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Performance Assessment of Oyster Shell Powder Laterite Stabilization

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ABSTRACT

The effect of oyster shell powder (OSP) on California bear ratio (CBR) of stabilized lateritic soil has been thoroughly expressed. The lateritic soils used in this study were classified as A-2-6 and A-2-7 soils based on AASHTO System of classification. The study was to monitor the variation of CBR for unsoaked and soaked conditions on OSP stabilized lateritic soil. These were carried through laboratory investigations. The results showed that there was a significant improvement of the CBR values which increases as the OSP content increases for both unsoaked and soaked condition. The values were subjected to emperical application that generates an expressed model to predict CBR values from OSP stabilized latertic soil. The developed model generated theoretical values that were compared with other experimental values, both parameters developed best fits validating the model for CBR.. Experts will definetely apply these concept to monitor the strenght of stabilized latertic soil in the study location.

KEYWORDS: predicting, CBR, lateritic soil and oyster shell powder.

1.INTRODUCTION

Pavement designers have always been searching for technical and economical solutions for roadway applications. Soil stabilization technique, which is normally used or the improvement of local soils, is considered an economical solution in places where granular materials are not available (Portelinha, et al 2012). Hydrated lime and Portland cement have been considered excellent stabilizers for the improvement of different soils and have been extensively used in the past decades. Beneficial effects of compacted soil-lime and soil cement mixtures on geotechnical properties have been discussed in the technical literature (Herrin & Mitchell, 1961; Moh, 1965; Kennedy et al. 1987; Bhattacharja et al. , 2003; Felt & Abrams, 2004; Galvão et al. , 2004;; Osinubi & Nwaiwu, 2006; Consoli et al., 2009; Sariosseri & Muhunthan, 2009; Cristelo et al. 2009). Ordinarily, these stabilizers can promote plasticity reduction, grain size distribution alterations caused by flocculation reactions, and expressive mechanical strength increase.

The most widely used additive in Rivers state, Nigeria is cement. Cement is a binding material made primarily from finely ground clinker, a manufactured intermediate product that is composed predominantly from hydraulically active calcium silicate minerals formed through high temperature burning of limestone in a kiln. This process requires significant emissions of in particular carbon dioxide but also nitrogen oxide, sulphur oxide and particulates. This makes the cement industry one of the top two manufacturing industry source of greenhouse gases which depletes the ozone layer thereby causing climate change and environmental degradation. This negative impact of cement production on the environment has led to the intense research of alternative materials to cement in order to reduce its consumption thereby reducing its demand.

Also, over the years, the cement industry in Nigeria has grown but still has not been able to fully meet the demands of the Nigerian economy. The gap between the demand for cement and local production has always been met by importation of the product. With the continual depletion of the country's foreign exchange reserve, the continual importation of cement to meet local demand adds more strain to the already poor situation of the county which impact negatively of the nation's economy. The use oyster shell powder will help in reducing the gap between the demand for cement and local production as an alternative to cement, this will boost the economic by reducing the pressure on the foreign exchange. Oyster is a saltwater sessile (immobile) mollusk that is commonly found clinging onto shipwrecks, debris and harbor walls. Chemical and microstructure analysis reveal that oyster shells are predominantly composed of CaO (Yoon et al, 2013), similar to that of lime, which has been used in soil stabilization. With similar chemical composition with lime, oyster shell waste can be successfully used in soil stabilization for road construction. The recycling of the waste in this form will help to reduce if not totally solve the environmental challenges faced by the communities due to the presence of the waste, reduce the pressure of cement demand which will lead to reduction of environmental degradation caused by cement production and foreign exchange demand needed to import the shortfall in cement production and demand.

2. MATERIALS AND METHOD

The soil samples used in this study were collected from different locations in Eleme, Khana, Ikwerre, Ogba-Egbema-Ndoni, and Ahoada-East Local Government Areas of Rivers State, southern Nigeria. Oyster shells used in this study were collected from a refuse dump Oba-ama a coastal town in Okrika Local Government Area of Rivers State. The samples were washed to remove any dirt, dried and grounded to powder form using an industrial grinder in Port Harcourt.

The sieve analysis, liquid limit, plastic limit and compaction tests were conducted in accordance to BS 1377 (1990) methods of testing soils for civil engineering purposes for the purpose of identification of the lateritic soils and the result presented in Table 1.

In specimen preparation, the method adopted in preparing the test specimen was in accordance with the CBR test method as described in "BS 1377" and standardized under "AASHTO designation T 193". Compacted soil sample were prepared in the CBR standard mould and at the optimum moisture content, earlier determined from compaction test. The CBR was determined by conducting a load - penetration test on the unsoaked and soaked samples at each of the percent OSP additions. For the soaked condition test, the base-plate and 4.5 kg of masses was placed on top of the compacted soil inside the mould, and the entire apparatus was immersed under the water in the soaking tank. The soaked index measuring tripod was attached on top of the immersed apparatus and the initial data was recorded. The soaked index was recorded after 24 hours. The apparatus was then removed from the soaking tank. The plate and collar of the mould was removed, but keeping the surcharge weight. The apparatus was placed under the penetration piston of the loading device. The loading device was initialized and the load at every 0.25 mm of deformation was recorded until 7.5 mm of deformation was achieved. Afterward, the mould was reversed and the load at various deformations was determined for the reversed side (bottom) of the specimen. The specimen was then removed from the loading device, and a small portion of sample was collected for the determination of the moisture content of the specimen after the CBR test. The CBR (both unsoaked and soaked) test was carried out on the natural soils and the modified soils (in varying percentages). The tabulated results of the CBR value of various samples of OSP modified lateritic soil in varying percentages are shown in Tables 2 – 13 and the graph of CBR value against percent of OSP of various samples are shown in figure 1 – 5

3.RESULTS AND DISCUSSION

Results are presented in tables including graphical representation of Unsoaked and soaked California bearing ratio [CBR]

Table 1: Physical properties of lateritic soil

Sample	Properties						
	%age Passing Sieve No. 200	LL (%)	PL (%)	PI (%)	MDD Kg/m^3	OMC (%)	AASHTO Classification
1	37.4	32	200	12.0	1733	18.4	A-2-6
2	47.1	43	29.8	13.2	1492	27.1	A-2-7
3	45.8	43	27.8	15.2	1585	25.6	A-2-7
4	36.0	44	29.1	14.9	1749	17.9	A-2-7
5	43.3	29	15.5	12.5	1904	12.4	A-2-7

The lateritic soils are classified as an A-2-6 and A-2-7subgroup soils based on the American Association of State and Highway Transportation Officials Soil Classification System (AASHTO, 1986).

Table 2: CBR (unsoaked condition) test results of Lateritic soil samples

Percentage of OSP	Sample				
	1	2	3	4	5
0	5.46	12.97	4.53	5.53	13.41
2	9.86	15.28	9.80	8.76	16.67
4	13.22	18.62	14.12	12.98	21.96
6	16.67	24.00	19.51	15.23	24.14
8	21.13	26.58	23.77	20.67	27.38
10	25.76	32.05	26.12	24.94	32.78

Table 3: CBR (soaked condition) test results of Lateritic soil samples

Percentage of OSP	Sample				
	1	2	3	4	5
0	2.61	9.94	2.75	2.75	10.58
2	5.32	12.87	6.72	6.94	13.90
4	8.06	16.46	12.08	10.96	17.95
6	13.32	21.77	14.34	13.18	21.14
8	16.74	23.95	18.68	18.52	24.38
10	20.96	29.86	22.84	22.85	30.17

Table 4: Predicted and measured CBR (unsoaked) values of sample 1

Percentage of OSP	Predicted values (%)	Measured values (%)
0	7.34	5.46
2	11.59	9.86
4	16.24	13.22
6	21.28	16.67
8	26.73	21.13
10	32.56	25.76

Table 5: Predicted and measured CBR (unsoaked) values of sample 2

Percentage of OSP	Predicted values (%)	Measured values (%)
0	7.34	12.97
2	11.59	15.28
4	16.24	18.62
6	21.28	24
8	26.73	26.58
10	32.56	32.05

Table 6: Predicted and measured CBR (unsoaked) values of sample 3

Percentage of OSP	Predicted values (%)	Measured values (%)
0	7.34	4.53
2	11.59	9.8
4	16.24	14.12
6	21.28	19.51
8	26.73	23.77
10	32.56	26.12

Table 7: Predicted and measured CBR (unsoaked) values of sample 4

Percentage of OSP	Predicted values (%)	Measured values (%)
0	7.34	5.53
2	11.59	8.76
4	16.24	12.98
6	21.28	15.23
8	26.73	20.67
10	32.56	24.92

Table 8: Predicted and measured CBR (unsoaked) values of sample 5

Percentage of OSP	Predicted values (%)	Measured values (%)
0	7.34	13.41
2	11.59	16.67
4	16.24	21.96
6	21.28	24.14
8	26.73	27.38
10	32.56	32.78

Table 9: Predicted and measured CBR (soaked) values of sample 1

Percentage of OSP	Predicted values (%)	Measured values (%)
0	5.88	2.61
2	9.59	5.32
4	18.71	8.06
6	18.24	13.32
8	23.18	16.74
10	28.53	20.96

Table 10: Predicted and measured CBR (soaked) values of sample 2

Percentage of OSP	Predicted values (%)	Measured values (%)
0	5.88	9.94
2	9.59	12.87
4	18.71	16.46
6	18.24	21.77
8	23.18	23.95
10	28.53	29.86

Table 11: Predicted and measured CBR (soaked) values of sample 3

Percentage of OSP	Predicted values (%)	Measured values (%)
0	5.88	2.75
2	9.59	6.72
4	18.71	12.08
6	18.24	14.34
8	23.18	18.68
10	28.53	22.84

Table 12: Predicted and measured CBR (soaked) values of sample 4

Percentage of OSP	Predicted values (%)	Measured values (%)
0	5.88	3.64
2	9.59	6.94
4	18.71	10.96
6	18.24	13.18
8	23.18	18.52
10	28.53	22.85

Table 13: Predicted and measured CBR (soaked) values of sample 5

Percentage of OSP	Predicted values (%)	Measured values (%)
0	5.88	10.58
2	9.59	13.9
4	18.71	17.95
6	18.24	21.14
8	23.18	24.38
10	28.53	30.17

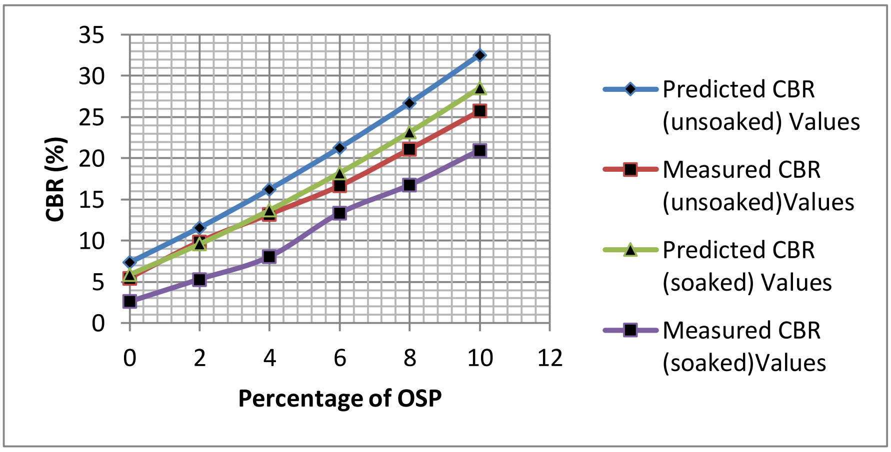

Figure 1: Effect of Percentage OSP content on CBR of sample 1

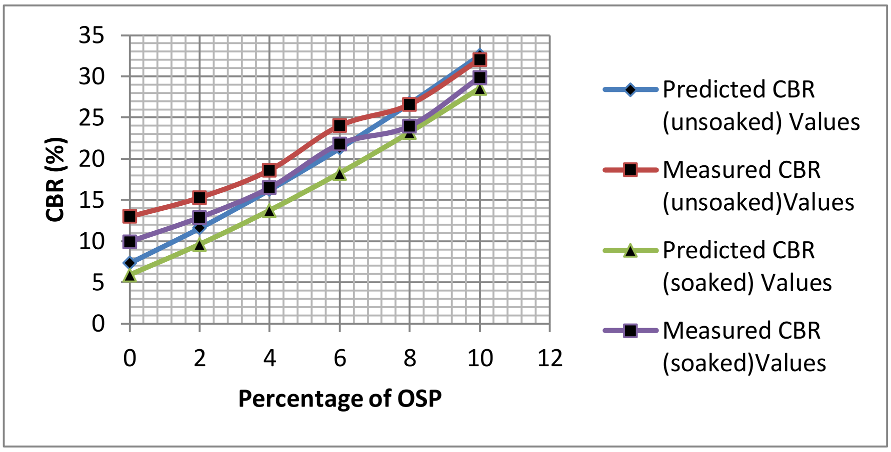

Figure 2: Effect of Percentage OSP content on CBR of sample 2

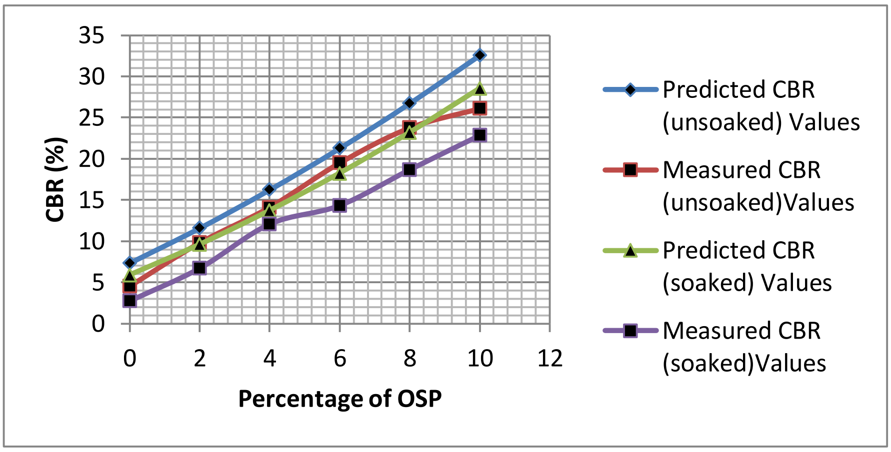

Figure 3: Effect of Percentage OSP content on CBR of sample 3

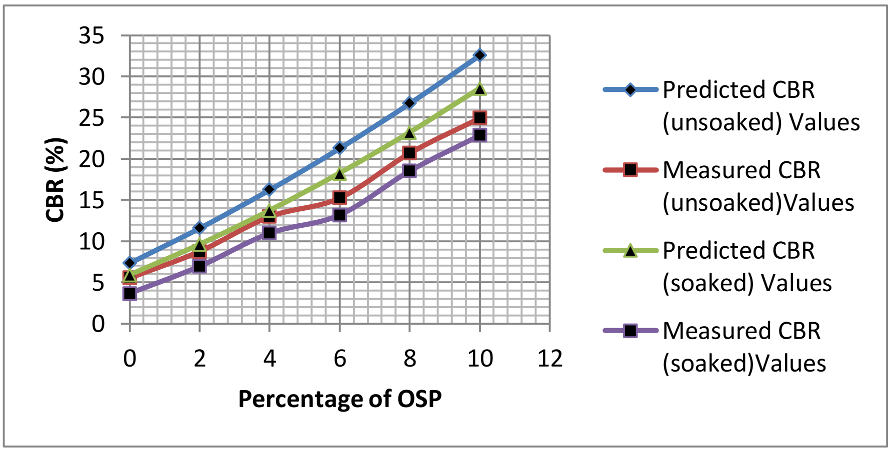

Figure 4: Effect of Percentage OSP content on CBR of sample 4

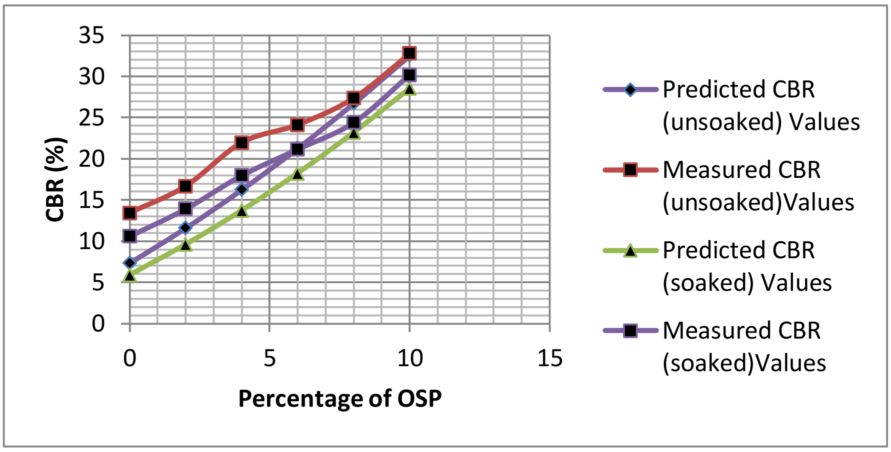

Figure 5: Effect of Percentage OSP content on CBR of sample 5

CBR value is used as an index of material strength. This method is well established and popular for design of the base and sub-base material for road pavement. The variations of CBR with the addition of OSP to lateritic soil for both unsoaked and soaked conditions were reported in Figures 1 – 5. The results of the CBR test carried out for different lateritic soil – OSP mixtures exhibit weakening in soaked conditions as compared to that of unsoaked conditions. For sample 1, the CBR (unsoaked) ranges from 5.46% to 25.76% as the percentage OSP content increase from 0 to 10% Table 2. Similar values in soaked condition increased from 2.61% and 20.96% Table 3. The higher CBR value in unsoaked condition is as a result of the capillary forces created at optimum moisture content and MDD condition in addition to the friction resisting the penetration of the plunger. However, in soaked condition, the CBR values exhibited very low due to the destruction of the capillary forces. The same observations were made for samples 2, 3, 4, and 5. For sample 2, it increased from 12.97% to 32.05%; sample 3,4.53% to 26.12%; it increased from 5.53% to 24.95% for sample 4; sample 5, it moved up from13.41% to 32.78% Figure 1 – 5 gives the graphical representation on how the CBR values for unsoaked condition varies with percentage OSP content for soil sample 1 to 5. For figure 1, it can be seen that as the OSP content increases from 0 to 10 percent, the CBR value of soil sample 1 also increases from 5.46% to 25.76% giving the graph an upward movement to the right. The same trend is repeated for soil sample 2 to 5. CBR values for soaked condition are also stated in Table 3, in Figure 1, at 0% OSP content, the CBR is 2.61% for sample 1 as the OSP content increase to 2% and increase further to 10%, the CBR value also increase from 5.32% to 20.96%. The other soil samples also showed the same pattern in CBR value increase as the OSP content increases. Figure 1 – 5 gives the variation between the CBR (soaked) values of soil sample 1 to 5. It can be observed that the graphs all follow the same trend moving upward to the right confirming the increase in CBR as OSP content increases. This is consistent with other observations by (Ghosh and Subbarao, 2006 and Mackos et al., 2009). The increase in CBR value after addition of OSP is due to the formation of various cementing agents due to pozzolanic reaction between the amorphous silica and / or alumina present in natural soil and OSP. This reaction produces stable calcium silicate hydrates and calcium aluminate hydrates as the calcium from the OSP reacts with the aluminates and silicates solubilized from the clay. Microsoft excel program was used to develop an equation that relates the CBR values of lateritic soils for unsoaked condition and percentage OSP content.

$$B_u = 0.00496p^2 + 2.0264p + 67.3397 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. \ 1$$

Where:

B_u = CBR (unsoaked condition)

p = Percentage of OSP

The same program was also used to develop an equation that relates the CBR values of lateritic soils for soaked condition and percentage OSP content.

$$B_s = 0.0513p^2 + 1.7527p + 5.8756 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. \ 2$$

Where:

B_s = CBR (soaked condition)

p = Percentage of OSP

Equation 1 was used to predict the CBR values of lateritic soils for unsoaked condition. The R^2 value was determined to be 99.42% which indicates a strong positive correlation between the predicted and the measured CBR values. The same strong positive correlation was also observed for soaked condition in Equation 2 which has a R^2 of 99.66%. The predicted and measured CBR values (unsoaked and soaked conditions) were compared in Tables 4 – 13 and in Figure 1 – 5, it can be seen that that the predicted and measured values are close and their graphs follow the same trend. These observations verifies equation 1 and 2, that they can be used to predicted CBR values for unsoaked and soaked conditions for lateritic soil – OSP mixtures respectively.

4. CONCLUSION

According to the Nigerian specification for road sub-base material, a CBR (soaked) value of ≥ 25% is acceptable while AASHTO the recommended value is ≥ 30%. The CBR results show that the lateritic soil samples used in this study fail to meet this requirement in their natural state. But when the lateritic soil samples were stabilized at 8 and 10% OSP, the specification requirement was achieved. This goes to prove that the OSP can be successfully used in the stabilization of lateritic soils.

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