ($Ca(OH)_2$) present in the soil. The gradual decrease in the CBR value after 6% GSA content could be due to excess GSA content that were not mobilized in the reaction, which consequently occupied spaces within the soil sample. Thus, reducing bonding in the soil – GSA mixtures.

IV. CONCLUSION

From the above results of this study, the following conclusions were drawn:

1. The soil is lateritic in nature identified by [6] to be A – 7 – 6 soil group. It is silt – clayey soil of high plasticity;
2. The treatment with the GSA content showed increase in the coarse particles of the soil through cementation;
3. There was also improvement in the mechanical strength of the soil as the CBR value (of 6% before treatment) increased to 18% after treatment.

It is therefore recommended that it should be employed with other additive like cement for the formation of secondary cementitious compounds which will be produced from the cement hydration. A further study should be engaged.

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