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Understanding the effect of compaction energies on the strength indices and durability of oyster shell ash-lateritic soil mixtures for use in road works

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Abstract

The current study examined the use of experimental and statistical approach to assess the influence of compaction energies on geotechnical behaviour of lateritic soil stabilized with up to 15 % oyster shell ash (OSA) by weight of the dry samples. The outcomes portray that the maximum dry densities (MDDs) of both untreated and treated soil samples decreased with increased compactive efforts whereas the optimum moisture content (OMCs) reduced. California bearing ratio, CBR (soaked and unsoaked) and unconfined compressive strength, UCS (7 and 28 days) values increased with higher compactive effort and OSA content. The statistical results indicated that OSA content, compactive energy (CE), plasticity index (PI) and percentage fine content (PF) have effect on the strength characteristics of lateritic soil. Generally, the study indicated that OSA content up to 9 % and higher compactive effort is adequate for enhancing the geotechnical behaviour of lateritic soil. However, rather than use OSA as stand-alone additive, it is recommended that cement or lime be used as admixture in OSA-lateritic soil so as to provide an effective hydraulically bound material for construction application.

Keywords: Lateritic soil, Oyster shell ash, Compaction energies, Strength characteristics, Durability, Statistical analysis

1. Introduction

Lateritic soils also termed as residual soils derived through weathering process, they contain substantial quantities of both quartz and kaolinite. The ratio of silica (SiO_2) to sesquioxides ($Fe_2O_3 + Al_2O_3$) less than 1.33 is a sign of laterite whereas values between 1.33 and 2.0 is a sign of lateritic soil and a value greater than 2.0 is a sign of non-lateritic soil [1, 2]. These soils are found in six main regions of the world which are as follows: Africa, India, South East Asia, Australia, Central and South America [3]. Some deposits of lateritic soil available for use as road construction material have poor engineering characteristics which makes them unfit. These inadequacies in engineering characteristics of this available soil sample poses a great challenge for the engineers. Therefore, improvement of such soil is the most viable means for it to be used for construction purpose.

Soil improvement is recurrently called soil stabilization which entails the blending of a natural soil with a cementing material or other chemical or non-chemical materials. Also, stabilization of soils in other words is soil reinforcement. Substantial research works has been carried out to improve various treatment methods to deficient lateritic soils. As a result of this, soil stabilization was grouped into five different techniques which are mechanical stabilization, cementitious stabilization, bituminous stabilization, chemical stabilization and specialized methods of stabilization [4]. The most common and essential technique of soil improvement is densification whereas the commonly used method is compaction [5] and engineers consider compaction as a design tool because it plays important role in the life of civil infrastructures [6]. Besides that, different compaction energies are one of the other essential aspects that affect the compaction of a soil. It is quite pertinent to note that preliminary testing by various compaction energies is central to selecting the type of field equipment and or appropriating number of passes for each placement as well as monitoring the soil behaviour of earth constructions.

Cement and lime are the two conventional soil stabilization materials. Due to the high cost of buying cement, it makes it unaffordable to contractors who may not have foreseen the need of cement stabilization during earthwork phase of pavement construction. Inasmuch as cement stabilization is beneficial, the release of CO_2 to the atmosphere during cement production poses a great threat to the environment at large [7]. These have mandated researchers to harness possibility of the usage of waste materials for improving deficient soils thereby acting as a viable means of curbing the problem of disposal. Several documented literatures have reported promising results associated with the use of agro-industrial waste materials for the improvement of deficient soil. They include periwinkle shell ash [8], bagasse ash [9-12] iron ore tailing [13, 14], metakaolin [15], granulated blast furnace slag [16], cement kiln dust [17] groundnut shell ash [18]. However, other materials which have improved deficient soils include waste wood ash [19-25], coconut husk ash [26-28], millet husk ash [29], corn cob ash [30, 31], rice husk ash (RHA) [28, 32-35], locust bean pod ash (LPBA) [36-40], quarry dust [41] and others such solid waste derivative, biomass. glass fine, hair fibres [42-45].

Oyster shell is calcined to derive its ash termed oyster shell ash (OSA). About 3.08 million tons of oyster shell waste is

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generated globally [46-48]. This waste is deposited in much quantities in the coastal areas all over the world. The geographic distribution of oyster shell varies with the rate of Mollusca farming [46]. In South Korea, 300,000 tons of oyster shells were annually disposed [49, 50]. Santos and Costa [51] reported that 21,554 tonnes of oysters were produced in Brazil. In Nigeria large quantity of oyster shell is deposited along coastal States such Akwa Ibom, Bayelsa, Cross River, Rivers, Edo and Delta state. Good amount of these shells are discarded indiscriminately into the environment and are kept in stock piles in these areas. Over time, microbial activities which aids decomposition process occurred and brings about very obnoxious and toxic gases (H_2S and NH_3), thereby leading to associated environmental problems and health hazards. The lack of guidelines, inspection and legislation in some oyster-producing countries and or communities indicate to a large extent the significant environmental influence created by oyster shell. Oyster shell is a rich calcium source as raw materials in several areas of application [52-56]. Interestingly, the use of oyster shell ash becomes essential because of the necessity of disposing oyster shells from the environment as well as sourcing for cheap and readily available pozzolanic materials for soil improvement purpose. So the two fold intent of enhancing soil strength and reliable discarding of waste material can be realized.

Generally, a considerable amount of literatures has been published on soil stabilization and these literatures depicts that not much has been done in the use of oyster shell ash to stabilize deficient lateritic soil and the effects of the various compaction energies on the stabilized soil. Therefore, the study was aimed at understanding the behaviour of various compaction energies on the strength indices and durability of oyster shell ash-lateritic soil mixtures for use in road works. Having a better understanding of the compaction behaviour of lateritic due to the effect of oyster shell ash will enhance the potentials of incorporating oyster shell ash in soil stabilization for road construction purpose and provide mechanism for safe waste disposal.

2. Materials and methods

2.1 Materials

Locally available lateritic soil obtained as a disturbed sample from a deposit at Ikot Inyang (Latitude 5^0 10ˈ 29ˈˈ N and Longitude 7^0 55ˈ 8ˈˈ E), Ibiono Local Government Area, Akwa Ibom State, in the Southern part of Nigeria was used in the study. Processing of oyster shell to its ash and the chemical compositions of both oyster shell ash and the tested soil in the current study have been presented [57].

2.2 Methods of testing

Atterberg limits test was carried out on soil and soil-OSA mixtures based on guidelines detailed in [58, 59]. Samples of soil were mixed with 0, 3, 6, 9, 12 and 15 % oyster shell ash by dry weight of soil for the following test: compaction, California bearing ratio (CBR) and Unconfined compressive strength (UCS) test compacted with the compactive efforts of BSL, WAS and BSH. These tests were based on guidelines detailed in [58]. The CBR was executed to ascertain the appropriateness of a soil for use as either a sub-base or base material for construction purpose. In CBR 5.0 kg of soil / soil-admixture sample were mixed at their respective OMCs in 2360 cm^3 mould. Durability assessment of lateritic soil-OSA specimen is a measure of its resistance to loss in strength for tropical region like Nigeria [60, 61]. This was achieved by dividing the UCS values of soil samples cured for 7 days thereafter immersed in water for another 7 days with the UCS values of another set treated soil samples cured for 14 days [14]. The result of laboratory experiment was analysed using MS Excel and Mini Tab R15 statistical tools. Regression equations were developed using Minitab R15 software.

Table 1 Engineering properties of untreated soil

Property	Quantity
Percentage passing BS No 200 sieve (%)	42.40
Natural moisture content (%)	15.74
Liquid limit (%)	49.30
Plastic limit (%)	20.50
Plasticity index (%)	28.80
Specific gravity	2.58
Coefficient of uniformity, Cu	30
Coefficient of curvature, Cc	1.2
AASHTO classification	A-7-6 (8)
USCS	CL
Maximum dry density Mg/m^3	1.86
Optimum moisture content (%)	13.10
Unconfined compressive strength, kN/m^2	18.9
California Bearing Ratio (24 soaking) (%)	8
pH	6.70
Colour	Reddish brown

Table 2 Chemical analysis of the various materials.

Oxide	Lateritic Soil (%) [57]	*OSA (%) [57]
Fe_2O_3	17.52	7.30
Al_2O_3	33.36	8.97
SiO_2	37.8	21.71
CaO	0.081	56.99
MgO	-	0.80
SO_3	0.31	0.72
ZnO	0.007	-
Cr_2O_3	0.011	-
V_2O_5	0.023	-
TiO_2	0.678	0.041
Na_2O	-	0.35
LOI	10	3

3. Results and discussions

3.1. Material characterisation

Preliminary investigation results on the natural soil are reflected in Table 1. The American Association of State Highway and Transportation Officials, AASHTO [62] classification portrays that the natural soil falls within the A-7-6, with group index of (8) whereas based on Unified Soil Classification System, USCS [63], it falls under CL (well graded gravel with clay and sand). The soil is reddish - brown having liquid limit, plastic limit and plasticity index of 49.30, 20.50 and 28.80 %, respectively. The chemical compositions of the soil and OSA used in the current investigation indicate that oyster shell ash is a calcium source [52-56, 64] and has shown potential in lateritic soil stabilization [57] (Table 2). Figure 1 is the grain size distribution of the untreated soil having coefficient of uniformity (Cu) and curvature (Cc) of 30 and 1.2, respectively. The soil is well graded based on Cu > 4 and $1 \leq Cc \leq 3$.

3.2 Compaction characteristics

3.2.1 Maximum dry density, MDD

Presented below in Figure 2 is the MDD of lateritic soil-OSA mixtures for the three compactive efforts. The MDD results for the untreated soil at BSL, WAS and BSH are 1.856, 1.950 and 1.980 Mg/m^3 respectively. The MDD generally decreased with addition of OSA to the soil and increased compactive efforts from BSL to BSH. However, at the early stage of compaction exercise (at 3 % OSA addition to the soil) there was an increase in MDD values and this could be ascribed to the flocculation as well as agglomeration of the soil – OSA mixtures. Also, the specific gravity of the tested soil and OSA may be accountable for the

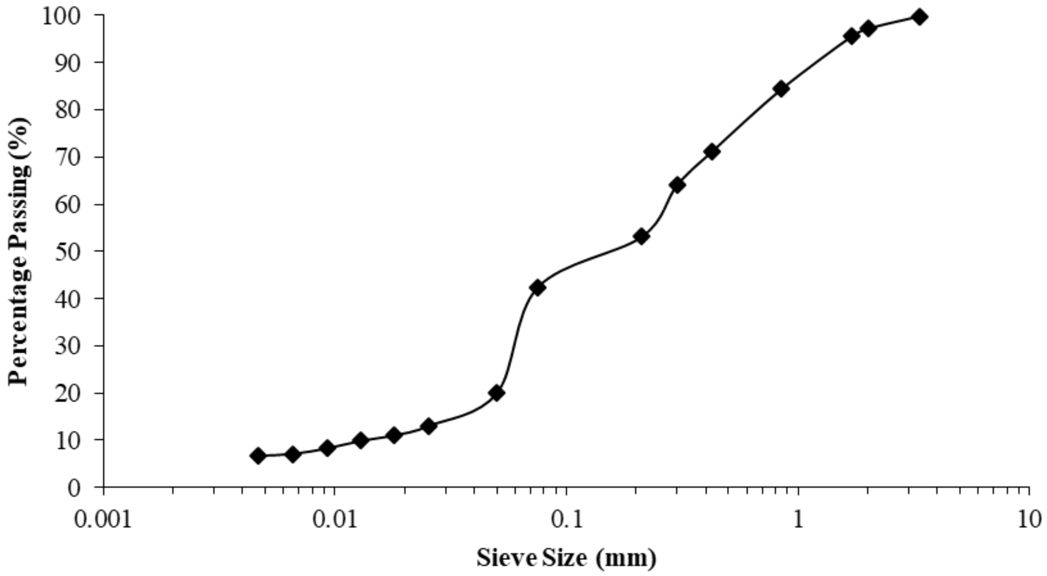

Figure 1 Particle size distribution for untreated soil

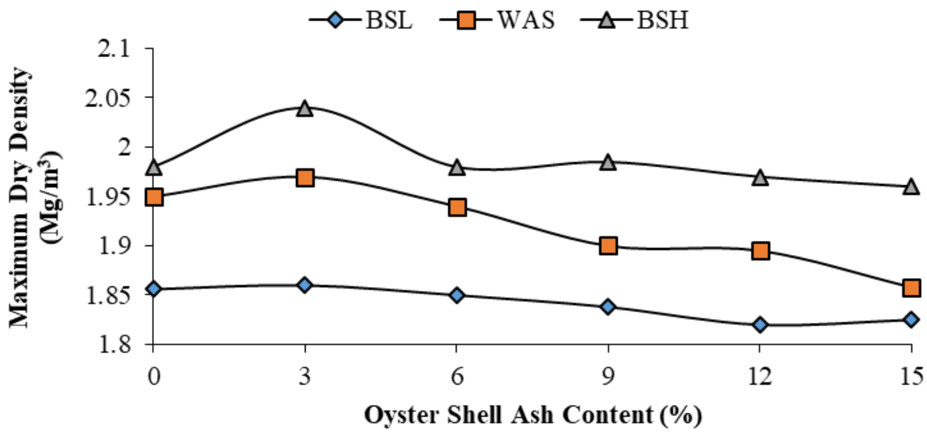

Figure 2 Relationship showing effect of oyster shell ash content on maximum dry density of lateritic soil - oyster shell ash mixtures

reduction in MDD reported in this current study. With OSA having a lower specific gravity (2.33) compared to that of the lateritic soil (2.58) which results in substituting the 2.58 specific gravity of the soil with that of OSA. Partly also, the increasing trend of MDD with increased compaction energies may be unconnected to densification of the soil mixtures and these outcomes matches the reports of [65-68].

3.2.2 Optimum moisture content, OMC

The OMC changes with OSA for the three compaction energies are presented in Figure 3. Generally, the OMC increased with addition of OSA in the soil and declined with higher compaction energies. The OMC increased from 13.10, 11.80 and 11 % of the untreated soil to peak values of 14.50, 14.0 and 13.32 % when treated with 12 % OSA using BSL, WAS and BSH energy levels respectively. The important of increasing OMC with addition of OSA may be accredited to the amplified yearning for water which matches with the higher quantity of the additive. However, another reason for this trend of result could be linked to the increase in surface area initiated by the greater amount of additives, which necessitates more water for the lubrication of the mixture. This trend of result is consistent with the research works of [65, 69-71].

3.3 Strength characteristics

3.3.1 California bearing ratio, CBR

The CBR values of lateritic soil with addition OSA for the three energy levels used is shown in Figure 4. The trend using BSL compaction energy was established by [57]. Consequently, CBR of WAS and BSH assumed similar trend but with slight deviations in values. The CBR showed a general increase as both compactive efforts and OSA content increased. It is normal for CBR values to increase with increasing compaction efforts. This usually signifies that the denser the soil due to higher compaction energy, the higher the strength of the soil. Also, CBR increased with increasing OSA up to optimal of 9 %. It was reported in [57] that the increase is due to the reaction of the silica and alumina in the soil with the calcium oxide in the OSA. Also, it was also corroborated in [57] that OSA which has shown similarity in composition with lime reacted with alumina and silica content in lateritic soil to form fundamental compounds of (calcium silicate hydrates and calcium aluminate hydrates CSH and CAH) that are responsible for strength. These results uphold the outcome of other researchers [8, 15, 14, 72] who used varying concentrations of admixtures. It is understandable that the various compactive energies is apparently immaterial to the chemistry of reaction between lateritic soil and OSA. However, increased compactive effort could act to effectively destroy and or readjust particle lump, shear planes as well as establish a more homogenous OSA-soil mixture during compaction. This observation is central to creating more surface area of contact between the soil and OSA thereby upholding the steady reaction between the soil composition and OSA. Furthermore, CBR decreased slightly with additional treatment beyond 9 % OSA. The implication is

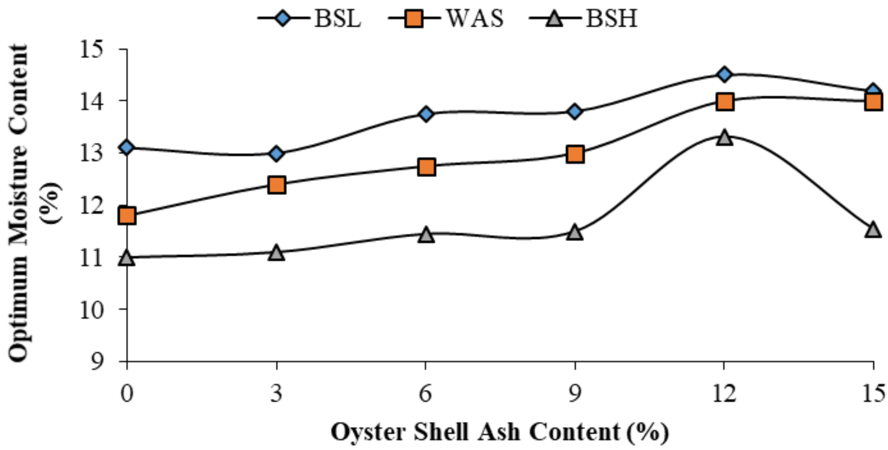

Figure 3 Relationship showing effect of oyster shell ash content on optimum moisture content of lateritic soil - oyster shell ash mixtures.

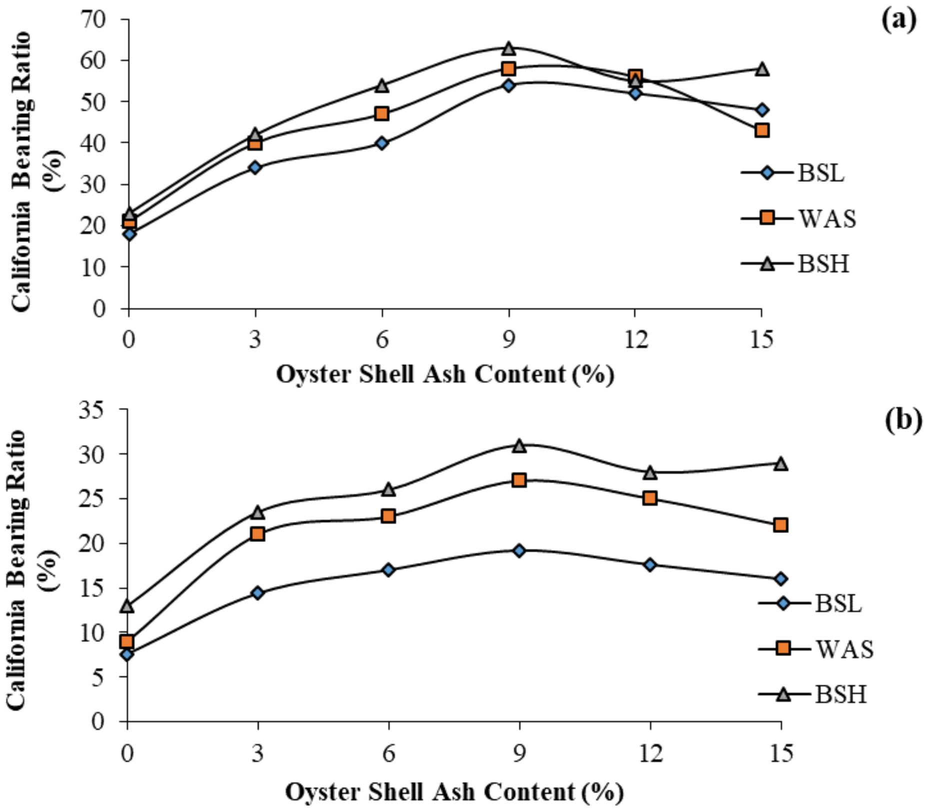

Figure 4 Variation of California bearing ratio of lateritic soil – oyster mixtures for (a) Unsoaked specimens and (b) Soaked specimens.

that excess of 9 % OSA which did not take part in the reaction could have affected the grading mixture thereby result to more fine content and reduction in shear strength, cohesion and interlocking friction between soil-OSA [8, 73]. The unsoaked CBR for BSL, WAS and BSH gave maximum values of 54, 58 and 63 % at 9 % OSA content, respectively (Figure 4a). Similarly, the highest CBR results of 19, 27 and 31 % were achieved at 9 % OSA content for BSL, WAS and BSH, respectively (Figure 4b). These outcomes were in line with the consistent style of enhancing CBR values with higher compactive effort which is consistent with the findings of [61].

This study adopted the Nigerian General Specification, NGS (74) highway specification guide which was used to correlate the following: (1) 19 % peak CBR (soaked) of BSL compaction satisfy the benchmark requirement of greater than or equal 15 % for subgrade, (2) 27 % peak CBR (soaked) of WAS fell short the requirement (greater than or equal 30 %) for sub-base of heavy traffic road (sub base type 1) but above or satisfy 20 % minimum CBR for sub-base of low vehicular traffic road (sub base type 2) and (3) all CBR values (unsoaked) obtained for WAS and or BSH fell short the standard need of (greater than or equal 80 %) for base course. It can be concluded that 9 % OSA is the optimum percentage consistent with the maximum CBR of OSA treated lateritic soil. Despite the use of higher compactive effort of WAS and BSH, their CBR values (unsoaked and soaked) could not fulfil the benchmarks as recommended in NGS [74] roads and bridges for sub base and base courses. Based on this, the suitability of using OSA as a sole stabilizer in lateritic soil improvement may not achieve the desired and feasible results in service, especially under exposure in adverse condition for sub base type 2 and base course. Thus, if it should be considered, then it is recommended for subgrade and or sub-base type 1 for interior rural or village roads where traffic volume is at the very minimum.

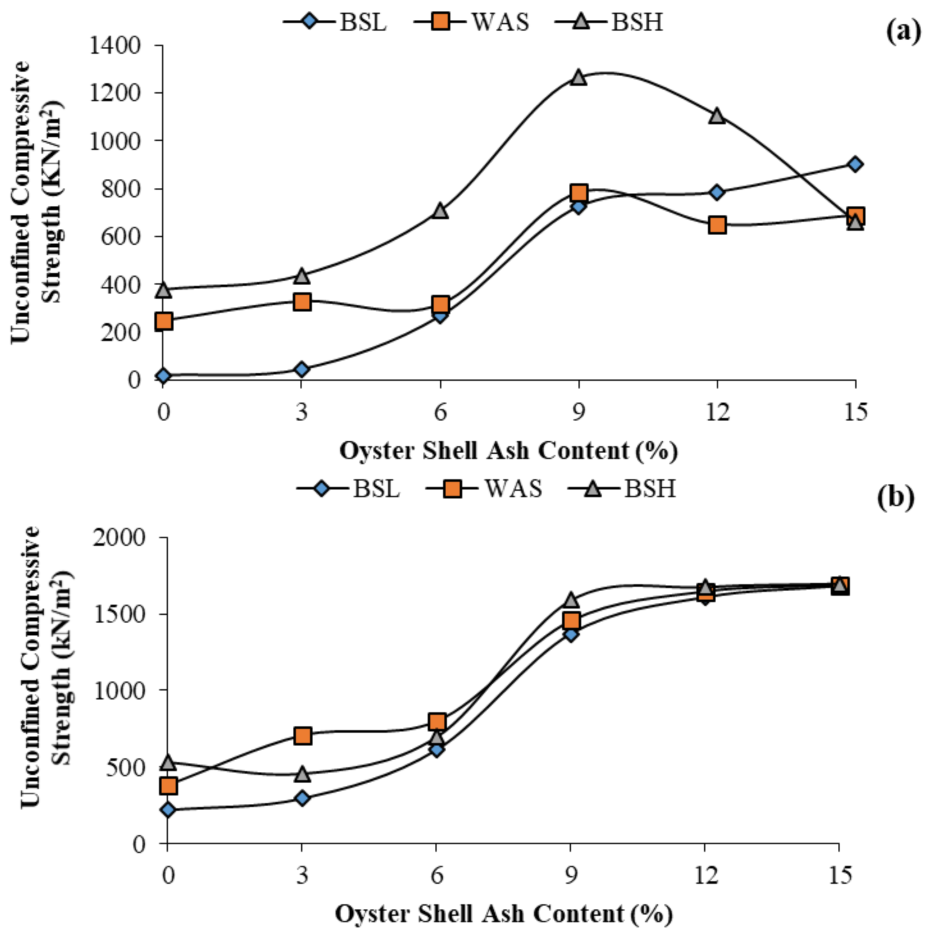

Figure 5 Variation of unconfined compressive strength of lateritic soil – oyster shell ash mixture after (a) 7 days curing age and (b) 28 days curing age.

3.3.2. Unconfined compressive strength, UCS

Figure 5 demonstrates the changes in UCS of lateritic soil with OSA for the three compaction energies after 7 and 28 days of curing time. Generally, it was evident that the UCS improved with increase OSA content, compactive effort and curing time, attaining peak values of 724.87, 784.13, 1265 kN/m^2 at 9% OSA content for BSL, WAS and BSH respectively, for 7 days curing (Figure 5a). A parallel behaviour is observed for 28 days curing period except that the increase was marginal beyond 9 % OSA (Figure 5b). The observed trend can be attributed to the surface exchangeable interaction between the clay particles of the soil and the predominant calcium oxide in OSA [57]. The ions reaction between Ca^{2+} ion in the OSA additive and lower valence ion in the soil clay minerals brought about flocculation and agglomeration of clay particles [8, 14, 15, 57, 61]. Basically, the UCS increased due to: (1) the formation of fundamental compounds of (calcium silicate hydrates, CSH and calcium aluminate hydrates, CAH) that were accountable for strength increase [8, 14, 15, 57, 61], (2) increased curing time which allow for complete reaction between clay mineral-OSA additive and (3) increased compactive effort which may conveniently realign particle lump, shear planes as well as establish an effective homogenous OSA-soil mixture and improve surface area of particle mixtures thereby sustaining the ions reaction between the soil composition and OSA.

This study utilized the 7 day UCS results to establish requirement for adequate stabilization based on report of [61, 75, 76]. The results in this study (Figure 5a), indicate that the maximum UCS for 7 days curing period was 904, 784.13 and 1265 KN/m^2 for BSL, WAS and BSH compactive efforts, respectively. These values were below the minimum criterion of 1710 kN/m^2 as stipulated for adequate cement stabilization [75], while only BSH compactive satisfy the 1034.25 kN/m^2 criterion for adequate lime stabilization of soil [61]. Also, the UCS results at optimal 9 % OSA content were within 687 – 1373 kN/m^2 as documented for sub-base using WAS [76], which can be coupled with the satisfactory CBR criterion obtained for CBR of sub-base type 2 for lightly traffic road pavement.

3.4 Durability assessment

In order to assess the worst situations on site for any soil to be used as road construction material, immersion of the cured sample in water before testing its compressive strength is done to ascertain that the stabilized material do not fail under worst conditions. The resistance to loss in strength of lateritic soil with OSA content for the three compactive efforts are shown in Figure 6. It can be inferred from the obtained results, which are shown in a tabular form that the resistance to loss in strength values decreased from 10.27 to 7.71 % for BSL; 15.09 to 8.29 % for WAS; and 17.67 to 10.19 % for BSH at 15 % OSA content and the specimens recorded loss in strength less than the durability requirement of 20 % [61].

3.5 Statistical Analysis

3.5.1 Analysis of variance for unconfined compressive strength

Two-way analysis of variance (ANOVA) without replication at 5 % level of significance and 95 % confidence interval was used to ascertain the influence of OSA and curing age on the UCS values measured in the laboratory for the compactive efforts of BSL, WAS and BSH respectively. The ANOVA for UCS is

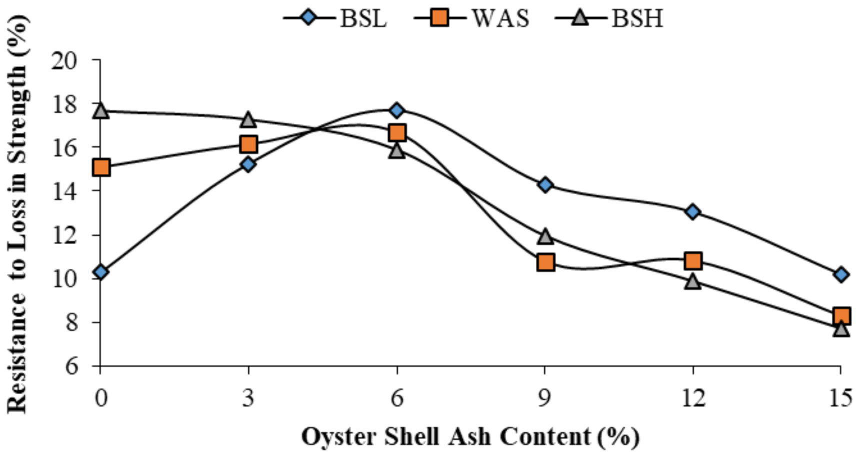

Figure 6 Variation of resistance to loss in strength of lateritic soil – oyster shell ash mixtures

Table 3 Two-way analysis of variance for UCS considering different curing periods

Parameter	Source of Variation	DOF	Fcal	P-value	F crit	Remark
BSL	OSA	5	31.6038	8.12E-06	3.3258	SS
	Curing age	2	15.9631	0.000772	4.1028	SS
WAS	OSA	5	36.1457	4.35E-06	3.3258	SS
	Curing age	2	25.4969	0.000118	4.1028	SS
BSH	OSA	5	97.9488	3.67E-08	3.3258	SS
	Curing age	2	8.3998	0.00723	4.1028	SS

DOF= Degree of freedom; SS= Significant effect

Table 4 Two-way analysis of variance for California bearing ratio

Parameter	Source of Variation	DOF	Fcal	P-value	Fcrit	Remark
Unsoaked CBR	OSA	5	51.3079	8.31E-07	3.3258	SS
	Compactive effort	2	9.4284	0.004998	4.1028	SS
Soaked CBR	OSA	5	37.4891	3.66E-06	3.3258	SS
	Compactive effort	2	58.2586	3.08E-06	4.1028	SS

documented in Table 3 and the effect of OSA content was more prominent compared to that of curing age for all compactive efforts. It is therefore of great importance to carefully check the OSA content during field compaction or any field application to attend desired results during construction.

3.5.2 Analysis of variance for California bearing ratio

Analysis of variance was carried out to measure the relative significance of OSA and compactive effort on CBR (soaked and unsoaked) values (see Table 4). A Two way analysis of variance taking 5 % level of significance and 95 % confidence interval shows statistically significant effect of OSA and compactive effort on the CBR (soaked and unsoaked), compacted using BSL, WAS and BSH energy respectively. The effect of OSA content was more pronounced than that of compactive effort for unsoaked CBR. For the CBR (soaked condition), ingress of water into the soil weakens the effect of OSA on the treated soil which shows less significant effect than the compaction energy (see Table 4). Therefore, when lateritic soil is treated with OSA during pavement construction, both the OSA content and compactive efforts should be accurately measured out.

3.6 Regression analysis

3.6.1 Regression analysis for unconfined compressive strength

Regression analysis predict the interaction between sets of variables (one or more) called independent variables and a single variable called dependent variable. Researches in sciences and engineering have applied regression analysis to buttress relationships between two variables or sets of variables [18, 77-80]. Equation 1 shows the regression equation for UCS 7 days curing. The regression equation indicates that all the parameters considered have influence on the UCS values of stabilized soil with correlation coefficient value of $R^2 = 59.3$ %. The coefficients of regression equation for each parameter would reveal the level of the effect of the parameter on the UCS. OSA and OMC have positive coefficients which depict the fact that increase in these parameters (OSA and OMC) lead to improvement in UCS of the compacted soil. Similarly, the MDD, PF, PI and CE have negative coefficients, which depict decrease in UCS with increase in these variables. Care should be taken to ensure these variables are properly controlled at the site during field compaction to achieve a durable road pavement.

The line fit plot (see Figure 7) shows relationship between the measured UCS values in the laboratory and the predicted values from the regression model, with respect to the effect of OSA on the UCS of compacted lateritic soil- OSA mixtures. It is evident from the fit line plot that the model overestimated the UCS values at 3, 6 and 9 % OSA content, when predicted UCS values from the regression model was compared with the laboratory measured values. Where; UCS = Unconfined compressive strength; OSA = Oyster shell ash, MDD = Maximum dry density, OMC = Optimum moisture content, PF =Percentage fine, PI = Plasticity index, CE = Compactive effort.

$$\mathrm{UCS} = 7366 + 46.8\,\mathrm{OSA} - 2080\mathrm{MDD} + 54\mathrm{OMC} - 76.9\mathrm{PF} - 20.9\mathrm{PI} - 357\mathrm{CE} \qquad R^2 = 59.3\% \tag{1}$$

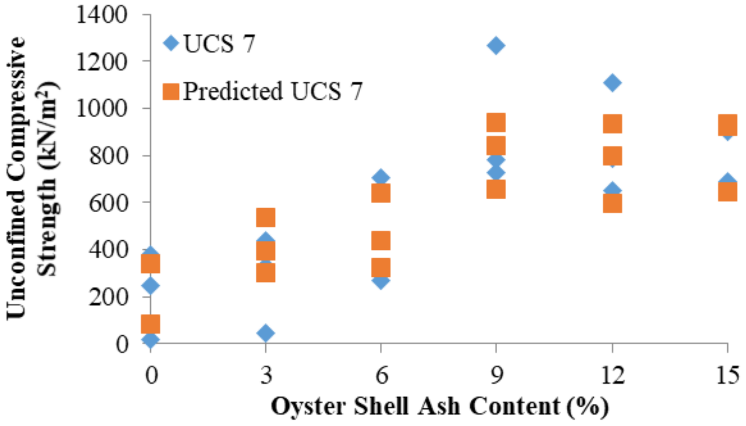

Figure 7 UCS of lateritic soil - OSA mixtures using line fit plot.

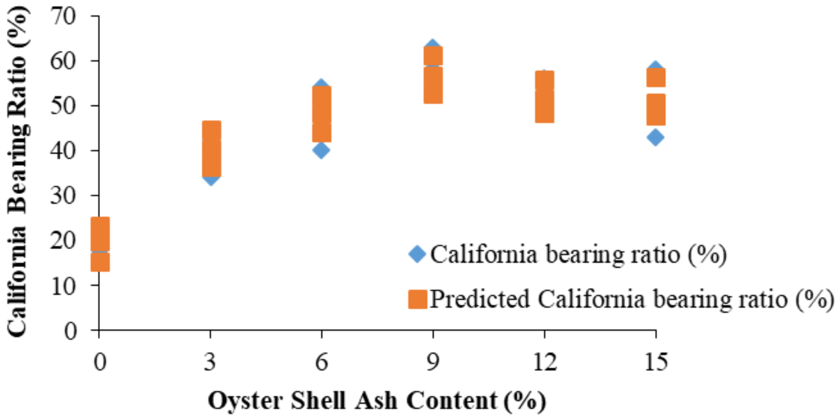

Figure 8 California bearing ratio (unsoaked) of lateritic soil – OSA mixtures using line fit plot

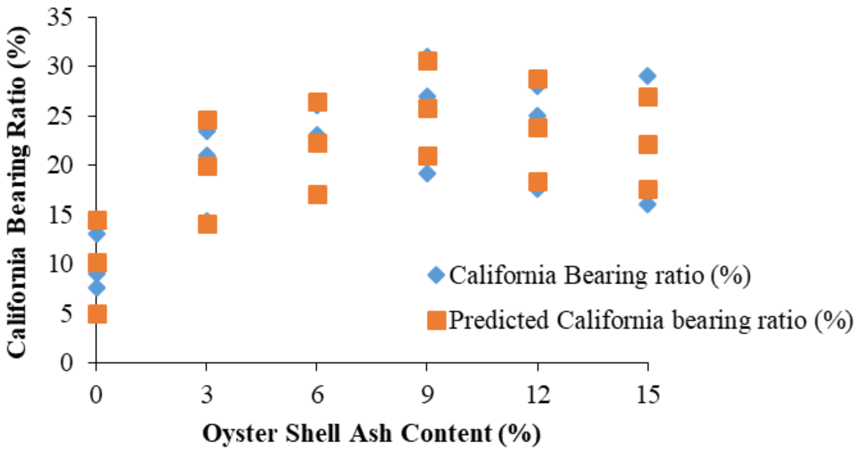

Figure 9 California bearing ratio (soaked) of lateritic soil – OSA mixture using line fit plot

3.6.2. Regression analysis for California bearing ratio (unsoaked and soaked)

Regression equation for California bearing ratio (unsoaked and soaked) are presented in equations 2 and 3 correspondingly. Result of regression analysis show that all the parameters considered have effect on the unsoaked CBR of the treated soil with correlation coefficient value of R^2 = 92.7 % (see equation 2). The coefficients of each parameter reveal the magnitude of the effect of the parameter on the unsoaked CBR. OSA and MDD have positive coefficients which depict the fact that increase in these parameters (OSA and MDD) will lead to improvement in unsoaked CBR of the compacted soil. Similarly, the OMC, PF, PI and CE have negative coefficients, which depict decrease in unsoaked CBR with increase in these variables.

The line fit plot (see Figure 8) shows relationship between measured and predicted unsoaked CBR values with respect to the influence of OSA on the unsoaked CBR of compacted lateritic soil- OSA mixtures. It is evident from the fit line plot that the model produced almost a perfect prediction of unsoaked CBR from measured laboratory values with most of the points(i.e. for predicted and measured values) on the line fit plot (see Figure 8) overlapping each other. This agrees with ANOVA results above which shows significant improvement on the unsoaked CBR with OSA content.

$$CBR_{Unsoak} = 141 + 1.26\,OSA + 9.2MDD - 0.92OMC - 1.58PF - 2.11PI - 2.47CE \qquad R^2 = 92.7 \tag{2}$$

Regression analysis for soaked CBR (see equation 3) show that all the parameters considered have effect on the soaked CBR of the stabilized soil with correlation coefficient value of R^2 = 94.6 %. The coefficients of each parameter reveal the extent of influence of the parameter on the soaked CBR. OSA, MDD and OMC have positive coefficients which depict the fact that increase in these parameters (OSA, MDD and OMC) will lead to the enhancement in soaked CBR of the compacted soil. On the other hand PF, PI and CE have negative coefficients, which depict decrease in soaked CBR with increase in these variables. The line fit plot (see Figure 9) shows relationship between the measured soaked CBR values in the laboratory and the predicted values from the regression model, with respect to the effect of OSA on the soaked CBR of compacted lateritic soil- OSA mixtures. It is evident from the fit line plot that the model overestimated the soaked CBR with most predicted soaked CBR being higher than the measured laboratory values in most of the points (i.e. for predicted and measured values) on the line fit plot (see Figure 9) overlapping each other. This agrees with ANOVA results above which shows significant improvement on the soaked CBR with OSA content.

$$CBR_{Soak} = 33 + 0.475OSA + 19.1MDD + 0.48OMC - 0.909PF - 0.938P - 4.01CE \qquad R^2 = 94.6\,\% \tag{3}$$

4. Conclusion

After performing various laboratory tests on the test soil, an elaborate understanding on the effect of compaction energies on the strength parameters and durability of oyster shell ash-lateritic soil mixtures has been accomplished. In the course of this present study, statistical tests were also engaged on the strength parameters. The studied soil mixtures was judged via index tests, compaction tests, strength tests by means of BSL, WAS and BSH compactive energies. Furthermore, the strength tests considered during this experimentation are CBR and UCS of the soil mixtures. Also, the durability assessment of the soil–OSA mixtures was gauged via immersing soil material in water so as to determine the resistance to loss in strength. The documented outcomes for the compaction exercise revealed that the MDD decreased with corresponding increase in OMC. The result has also shown that increased compaction energy brought about an expected increase in dry density with lower moisture content. For the various soil treatment protocols considered, the strength properties generally increased with higher compactive effort and curing time. Lastly, it is noticeable that OSA content, compactive energy (CE), plasticity index (PI) and percentage fine content (PF) could have serious consequence on the strength properties of lateritic soil if not carefully controlled in the field. For that reason, these parameters should be strictly monitored during ground improvement for engineering construction.

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