Axial Load and Compaction Behavior of Pozzolan Stabilized Lateritic Soil with Coconut Shell Husk Ash and Palm Kernel Shell Husk Ash Admixtures

Onyelowe, K. C

Department of Civil Engineering, College of Engineering, Michael Okpara University of Agriculture, Umudike. P.M.B.7267, Umuahia 440109, Abia State

Abstract: *The effect of coconut shell husk ash (CSHA) and palm kernel shell husk ash (PKSHA) on the axial load and compaction behavior of pozzolan stabilized lateritic soil was studied. Oboro lateritic soil was collected for the study, characterized and the grading curve showed that the soil is an A-7-6(20) according to AASHTO and CH inorganic sandy clay according to Unified Classification System. The admixtures each under study were applied in proportions by weight of soil sample as 2%, 4%, 6%, 8% and 10%. Addition of the varied proportions of CSHA and PKSHA increased optimum moisture content and decrease maximum dry density. From the triaxial test examination, the value of unit weight and dry unit weight of triaxial test decreased at different percentages of CSHA and PKSHA but that of PKSHA reduced drastically than that of CSHA when both are compared Unconfined Compression Strength (UCS) increased with respect to the curing days and also increased at different percentages of CSHA and PKSHA. At 0% admixture, UCS was 6.43KN/m^2, 8.65KN/m^2 and 14.80 KN/m^2 for 0, 7 and 14days respectively. It improved to 10.79KN/m^2, 31.82KN/m^2 and 40.00 KN/m^2 respectively at 10% CSHA and 11.38KN/m^2, 33.43KN/m^2 and 41.64 KN/m^2 at 10% PKSHA for 0, 7 and 14days respectively. With the improvement of the strength properties of the weak soil studied by using CSHA and PKSHA, the admixtures are strongly recommended for use as admixtures for the improvement of the geotechnical properties of weak engineering soil.*

Keywords: *Axial load, compaction, pozzolan, coconut shell husk ash, palm kernel shell husk ash.*

1. INTRODUCTION

Soil stabilization has widely been recommended for developing countries for various elements of their pavements. The reasons usually are that the use of local conditions is of paramount importance. While developing any soil stabilization technique for any country, climatic conditions can affect the behaviors of stabilized soil materials as well as construction procedures. Soil stabilization can improve the shear strength of the soil and control shrinkage and swell properties of the soil thus improving the load bearing capacity of foundation soils (Brenema, 2010; Amoanyi, 2012; Okagbue, 2007).

There are lots of additives that have been experimented on with effects to improve geophysical properties of soil at lower cost by replacing certain percentage of cementitious stabilizers with non cementitious additives (Olaniyan, 2008). Some of these non cementitious stabilizers include;

i.) Quarry dust obtained as waste in quarry sites

ii.) Bagasse ash obtained as waste from sugar cane processing factory.

iii.) Egg-shell ash

iv.) Palm-kernel ash

v.) Coconut shell ash

vi.) Saw dust ash

vii.) Cocoa pod ash, etc. (Onyelowe, 2012)

An innovative use of coconut shell husk ash (CSHA) and palm kernel shell husk ash (PKSHA) to stabilize roads during construction and treatment of soil to obtain a high quality material will help in developing countries including Nigeria since they are cheap and will considerably reduce the cost of construction, having considered them as a waste and a nuisance to the environment. Utilizing it in this means of construction will help reduce this nuisance, thus reducing environmental burden (Oluremi et al, 2012; Oyelade, 2011; Owolabi and Dada, 2012; Otunyo et al, 2010; Amu et al, 2011). Furthermore, almost all the admixtures used in stabilization process in Nigeria are imported, enormous amount of foreign currencies spent on importation of these admixture stabilizers will be saved if coconut shell husk and palm kernel shell husk proves effective.

Coconut Shell Husk

Coconut shell husk is an agricultural waste and is available in very large quantities throughout the tropical countries of the world. Moreover, coconut is becoming an important agricultural product for tropical countries around the world as a new source of energy-biofuel. Previously, coconut shell husk was burnt as a means of solid waste disposal which contributed significantly to CO_2 and methane emissions (Oluremi et al, 2012; Oyelade, 2011; Vignash et al, 2014). However as the cost of fuel oil, natural gas and electricity supply has increased and become erratic, coconut shell has come to be regarded as source of fuel rather than refuse. Presently, the Nigeria coconut shell is used as a source of fuel for the boilers, and residual coconut shell is disposed off as gravel for plantation roads maintenance. Black smiths also buy the coconut shell as fuel material in their casting and forging operations (Bamgboye, 2006).

Palm Kernel Shell Husk

Palm kernel shell husk is an agricultural waste obtained from milling of oil. In ever increasing efforts to convert waste to wealth, the efficacy of converting palm kernel shell husk to beneficial use become an idea worth welcoming.

Oil palm is produced in 42 countries worldwide on about 27million areas, average yields are 10,000Ibs/acre and per acre yield of oil from Africa oil is more than four(4) fold that of any other oil crop, which has contributed to the vast expansion of the industry over the last few decades approximately, 153,578,600(million) tones (Owolabi and Dada, 2012). The estimate of total solid waste of oil palm production in Nigeria for a year is over 1.1 million tones. All this waste resulting from the milling industries in Nigeria constitutes nuisance to the environment as little or nothing has been done to reduce their occurrence in the environment and disposal after extraction of the palm kernel seeds poses serious challenges (Otunyo et al, 2010; Amu et al, 2011). The primary aim of this study was to examine the effect of CSHA and PKSHA on the axial strength and compaction properties of pozzolan stabilized Oboro, Amaoba lateritic soil and to establish feasibility of the admixtures as admixtures in the improvement of the above properties of the studied soil.

2. MATERIALS AND METHODS

Materials

Materials used for the research work include Amoaba lateritic soil, OPC and coconut shell husk and palm kernel shell husk Ash as admixture. Laterite samples were gotten from amaoba borrow pit site situated along latitude $05^\circ\ 26^{1}\ 44.288^{11}$ N and longitude $07^\circ\ 32^{1}\ 33.229^{11}$ E (www.google.com, 2015) used as a source of laterite for civil engineering works within IKWUANO Umuahia, South Eastern Nigeria was investigated under normal laboratory conditions. The laterite was obtained having little content of moisture in it i.e. semi-solid state and it was reddish brown in colour. Coconut and palm kernel shells and husks were collected from dump site within Umuahia. The shells and husks were then sun dried for 3 weeks and then burnt without gasoline or fuel on a clear dried surface. The ash was sieved using the 0.75µm BS TEST sieve to achieve a smooth, uniform and fine particle. The ash was found to be hygroscopic hence the ash was stored in an air-tight container. The pozzolan soil sample used for this research work was collected from ohyia near mechanical village Enugu Port-Harcourt expressway, in Umuahia South Local Government Area of Abia State. The sample was collected in a bag and it was air dried to eliminate the moisture in it. It was then crushed to powder form using core cutter with bulk density mould.

Methods

The physical characteristics of Amaoba laterite was determined which include; particle size distribution, compaction/moisture content, triaxial test and unconfined compressive strength in accordance to; (ASTM D-1632; ASTM D-1633; ASTM D-5102-09; ASTM D-2166-06; IS: 2720-Part XVI, 1990).

Particle Size Distribution

Orderly arranged British Standard Sieves to BS1377 (1990); 4.36mm, 2.36mm, 1.18mm, 600µm, 425µm, 300µm, 212µm, 150µm, 75µm; Lid and receiver; balance readable and accurate to 0.1g, drying oven, sieve brush and the mechanical shaker were the apparatuses used for the PSD test.

Soil Compaction/Moisture Content Test

A cylindrical metal mould having an internal diameter of 105mm, internal effective height of 115.5mm and a volume of $1000cm^3$ (the mould shall be fitted with a detachable base plate and a removable extension 50mm high); a metal rammer having a 50mm diameter circular face and weighing 2.5Kg (the hammer was equipped with a suitable arrangement for controlling the height of drop to 300mm); a balance readable and accurate to 1g; a palette knife (100mm long and 20mm wide); a straight edge steel strip 300mm long, 25mm wide and 3mm thick with one bevelled edge; 20mm BS test sieve and a receiver; large metal tray (600mmx500mm with sides 80mm deep) were apparatuses used for moisture content and MDD examination.

3. RESULTS AND DISCUSSION

Results

Figures 1 to 6 show the behavior of dry density and moisture content of pozzolan stabilized lateritic soil with proportions of CSHA and PKSHA as admixtures.

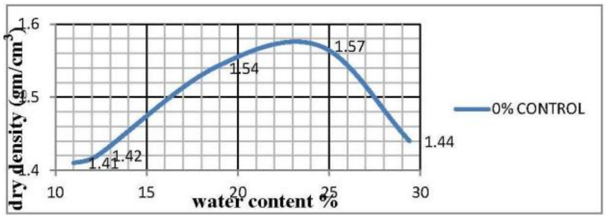

Figure 1: *A graph of dry density against water content at 0 % (control)*

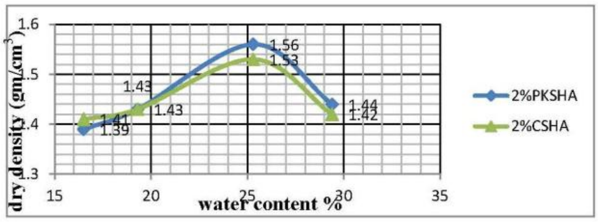

Figure 2: *A graph of dry density against water content at 2 % CSHA and 2% PKSHA*

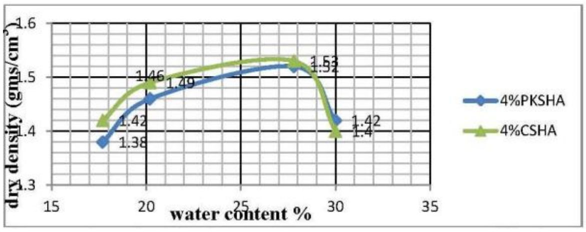

Figure 1: *A graph of dry density against water content at 4% CSHA and 4% PKSHA*

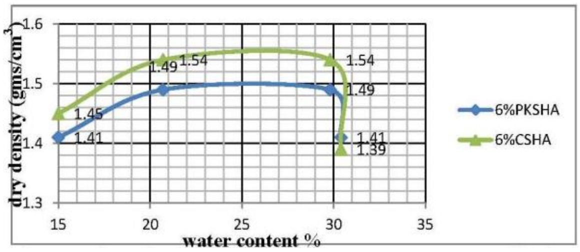

Figure 2: *A graph of dry density against water content at 6% CSHA and 6% PKSHA*

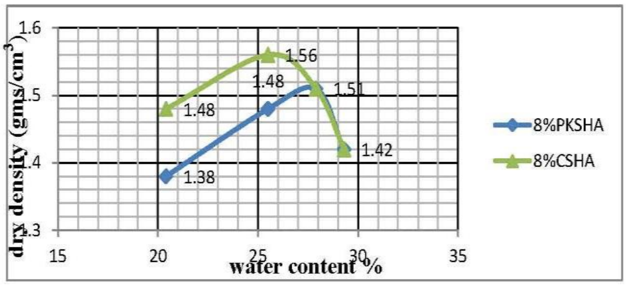

Figure 3*: A graph of dry density against water content at 8% CSHA and 8% PKSHA*

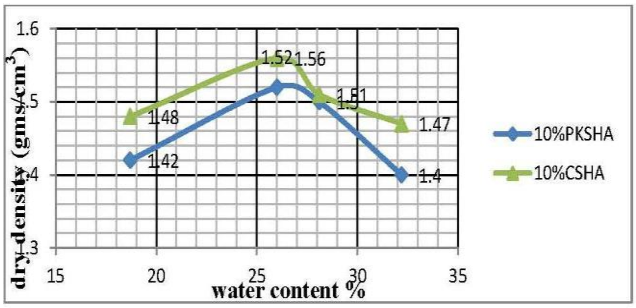

Figure 4: *A graph of dry density against water content at 10% CSHA and 10% PKSHA*

Figures 7 to 17 show the behavior of deviator stress and axial strain of pozzolan stabilized lateritic soil with proportions of CSHA and PKSHA as admixtures.

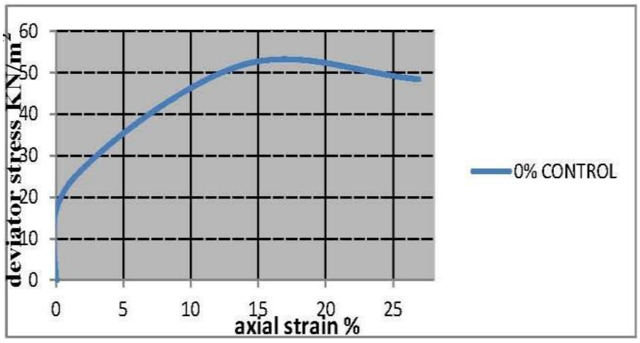

Figure 5: *Graphical representation of deviator stress against axial strain at 0% admixture.*

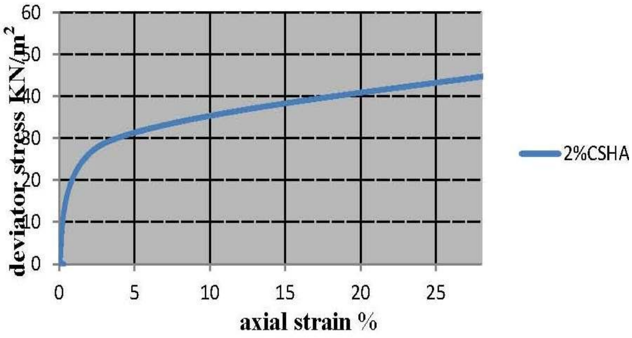

Figure 6: *Graphical representation of deviator stress against axial strain at 2% CSHA*

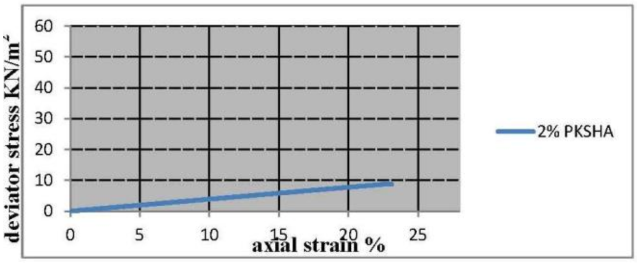

Figure 7: *Graphical representation of deviator stress against axial strain at 2% PKSHA*

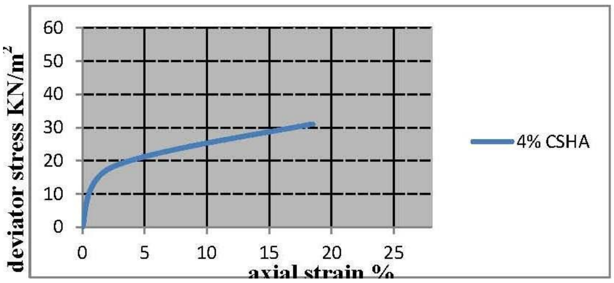

Figure 8: *Graphical representation of deviator stress against axial strain at 4% CSHA*

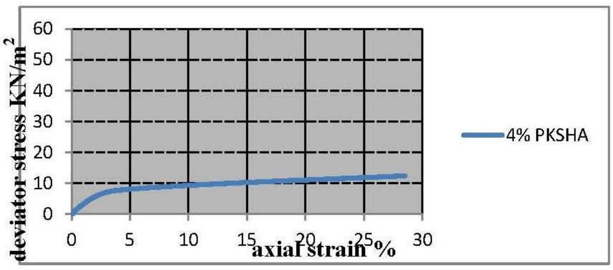

Figure 9: *Graphical representation of deviator stress against axial strain at 4% PKSHA*

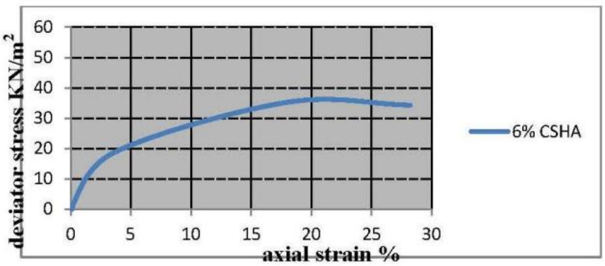

Figure 10: *Graphical representation of deviator stress against axial strain at 6% CSHA*

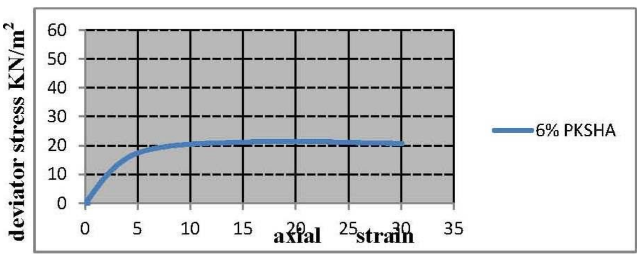

Figure 11: *Graphical representation of deviator stress against axial strain at 6% PKSHA*

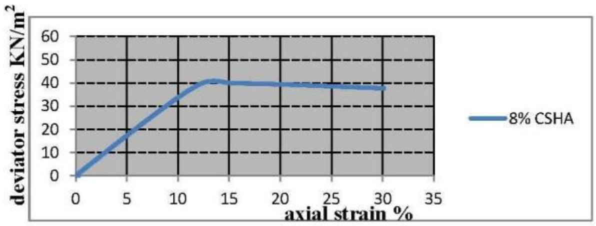

Figure 12: *Graphical representation of deviator stress against axial strain at 8% CSHA*

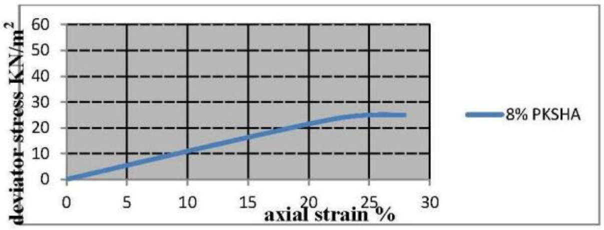

Figure 13: *Graphical representation of deviator stress against axial strain at 8% PKSHA*

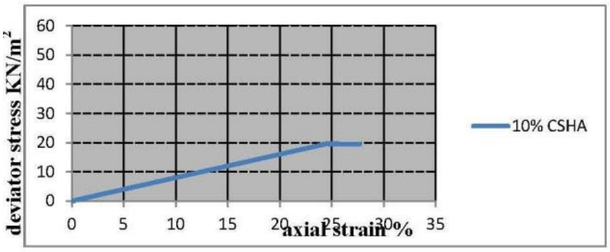

Figure 14: *Graphical representation of deviator stress against axial strain at 10% CSHA*

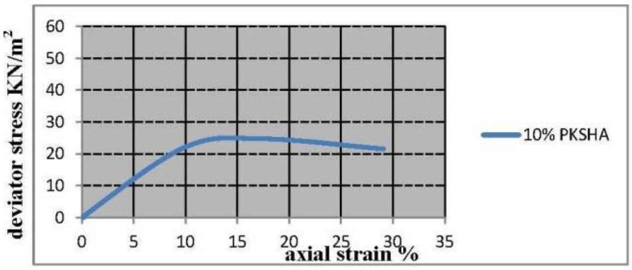

Figure 15: *Graphical representation of deviator stress against axial strain at 10% PKSHA*

Tables 1 and 2 show the behavior of unconfined compressive strength of pozzolan stabilized lateritic soil with proportions of CSHA and PKSHA as admixtures and curing time.

Table 1: *Unconfined compressive strength test result for CSHA*

Admixture CSHA	UCS(KN/M^2)		
CURING	0 day	7days	14days
0 % CONTROL	6.43	8.65	14.80
2% CSHA	6.80	10.97	21.56
4% CSHA	7.25	18.88	24.98
6% CSHA	8.67	20.75	28.56
8% CSHA	9.80	24.99	30.99
10% CSHA	10.79	31.82	40.00

Table 2: *Unconfined compressive strength test result for PKSHA*

Admixture PKSHA	UCS(KN/M²)		
CURING	0 day	7days	14days
0 % CONTROL	6.43	8.65	14.80
2% PKSHA	7.10	11.38	22.60
4% PKSHA	7.85	19.84	26.61
6% PKSHA	9.30	21.20	29.86
8% PKSHA	10.24	26.92	32.89
10% PKSHA	11.38	33.43	41.64

4. RESULTS DISCUSSION

Effect of CSHA and PKSHA on Compaction Test of Pozzolan Stabilized Lateritic Soil

From Figure 1, it is observed that at 0% (control) maximum dry density and optimum water content are 24% and 1.57gm/cm^3, from Figure 2 its observed that at 2% CSHA and 2% PKSHA maximum dry density and optimum moisture content obtained were 1.56gm/cm^3, 27% and 1.56 gm/cm^{3}and 25% respectively. From Figures 3 and 4, the following MDD and OMC of 1.53, 1.52, 1.54, 1.51 and 27.4, 27.3, 27.8, 29.8 for 4% CSHA and 4% PKSHA, 6% CSHA and 6% PKSHA respectively were recorded. From Figures 5 and 6 at 8% CSHA, 8% PKSHA, and 10% CSHA and 10% PKSHA the following MDD of 1.56, 1.51, 1.56, 1.52 and OMC of 26, 27.9, 27 and 26 were obtained. From the general effect of CSHA and PKSHA on pozzolan stabilized lateritic soil, it was observed that addition of CSHA and PKSHA increased optimum moisture content and decrease maximum dry density. The increment in the OMC was almost at the same rate for both CSHA and PKSHA while the decrease in the MDD varies with different percentages of CSHA and PKSHA when compared to (0% control).

Effect of CSHA and PKSHA on Triaxial Test and unconfined compressive strength of Pozzolan Stabilized Lateritic Soil

From Figure 7 to Figure 17, it's observed that the height (mm), diameter (mm), axial strain (%), volumetric strain%, deviator stress (KN/m^2), vertical effective stress (KN/m^2), horizontal effective stress (KN/m^2), void ratio, friction angle(deg) and water content varies at 0% (control) and on addition of different percentages of CSHA and PKSHA. It's also observed that unit weight (KN/m^3) is greater than dry unit weight (KN/m^3). It's also noted that the value of unit weight and dry unit weight decreased at different percentage of CSHA and PKSHA but that of PKSHA reduced more than that of CSHA when both are compared. More importantly, the behavior curves have shown that CSHA admixture proved to have higher deviator stress to axial strain than PKSHA.

From Tables 1 and 2 shows the unconfined compressive strength of pozzolan stabilized soil for 0% and at different percentages of CSHA and PKSHA at 0day, 7days and 14days. From the results obtained, it was noted that UCS increased with respect to the curing days. UCS also increased at different percentages of CSHA and PKSHA. The UCS of PKSHA increased more than that of CSHA.

5. CONCLUSION

From the foregoing results and discussions, it is concluded as follows;

1. Addition of CSHA and PKSHA increased optimum moisture content and decreased maximum dry density. The increment in the OMC was almost at the same rate for both CSHA and PKSHA while the decrease in the MDD varies with different percentages of CSHA and PKSHA when compared to 0% admixture.
2. That the value of unit weight and dry unit weight of triaxial test decreased at different percentages of CSHA and PKSHA but that of PKSHA reduced more than that of CSHA when both were compared. More importantly, the behavior curves have shown that CSHA admixture proved to have higher deviator stress to axial strain than PKSHA.
3. UCS increased with respect to the curing days. UCS also increased at different percentages of CSHA and PKSHA. The UCS of PKSHA increased more than that of CSHA when compared and marks a better admixture for the improvement of unconfined compressive strength of pozzolan stabilized weak engineering soil.

Finally from the series of investigation, it is concluded that both coconut shell husk ash and palm kernel shell husk ash are good stabilizing admixtures as they have improve the strength characteristics of pozzolan stabilized lateritic soil and they are strongly recommended for stabilization of poor engineering soils.

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