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Engineering Properties of Sawdust Modified Clay Soil

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ABSTRACT

Clay is a raw material that has many uses across the different industries around the world. The principal use of clay in some part of Nigeria are: pots making, ornamental decoration and ceramics etc. The study examine engineering properties of sawdust modified clay soil and to determine thegeotechnical properties of these materials be established to define the suitability of sawdust modified clay soil for engineeringpurposes. Test such as: porosity, permeability, atterberg limit, cold compressive strength, impact strength, unconfined compressive strength and absorption test. The clay samples were collected from Ondo state, Niger state, Ekiti state and Lagosstate respectively in Nigeria. It was cleaned, soaked, dried, crushed and sieved then moulded to some definite shapes such as cylindrical and rectangular shape depending on the type of test carried out on the various clay samples. 0%, 45%, 50% and 60%percentages of sawdust were varied with the clay sample and moulded.. Results obtained shows that natural water content are fairly okay which varied between2.34% and 3.5% . The atterbag limit classified soil as MH, ML,CL and ML for for all the location respectively according [21]. The permeability test shows that all the sample are within the range of semi pervious clay material according to USBR specification. The effect of sawdust on the clay materials as shown in figure 1,2 and 3 shows that the modified clay has a lower strength, a higher water absorption and a higher porosity as the sawdust content in the clay sample increases and vice versa, this is due to effect of pores created by sawdust. Results obtained show that Lagos has the highest water retention potential compare to other locationand has the lowest rate of water absorption, highest resistance to shattering which make the sample the strongest in term of compressive strength and also very suitable as a filter media for industrial application.

Key words: *porosity, permeability, compressive strength, impact test, water absorption test*

INTRODUCTION

Clay is a soil separate with a particle diameter of [21]. Apart from petroleum, gas and coal resources, the exploration, mining and exploitation of Nigeria mineral resources have not received sufficient attention[1]. Delving into geological survey of Nigeria soil, it was reported that clay as one of the major Nigeria minerals deposits cover an estimated proven reserves of billions of tones, and these days mineral are discovered all over the states in the country[16].

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Clay a fine textured earth that is plastic when wet but hard and compact when dry or a term used to refer to the finest grain particles in a sediment, soil, or rock[12]. Clay is a very fine grained, unconsolidated rock matter, which is plastic when wet, but becomes hard and stony when heated. It has its origin in natural processes, mostly complex weathering, transported and deposited by sedimentation within geological periods. Clay is composed of silica (SiO_2), Alumina (Al_2O_3) and water (H_2O) plus appreciable concentration of oxides of iron, alkali and alkaline earth, and contains groups of crystalline substances known as clay minerals such as quartz, feldspar and mica[8]. Clay minerals are the most important industrial minerals. Millions often are utilized yearly in various applications. These applications include uses in geology, the process industries, agriculture, environmental remediation and construction[7]. The reason for utilization of certain clay minerals in specific application is that the physical and chemical properties of a particularclay mineral are dependent on its structure and composition. The structure and composition of kaolins, smectites,and palygorskite and sepiolite are very different even though they each have octahedral and tetrahedral sheets as their basic building blocks. However, the arrangement and composition of these octahedral and tetrahedral sheets account for major and minor differences in the physical and chemical properties of kaolin, smectites and palygorskit[14]. Clays have received considerable attention especially as potential adsorbents for environmental research. Many researchers around the world, have beamed their search lights on the phase developments that occurred by sintering clay in the presence of some oxides[4,13,19]. Deposits of clay raw material are widely distributed in Nigeria[3,9,10,11,17,18,19]. In order to determine the profitability of utilizing clay from a particular deposit for any application, it is of paramount importance to examine the microstructural morphology, determine the mineralogical composition and analyse the various available phases in such clay deposit. Nigeria has appreciable distribution of industries engage in metal and process industries hence the need for raw materials to support their growth. Clay products such as ceramics wares, bricks, and roofing and floor tiles are cheaper and durable building materials than cement especially under tropical conditions[15]. A lot of project research has been carried out about the conversion of clays for industrial uses. The percentage of minerals oxide (Fe_2O_3, MgO, CaO, Na_2O.) in the clay ultimately determines the area of application of the clay such as in bricks, floor, tiles, paper, while the quantity of the alkali metal oxides (Na_2O, K_2O, CaO) indicates their suitability for making ceramic product and other refractory materials[5]. The present economic state imposes the need for internal sourcing of raw materials to meet up increasing demands[6]. The objective of this study is to investigate theengineering properties of sawdust modified clay soil.

MATERIAL AND METHOD

The clay soil used in this investigation were collected from the following four state in Nigeria.(Ekiti:Ijero,Lagos,Ondo:Akure and Niger:Minna) with the use of Digger and shovel and polytene bag and was transported to the federal polytechnic Ado Ekiti Civil Engineering Geotechnic Laboratory for analysis.

EXPERIMENTAL PROCEDURE

NATURAL MOISTURE CONTENT

About 20 grams of the wet soil was put into aluminum drying container whose weight is known. The weight of the soil plus the container was then determined. The container was placed in a drying oven with its lid removed and placed under it. The soil was then dried in the oven for a period of 18 hours at a temperature of 100^0c.

COLOUR

The clay soils color were determined by visual inspection method

ATTERBERG LIMITS TEST

This is performed to determine the plastic limit (PL) and liquid limit (LL) of the clay soils[5]. The Atterberg limits are a basic measure of the critical water contents of a fine-grained soil, such as its shrinkage limit, plastic limit, and liquid limit. As a dry, clayey soil takes on increasing amounts of water, it undergoes dramatic and distinct changes in behaviour and consistency.(Wikipedia).

LIQUID LIMIT

200g oven dried sample of the soil passing the 425 mm sieve was mixed with water on a glass plate in order to property saturate it and was covered for about 24 hours. At the end of the period, the sample was properly remixed using spatulas. The cone penetrometer was properly adjusted in position in readiness for the test. The sample cup was filled with the mixed sample and the initial reading was observed. It was allowed to penetrate into the sample for five seconds and the final reading was equally noted. Some quantity of soil was then taken from the cup for moisture content determination. The soil in the cup was returned to the glass plate. The water content determination. The soil in the cup was returned to the glass plate. The water content was slightly increased and the soil was properly re-mixed, the cup was properly cleaned. The whole process was repeated five times.

PLASTIC LIMIT (PL)

This is the moisture content limit after which the soil transforms into a malleable, plastic mass. From the same soil sample, threads of about 3mm diameter were obtained by kneading and rolling and the moisture content determined.

LINEAR SHRINKAGE

Linear shrinkage (LS) is defined as the change in length divided by the initial length when the water is reduced to the shrinkage linit.it is expressed as percentage ,and reported to the nearest whole number.

Thus $$LS = \frac{\text{Initial length-final length}}{\text{Initial length}} \times 100$$

The linear shrinkage can be determined in a laboratory (IS:270-XX).A soil about 150 gm in mass and passing through a 425 q sieve is taken in a dish. It is mixed with distilled water to form a smooth paste at a water content greater than the liquid limit. The sample is placed in a brass mould, 140 mm long and with a semi-circular section of 25 mm diameter. The sample is allowed to dry slowly first and then in an oven. The sample is cooled and its final length measured. The linear shrinkage is calculated using the following equation.

$$LS = 1- \frac{\text{length of oven-dry sample}}{\text{Initial lenth of specimen}} \times 100$$

FALLING HEAD PERMEABILITY TEST

For falling (variable) head permeability test: $K = \frac{2.3aLlog}{A.t} \frac{(h_1)}{(h_2)}$

Where,k= Coefficient of permeability at T℃ (cm/sec),n Q= Quantity of water collected (cm^3) in time t (second), L= Length of soil specimen (cm), H= Constant hydraulic head (cm), A= Cross-Sectional area of stand pipe (cm^2), a= Cross-Sectional area of the soil specimen (cm^2), t = ($t_1 t_2$) Time interval (sec.) for the head to fall from h_1 to h_2, H_1 = Initial head of water at time t_1 in the pipe above the outlet (cm), H_2 =Final head of water at time t_2 in the pipe above the outlet (cm)

WATER ABSORPTION

The test was carried out using the flat bar samples of both pure and blended clay. The bars were first weighed using an electronic weighing balance, soaked in a bowl of water for 24 hours(ASTM C373 - 14a). Each was then removed from water, allowed to drip and the remaining was gently wiped to ensure that no water was attached to the surface and was re-weighed again. The difference in weight was then used in computing the percentage water absorption applying the formula below:

$$\%\ \text{Water Absorption} = \frac{soakedweight-dryweight}{dryweight} \times 100\% \ldots\ldots\ldots\ldots\ldots\ldots$$

IMPACT TEST

Procedure: The fired sample was weighed using a beam balance, and then allowed to drop from a height of about 1m. The shattered pieces are then picked up and the largest piece is weighed to determine the shattered (final) weight. Impact = $\frac{W_i - W_f}{W_i}$ x 100%

W_i = initial weight ,W_f = final weightds

COMPRESSIVE STRENGTH

The clay samples were placed in a sample mould and rammed with Paul Weber hydraulic press of capacity 350 KN. The rammed samples which measured 9.8 x 9.8 x 9.8 cm each and cubical in shape were then removed from the mould and fired to 1,200^{o}C. They were allowed to cool in air before the test was carried out on an *x* test Seidner mechanical strength-testing machine. The actual cold compression strength (*CCS*) was calculated using Eq. (4) (Ryan 1978): *CCS* = Crushing Force (KN)/Surface Area(m^2).

POROSITY

A known volume (Vk) of a measuring cylinder was set up as VK and another new volume (Vn) was determined by inserting the prepared clay sample into the cylinder as VN ,the set up was then left for about three hours. Then thefinal volume was determined as VF. POROSITY=(VK-VF)/VK*100

RESULTS AND ANALYSIS

Table 1. Showing the properties of the natural state of soil samples without modification with saw dust

Locations	Colours of Clay Samples	Natural Moisture Content	Atterbag Limits				Permeability (K) m/sec	Impact test (%)	Compressive strength (mpa)	USCS classification
			LL%	PL%	PI%	LS%				
Ekiti	Burnt umber brown	2.34	58.5	41.2	17.3	29	$2.05*10^{-4}$	0.39	13.5	MH
Lagos	Rust brown	3.5	54	44.1	9.9	33	$2.002*10^{-4}$	0.33	14.5	ML
Niger	Ecro brown	2.59	42.5	28.5	14	21	$2.057*10^{-4}$	0.42	6.5	CL
Ondo	Sandy brown	3.0	64	41.2	22.8	28	$1.86*10^{-4}$	0.56	4.4	MH

Table 2. Showing the properties of the modified clay soil saw dust

Location/ % of Mix		Ekiti State			Lagos State				Niger State				Ondo State			
	Control	40/60	50/50	55/45	Control	40/60	50/50	55/45	Control	40/60	50/50	55/45	Control	40/60	50/50	55/45
Porosity %	4.0	5.2	4.7	4.0	1.5	2.0	1.9	1.7	6.0	5.8	5.4	4.9	10	11.6	10.9	10.3
Water Absoption %	35	98	75	55	15	58	45	36	22.4	64	62	54	41	98	74	69
Compressive Strength (mpa)	14.12	8.21	4.17	6.65	14.66	3.99	5.49	7.49	14.50	3.23	8.60	11.12	12.26	2.19	4.85	6.53

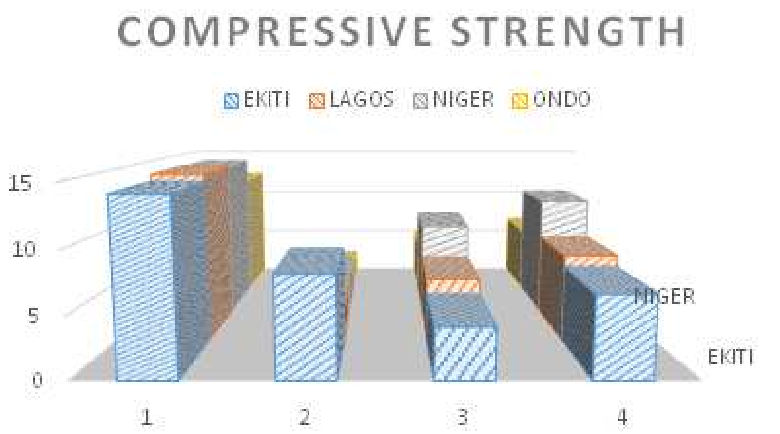

Figure 1.0 showing the result of compressive strength

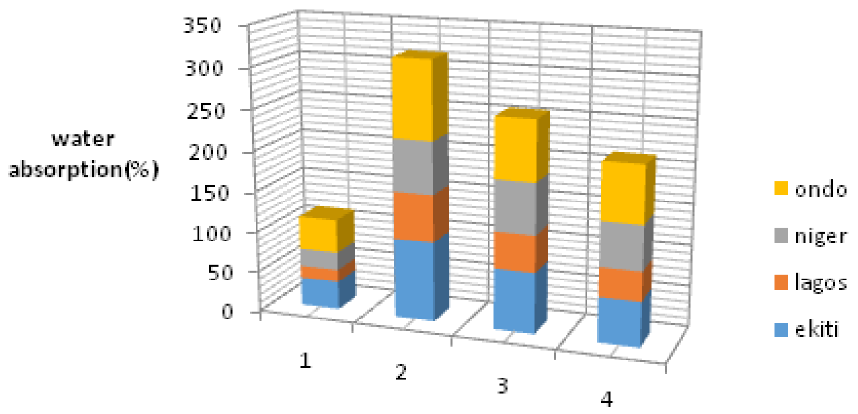

figure 2.0 showing the graph bof water absorption against mix desigm for all location

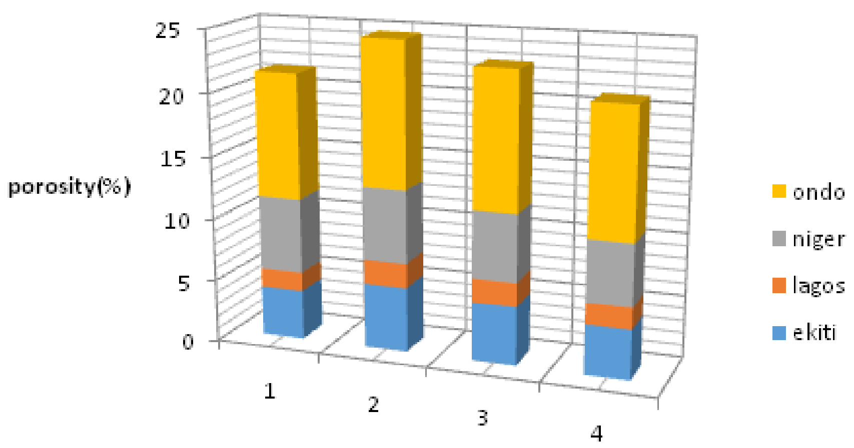

figure 3.0 showing porosity against mix design for all location

SOIL CLASSIFICATION

The Clay soils are classified as MH, ML, CL and MH for all the location respectively according to unified soil classification system (USCS)

COLOR

Table1shows variouscolor that wasidentified: Burnt umber brown, Rust brown, Ecro brown and sandy brown for Ekiti Lagos, Niger and Ondo state respectively.

NATURAL MOISTURE CONTENT

Table 1 shows the moisture content of the clay at their natural which varied between 2.34 and 3.5% with Lagos clay soil showing maximum moisture and higher retention potential.

PERMEABILITY

The coefficient of permeability (k) testfor the unmodified clay soil Performed on the clay samples varied between $1.86*10^{-4}$ and $2.1*10^{-4}$

IMPACT TEST

Table 1 shows the impact test performed varied between 0.39 and 0.56% for the unmodified clay soil

COMPRESSIVE STRENGTH

Table 1,Table2 and Figure 1 show the result of strength which varied between 4.4 and 14.5Mpa forthe unmodified clay soil while the modified clay sample varied between 2.19 and 14.66Mpa respectively for all the location.

WATER ABSORPTION

Table 2 and Figure 2 show the results of water absorption which varied between 15 and 41% forthe unmodified clay soil while the modified clay sample varied between 36% and 98% respectively for all the location.

POROSITY

Table 2 and Figure 3 show the results of porosity which varied between 1.5 and 10% forthe unmodified clay soil while the modified clay sample varied between 1.7% and 11.6% respectively for all the location.

CONCLUSION

The natural moisture content from the result obtained in all the location shown that all are within range except Lagos that is fairly high which may be due to soil potential of retaining water. The result of atterberg limits test performed show that the materials are classified as clayey soil under groupofMH, ML, CL and MH for all the location respectively according to unified soil classification system (USCS).The permeability test performed on the natural state of the clay soils shows that all sample are within the group range of semi pervious material according to USBR specification that any Kbetween 10^{-6} to 10^{-4} cm/sec is classified as semi pervious. Impact test conducted shows that Lagos and Ekiti reveal a higher resistance to shattering effect as it drop a height while Niger and Ondo reveal a weaker resistance effect of fall from a height. Compressive strength test performed on both the modified and the unmodified reveal that at 0% the strength was better for all the location while at the addition of the sawdust in accordance with the design mix for this study, the strength begin to decline as the percentage of the sawdust increases in the clay. However Lagos clay gave the highest strength which justified its low water absorption potential. Water absorption test performed shows that sawdust has a negative impact on water absorption potential ability of the clay soil. The result reveal that as the percentage of the sawdust increases the rate of absorption increases and vice versa. Porosity test reveal similar effect on the modified clay soil which mean that as the sawdust content increases the porosity also increases

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