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Effects Of Locally Available Additives On Geotechnical Properties Of Ijero Local Government Soil, Ekiti State, Nigeria

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***Abstract*—This research work analyzed the effects of Palm Kernel Shell Ash (PKSA) and Sawdust Ash (SDA) additives on Geotechnical properties of Ekiti State soil and the study area is within Ijero Local Government Area. Four soil samples (i.e. A, B, C and D) were collected at some locations within the study area and subjected to the following geotechnical tests in the laboratory: Sieve analysis, Atterberg limits and Compaction. The additives were added to the soil samples at 0%, 2%, 4%, 6% and 8% proportions by soil weight. After the soil treatment (i.e. addition of additives to the soil samples), the LL, PI and MDD values increase as the quantities of additives increase some soil samples. This portrayed that the use of PKSA and SDA to stabilize the soil in the study area slightly improve it. The improvement would have been higher if not for the presence of high clay content in the study area. Thus this study proved that it is possible to use PKSA and SDA as cheap stabilizing agent. This will go a long way in reducing agricultural and industrial waste in the environment. However, in order to improve on the use of these additives, the additives should not be used for soil with extremely high content of clay, thus could be used for soil with very low content of clay. There is need for further study on these additives.**

Keywords*—Palm Kernel Shell Ash (PKSA);Saw dust Ash (SDA); Maximum Dry Density (MDD); Liquid Limit (LL); Plasticity Index (PI).

I. INTRODUCTION

It is hard to overlook the importance(s) of soil in construction of structures and other aspect of Civil Engineering practices. All structures are built on soil for stability. If there is any deficiencies in the properties of soil that makes it unfit for structure to be built on it, there is need to either excavate the soil or improve its Engineering performance for optimum use. The formal is expensive and requires the use of heavy equipment. The latter which is improvement of Engineering performance of soil could be done through the use of stabilizing agents / additives. The locally available additives such as PKSA and SDA can be used. The overall cost of improving soil properties with the use of conventional additives could be high and unaffordable but if locally available additives are found suitable for stabilizing soil, this will reduce the cost of improving the soil properties. These locally available additives could be agricultural wastes, industrial wastes, domestical wastes etc. Most of these wastes are hazardous to man and environment. Even burning them can deplete the ozone layer ([5],[6],[7],[8]).

However, if these waste products are well treated, used or modified, they become additives that may improve soil properties. These wastes include pulverized fuel ash, palm kernel shell ash (PKSA), saw dust ash (SDA), slag, rice husk, fly ash, coconut shell ash, maize cobs, reclaimed asphalt pavement etc (([5],[6],[7],[8]).

Thus, in this research work, the effects of locally available additives (i.e. PKSA and SDA) on geotechnical properties of Ijero Local Government Area (LGA) soil in Ekiti State, Nigeria would be analyzed. These additives are in large quantities and affordable in the study area. This study will also help in acquisition of Engineering information concerning Ijero LGA and Ekiti State soil as whole.

STUDY AREA - The study area is Ijero-Ekiti which is the headquarter of Ijero Local Government Area (LGA) of Ekiti State in Southwestern part of Nigeria. It is located in North Senatorial district of Ekiti State on Latitude 7.710 North and Longitude 5.300 East. It is mainly an upland zone of rhythmically undulated surface with elevation of 1,332meters above sea level. Ijero LGA has approximately 473.5km2 landed area. It is bounded by Moba LGA in the North, Ido – osi and Irepodun/Ifelodun LGAs in the East, Ekiti west LGA in the South and Ila-Oragun LGA (Osun State) in the West and Northwest as shown in Fig. 1. It is in the humid tropical part of South-western Nigeria ([9]).

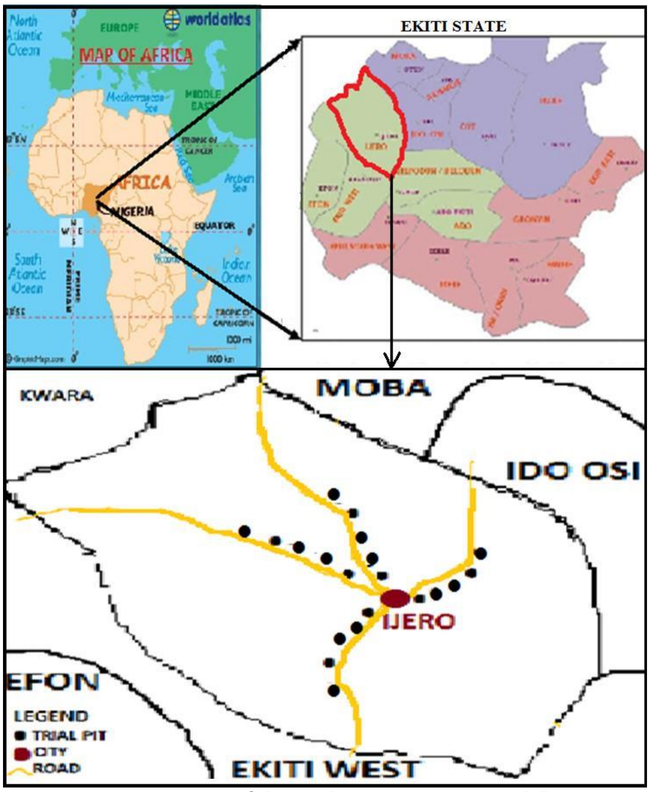

Fig. 1: Location of the Study Area - Ijero LGA ([2])

II. MATERIALS AND METHODS

Palm Kernel Shell Ashes (PKSA): Palm kernel shell is an industrial waste and of considerable availability in the Southwestern part of Nigeria. Some cleaned quantities of palm kernel shells were crushed and subjected to laboratory furnace to produce PKSA. It was eventually sieved with 75µmm sieve cell and the final product was used for this study.

Sawdust Ashes (SDA): Sawdust is also an industrial waste of agricultural products that are of considerable availability in the Southern part of Nigeria. Some cleaned quantities of sawdust were subjected to laboratory furnace to produce SDA. It was eventually sieved with 75µmm sieve cell and the final product was used for this study.

Soil Sample Collection and Analysis: Soil samples were collected from the study area at random from trial pits at average depth of 2m using disturbed sampling method. The details of the collected soil samples were shown in Table 1. The collected soil samples were stored in polythene bags to prevent moisture contents' losses. Then taken to the laboratory where detrimental materials were removed. This process is followed by air drying, pulverization and sieving of the soil samples in other to remove large particles. Sizes of sieve used for this purpose ranges between 9.55mm and 0.075mm. Testing of the soil samples commenced immediately after all the above processes.

The additives were mixed with the soil samples in the proportion of 0 to 8%. All tests were performed according to [4] standard methods. All the properties were studied and determined to ensure that all relevant parameters would be available for establishment of correlations among them. The tests carried out on each of the selected samples are Particle size distribution, Atterberg limits and Compaction. The results were grouped according to [1] and compared with [1] and [3] standard values.

Table 1: Details of collected Soil Samples

SAMPLE CODE	LOCATION	GEOG. COORDINATES	
		LATITUDE	LONGITUDE
ROUTE	IJERO - ARAMOKO ROAD	7.5772^{O}	5.0542^{O}
ROUTE	IJERO - ARAMOKO ROAD	7.5664^{O}	5.0677^{O}
ROUTE	IJERO - IDO OSI ROAD	7.57284^{O}	5.0883^{O}
ROUTE	IJERO - IDO OSI ROAD	7.56183^{O}	5.0888^{O}
ROUTE	IJERO - IKORO ROAD	7.47856^{O}	5.3214^{O}
ROUTE	IJERO - OKE ORO ROAD	7.48239^{O}	5.30253^{O}

Atterberg Limits: These tests are also called Consistency Tests and consist of Liquid Limits (LL), Plastic Limit (PL) and Plasticity Index (PI) which were carried out on both the treated and untreated soil samples. According to [8], the tests were used in assessing the natural reactions to water of the soil samples.

Compaction: This test has significant of ascertaining the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of soil samples. The test was carried out for both the untreated and treated soil samples.

Particle Size Distribution: This is used for analyses, grouping and establishment of soil samples' particles (i.e. clay, sand and gravel fraction), sizes and relative proportion by mass. The results of this test on the soil samples were classified according to [1].

III. RESULTS AND DISCUSSION

Table 2: Summary of the Particle Size Analysis Tests of Untreated Soil Samples

S / CODE	1	2	3	4	5	6
Sieve Size	% Wt Passing	% Wt Passing	% Wt Passing	% Wt	% Wt Passing	% Wt Passing
12.50	100.0	100.0	100.0	100.0	100.0	100.0
9.50	99.2	99.9	100.0	100.0	92.4	96.8
4.75	95.6	98.3	93.6	98.4	80.8	95.2
2.36	91.2	96.7	80.0	88.4	67.6	91.6
1.18	86.4	93.5	62.0	61.2	56.8	84.0
0.60	81.2	90.3	50.4	44.0	49.6	74.4
0.30	77.2	88.3	43.2	35.2	42.0	64.4
0.15	76.8	88.2	38.0	30.0	34.4	52.4
0.075	76.4	88.1	36.4	27.6	31.2	48.8

The results derived for the untreated soil samples as shown in Table 2, portray that the soil samples had percentages finer passing through 0.075mm fractions varied between 27.6% and 88.1% - Soil samples 4 & 5 have their percentages finer passing through 0.075mm fractions less than 35% while that of remaining soil samples were greater than 35%. Thus, the untreated soil samples 4 & 5 could be generally classified as Granular soil materials while the untreated soil samples 1, 2, 3 & 6 could be generally classified as Silt – Clay soil materials.

Table 3: Summary of the Soil Classification of the Untreated Soil Samples according to AASHTO Classification

SAMPLE CODE	1	2	3	4	5	6	REQUIRED LIMITS
% GRAVEL	8.8	3.3	20.0	11.6	32.4	8.4	35.0 - 50.0
% SAND	14.8	8.6	43.6	60.8	36.4	42.8	43.0 - 51.0
% SILT-CLAY	76.4	88.1	36.4	27.6	31.2	48.8	7.0 - 14.0

From Table 3, the results portray that the all untreated soil samples were not having enough gravel material constituents when compared with the required limits. Untreated soil samples 1, 2, 5 and 6 were not also having enough sand material constituents, while untreated soil sample 4 were having more sand material constituents when compared with the required limits. The results also showed that silt – clay material constituents were very high for all the untreated soil samples.

Using [1] Classification system and the available data from Table 4, the untreated soil samples 1, 2 and 3 fell under group classification of A–4; untreated soil sample 4 fell under group classification of A – 2 – 4; untreated soil sample 5 fell under group classification of A – 2 – 6; while untreated soil sample 6 fell under group classification of A - 6.

Table 4: Summary of the Atterberg limits and Compaction Test Results of Untreated Soil Samples

SAMPLE CODE	COMPACTION TEST		ATTERBERG LIMITS		
	MDD(Kg/m^3)	OMC (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)
1	1575.0	14.3	22.9	16.6	6.3
2	1463.0	16.2	22.5	17.5	5.0
3	1689.0	12.5	22.5	13.0	9.5
4	1644.0	15.6	18.0	12.0	6.0
5	1519.0	13.6	22.0	8.4	13.6
6	1666.0	12.4	21.0	10.0	11.0

The untreated soil samples 1, 2 and 3 have significant constituent materials of mainly silty soil. Though from Table 3, it could be observed that untreated soil sample 3 has significant constituent materials of mainly silty, gravel and sand. The untreated soil samples 4 and 5 have significant constituent materials of mainly silty or clayey, gravel and sand. While untreated soil sample 6 has significant constituent materials of mainly clayey soil. Generally, betterment of the untreated soil samples could be arranged in ascending order of 4 > 5 > 3 > 1 > 2 > 6.

The general rating of the untreated soil samples 4 and 5 as sub-grade materials is excellent to good. Though that of untreated soil sample 4 (i.e. A – 2 – 4) is the best. While that of untreated soil sample 1, 2, 3 and 6 is fair to poor and untreated soil sample 6 is the worst. All the untreated soil samples met the required specifications for subgrade (i.e. LL ≤ 80%, PI ≤ 55%); while only untreated soil sample 4 met the required specifications for subbase and base (i.e. LL ≤ 35% and PI ≤ 12%) course materials in their liquid limits (LL) and plasticity indices (PI). All the untreated soil samples did not met the required specifications for the maximum dry density (i.e. MDD >1760Kg/m3 for Subgrade and MDD > 2000Kg/m3 for Subbase and Base).

Graphs were plotted from Table 5 for LL values against Additives contents (AC) for all the treated soil samples as shown in Fig. 2. It could be seen from the graphs that LL values increase as Additives contents increase. Though the LL increments were more pronounce in PKSA than SDA Additives. Maximum LL value has increased from 22.90% (untreated soil) to 42.01% (PKSA treated soil sample 2 @ 6% and 35.60% (SDA treated soil 6 @ 6%). This portrayed that the percentages of finer particles than 0.075mm of the soil samples have increased which make the soil less suitable. Though most of the soil samples still retained their group classifications.

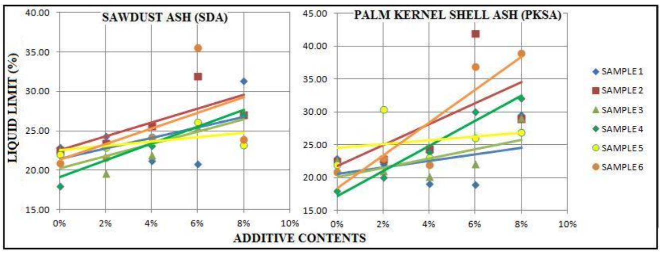

Fig. 2: Graphs of the Liquid Limits Tests for the Treated Soil Samples

Table 5: Summary of the Atterberg Limits and Compaction Test Results of Treated Soil Samples

SAMPLE CODE	ADDITIVE CONTENTS	SAW DUST ASH (SDA)					PALM KERNEL SHELL ASH (PKSA)				
		LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	MDD (Kg/m^3)	OMC (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	MDD (Kg/m^3)	OMC (%)
1	0%	22.90	16.60	6.30	1575.00	14.30	22.90	16.60	6.30	1575.00	14.30
	2%	24.35	18.40	3.70	1314.00	29.40	22.10	15.20	6.90	1620.00	14.22
	4%	21.20	15.00	4.10	1493.00	20.60	19.10	14.70	4.40	1452.00	24.00
	6%	20.80	14.20	4.70	1381.00	23.10	18.90	12.20	6.70	1405.00	21.00
	8%	31.30	14.20	15.30	1721.00	16.20	29.50	16.00	13.50	1473.00	15.40
2	0%	22.50	17.50	5.00	1463.00	16.20	22.50	17.50	5.00	1463.00	16.20
	2%	23.40	18.00	4.90	1459.00	23.40	22.90	12.10	10.80	1480.00	23.30
	4%	25.60	19.00	5.50	1460.00	23.30	24.50	20.50	4.00	1473.00	22.20
	6%	31.90	19.00	23.01	1391.00	22.20	42.01	16.40	25.61	1441.00	18.00
	8%	27.03	18.10	10.90	1417.00	20.00	29.00	18.10	10.90	1463.00	16.20
3	0%	22.50	13.00	9.50	1689.00	12.50	22.50	13.00	9.50	1689.00	12.50
	2%	19.60	11.00	10.00	1483.00	21.40	21.00	10.90	10.10	1441.00	18.00
	4%	21.90	16.00	4.10	1555.00	22.20	20.10	11.50	8.60	1440.00	25.00
	6%	25.40	15.00	7.10	1463.00	23.00	22.10	12.70	9.40	1475.00	22.00
	8%	27.30	15.00	14.10	1739.00	13.50	29.01	18.00	11.01	1537.00	17.10
4	0%	18.00	12.00	6.00	1644.00	15.60	18.00	12.00	6.00	1644.00	15.60
	2%	22.90	15.40	7.50	1459.00	23.10	20.10	10.90	9.20	1583.00	20.00
	4%	23.10	16.00	7.10	1483.00	21.40	24.00	15.30	8.70	1541.00	23.30
	6%	26.10	12.00	14.10	1536.00	17.20	30.10	18.40	11.70	1473.00	22.20
	8%	27.01	25.00	2.01	1488.00	21.00	32.10	15.00	17.10	1689.00	12.50
5	0%	22.00	8.40	13.60	1519.00	13.60	22.00	8.40	13.60	1519.00	13.60
	2%	22.90	15.40	7.50	1391.00	22.20	30.40	22.90	7.50	1393.00	22.00
	4%	24.20	16.00	7.10	1488.00	21.00	23.10	16.10	7.00	1440.00	25.00
	6%	26.10	12.00	14.10	1463.00	23.00	26.10	19.30	6.80	1508.00	19.40
	8%	23.20	20.10	6.91	1596.00	12.80	27.01	20.00	7.01	1541.00	23.30
6	0%	21.00	10.00	11.00	1666.00	12.40	21.00	10.00	11.00	1666.00	12.40
	2%	21.70	20.00	3.00	1417.00	20.00	23.00	8.40	14.60	1570.00	21.00
	4%	24.20	16.00	6.00	1532.00	24.00	22.00	10.20	11.80	1379.00	23.30
	6%	35.60	16.00	21.00	1360.00	25.00	37.00	14.20	22.80	1508.00	19.40
	8%	24.00	18.40	5.60	1393.00	22.00	39.00	15.00	24.00	1570.00	21.00

Graphs were plotted from Table 5 for PI values against Additives contents (AC) for all the treated soil samples as shown in Fig. 3. It could be seen from the graphs that PI values for all the soil samples (except soil sample 5) increase with increase in Additive contents. While PI values for soil sample 5 decrease with increase in Additive contents. Maximum PI value has increased from 16.60% (untreated soil) to 25.61% (PKSA treated soil sample 2 @ 6%) and 19.60% (SDA treated soil 6 @ 6%). This buttressed the observation for the LL values thus showed that the soil samples were tending towards less suitable soils.

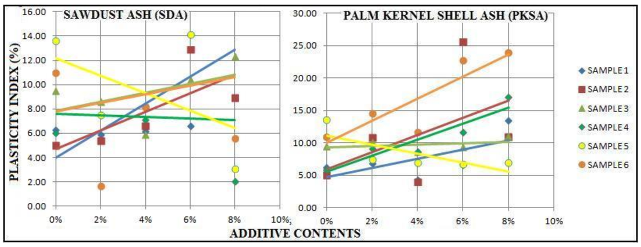

Fig. 3: Graphs of the Plasticity Index Tests for the Treated Soil Samples

Graphs were plotted from Table 5 for MDD values against Additives contents (AC) for all the treated soil samples as shown in Fig. 4. It could be seen from the graphs that MDD values for the soil samples 1, 3, 5 (SDA) and 5 (PKSA) increase as the Additives contents increase. While soil samples 2, 4, 6 (SDA) and 1, 2, 3, 4 and 6 (PKSA) decrease as the Additives contents increase. The increments as the additives increase were due to coatings of the soil samples particles by the Additives contents particles. Thus, made it denser. While the decrement as the additives increase portrayed the replacement of the soil samples particles by the Additive contents particles which could bring about the reduction in MDD.

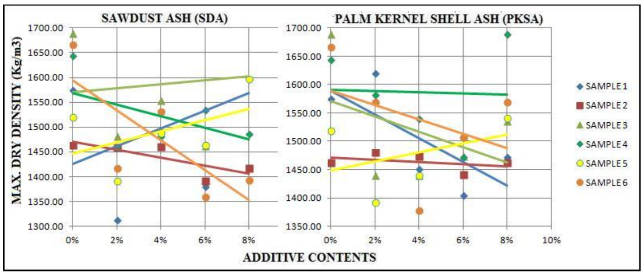

Fig. 4: Graphs of the Maximum Dry Density Tests for the Treated Soil Samples

IV. CONCLUSION

It is now of need to say that there is a way of using alternative materials (additives) which are locally available materials as stabilizing agent in order to reduce the cost of stabilizing soil to improve its Engineering performance in developing country like Nigeria. The use of PKSA and SDA to stabilize the soil in the study area slightly improve it. The improvement would have been higher if not for the presence of high clay content in the study area.

This study has depicted that it is possible to use PKSA and SDA as cheap stabilizing agent. This will go a long way in reducing agricultural and industrial waste in the environment. However, in order to improve on the use of these additives, the additives should not be used for soil with extremely high content of clay, thus could be used for soil with very low content of clay. There is need for further study on these additives.

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