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Predicting The Effect on California Bearing Ratio of Laterite Modified with Oyster Shell Powder

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ABSRACT
The effect of california bear ratio for modifield lateritic soil with oyster shell has been tholroughly expressed. The study were to monitor the variation of californaia bearing ratio on modified lateritic soil with oyster shell, these were carried through laboratort investigationbs, the values were sujected to emperical application that generates an expressessed model to predict [CBR] strength from mofdield latertisc soil with oyster shell, such modification developed the maximium strength for [CBR] at ten percent dosage of oyster shell powder,, 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 modifild latertic soil in the study location.

Keywords: predicting, [CBR] lateritic soil and oyster shell powder

I. 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 availablePortelinha, et al 2012. Hydrated lime and Portland cement have beenconsidered 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; Kolias et al. 2005; 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. Thereby, benefits of the soil stabilization for pavement applications can be available since the construction phase until to the final product.The chemical composition and mineralogy of Laterite soils is derived from the constituents of the parent rocks through the formation process. The constituent clay minerals are bound together by the oxides and hydroxides of iron and aluminum. The cementation forms a coating for the clayey constituents of the soil and further bound them into coarser aggregations which suppress the normal behavior of clay (Townsend et al., 1973), and determines the resistance to degradation of the soil grains (Malomo, 1989). Laterite soil chemistry and mineralogy is shown by studies to greatly influence the geotechnical properties, and in certain circumstances, significantly affects the economic potential in the construction industry (Ogunsanwo, 1995). Townsend et al., (1973) describes the amorphous allophonic constituents as largely responsible for the exhibited physicochemical behavior of the soil, because of the large specific surfaces and high moisture-retention capabilities characteristic of these materials. This is confirmed by the crystallization of accumulated sesquioxides in the pore spaces which leads to bonding of soil elements and the formation of concretionary structure (Malomo, 1989). Studies reveal that mineralogy has very good correlation with the degree of weathering, as kaolinite content is high in early stages of weathering and decreases with increasing weathering; whereas the amount of sesquioxides increases (Tuncer and Lohnes, 1977). Furthermore, the silica/sesquioxide ($SiO_2/R2O_3$) ratio provides a possible means of predicting the engineering characteristics of lateritic soils

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(Townsend et al., 1973), and the presence of iron gives it the reddish color.Generally, residual soils are composed of Silica (SiO_2), Aluminum Oxide (Al_2O_3), Iron-III-Oxide (Fe_2O_3), Tin oxide (TiO_2), Magnesium Oxide (MgO), Calcium Oxide (CaO), Sodium Oxide (Na_2O), Potassium Oxide (K_2O), and Copper (Cu). Others are Feldspar, Quartz, Kaolinite, Muscovite, Goethite, Montmorillonite and traces of other clay minerals as may be found in the parent rock underlining the lateritic soil formation. However, the proportions of these elements vary vertically and horizontally in any given formation, as while as, from region to region. An example of the influence of weathering on the chemical composition is the Iron-Oxide content, which is low in the lateritic shale (skeletal arrangement) but comparatively high in the sandstone (matrix arrangement) laterites (Madu, 1976 and Malomo, 1989).The physical properties of residual soil vary from region to region due to the heterogeneous nature and highly variable degree of weathering controlled by regional climatic and topographic conditions, and the nature of bedrock, (Nandi, 1988, Rahardjo et al., 2004). Studies have revealed that the variation in the properties of lateritic soils is greatly influenced by large amount of tropical rainfall combined with hot and climatic conditions which penetrates deep into the bedrock to a varying degree. Consequently, the physical properties of laterite soil vary vertically and horizontally with depth and from region to region. Research, (Tuncer et al., 1977 and Rahardjo et al., 2004), conducted on the effect of weathering on the physical properties of Laterite

II. MATERIALS AND METHOD

California bear ratio (CBR) Test

The CBR test an empirical test originally developed by O.J. Porter for the California Highway Department during the 1920s. The CBR test evaluates the shearing resistance or strength of the soil. It is simply the resistance to penetration of 2.54mm of standard cylindrical plunger 49.6mm diameter expressed as a percentage of the known resistance of the plunger to various penetrations in crushed aggregates notably 13.4KN at 2.5mm penetration and 20.2KN at 5.0mm penetration (Emesiobi F.C., 2000). Though the test originated in California, the California Department of Transportation and most other highway agencies have since abandoned the CBR method of pavement design. In the 1940s, the US Army Corps of Engineers (USACE) adopted the CBR method of design for flexible airfield pavements. The USACE and USAF design practice for surfaced and unsurfaced airfields is still based upon CBR today (Emesiobi F.C., 2000). Presently in Nigeria, the CBR method is still widely used in flexible pavement design.In the laboratory the CBR test was carried out 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 slag 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 graph of CBR value against percent of OSP of various samples is shown in chapter 4 and the tabulated results of the CBR value of various samples of OSP modified lateritic soil in varying percentages

III. RESULTS AND DISCUSSION

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

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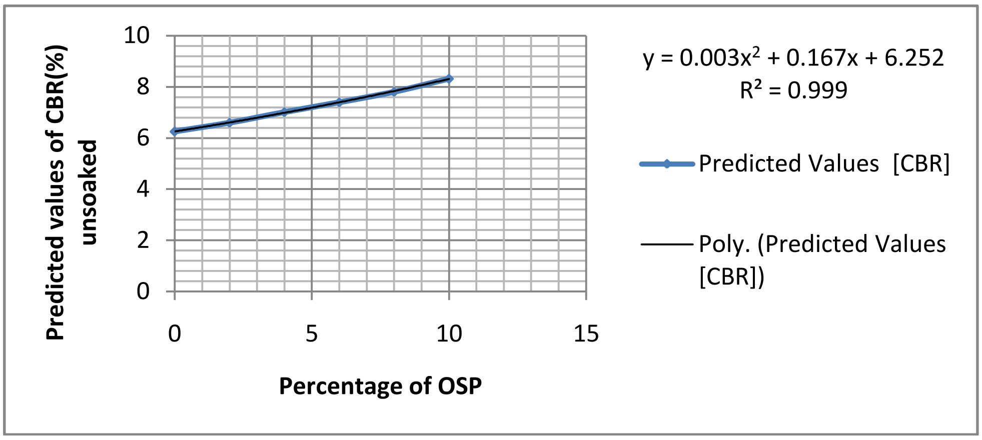

Figure 3.1: Effect of Percentage OSP content on CBR (Unsoaked) value of lateritic soil

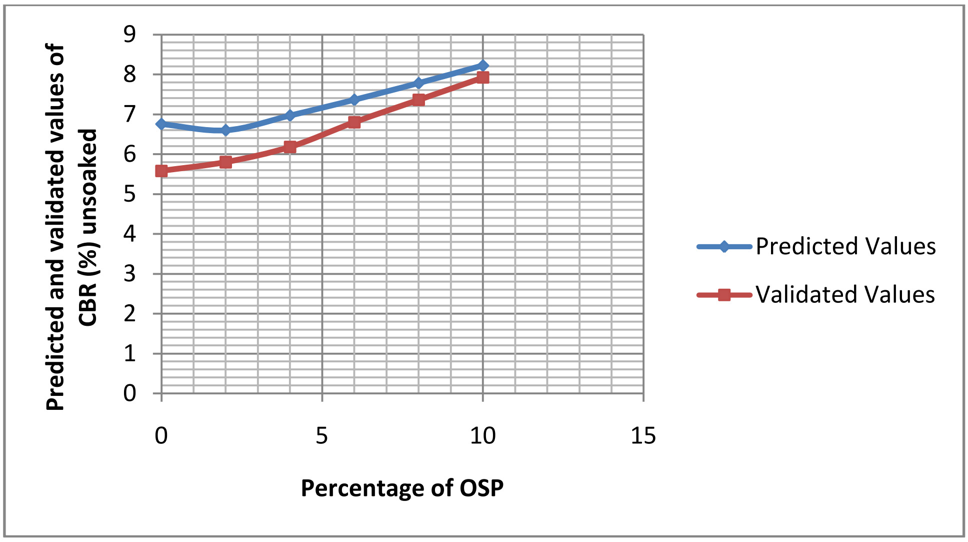

Figure 3.2: Effect of Percentage OSP content on CBR (Unsoaked) value of lateritic soil sample 11

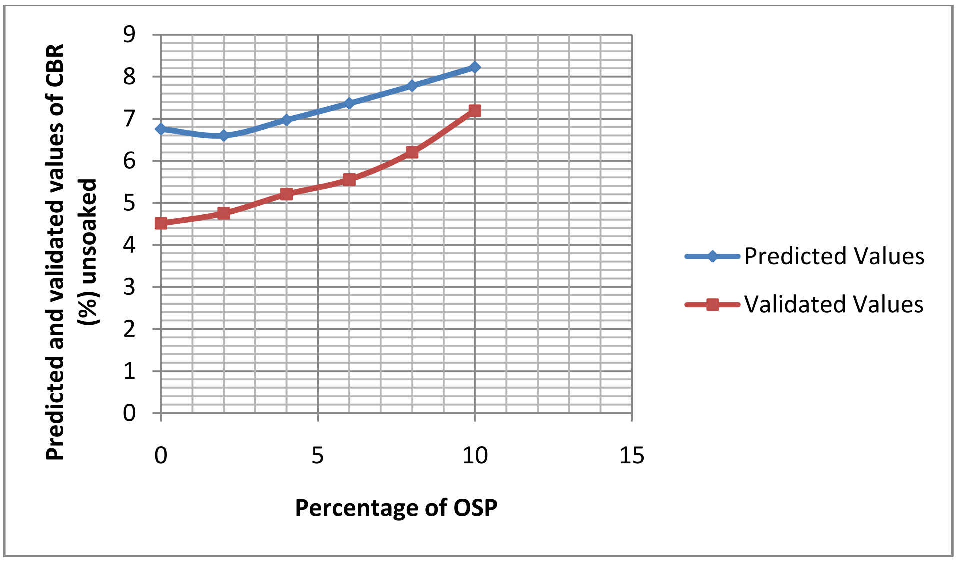

Figure 3.3: Effect of Percentage OSP content on CBR (Unsoaked) value of lateritic soil sample 12

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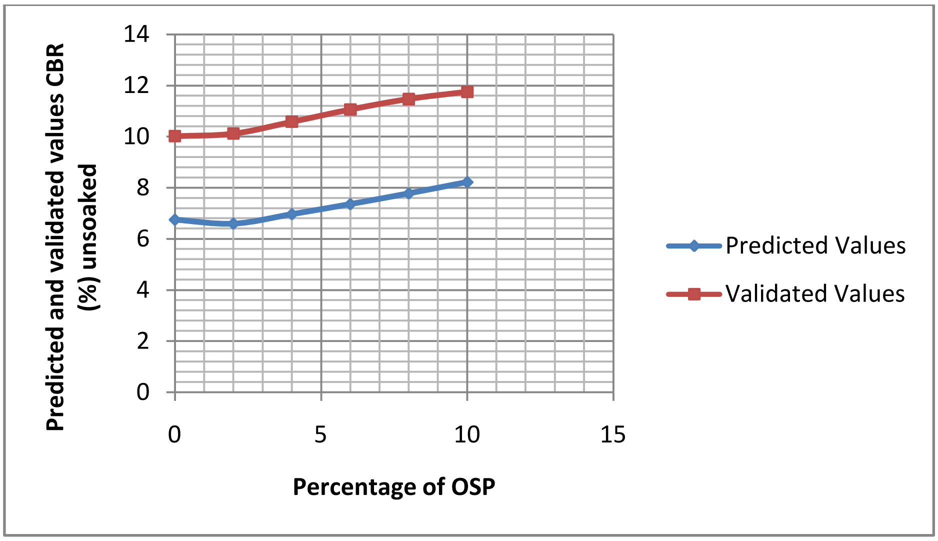

Figure 3.4: Effect of Percentage OSP content on CBR (Unsoaked) value of lateritic soil sample 13

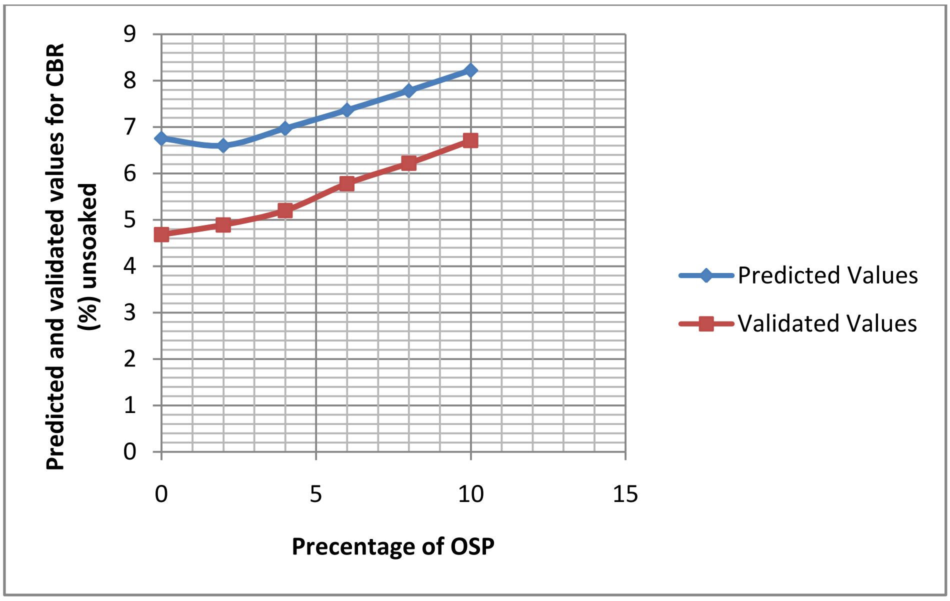

Figure 3.5: Effect of Percentage OSP content on CBR (Unsoaked) value of lateritic soil sample 14

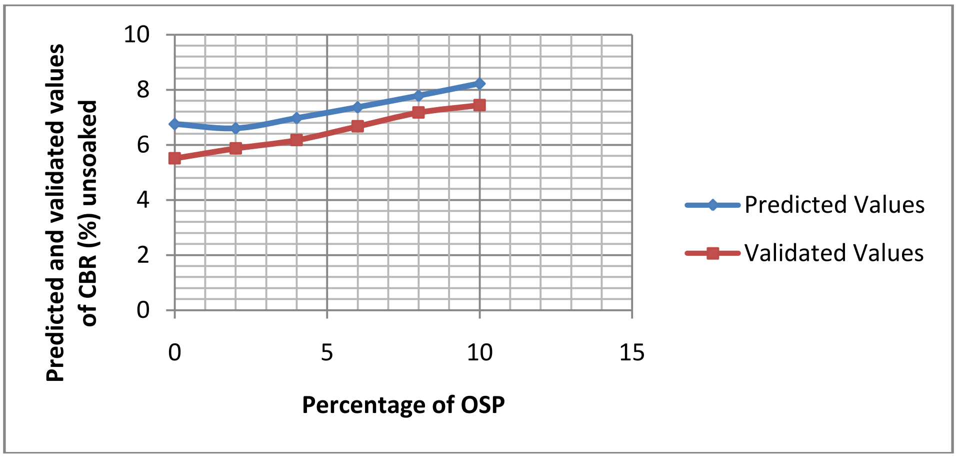

Figure 3.6: Effect of Percentage OSP content on CBR (Unsoaked) value of lateritic soil sample 15

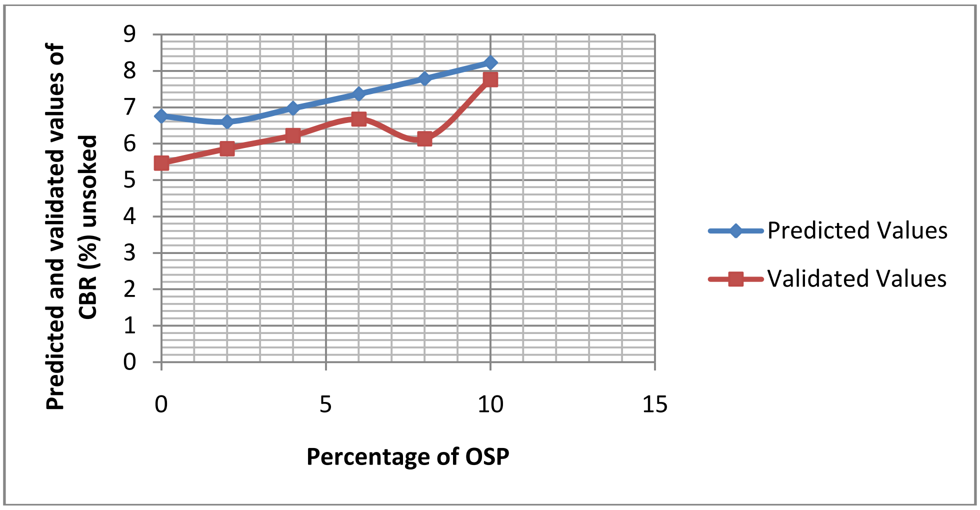

Figure 3.7: Effect of Percentage OSP content on CBR (Unsoaked) value of lateritic soil sample 16

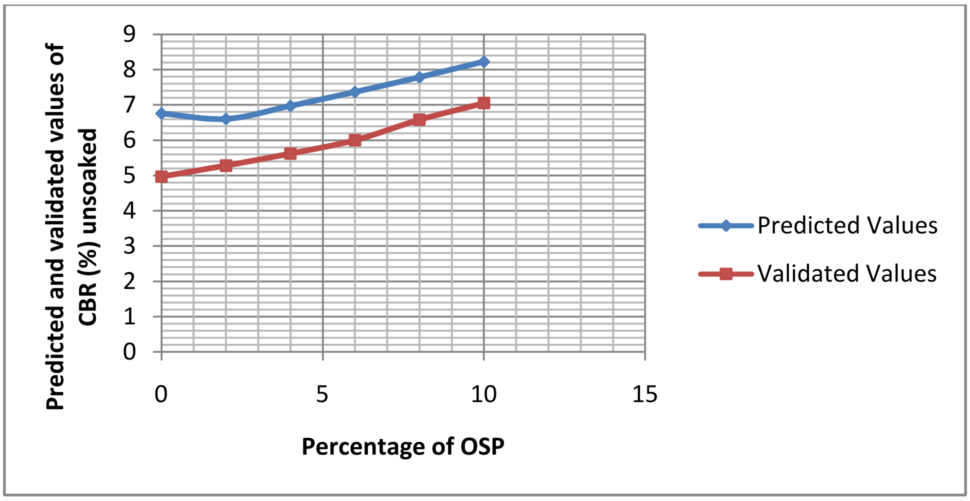

Figure 3.8: Effect of Percentage OSP content on CBR (Unsoaked) value of lateritic soil sample 17

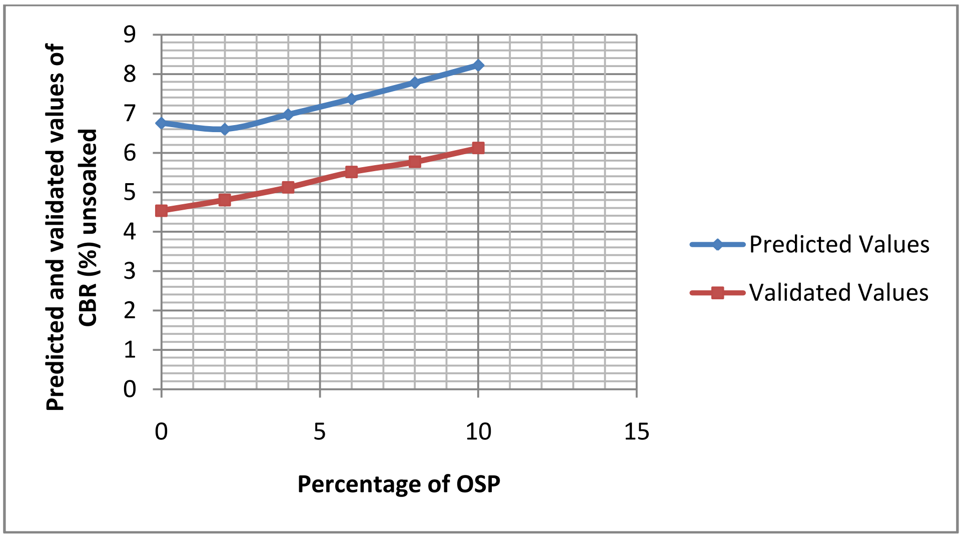

Figure 3.9: Effect of Percentage OSP content on CBR (Unsoaked) value of lateritic soil sample 18

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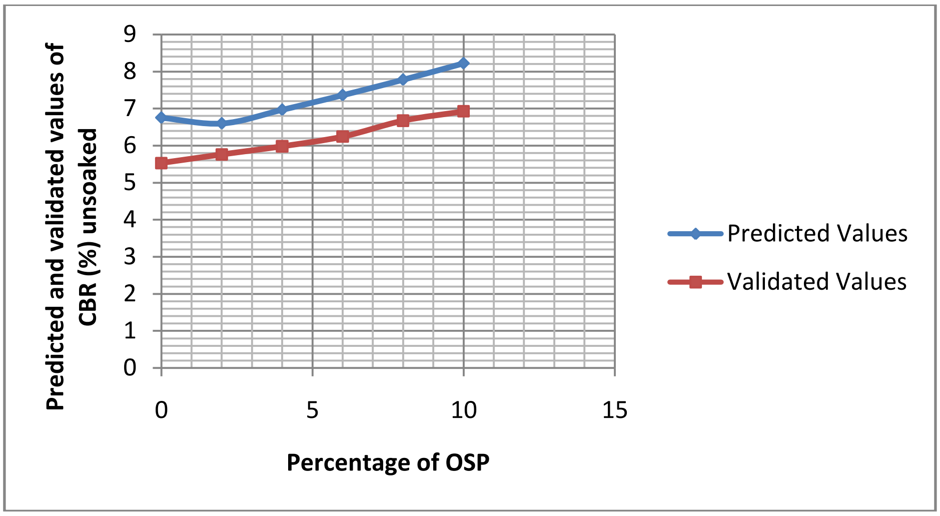

Figure 3.10: Effect of Percentage OSP content on CBR (Unsoaked) value of lateritic soil sample 19

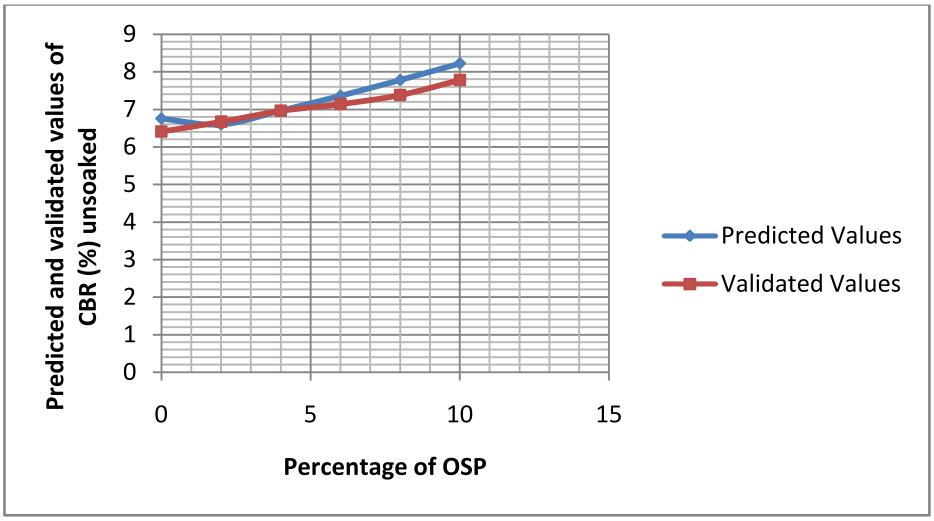

Figure 3.11: Effect of Percentage OSP content on CBR (Unsoaked) value of lateritic soil sample 20

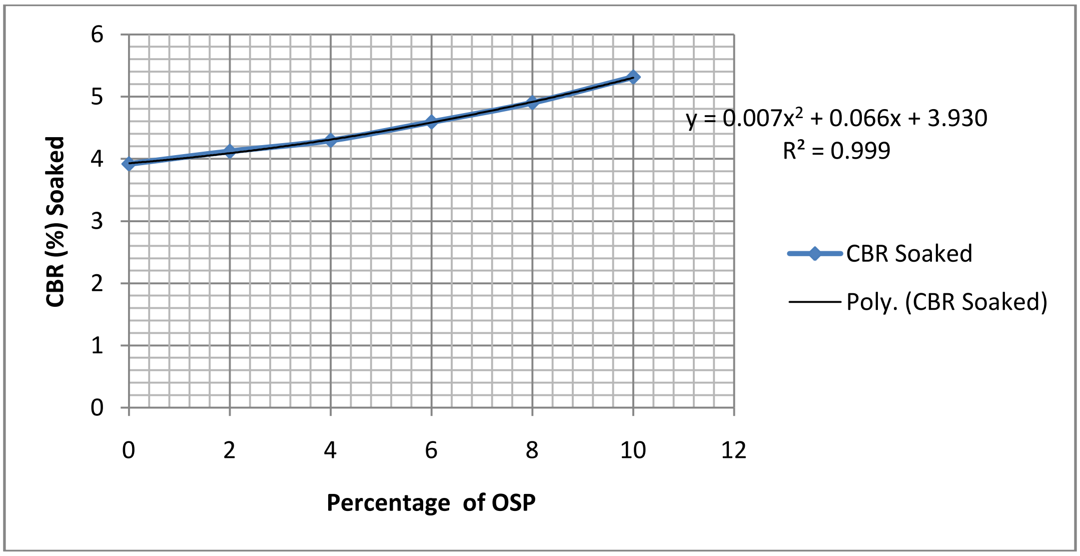

Figure 4.45: Graph of predicted CBR (soaked) value against varying percentage of OSP

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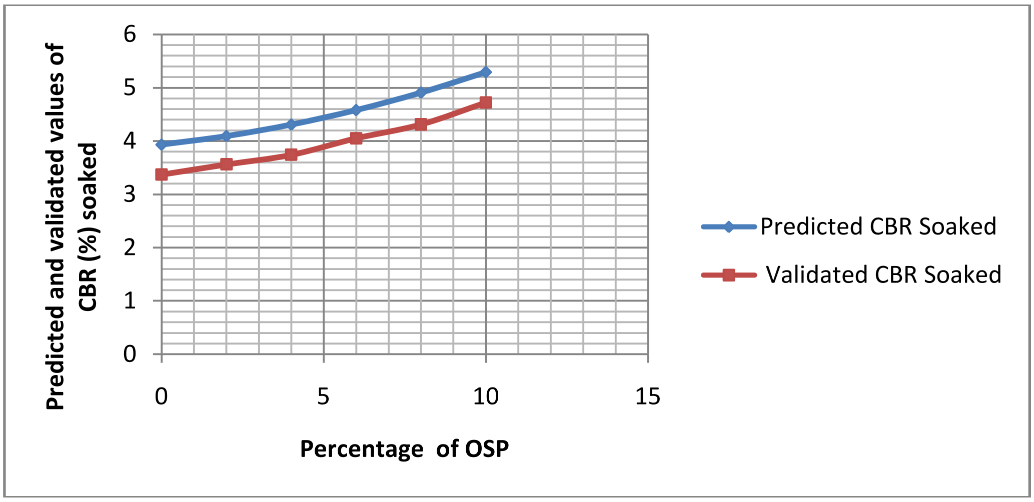

Figure 3.12: Effect of Percentage OSP content on CBR (soaked) value of lateritic soil sample 11

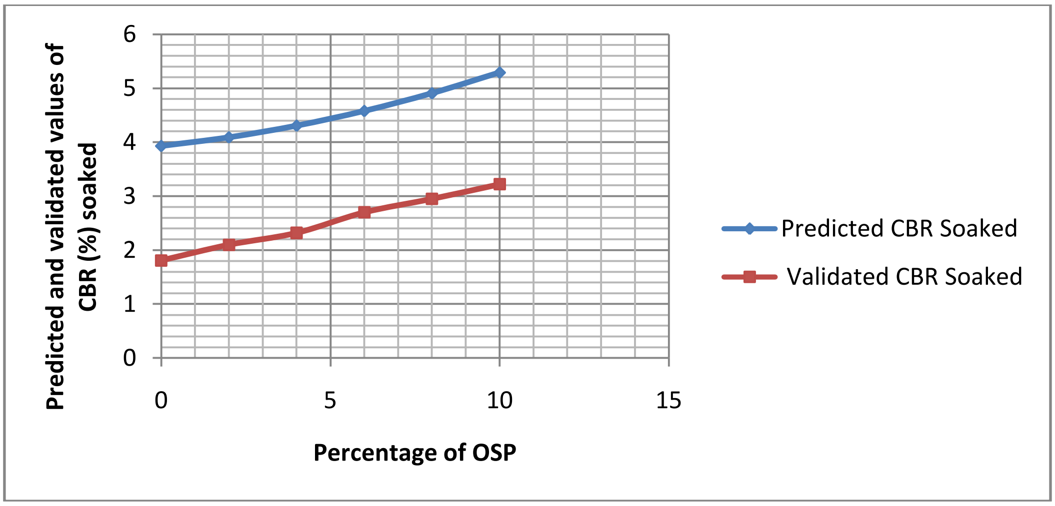

Figure 3.13: Effect of Percentage OSP content on CBR (soaked) value of lateritic soil sample 12

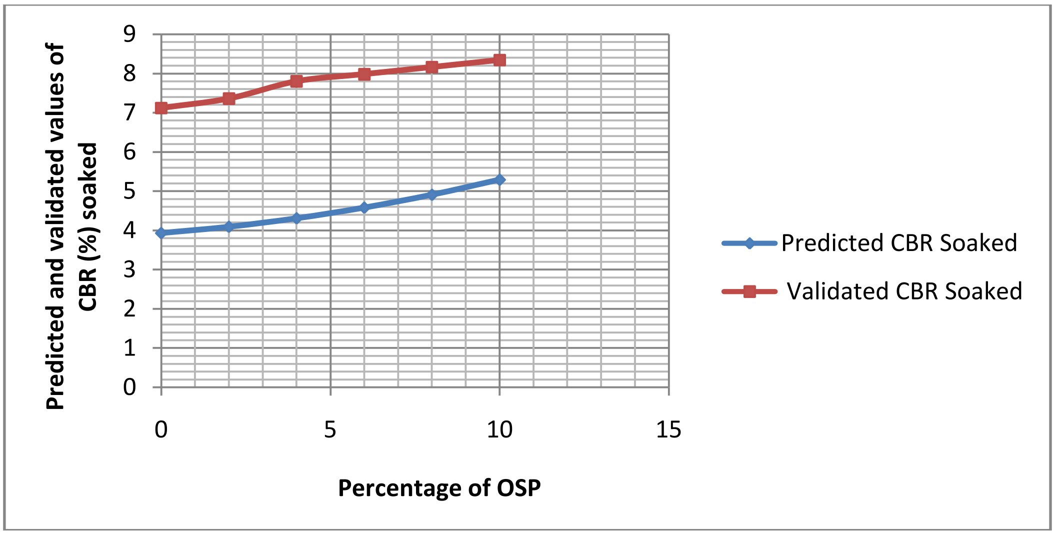

Figure 3.14: Effect of Percentage OSP content on CBR (soaked) value of lateritic soil sample 13

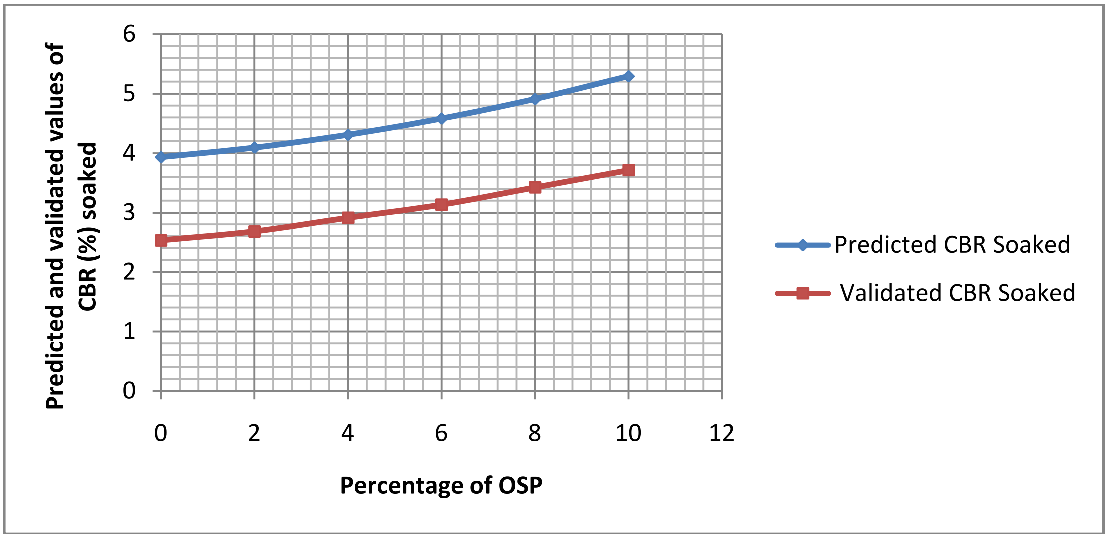

Figure 3.15: Effect of Percentage OSP content on CBR (soaked) value of lateritic soil sample 14

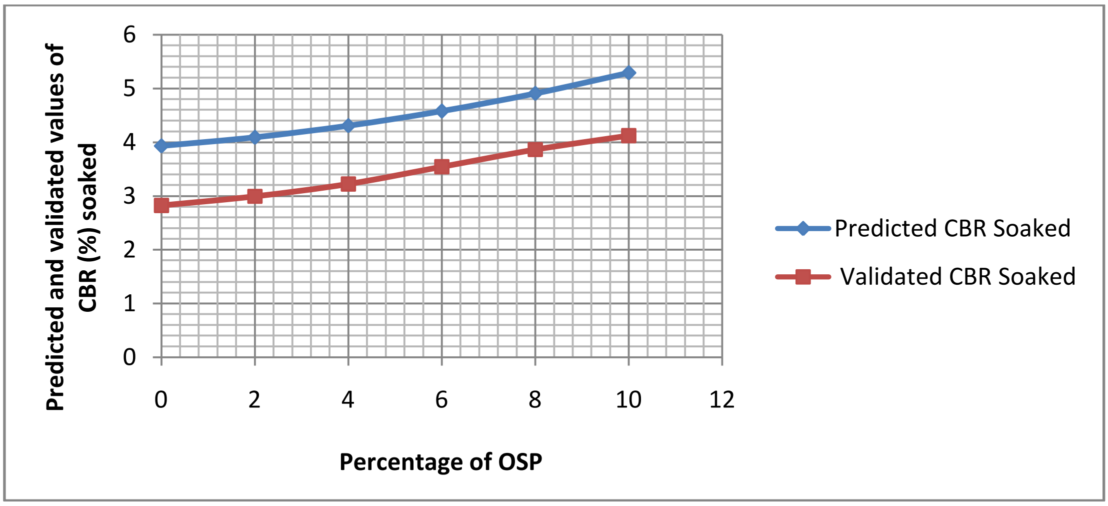

Figure 3.16: Effect of Percentage OSP content on CBR (soaked) value of lateritic soil sample 15

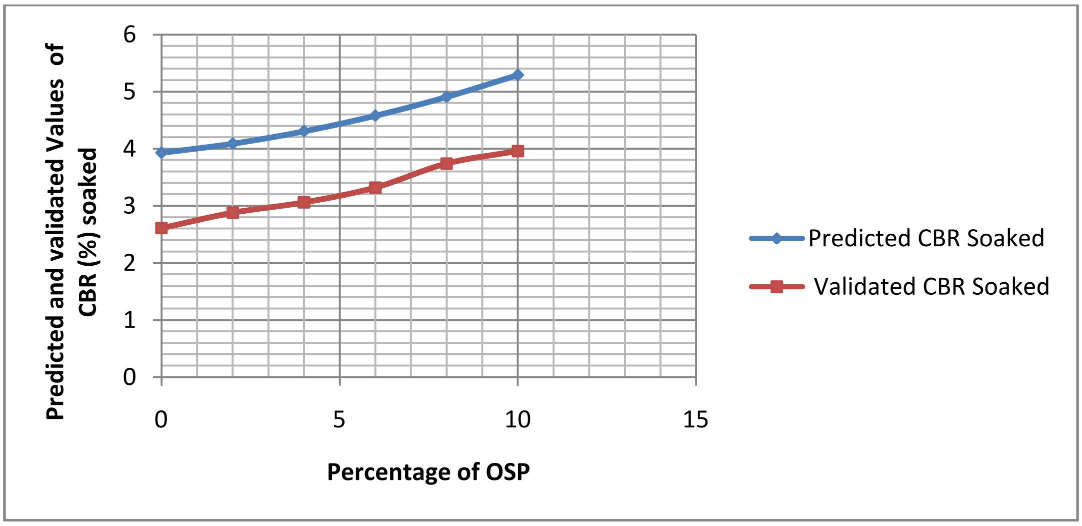

Figure 3.17: Effect of Percentage OSP content on CBR (soaked) value of lateritic soil sample 16

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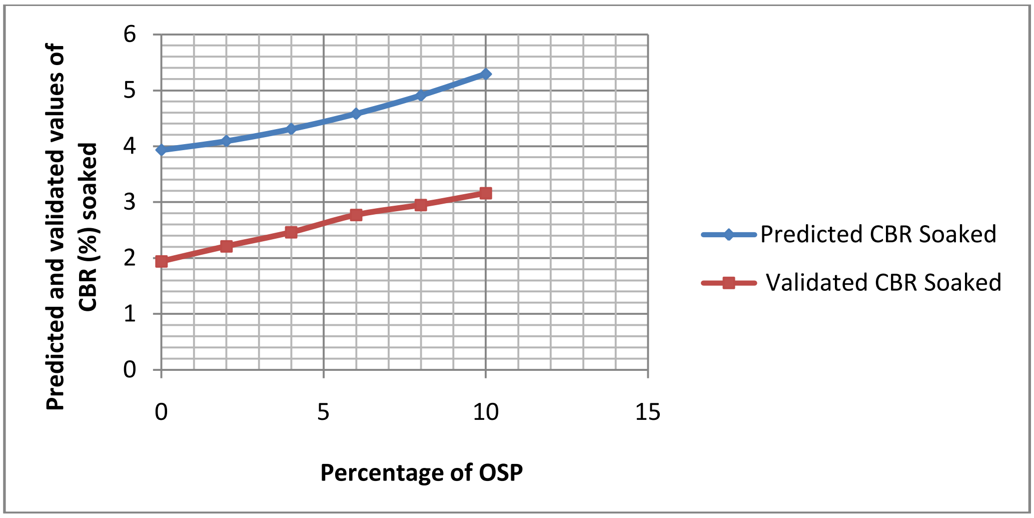

Figure 3.18: Effect of Percentage OSP content on CBR (soaked) value of lateritic soil sample 17

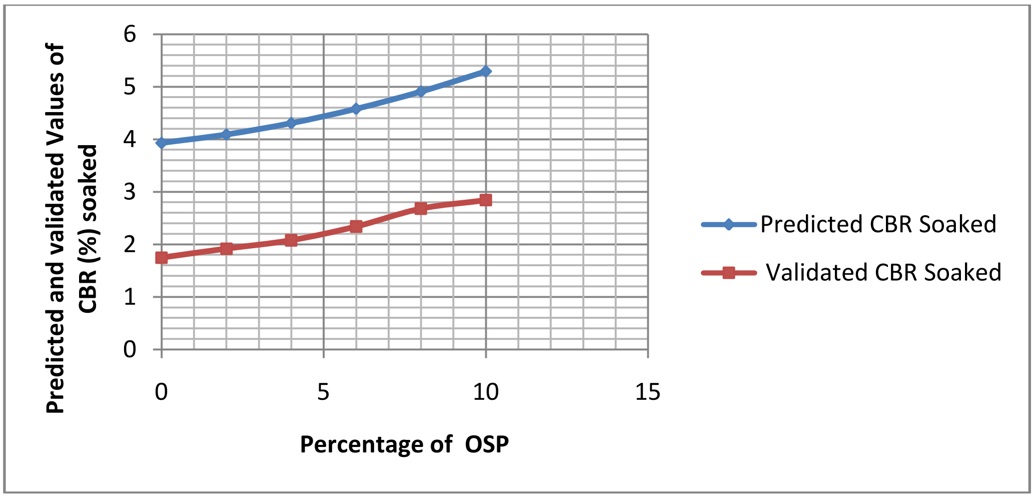

Figure 3.19: Effect of Percentage OSP content on CBR (soaked) value of lateritic soil sample 18

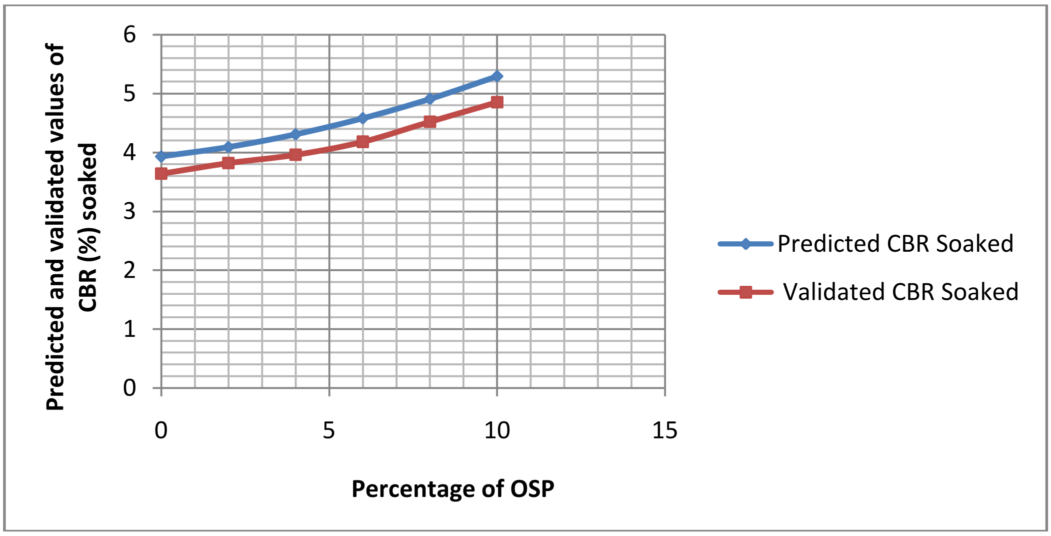

Figure 3.20: Effect of Percentage OSP content on CBR (soaked) value of lateritic soil sample 19

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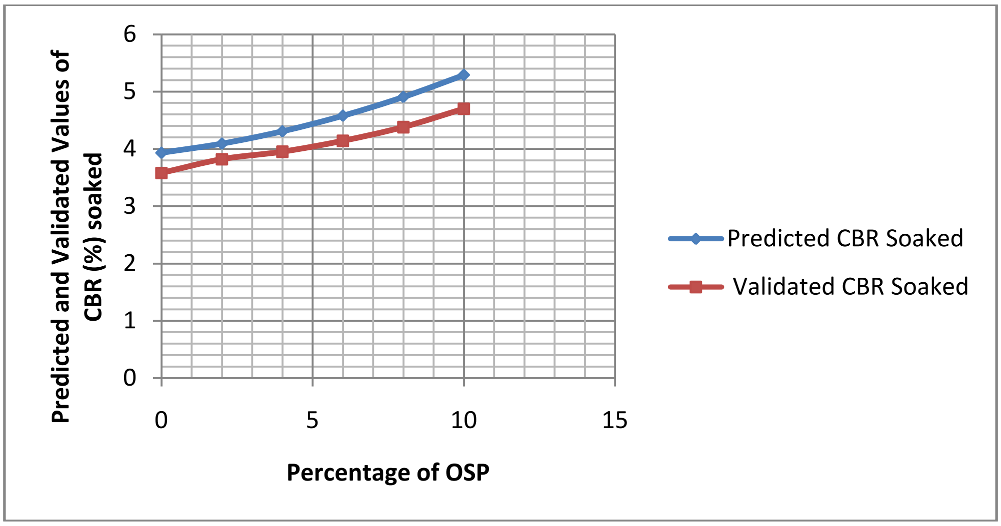

Figure 3.21 Effect of Percentage OSP content on CBR (soaked) value of lateritic soil sample 20

The Microsoft excel program was used to develop an equation that relates the CBR values of lateritic soils for Unsoaked condition and percentage OSP content.

$$y = 0.0038x^2 + 0.1671x + 6.252 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \quad 3.1$$

Equation 3.1 was used to predict the CBR values of lateritic soils for Unsoaked condition. The R^2 value was determined to be 99.94% which indicates a strong positive correlation between the predicted and the measured CBR values. Table 1e gives the predicted vales of 0 – 10% OSP content. It can be seen that the predicted CBR value increased from 6.75% - 8.22% as the OSP content increased from 0 – 10% which is the same trend as the reported measured values. The predicted and measured CBR values for unsoaked condition for lateritic soil sample 11 to 20 were compared in Table 2e to 11e and their graphs of CBR values against percentage OSP content were also compared in Figure 4.35 – 4.44. It can be seen that that the predicted and measured values are close and thee graphs follow the same trend. These observations validates equation 3.1, that it can be used to predicted CBR values for Unsoaked condition for lateritic soil – OSP mixtures

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

$$y = 0.0071x^2 + 0.0667x + 3.9305 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \quad 4.21$$

Equation 4.21 was used to predict the CBRvalues of lateritic soils for soaked condition. The R^2value was determined to be 99.9% which indicates a strong positive correlation between the predicted and the measured CBR values. Table 12e gives the predicted vales of 0 – 10% OSP content. It can be seen that the predicted CBR value increased from 3.93% - 5.29% as the OSP content increased from 0 – 10% which is the same trend as the reported measured values. The predicted and measured CBR values for soaked condition for lateritic soil sample 11 to 20 were compared in Table 213e to 11e and their graphs of CBR values against percentage OSP content were also compared in Figure 4.46 – 4.55. It can be seen that that the predicted and measured values are close and the graphs follow the same trend. These observations validates equation 4.21, that it can be used to predicted CBR values for soaked condition for lateritic soil – OSP mixtures

IV. EFFECT OF OSP ON CBR OF LATERITIC SOIL

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. In this investigation CBR tests were carried out to characterize the bearing capacity of the OSP stabilized lateritic soils.

The variations of CBR with the addition of OSP to lateritic soil for both Unsoaked and soaked conditions were reported in figures 4.35 – 4. The results of the CBR test carried out for different lateritic soil – OSP mixtures exhibit the weakening in soaked conditions as compared to that of Unsoaked conditions (see table 23e in appendix E). For the unsterilized soil, the CBR ranges from 4.51% to 10.02%, Table 23e. Similar values in soaked condition lies between 1.81% and 7.21%. 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.CBR values were determined for lateritic soils stabilized with OSP. OSP was added between 0 – 10% to observe the effect of OSP mixture. As the OSP was added each soil mixtures showed improvement in CBR values. The results presented are for soaked and Unsoaked conditions. In Unsoaked condition, the CBR value increased from 5.58% to 7.92%, an increase of 41.9% as the OSP content increases from 0 – 10% for lateritic soil sample 11. the same observations were made for other lateritic soil samples tested but they gave different percentage increase in CBR, the increase was 59.4%, 17.3%, 43.4% and 35% for soil samples 12, 13, 14 and 15 respectively for Unsoaked condition Table 23e in appendix E. Figure 4.35 – 4.44 gives the graphical representation on how the CBR values for Unsoaked condition varies with percentage OSP content for soil sample 11 to 20. For figure 4.36, it can be seen that as the OSP content increases from 0 to 10 percent, the CBR value of soil sample 12 also increases from 4.51% to 7.19% giving the graph an upward movement to the right. The same trend is repeated for soil sample 13 to 20. This is consistent with other observations by Ghosh and Subbarao, (2006), Mackos et al., (2009) and Ismaiel, (2006). 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.

CBR values for soaked condition are stated in Table 23e in appendix E, in figure 4.46, at 0% OSP content, the CBR is 3.37% for lateritic soil sample 11 as the OSP content increase to 2% and increase further to 10%, the CBR value also increases to 3.56 and further also to 4.72%, an increase of 32.6%. Other soil samples also increase in CBR value as the OSP content increases but at different percentage increase, for sample 12, 13, 14 and 15, the increase was 77.9%, 15.7%. 46.6% and 46.1 respectively. Figure 4.47 – 4.55 gives the variation between the CBR values of soil sample 12 to 20. 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.

4.1 Effect of OSP on Compressive Strenght (CS) of lateritic soil

The unconfined compressive strength test is one of the widely used laboratory tests in pavement design and soil stabilization applications. It is often used as an index to quantify the strength enhancement of materials due to treatment. The results of compressive strength tests for varying percentage OSP content stabilized soils are reported.Load bearing capacity recording were done at failure i.e. peak strength of all the samples.

The compressive strength values changed with addition of OSP and curing period. At 7 days curing, the compressive strength of lateritic soil sample 11 increases from 0.021N/mm^2 to 0.261N/mm^2, at 14 days it went up from 0.051N/mm^2 to 0.263N/mm^2, for 21 days it increased from 0.102N/mm^2 to 0.305N/mm^2 and while at 28 days it increased from 0.85N/mm^2 to 0.351N/mm^2 as the OSP content increased from 0 to 10% for each of the curing periods. It can be observed that compressive strength of soil sample 11 increased with the addition of OSP and also with the increase in the period of curing. The same observations were noticed with other soil samples tested. See Figure 4.56 – 4.66 for 7 days, Figure 4.68 – 4.77 for 14 days, Figure 4.79 – 4.88 for 21 days and Figure 4.90 – 4.99 for 28 days curing. These findings are consistence with Singh and Gosh (2006), Felt et al., (2008). The increase in compressive strength was linear up to 10% of OSP content which is the highest see Table 1f and appendix F and figures 4.36 – 4.90. The addition of OSP to the soil water system produces (Ca^{+2}) and (OH^{-}). In cation exchange, bivalent calcium ions (Ca^{+2}) are replaced by monovalent cations. The Ca^{+2} ions link the soil minerals (having negative charge) together, thereby reducing the repulsion forces and the thickness of the diffused water layer. This layer encapsulates the soil particles, strengthening the bond between the soil particles. The remaining anions (OH^{-}) in the solution are responsible for the increased alkalinity (George et al., 1992; Mallela et al., 2004; Geiman, 2005). After the reduction in water layer thickness, the soil particles become closer to each other, causing the soil texture to change. This phenomenon is called flocculation-agglomeration (Locat et al., 1990;Geiman, 2005). The silica and alumina that exist in the soil minerals become soluble and free

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from the soil when pH exceeds 12.4. The reaction between the released soluble silica and alumina and the calcium ions from lime hydration creates cementitious materials such as Calcium Silicate Hydrates (C-S-H) and Calcium Aluminate Hydrates (C-A-H). This finding is consistent with similar observations by Little et al., (1995); Eades and Grim, (1960); Eisazadeh et al., 2012). OSP content of 10% recorded the highest compressive strength for the different curing periods and 28 days curing gave the highest strength. This showed that availability of additional OSP has produced additional bonding between reactive elements.

V. CONCLUSION

The present investigation has been carried out with varying (0, 2, 4, 6, 8, and 10) percent of OSP mixed with lateritic soils and liquid limit, plastic limit, compaction California Bearing Ratio (CBR) for soaked and Unsoaked condition; the study has express the significant of California bearing ratio for design and construction of roads in deltaic environment, most of the investigation has proven the optimum strength of lateritic soil, it has also express the significance of modify lateritic soil due low strength of lateritic soil in the study area, these were developed predictive model generated from laboratory investigations, the empirical application express model that should predict the strength of the soil through California bearing ratio, the need to modify the soil with oyster shell were express from the results, experts will definitely apply these concept in monitoring and evaluation of California bearing ratio in the study area.

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