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Modeling and Simulation to Predict Homogeneous Curing Age of Compressive Strength from Lateritic Soil Improved with Oyster Shells

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ABSTRACT

This paper express the development of homogeneous curing age of compressive strength for lateritic soil modified with oyster shell. The study was to monitor the compressive strength at every twenty four hours, this is to observed increase rate of compressive strength at this period interval, several compressive strength in conventional practice are obtained at seven days interval to twenty eight days, this has been the conventional application used by other experts around the globe, compressive strength within seven days interval are not determine in the normal conventional application, the developed model generated theoretical values from the simulation, empirical data were used for validation, both parameters experienced increase but with slight variation due to some reaction from natural chemical deposition in the lateritic soil, these parameters observed favorable fits validating the derived model for the study. Experts will definitely use this model to monitor compressive strength at every twenty four hours interval.

Keywords: *modeling, curing age, compressive strength, and oyster hell*

INTRODUCTION

The performance of hot mix asphalt (HMA) pavement is significantly affected by cementitious stabilized layers (CSL), especially when CSL are located directly underneath HMA layers. Stabilized subbase and base layers can reduce the rutting of HMA pavement as a result of minimal rutting in the subgrade, subbase, and base [1, 2, 3,]. The bottom-up fatigue cracking of HMA also can be reduced [7, 8, 9,]. Highways in many parts of the world that use stiff bases and thin HMA layers also have encountered this problem [6, 7, 10, and 12]. The shrinkage, caused by a loss of moisture and temperature variation, typically initiates shortly after construction and continues thereafter. According to [8, 9, 12], Highways in many parts of the world that use stiff bases and thin HMA layers also have encountered this problem [4, 5, 6]. The shrinkage, caused by a loss of moisture and temperature variation, typically initiates shortly after construction and continues thereafter [11, 14, and 15]. The cracking is due to the bond between the surface layer and stabilized base [8]. Transverse cracking is also a concern for pavements with a stabilized subbase and granular base, but at a much later stage [17]. The shrinkage cracking of the subbase causes stress concentrations at the locations of the cracks and eventually affects the stress distribution in the surface layer [1, 2] Reports that shrinkage cracking in CSL causes transverse cracking in HMA is prominent in thin HMA pavement. [4] Reports that lack of mellowing for lime slurry stabilized base layers causes shrinkage cracking and then transverse cracking in the HMA surface. [12, 13] it was found that a high modulus value causes wide shrinkage cracks and low load transfers across the crack. [8] In similar condition it was observed that high-strength CSL are prone to shrinkage cracking, based on Long-Term Pavement Performance (LTPP) and other pavements.

However, for asphalt pavements that use high-stiffness CSL as the base, the HMA surface layer is prone to top-down fatigue cracking [11,12], as shown in Figures A-3, A-4, and A-5. This top-down fatigue cracking has been confirmed by other researchers [10,11,14,15,16] it was also found that a high modulus value of cement-stabilized full-depth recycled base leads to more longitudinal cracking in the wheel path. The literature supports that high stiffness or modulus values of CSL lead to top-down cracking in asphalt pavement. Stiffness and modulus values also are needed for the response model of a pavement structure to determine stress and strain. The shrinkage cracks reflect through the upper layers and appear in the HMA surface, as shown in Figure A-6. [18,19,20] report that longitudinal dry-land cracking initiates in untreated expansive soil and appears in the HMA surface, as shown in Figure A-7.

Adding lime reduces the plasticity index (PI) value, suction, compression index value, and the swelling potential of expansive soils. Experts [6,10] also report that the subgrade beneath the pavement at the centerline has high moisture content whereas the moisture content underneath the shoulder fluctuates. The shrink and swell caused by moisture change can lead to longitudinal dry-land cracking. [9, 10] these indicate that the shrink-swell of subgrade comprised of expansive soil results in dry-land cracking. The shrinkage cracking in the subgrade reflects through the CSL and appears at the HMA surface. This phenomenon also is confirmed by forensic studies by experts [4, 5, 6, and 17] in which expansive soil causes dry-land cracking.

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	=	Depth

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 at different curing Age, lateritic soil deposition modified with oyster shell were induces at every increase of two percent to ten percent, the experimental result are applied to compare 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 at various days*

Days	Compressive Strength
7	0.026
8	0.028
9	0.031
10	0.033
11	0.035
12	0.038
13	0.041
14	0.045

Table2. *Predictive and Validated of Compressive Strength at Various Days*

Days	Predicted Values	Validated Values
7	0.026	0.025
8	0.028	0.029
9	0.03	0.031
10	0.033	0.032
11	0.035	0.035
12	0.038	0.037
13	0.041	0.042
14	0.045	0.044

Table3. *Compressive Strength at Various Days*

Days	Predicted Values
14	0.032
15	0.034
16	0.036
17	0.038
18	0.04
19	0.042
20	0.045
21	0.047

Table4. *Predictive and Validated of Compressive Strength at Various Days*

Days	Predicted Values	Validated Values
14	0.032	0.035
15	0.034	0.036
16	0.036	0.038
17	0.038	0.04
18	0.04	0.042
19	0.042	0.045
20	0.045	0.047
21	0.047	0.049

Table5. *Compressive strength at various days*

Days	Predicted Values
7	0.15
8	0.17
9	0.19
10	0.2
11	0.22
12	0.24
13	0.26
14	0.3

Table6. *Predictive and Validated of Compressive Strength at Various Days*

Days	Predicted Values	Validate values
7	0.15	0.152
8	0.17	0.175
9	0.19	0.187
10	0.2	0.205
11	0.22	0.226
12	0.24	0.241
13	0.26	0.265
14	0.3	0.302

Table7. *Compressive strength at various days*

Days	Predicted Values
7	0.18
8	0.2
9	0.22
10	0.24
11	0.26
12	0.3
13	0.33
14	0.37

Table8. *Predictive and Validated of Compressive Strength at Various Days*

Days	Predicted Values	Validate values
7	0.18	0.187
8	0.2	0.189
9	0.22	0.206
10	0.24	0.226
11	0.26	0.266
12	0.3	0.302
13	0.33	0.324
14	0.37	0.311

Table9. *Compressive strength at various days*

Days	Predicted Values
7	0..22
8	0.25
9	0.29
10	0.34
11	0.39
12	0.46
13	0.53
14	0.61

Table10. *Predictive and Validated of Compressive Strength at Various Days*

Days	Predicted Values	Validate Values
7	0..22	0.22
8	0.25	0.25
9	0.29	0.283
10	0.34	0.287
11	0.39	0.34
12	0.46	0.402
13	0.53	0.52
14	0.61	0.61

Table11. *Compressive strength at various days*

Days	Predicted Values
14	0.19
15	0.22
16	0.23
17	0.24
18	0.26
19	0.28
20	0.29
21	0.31

Table12. *Predictive and Validated of Compressive Strength at Various Days*

Days	Predicted Values	Validated Values
14	0.19	0.095
15	0.22	0.222
16	0.23	0.233
17	0.24	0.248
18	0.26	0.258
19	0.28	0.288
20	0.29	0.28
21	0.31	0.308

Table13. *Compressive strength at various days*

Days	Predicted Values
14	0.17
15	0.18
16	0.19
17	0.2
18	0.21
19	0.22
20	0.23
21	0.24

Table14. *Predictive and Validated of Compressive Strength at Various Days*

Days	Predicted Values	Validated Values
14	0.17	0.141
15	0.18	0.175
16	0.19	0.187
17	0.2	0.192
18	0.21	0.211
19	0.22	0.226
20	0.23	0.223
21	0.24	0.241

Table15. *Compressive strength at various days*

Days	Predicted Values
14	0.18
15	0.19
16	0.2
17	0.21
18	0.22
19	0.23
20	0.24
21	0.25

Table16. *Predictive and Validated of Compressive Strength at Various Days*

Days	Predicted Values	Validate Values
14	0.18	0.187
15	0.19	0.206
16	0.2	0.212
17	0.21	0.224
18	0.22	0.23
19	0.23	0.232
20	0.24	0.241
21	0.25	0.241

Table17. *Compressive Strength at Various Days*

Days	Predicted Values
21	0.201
22	0.208
23	0.216
24	0.224
25	0.233
26	0.241
27	0.25
28	0.26

Table18. *Predictive and Validated of Compressive Strength at Various Days*

Days	Predicted Values	Validate Values
21	0.201	0.203
22	0.208	0.205
23	0.216	0.211
24	0.224	0.222
25	0.233	0.232
26	0.241	0.258
27	0.25	0.253
28	0.26	0.266

Table19. *Compressive Strength at Various Days*

Days	Predicted Values
21	0.199
22	0.206
23	0.214
24	0.229
25	0.23
26	0.239
27	0.248
28	0.257

Table20. *Predictive and Validated of Compressive Strength at Various Days*

Days	Predicted Values	Validate Values
21	0.199	0.192
22	0.206	0.211
23	0.214	0.222
24	0.229	0.224
25	0.23	0.232
26	0.239	0.241
27	0.248	0.251
28	0.257	0.261

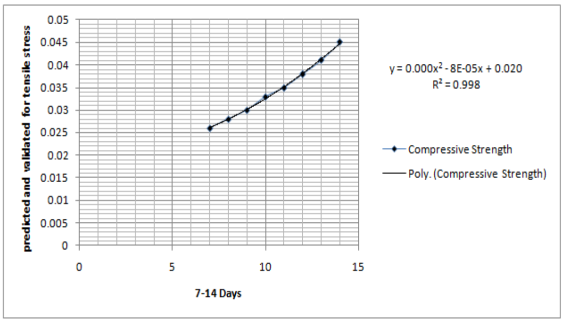

Figure1. *Compressive Strength at Various days*

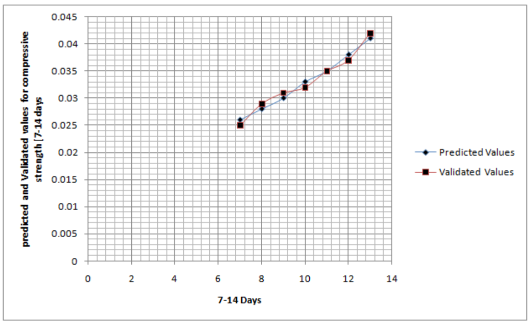

Figure2. *Predictive and Validated of Compressive Strength at Various Days*

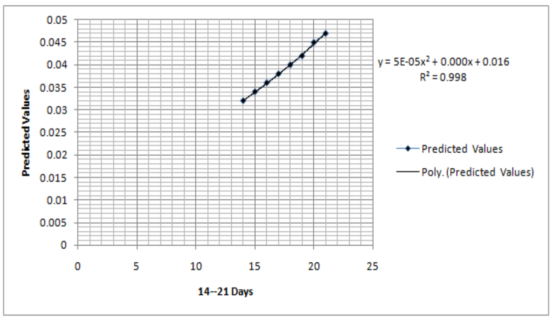

Figure3. *Compressive Strength at Various Days*

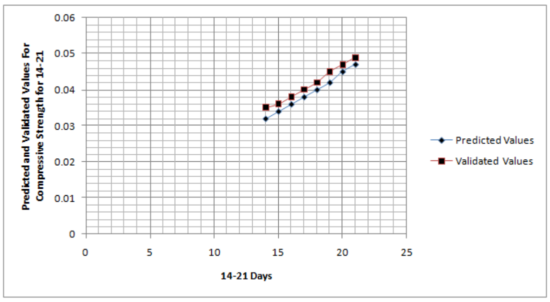

Figure4. *Predictive and Validated of Compressive Strength at Various Days*

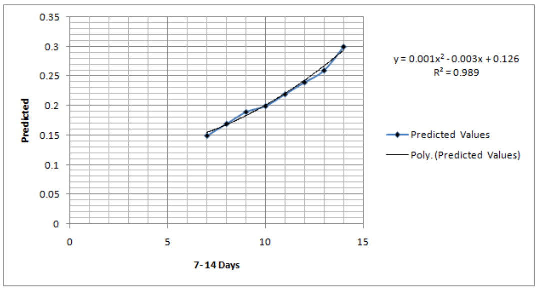

Figure5. *Compressive strength at various days*

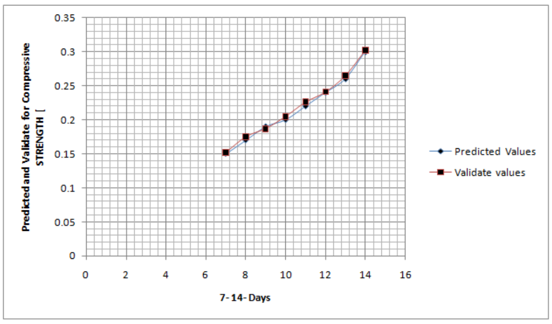

Figure6. *Predictive and Validated of Compressive Strength at Various Days*

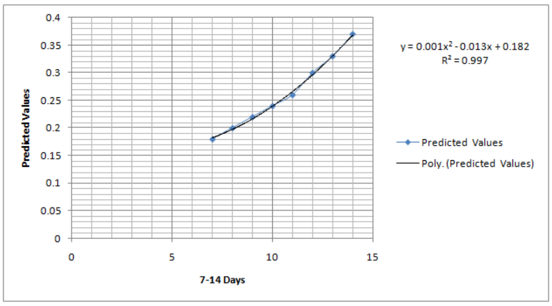

Figure7. *Compressive strength at various days*

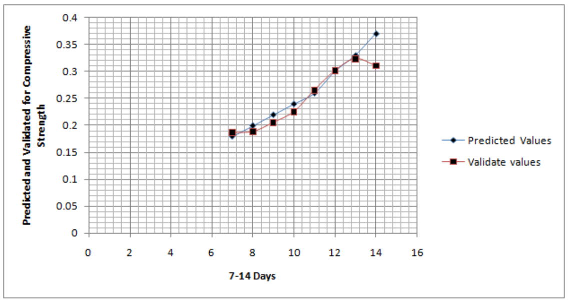

Figure8. *Predictive and Validated of Compressive Strength at Various Days*

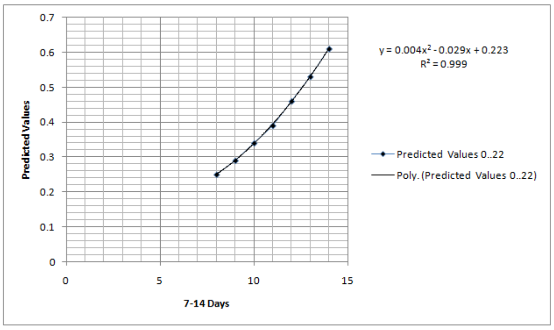

Figure9. *Compressive strength at various days*

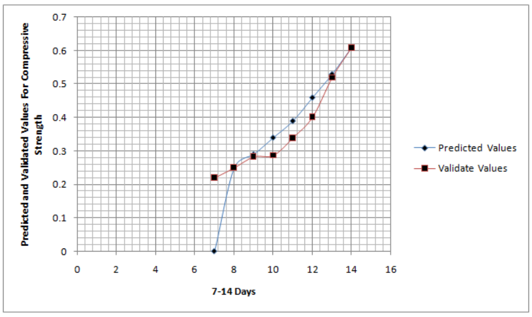

Figure10. *Predictive and Validated of Compressive Strength at Various Days*

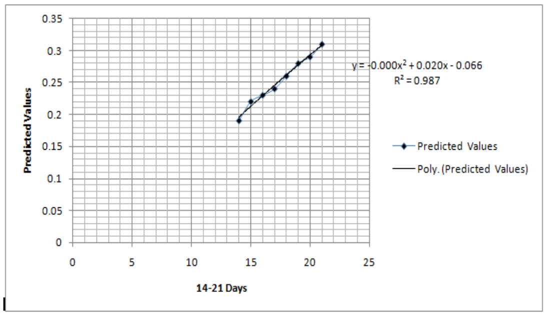

Figure11. *Compressive Strength at Various Days*

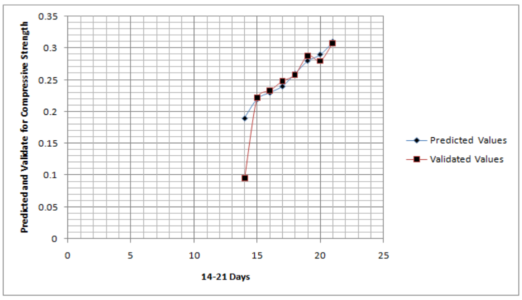

Figure12. *Predictive and Validated of Compressive Strength at Various Days*

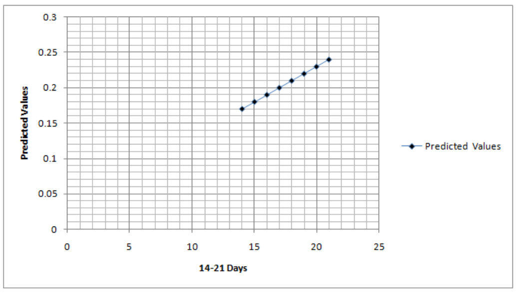

Figure13. *Compressive Strength at Various Days*

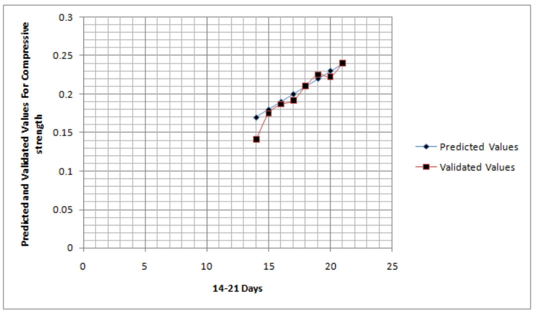

Figure14. *Predictive and Validated of Compressive Strength at Various Days*

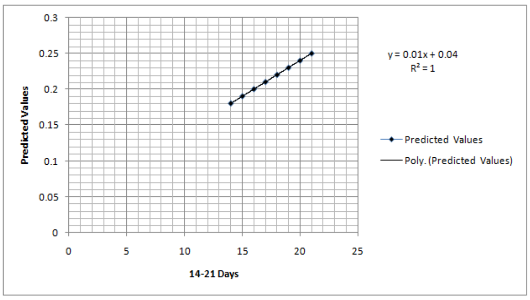

Figure15. *Compressive Strength at Various Days*

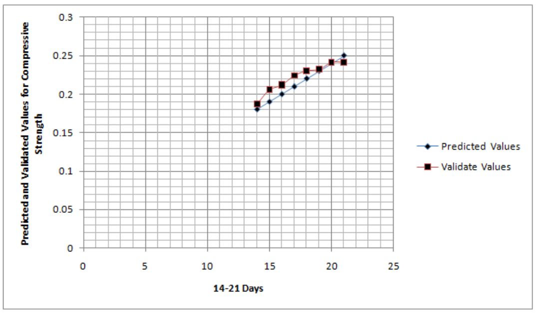

Figure16. *Predictive and Validated of Compressive Strength at Various Days*

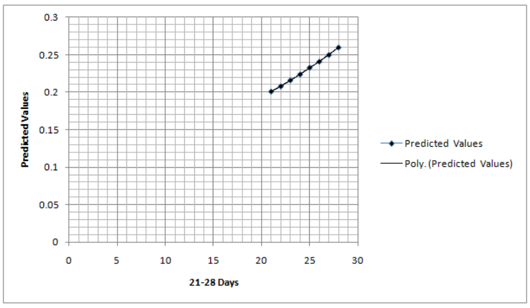

Figure17. *Compressive Strength at Various Days*

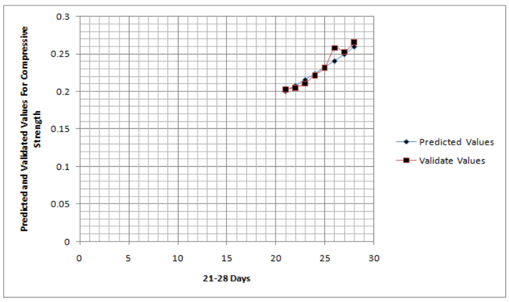

Figure18. *Predictive and Validated of Compressive Strength at Various Days*

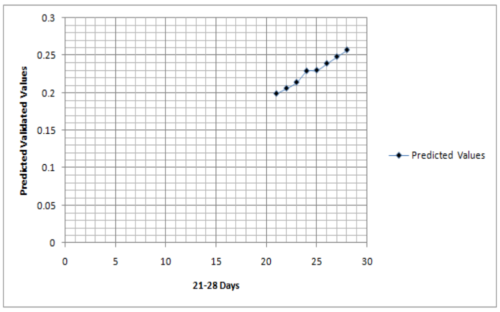

Figure19. *Compressive Strength at Various Days*

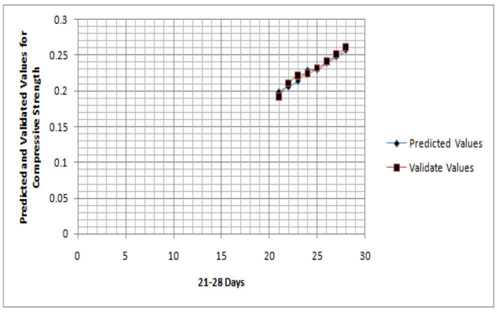

Figure20. *Predictive and Validated of Compressive Strength at Various Days*

The figure above express the behaviour modified lateritic soil there rate of strength increase base on the percentage of calcium carbonate induces inside the lateritic soil, the stabilization rate of the soil are base on the rate of percentage increment into the soil at various period, the enhancement of the formation monitored at various day has express various strength in different figure, increase in compressive strength at every twenty four hours were observed in the figures, but variation of strength experiences at various figures were expressed in the study. Variation of compression were observed to influences the strength variable observed in every twenty four hours, slight fluctuation were also experiences in some of the figures due to reaction of natural chemical deposition including environmental factors, the trend in all the figure express vacillation observed in most of the figures due to variation plasticity in the lateritic formation, these conditions pressure the fluctuation of the stabilization at different percentage, the rate of stabilization in such lateritic soil in deltaic environment were to determine the rate stability that can obtained the maximum strength to withstand the axial load for flexible pavement, oyster shell were induces inside the lateritic soil to monitored its compressive strength for every twenty four hours thus twenty eight days. The generated strength in the study produce the graphical representation in other to observe the rate of compressive strength at every induced percentage of calcium carbonate, these were generated through the simulation values developed from the derived model, the prediction were compare with experimental values, both parameters express favorable fits validating the derived model for the study.

CONCLUSION

Several experts in civil engineering has been applying the conventional way of monitoring compressive strength at every seven days interval, the obtained strength are generated at this standard interval of seven days each, these has been the usual practice to monitored the compressive strength of lateritic soil modified with any material or substances, but other days in simultaneous condition are not determined in such application, these normal approach to determine compressive strength produce results of the seven day interval each, other day within the seven days interval to twenty eight days are not determined, this strength obtained from other days should have been applied to monitor the simultaneous days but are not determined, the study to determine the compressive strength at every twenty four hours were applied through modeling approach, the compressive strength of lateritic soil modified with calcium carbonate were developed to monitor the system at every twenty four hours interval, the study generated the compressive strength from seven to twenty eight days, validation of the results were through empirical model data, both parameters express favorable fits.

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