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Potentials Of Palm Kernel Shell And Sawdust Ashes For Stabilization Of Gbonyin Local Government Area Soil, Nigeria.

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***Abstract*—this study is aimed at assessing the effects of some locally available additives (i.e. Sawdust Ash - SDA and Palm Kernel Shell Ash - PKSA) on geotechnical properties of Ekiti state soil and the Study area is within Gbonyin Local Government Area. Samples of soil were obtained from eight locations within the study area and carried to laboratory for some tests (i.e. Particle Size Analysis, Atterberg Limits and Compaction tests). The additives were added to the soil samples at 0%, 2%, 4%, 6% and 8% proportions. The untreated soils samples were generally rated as "excellent to good" sub-grade materials with significant constituent materials of silty or clayey gravel and sand. The results showed that Liquid Limit (LL), Plasticity Index (PI) and Optimum Moisture Contents (OMC) values increase with increase in additives contents. While the Maximum Dry Density (MDD) values decrease with increase in additives contents. It could be deduced that the general rating of the soil is tending towards "fair to poor" from "excellent to good". This portrayed that the percentages of finer particles of the soil have increased which make the soil less better. Initially, the soil samples did not met the specified requirements of MDD and so also after treatment with additives. Thus, the soil in the study area would not be suitable for construction purpose if stabilized with the locally available additives except there is means of compacting it very well. The soil only needs additive(s) that can improve its soil index properties more; especially the MDD values (increase) in order to make it suitable as subgrade, subbase and base course materials. Thus, earnest further study (ies) is needed on these findings.**

Keywords—Palm Kernel Shell Ash (PKSA);Saw dust Ash (SDA); Atterberg limits; Optimum Moisture Content (OMC); Maximum Dry Density (MDD); Liquid Limit (LL); Plasticity Index (PI).

I. INTRODUCTION

It is greatly significant to have reasonable costs of construction materials in providing fundamental feasible structures for the world populace especially that of underdeveloped and developing nations. The cost of construction materials continue skyrocketing with greater population becoming poorer in those nations especially Nigeria. This is so worrisome to the people of those nations and the whole world. This is due to the fact that most of these underdeveloped and developing nations are poor, agrarian and have a little above board standard of living. Nevertheless, it is necessary for those nations' people to have access to better infrastructure. In lieu of this fact, there is needed to make use of all available resources and wastes for the improvement of the standard of living of people in a country like Nigeria. This is due to the fact that all these resources and wastes are inexhaustible and lying fallow everywhere all over Nigeria ([7], [13], [17], [18], [19]).

Today, waste products are everywhere in the World and in large quantities, thus resulted in environmental hazard and problems of disposal. Through "Waste to Wealth policy" initiated in Nigeria, these waste products could be properly treated and used in improving or stabilizing soil with poor geotechnical properties especially expansive soils. Some of these wastes were locally available materials from agriculture and industries e.g. Saw Dust Ash (SDA), Palm Kernel Shell Ash (PKSA), rice husk, coconut shell ash, maize cobs, Cocoa Pod ash, Locust beans ash etc. They were usually products of milling stations, thermal power stations, waste treatment plants etc. ([7], [18], [19]).

The past studies carried out by [7], [8], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19] etc confirmed the possibilities of using the locally available materials as additives for improvement / stabilization of Geotechnical properties of different kinds of soil. This will help in proper disposal and management of wastes, thus, also reduces cost of construction of infrastructure. In this study, assessment of potentials of locally available additives (i.e. SawDust Ash - SDA and Palm Kernel Shell ash - PKSA) on Geotechnical properties of Ekiti State soil would be carried out. These additives are in large quantities in the study area and its environment. This piece of research work also will help in availability of technical information / data for Ekiti State soil, which will help in establishing their suitability for stabilization of soil purpose (s).

STUDY AREA - The study area as shown in Fig.1 was carved out from Ekiti East Local Government Area (LGA) on 1st of October, 1996 to be one of the sixteen local governments in Ekiti state, South-western part of Nigeria on its creation and its headquarter council secretariat cited at the eastern part of Ode Ekiti via Egbe-Isinbode road. The Local Government Council Area which was located in the North Eastern part of Ekiti State has a landed area of 378 square kilometer. It is located on Latitude 7.6^0 North and Longitude 5.5^0 East. The LGA is made up of eight major towns and several villages. The LGA shared territorial boundaries with seven LGAs viz; Ise/Emure, Ekiti East, Ikole, Irepodun/Ifelodun and Ado Ekiti in Ekiti State, and Akoko-North/West of Ondo State. The points of attraction in the area of study are Oloke rock at Ode, Apariko dam at Aisegba and others [1].

From geological view, Ekiti State is underlain by metamorphic rocks of the Precambrian basement complex of Southwestern part of Nigeria, the great majority of which are very ancient in age. These basement complex rocks show great variations in grain size and in mineral composition. The rocks are quartz gneisses and schists consisting essentially of quartz with small amounts of white mizageous minerals.

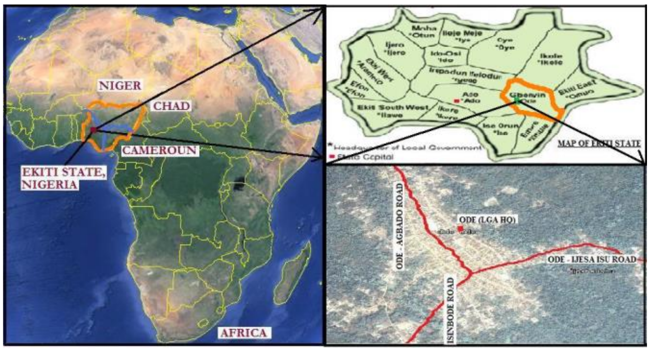

Fig. 1: Location of the Study area – Gbonyin LGA [3]

The rocks vary from very coarse-grained pegmatite to medium-grained gneisses in grain size and structure. The rocks are strongly foliated and occur as outcrops. The soils derived from the basement complex rock are mostly well drained, having medium to coarse in texture. The geological nature of the study area and its increased urbanisation make it more vulnerable and of public health concern when it comes to water quality ([4], [5]).

II. MATERIALS AND METHODS

Palm kernel shell ash (PKSA) is a by-product of the combustion of palm kernel shells under a controlled temperature of between 600 and 800oC. Utilization of PKSA is minimal and unmanageable while its quantity increases annually and most of the PKSA are disposed as waste in landfills causing environmental problems. Palm kernel shell is an industrial waste and it is available in large quantities especially in palm oil producing area of the southern part of Nigeria. Palm kernel shells have very low ash (about 3% weight) and sulphur (about 0.09% weight) contents. The PKSA is produced by subjecting some washed quantities of palm kernel shells obtained from the study area to furnace temperature of about 900 – 1000^OC at laboratory of the Federal University of Technology, Akure, Nigeria. PKSA passing through sieve cell of 75μmm was used for this study [19].

Sawdust is an organic waste resulting from the mechanical milling or processing of timber (wood) into various standard shapes and useable sizes. The dust is usually used as domestic fuel. The resulting ash known as saw-dust ash (SDA) is a form of pozzolana. Clean Sawdust without a large amount of bark has proved to be satisfactory. This does not introduce a high content of organic material that may upset the reactions of hydration. The SDA is produced by subjecting some cleaned quantities of sawdust obtained from a saw mill at Oke-Ureje in Ado Ekiti to laboratory furnace at the Federal University of Technology, Akure, Nigeria. SDA passing through sieve cell of 75μmm was used for this study [19].

Soil samples were collected at random from trial pits (depth between 1m to 2m) in the Study area as shown in table 1 using method of disturbed sampling. After collection, soil samples were stored in polythene bags to prevent loss of moisture contents. The samples were then taken to the laboratory where the deleterious materials such as roots were removed. The samples were air dried, pulverized 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.

Table 1: Details of the location of the Soil Samples taken

LOCATION	SAMPLE CODE	CHAINAGES	COORDINATES
ODE - AGBADO ROAD	1	2+500	Lat. 7.59602^0N, Long. 5.48541^0E
	2	3+000	Lat. 7.59613^0N Long. 5.48757^0E
ODE - IJESA ISU ROAD	3	2+000	Lat. 7.64359^0N, Long. 5.54986^0E
	4	3+000	Lat. 7.80363^0N, Long. 5.53589^0E
	5	3+500	Lat. 7.64458^0N, Long. 5.55486^0E
ODE - ISINBODE ROAD	6	3+500	Lat. 7.64354^0N, Long. 5.55012^0E
	7	4+000	Lat. 7.65485^0N, Long. 5.56981^0E
	8	4+500	Lat. 7.80381^0N, Long. 5.54104^0E

The additives were mixed with the soil samples in the proportion of 0 – 8%. All tests were performed according to standard methods contained in [9]. 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 each of the selected samples are Particle size distribution, Atterberg limits and Compaction. The results were compared to the standard specified values and grouped in accordance with [2] and [6].

PARTICLE SIZE DISTRIBUTION - The samples were washed with 0.075mm sieve and particle size distribution test were performed on the remaining dry samples that retained in the sieve after washing. This test is used in analyzing the particles (i.e. clay, sand and gravel fraction), group the particles into different ranges of sizes and to ascertain the relative proportion by mass of the untreated soil samples. The results of this test on the soil samples were classified according to [2] classification system.

ATTERBERG LIMITS - These tests (i.e. Liquid Limits (LL), Plastic Limit (PL) and Plasticity Index (PI)) were carried out on both the treated and untreated soil samples and help in assessing the samples spontaneous reactions to water. The results were compared to the standard specified values in accordance with [2] and [6].

COMPACTION - The standard proctor (BSL) type of compaction test was performed on the samples at treated and untreated state. The essence of this test is to ascertain the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of the treated and untreated soil samples.

III. RESULTS AND DISCUSSION

Table 2 showed results of particle size distribution test for the untreated soil samples. It showed that the untreated soil samples have less percentages finer than 0.0075 fractions (i.e. <35%), which varied between 20.4% and 32.4%. The average percentages of sand and gravel were 30.9% and 39.4% respectively. These results implied that the soil has large content of granular materials.

Table 2: Summary of Particle Size distribution Test Results for the Untreated Soil Samples

SAMPLE CODE	1	2	3	4	5	6	7	8
SIEVE SIZE (mm)	% PASSING	% PASSING	% PASSING	% PASSING	% PASSING	% PASSING	% PASSING	% PASSING
9.5	98	98.8	98.4	98.6	97.6	97.2	98	97.8
4.75	69.2	82.4	79.4	74	76	78	81.6	72.6
2.36	51.2	59.6	62.2	55.6	58.2	60	61.6	54.2
1.18	42	48	49	45.4	48.6	49.6	52.4	42.6
0.6	35.6	41.6	42.2	38.2	41.4	42.8	46	36.2
0.3	28.8	36	34.4	32.6	35	36.8	40.4	30.2
0.15	23.6	32	30	27.8	30.6	32.8	35.6	25.8
0.075	20.4	30	26.4	24.2	28.2	30	32.4	23.8

Table 3 showed Geotechnical Index properties of the untreated soil samples before stabilization process of the locally available additives (i.e. addition of PKSA and SDA additives). With reference to Table 3 and [6], the untreated soil samples could be generally classified as granular soils and fell under group classification of A - 2 - 4.

Table 3: Properties of the Natural Soil before Stabilization

SAMPLE CODE	ATTERBERG LIMITS			MDD (g/cm^3)	OMC (%)
	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)		
1	16.6	22.9	6.3	1.58	14.3
2	17.5	22.5	5	1.68	13.3
3	22	22.5	0.5	1.46	16.2
4	14	18	4	1.72	16.2
5	18.4	22	3.6	1.69	12.5
6	20	21	1	1.74	13.5
7	14	18	4	1.64	15.6
8	17	23.5	6.5	1.6	12.8

Its general rating as sub-grade materials is excellent to good. They have significant constituent materials of silty or clayey gravel and sand. These soil samples met the required specifications for subgrade (i.e. LL ≤ 80%, PI ≤ 55%), subbase and base (i.e. LL ≤ 35% and PI ≤ 12%) course materials in its liquid limits and plasticity indices, but fail to meet up the requirements for the maximum dry density (i.e. MDD <1.760g/cm3 and MDD > 2.0g/cm3). Table 3 also showed that OMC values varied between 12.50% and 16.20%. This portrayed that the moisture content in the study area is very high compared to specified values in accordance with [2] and [9].

Table 4 showed results of Atterberg Limits and Compaction tests for the treated soil samples (i.e. tests on variation of soil samples with additives (PKSA and SDA) contents).

Table 4: Summary of the Tests Results for the Treated Soil Samples

SAMPLE CODE	ADDITIVE CONTENT	PALM KERNEL SHELL ASH (PKSA)					SAW DUST ASH (SDA)				
		PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	MDD (g/cm^3)	OMC (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	MDD (g/cm^3)	OMC (%)
1	0%	16.6	22.9	6.3	1.58	14.3	16.6	22.9	6.3	1.58	14.3
	2%	15.2	23	7.8	1.62	14.2	18.4	22.1	3.7	1.49	14
	4%	14.7	16.1	1.4	1.45	24	15	19.1	4.1	1.48	23.3
	6%	17.2	22.7	5.5	1.41	21	14.2	18.9	4.7	1.47	22.2
	8%	16	24.5	8.5	1.47	15.4	14.2	29.5	15.3	1.44	18
2	0%	17.5	22.5	5	1.68	13.3	17.5	22.5	5	1.68	13.3
	2%	12.1	20.5	8.4	1.46	23.4	18	22.9	4.9	1.48	14.8
	4%	20.5	22.2	1.7	1.46	23.3	19	24.5	5.5	1.31	29.4
	6%	16.4	28	11.6	1.39	22.2	19	42.1	23.1	1.49	20.6
	8%	18.1	26.3	8.2	1.42	20	18.1	29	10.9	1.38	23.1
3	0%	22	22.5	0.5	1.46	16.2	22	22.5	0.5	1.46	16.2
	2%	20.9	24.7	3.8	1.44	18	20.9	21	0.1	1.44	25
	4%	11.5	22.6	11.1	1.49	21	11.5	20.1	8.6	1.58	20
	6%	12.7	22.1	9.4	1.48	22	12.7	22.1	7.1	1.54	23.3
	8%	18	27.2	9.2	1.54	17.1	18	29.1	11.1	1.48	21.9
4	0%	14	18	4	1.72	16.2	14	18	4	1.72	16.2
	2%	10.9	25.2	14.3	1.38	23.1	20.1	24	3.9	1.53	17.9
	4%	15.3	25.3	10	1.48	21.4	21	24	3	1.48	21.4
	6%	18.4	24	5.6	1.54	17.2	16	30.1	14.1	1.56	22.2
	8%	15	28.4	13.4	1.49	21	18	32	14	1.49	21
5	0%	18.4	22	3.6	1.69	12.5	18.4	22	3.6	1.69	12.5
	2%	30.4	31.8	1.4	1.39	22	15.4	22.9	7.5	1.63	16.7
	4%	21.1	25	3.9	1.44	25	16	23.1	7.1	1.49	20.7
	6%	24.3	25.3	1	1.51	19.4	12	26.1	14.1	1.5	20
	8%	25	26.1	1.1	1.54	23.3	25	27.1	2.1	1.47	22.2
6	0%	20	21	1	1.74	13.5	20	21	1	1.74	13.5
	2%	17.6	19.2	1.6	1.49	21	19.5	20.1	0.6	1.52	18.2
	4%	18.1	21.1	3	1.48	21.4	17	20.5	3.5	1.39	22.2
	6%	21.8	26.3	4.5	1.51	19	15	31.1	16.1	1.49	21
	8%	18	27.2	9.2	1.56	22.2	18	37.1	19.1	1.46	23
7	0%	14	18	4	1.64	15.6	14	18	4	1.64	15.6
	2%	8.4	22.2	13.8	1.57	21	20	23	3	1.33	20.1
	4%	22.2	24.2	2	1.38	23.3	16	22	6	1.47	15.4
	6%	14.2	28	13.8	1.5	20	16	37	21	1.57	21.4
	8%	15	25.2	10.2	1.57	21	18.4	22.1	3.7	1.39	22
8	0%	17	23.5	6.5	1.6	12.8	17	23.5	6.5	1.6	12.8
	2%	21.1	24	2.9	1.55	23	18	19	1	1.43	19
	4%	21.3	22.5	1.2	1.31	29.4	18	20.9	2.9	1.42	20
	6%	16	24.6	8.6	1.48	21.4	16	40.9	24.9	1.53	24
	8%	12	27.2	15.2	1.48	21.4	21	25	4	1.36	25

From Table 4, graph is plotted for LL values against Additives Contents (AC) as shown in Fig. 2. It can be deduced from Fig. 2 that LL values increase as

Additives Contents increase (i.e. SDA and PKSA) though very slight in some soil samples where it seems the influences of the additives were not so felt. Maximum LL value has increased from 23.5% (untreated soil) to 31.8% (PKSA treated soil) and 40.9% (SDA treated soil). This portrayed that the percentages of finer particles than 0.075mm of the soil samples have increased which make the soil less better.

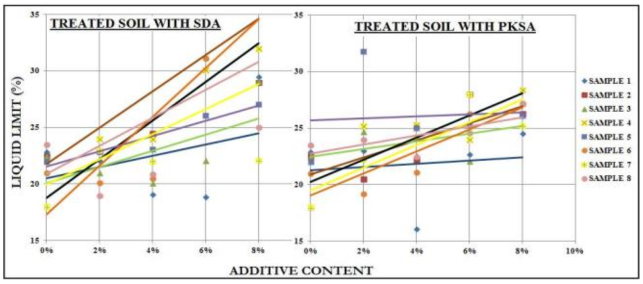

Fig. 2: Graphs of the Liquid Limits Tests for the Treated Soil Samples

From Table 4, graph is plotted for PI values against Additives Contents (AC) as shown in Fig. 3. It can be deduced from Fig. 3 that PI also increase as Additives Contents increase (i.e. SDA and PKSA) with exception of soil sample 5. Maximum PI value has increased from 6.5% (untreated soil) to 15.2% (PKSA treated soil) and 24.9% (SDA treated soil). This portrayed that the cohesive qualities of the binder resulting from the clay or fine contents have increased.

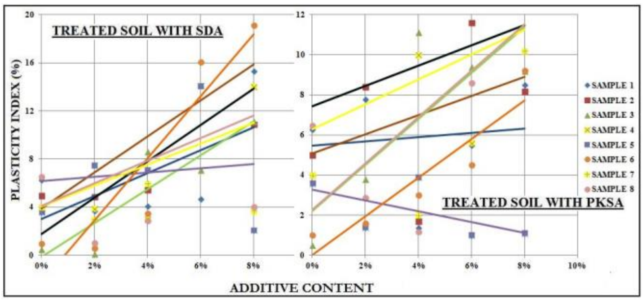

Fig. 3: Graphs of the Plasticity Index Tests for the Treated Soil Samples

From Table 4, graph is plotted for MDD values against Additives Contents (AC) as shown in Fig. 4. It can be deduced from Fig. 4 that MDD decrease as Additives Contents increase (i.e. SDA and PKSA) with exception of soil sample 3. This is due to replacement of soil fine particles by Additives fine particles which are of lower Specific Gravities. It could also be due to soil coating by the additives.

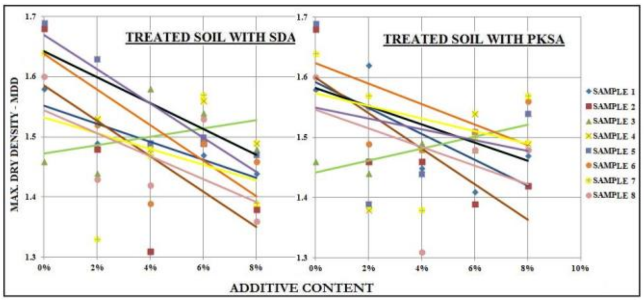

Fig. 4: Graphs of the Maximum Dry Density Tests for the Treated Soil Samples

From Table 4, graph is plotted for OMC values against Additives Contents (AC) as shown in Fig. 5. It can be deduced from Fig. 5 that OMC value increase as Additives Contents increase (i.e. SDA and PKSA). This is due to addition of the additives contents which decreased the quality and quantity of clay and coarse materials with formation of large surface areas. It also showed that OMC values for the treated soil samples varied between 12.5% and 29.4%. This portrayed that the moisture content remains very high compared to specified values in accordance with [9] and increase when compared with that of untreated soil samples. This also portrays that there is need for more water in order to compact the soil – Additives mixture.

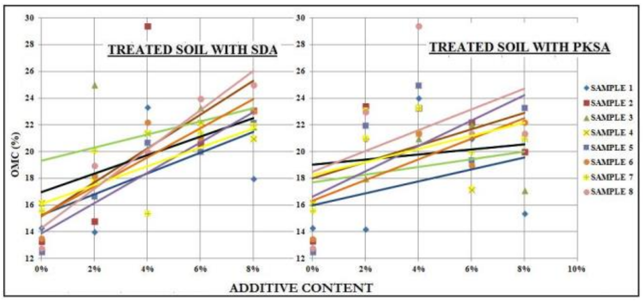

Figure 5: Graphs of the Optimum Moisture Contents Tests for the Treated Soil Samples

IV. CONCLUSION

Generally from the Atterberg limits values which their maximum values had increased (i.e. from 23.5% to 31.8% and 40.9% for LL; from 6.5% to 15.2% and 24.9% for PI), it could be deduced that the general rating of the soil is tending towards “fair to poor” from “excellent to good”. This portrayed that the percentages of finer particles of the soil have increased which make the soil less better. Initially, the soil samples did not met the specified requirements of MDD and so also after treatment with additives. Thus, the soil in the study area would not be suitable for construction purpose if stabilized with the locally available additives except there is means of compacting it very well. The soil only needs additive(s) that can improve its soil index properties more; especially the MDD values in order to make it suitable as subgrade, subbase and base course materials. Thus, earnest further studies are recommended on these findings.

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