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Predicting the Compressive Strength of Submerged Soil Modified with Calcium Carbonate in Coastal Area of Ahoada

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ABSTRACT

This study monitor model development on soil characteristics for compressive strength in coastal area of Ahoada, submerged soil were observed to deposit in coastal area of Ahoada in Niger delta environment, there engineering properties are considered to be problematic components in design and construction, these are significant in terms of soil composition, gradation and strength parameters. Several experts have applied empirical solutions to generate data for stabilization of lateritic soil improved by some other substances, but modeling approach has not been applied, this has not developed any definite solution on the behaviuor of submerged soil strength in coastal environment. The study applied mathematical modeling techniques that predict submerged soil in coastal area, the study monitored the compressive strength of submerged soil modified with oyster shell, the behaviour of the oyster shell were express through the developed model simulation values, these results were validated with experimental data, and both parameters express favourable fits validating the model for the study.

Keywords: *Predicting, compressive strength, submerged soil and calcium carbonate*

INTRODUCTION

The rate of compressive strength of soil varies in various environments; the practice of road designed depends on the soil strength known as engineering properties of soil formation. These characteristics determined soil strength and type of loads, the behaviour of soil in road design is imperative to know because it is one of the major parameters that will determine the live span of the pavement, flexible pavement durability depends on engineering properties that should be examined on design process, Roadbeds are considered the most problematic components in pavement design and construction. Their engineering properties differ significantly in terms of soil composition, gradation, and strength parameters. Soil stabilization techniques have been widely used to improve the engineering properties of roadbed soils. Stabilized soil with lime or Portland cement provides a strong roadbed that can carry traffic loads and reduce pavement failure. The use of lime and cement has been increased recently in the United States to modify subgrade and base materials due to the lack of high quality aggregate in many areas as well as for economic purposes. Generally, during the construction period, construction vehicles are run over the bare subgrade layers to provide construction sites with the necessary supplies. Such practices can harm the roadbed by causing an excessive deformation on the bare subgrade layers which later can be a major cause of the whole pavement rutting. The level of stresses applied to the subgrade by construction vehicles is likely to be higher than the level of stresses that the subgrade layer might experience after construction. However, subgrade layers can be protected before constructing the whole pavement by providing a suitable stabilized subgrade thickness to reduce these deformations [1].

Soil stabilization of subgrade not only provides a strong platform to the flexible pavement but also improves pavement performances under traffic loading and increases service life. Clayey, silty and sandy fine-grained soils exist locally in the state of Ohio. Such soils become extremely weak when they are exposed to a high percent of moisture. Soil stabilization techniques have been proven to modify such soils and improve their engineering properties. Chemically stabilized soils are able to provide a strong foundation to the pavement structure to carry traffic loading of the construction vehicles during and after construction with small deformations [3, 6]. The ODOT Construction Inspection Design Manual [3] recommends cement stabilization for A-3-a, A-4-a, A- 4-b, A-6-a, and A-6-b soils while lime stabilization is recommended for the fine-grained soils classified as A-7-6 or A-6-b. Soil stabilization with lime and cement has been effectively used to improve the engineering properties of fine-grained subgrade soils and provide a strong platform to carry construction traffic at early age. [5, 6, 7] investigated the early strength gain for fine-grained soils that are considered the weakest in the Ohio region through laboratory testing. The results showed that the resilient modulus, California bearing ratio and unconfined compressive strength of the stabilized subgrade soils with lime and cement are in all cases higher than the un-stabilized soils.

[7, 8] evaluated the structural benefits of chemically stabilized subgrade and base soils through laboratory and field testing. They noticed lime stabilized soils are influenced mainly by the pozzolanic reactivity between the lime and soil. A sufficient amount of lime is necessary to develop this reaction. He also concluded that this increasing in soil's strength and stiffness due to lime stabilization provides a good protection layer over the natural subgrade from the high stress level induced in the subgrade by traffic loading, which may result in a severe rutting in the pavement. In addition, the strong stabilized layer not only protects the underlying layer but also provides a good support to the overlaying layers such as the base and HMA layers.

On the other hand, early strength gains in cement stabilized subgrades are more rapid than lime stabilized subgrade. Also the strength gain in subgrade soils stabilized with Portland cement continues over time; however, a significant strength can be achieved at the age of 28 days with curing. Cement stabilized subgrade soils should be treated as a structural slab due to its considerable strength or stiffness [4, 5, 6, 7, 9, and 10]. However, the unconfined compressive strength (USC) test is more common and easier than the resilient modulus test. Thus, its data is readily available in literature which is essentially used for construction purposes of pavement layers' materials [9, 10, 11, 12, and 13] also found that the adopted correlation produces very reasonable resilient modulus values when the unconfined compressive strength of the treated soil lies within the range of 100 to 1500 psi. For lime stabilized subgrade soils, [9] correlation can be used to estimate the resilient modulus based on the unconfined compressive strength [1, 8, 10] studied Thompson's correlation through laboratory testing on lime stabilized soil sample. [14] Was the first researcher who applied finite element modeling to flexible pavement, which was essentially based on the elastic theory? His approach was later adopted to develop computer programs such as ILLIPAVE [8,12], MICHI-PAVE [11, 12], and FLEXPASS (Lytton. et.al 1990).

All these FE-based programs were developed based on the elastic theory to simulate elastic response of the flexible pavement. Particularly, it is the best model when it comes to predicting micro cracking and fractures' responses of the pavement [12, 13]. Many researchers have adopted this modeling approach to simulate flexible pavement due to its ability to produce reasonable results [4, 6, 8, 8, 9, 10, and 14]. Construct an axisymmetric model to investigate the permanent deformation of the base and subgrade layers. [7, 11] also created an axisymmetric model to simulate the permanent deformation of granular layers in the road pavements. [10, 12, 13] created an axisymmetric finite element model to simulate the response of a three-layer pavement system subjected to different types of load configurations [4,13], it also developed an axisymmetric finite element model to investigate flexible pavement responses

Governing Equation

$$N_z \frac{\partial C_m}{\partial z} = K \frac{\partial C_m}{\partial l} + ab \frac{\partial C_m}{\partial l} \quad (1)$$

Nomenclature

C_m	=	Compression strength
N_z	=	Variation of curing Days
K	=	Average Elastic Modulus
a	=	constant
b	=	constant
z, l	=	Time

Equation (1) is solve using method of separation of variable whereby we let C (z, l) =Z (z) L (l).

$$N_z \frac{Z'}{Z} = [Ka + ab]\frac{L'}{L} = \tau^2 \quad (2)$$

Therefore, we have a solution of the forms;

$$Z = A\ell^{\frac{\tau^2}{N_z}} and L = B\ell^{\left(\frac{\tau^2}{K+ab}\right)} \quad (3)$$

Which when combine gives equation (4) as thus;

$$C(z,l) = Ae^{\frac{\tau^2}{N_z}} B\ell^{\left[\frac{\tau^2}{K+ab}\right]} \quad (4)$$

$$C(z,l) = AB\ell^{\left[\frac{z}{N} + \frac{l}{K+ab}\right]\tau^2} \quad (5)$$

MATERIALS AND METHOD

Standard laboratory experiment were performed to monitor compressive strength of modified submerged soil with oyster shell at different location, the soil were modified at every increase of two percent to forty two percent, the experimental result are applied to be compared with the theoretical values to determined the validation of the model.

RESULT AND DISCUSSION

Results and discussion are presented in tables including graphical representation of compression modulus

Table1. *Compressive strength of submerged soil modified with oyster shell.*

Percentage	Compressive Strength
0	0.058
2	0.061
4	0.064
6	0.067
8	0.071
10	0.074
12	0.076
14	0.082
16	0.086
18	0.09
20	0.094
22	0.099
24	0.104
26	0.109
28	0.115
30	0.121
32	0.127
34	0.133
36	0.14
38	0.147
40	0.154
42	0.162

Table2. *Predicted and validated values from compressive strength of submerged soil modified with oyster shell.*

Percentage	Predicted Values	Validated Values
0	0.058	0.058
2	0.061	0.061
4	0.066	0.064
6	0.065	0.067
8	0.067	0.071
10	0.071	0.074
12	0.074	0.076
14	0.078	0.082
16	0.082	0.086
18	0.086	0.09
20	0.09	0.094
22	0.094	0.099
24	0.099	0.104
26	0.104	0.109
28	0.109	0.115
30	0.115	0.121
32	0.12	0.127
34	0.126	0.133
36	0.132	0.14
38	0.139	0.147
40	0.146	0.154
42	0.153	0.162

Table3. *Predicted and validated values from compressive strength of submerged soil modified with oyster shell.*

Percentage	Predicted Values	Validated Values
0	0.058	0.052
2	0.061	0.061
4	0.066	0.063
6	0.065	0.068
8	0.067	0.068
10	0.071	0.069
12	0.074	0.072
14	0.078	0.074
16	0.082	0.087
18	0.086	0.083
20	0.09	0.09
22	0.094	0.091
24	0.099	0.094
26	0.104	0.106
28	0.109	0.105
30	0.115	0.112
32	0.12	0.113
34	0.126	0.127
36	0.132	0.131
38	0.139	0.141
40	0.146	0.144
42	0.153	0.153

Table4. *Predicted and validated values from compressive strength of lateritic soil modified with oyster shell.*

Percentage	Predicted Values	Validated Values
0	0.052	0.054
2	0.061	0.059
4	0.063	0.065
6	0.068	0.067
8	0.068	0.071
10	0.069	0.067
12	0.072	0.074
14	0.074	0.076
16	0.087	0.089
18	0.083	0.086
20	0.09	0.093
22	0.091	0.094
24	0.094	0.096
26	0.106	0.104
28	0.105	0.107
30	0.112	0.114
32	0.113	0.115
34	0.127	0.128
36	0.131	0.132
38	0.141	0.143
40	0.144	0.146
42	0.153	0.155

Table5. *Predicted and validated values from compressive strength of submerged soil modified with oyster shell.*

Percentage	Predicted Values	Validated Values
0	0.058	0.056
2	0.061	0.058
4	0.064	0.066
6	0.067	0.068
8	0.071	0.072
10	0.074	0.072
12	0.076	0.075
14	0.082	0.079
16	0.086	0.088
18	0.09	0.089
20	0.094	0.095
22	0.099	0.097
24	0.104	0.102
26	0.109	0.107
28	0.115	0.117
30	0.121	0.119
32	0.127	0.125
34	0.133	0.128
36	0.14	0.141
38	0.147	0.143
40	0.154	0.152
42	0.162	0.158

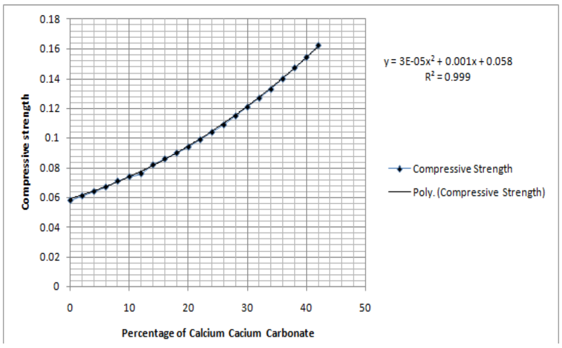

Figure1. *Predicted and validated values from compressive strength of submerged soil modified with oyster shell.*

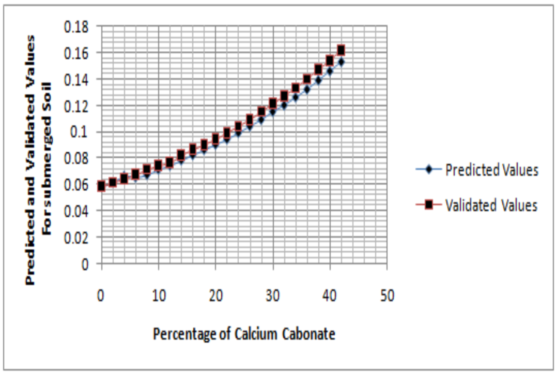

Figure2. *Predicted and validated values from compressive strength of submerged soil modified with oyster shell.*

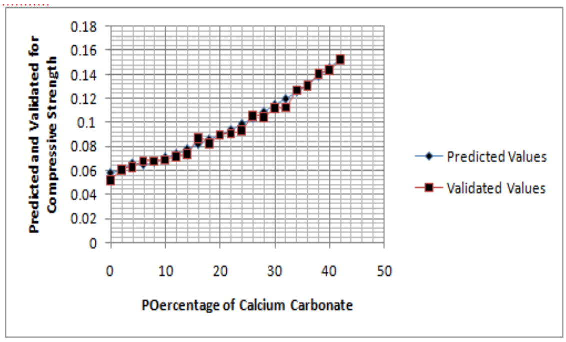

Figure3. *Predicted and validated values from compressive strength of submerged soil modified with oyster shell.*

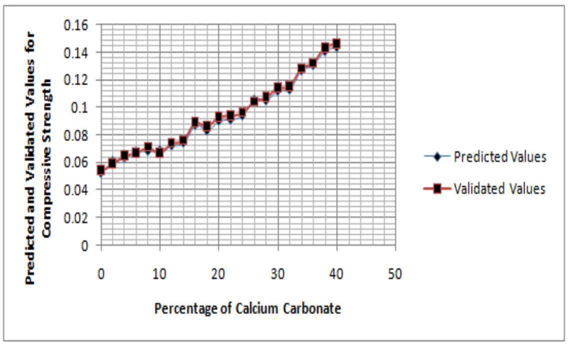

Figure4. *Predicted and validated values from compressive strength of submerged soil modified with oyster shell.*

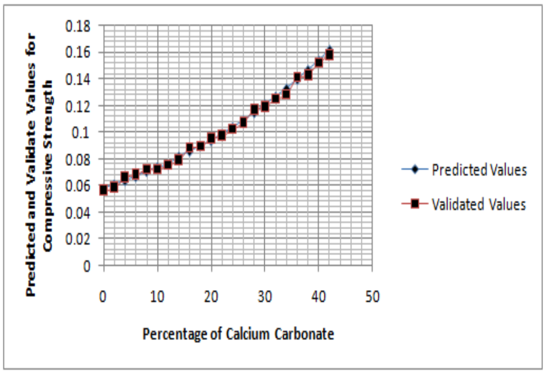

Figure5. *Predicted and validated values from compressive strength of submerged soil modified with oyster shell.*

The results express the behaviour of the system in terms of reaction of natural deposited mineral in submerged soil modified with oyster shell, figure one show the increase in the trend whereby the submerged soil increase through the improvement of strength from oyster shell, the rate of increase in strength are base on the behaviour of the soil modified with the calcium carbonate, the rate of increase experienced variable strength content in various soil due to the reaction of the natural minerals in the submerged soil, such condition were observed in some deposition applied to be modifies with oyster shell, the behaviour of the substance in submerged soil show that the improvement from oyster shell is very low strength, despite the increase of the strength, most researcher has modified submerged soil in coastal areas, but the strength obtained at predominant ten percent show low impact of the formation, this condition might be that it has lots of natural mineral that may have hinder the improvement of the strength in the study location. Most of the figures were observed to increase from zero percentage to forty two percent before it can modify the compressive strength required for the study. The parameters express the behaviour of the system in terms of its rate of compressive strength, the developed model prediction express these values through simulation parameters, these theoretical values generated from the validation were compared with experimental or validated values, both parameters express favorable fits validating the model for predicting submerged soil modified with oyster shell [calcium carbonates].

Conclusion

Soil stabilization is known to be substance and material change in the soil engineering properties that can improve the structural strength of the soil by increasing its shear strength and stiffness over period. The behaviour of submerged soil were observed to be too weak compared to lime or other materials, the modification were applied for every two percent of oyster shell stabilization, the study has express increase in compression strength, but experiences slow in the rate of modification. From the figure the trend express slow increase of the formation if modified with oyster shell [calcium carbonate], the formation were monitored in other to determine their rate of reaction with other deposited mineral in the soil, several experts should known that there is the tendency of reaction whereby the improvement will be hindered, these were observed from the simulation parameters generated in the figures, it has express the behaviour of the formation, the rate of improvement express their slow level of these type of soil, the system were developed to monitor the behaviuor of the formation if modified with oyster shell, the rate of increase has definitely shows the level of stabilization thus hindered by minerals in natural state. The validation of the model has express the behaviour of submerged soil in coastal areas.

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