Journal of Architecture and Construction
Volume 2, Issue 2, 2019, PP 30-37
ISSN 2637-5796

Development of Mathematical Model to Predict Concrete Density with Slight Modification with Ordinary Portland cement

Eluozo, S.N.[1*] and Dimkpa .K.[2]

[1]*Department of Civil Engineering, College of Engineering Gregory University Uturu (GUU), Abia State of Nigeria.*
[2]*Department of Architecture, Faculty of Environmental Science Rivers State University, Nkpolu Oroworukwo, Port Harcourt, Nigeria.*

Corresponding Author: *Eluozo, S.N. and Dimkpa .K. Department of Civil Engineering, College of Engineering Gregory University Uturu (GUU), Abia State of Nigeria, E-mail: Soloeluozo2013@hotmail.com*

ABSTRACT

This paper monitor the variation of concrete densities with slight modifiers, the study express different growth rate of concrete density at different curing age, fluctuation and linear trend were observed in all the figures from its graphical representations, this express the effect from the variation of mechanical properties, such significant effect on the density of concrete were observed from the study through the behavior of concrete densities growth at various trend, the variation of dense in the growth rate were monitored from the developed model and simulations, the effect from porosity and void ratio including permeability at different mixed deigned were observed from the growth rate, the study applying deterministic techniques for such non homogeneous system establish various direction in the derived solution that cause the variation of concrete material in the study. Validations of the model were carried out to determine the efficiency of this concept in monitoring concrete densities with slight modifications.

Keywords: *mathematical model, concrete density, slight modification, and ordinary Portland cement*

INTRODUCTION

Chemical reactions are known as hydration, this takes place between the water and cement, and it is observed that concrete usually experienced changes from a plastic to a solid state [1]. The concrete density and that of compressive strength of cement paste are influenced by numerous parameters such as water cementations materials ratio, supplementary cementations materials, use of admixture, curing, cement type, etc. [2]. Definitely it is observed that curing is the process to endorse hydration of cement, this consists of a control some rate of temperature and moisture movement from and into the concrete [3]. Thorough curing application has important influence on density and compressive strength of concrete [4]. The water-cement ratio (W/C) is defined as the proportion by mass of free water to cementations material in a concrete mix [5]. Normally, light weight aggregate concrete is observed to absorb more impact energy than normal weight concrete [7, 11, and 12]. The densities of normal weight concrete relay between the range of 2,200 to 2,600 Kg/m3 [8, 13]. The main purpose of light weight concrete is to decrease the dead load of a concrete structure [9, 14, and15]. Also, this type of concrete is used to improve buoyancy of the structures [10, 16 17].

THEORETICAL BACKGROUND

$$\frac{dc}{dX} + A_{(X)}C_{(d)} = K_{(X)}C_d{}^n ; n_{\geq 2} \tag{1}$$

Let $\beta = C_d{}^{1-n}$

$$\frac{d\beta}{dX} = (1-n)C_d{}^{-n}\frac{dc}{dX} \tag{2}$$

$$C_d{}^{-n}\frac{dc}{dy} = \left(\frac{1}{1-n}\right)\frac{d\beta}{dX} \tag{3}$$

But $\beta = C_d{}^{1-n}$

$$C_d{}^{1-n} = 2D\exp\left[(2n-2)\int K_{(x)}dx\right] \tag{4}$$

$$C_d{}^{1-n} = D\exp[(2n-2)K_{(x)}X] \tag{5}$$

MATERIAL AND METHOD

Density Test

After 28 days curing, one set (3 cylinders) of concrete specimen were taken out from storage for density test according to ASTM C 642 [19], for testing at particular day. These specimens were turned to SSD (Saturated Surface Dry) condition by removing water from the surfaces. Then SSD weight of samples in air (C) was measured. Next the specimens were placed in oven at a temperature of 100 to 110°C for 24 h. After that weight of the specimen was measured. This is oven dry weight of samples in air (A). After that, the specimens were placed under water in a bucket and weight under water (D) was obtained. Temperature of water at test day (T) was also recorded and water density (ρ) was calculated for that temperature. Then from "Equation 1", density of concrete was calculated. Density test results are shown in Figure 2. From this test results, it can easily be said that density increases with days. But rate of density change is low. Concrete with SC shows more density values than concrete with BC (Shohana 2015).

Dry density (bulk density), g1=…. (1) Here,

A= mass of oven-dried sample in air, (gram)

C= mass of saturated surface-dry sample in air, (gram)

D= mass of sample in water after immersion, (gram)

Table1. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

Curing Age	Predictive Values of Concrete Density [Kg]	Experimental Values of Concrete Density Kg
7	2362.7297	2362.76
14	2682.4876	2682.62
21	2624.6319	2625.01
28	2874.2708	2875.11

Table2. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

Curing Age	Predictive Values of Concrete Density [Kg]	Experimental Values of Concrete Density Kg
7	2352.72	2379.0008
14	2662.48	2583.7452
21	2654.63	2733.4332
28	2854.27	2828.0648

Table3. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

Curing Age	Predictive Values of Concrete Density [Kg]	Experimental Values of Concrete Density Kg
7	2156.23	2162.949
14	2415.14	2399.598
21	2625.21	2636.247
28	2875.04	2872.896

Table4. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

Curing Age	Predictive Values of Concrete Density [Kg]	Experimental Values of Concrete Density Kg
7	2168.549	2164.94
14	2400.298	2398.59
21	2632.047	2646.24
28	2863.796	2854.89

Table5. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

Curing Age	Predictive Values of Concrete Density [Kg]	Experimental Values of Concrete Density Kg
7	2181.024	2170.84
14	2415.048	2436.71
21	2649.072	2636.55
28	2883.096	2884.31

Table6. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

Curing Age	Predictive Values of Concrete Density [Kg]	Experimental Values of Concrete Density Kg
7	2185.267	2182.42
14	2418.234	2425.34
21	2651.201	2645.47

28	2884.168	2885.59

Table7. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

Curing Age	Predictive Values of Concrete Density [Kg]	Experimental Values of Concrete Density Kg
7	2324.77	2313.308
14	2408.11	2442.374
21	2667.02	2632.298
28	2872.24	2883.08

Table8. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

Curing Age	Predictive Values of Concrete Density [Kg]	Experimental Values of Concrete Density Kg
7	2323.31	2323.2511
14	2445.37	2445.6664
21	2633.29	2633.0459
28	2885.28	2885.3896

Table9. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

Curing Age	Predictive Values of Concrete Density [Kg]	Experimental Values of Concrete Density Kg
7	2155.172	2122.47
14	2331.054	2429.14
21	2457.446	2359.35
28	2534.348	2567.04

Table10. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

Curing Age	Predictive Values of Concrete Density [Kg]	Experimental Values of Concrete Density Kg
7	2154.214	2155.17
14	2330.138	2331.25
21	2456.572	2457.45
28	2533.516	2534.55

Table11. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

Curing Age	Predictive Values of Concrete Density [Kg]	Experimental Values of Concrete Density Kg
7	2142.84	2171.729
14	2353.68	2313.458
21	2461.41	2455.187
28	2579.36	2596.916

Table12. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

Curing Age	Predictive Values of Concrete Density [Kg]	Experimental Values of Concrete Density Kg
7	2172.76	2173.148
14	2315.45	2314.296
21	2454.48	2455.444
28	2596.91	2596.592

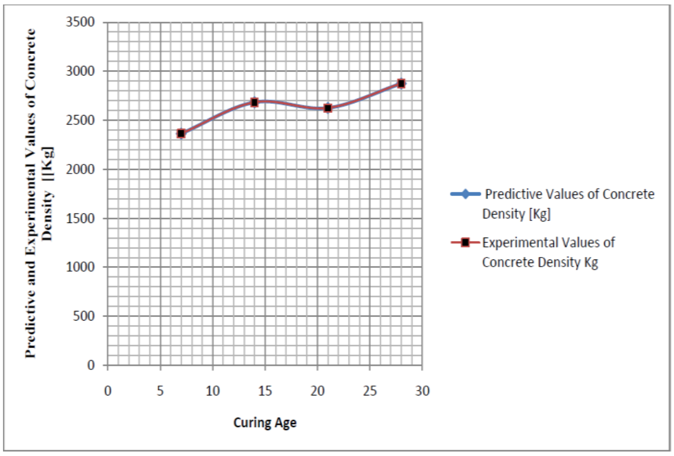

Figure1. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

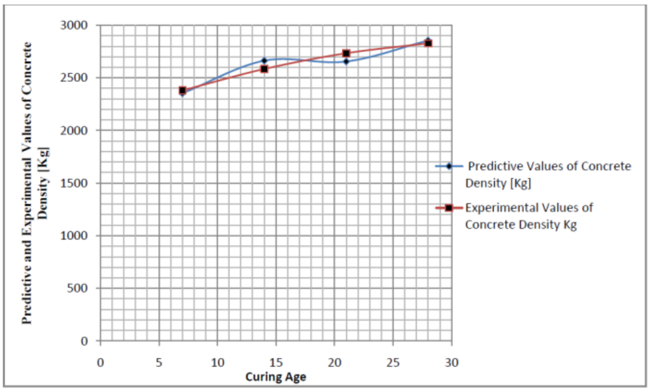

Figure2. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

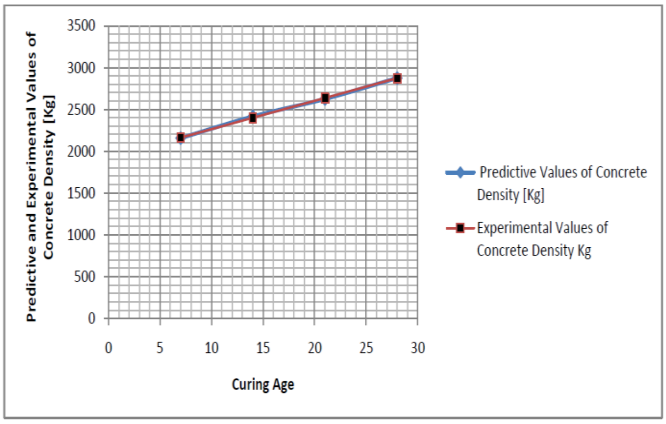

Figure3. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

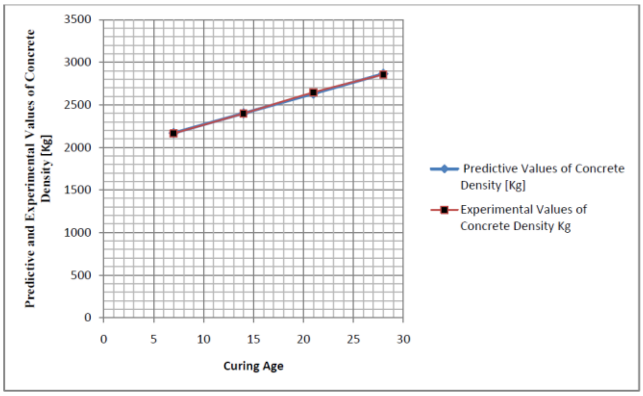

Figure4. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

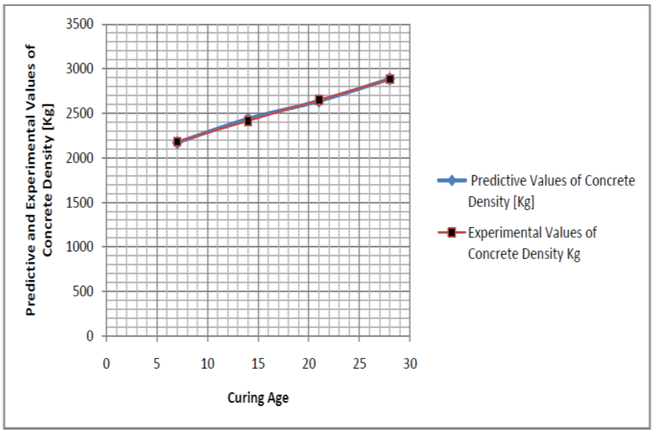

Figure5. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

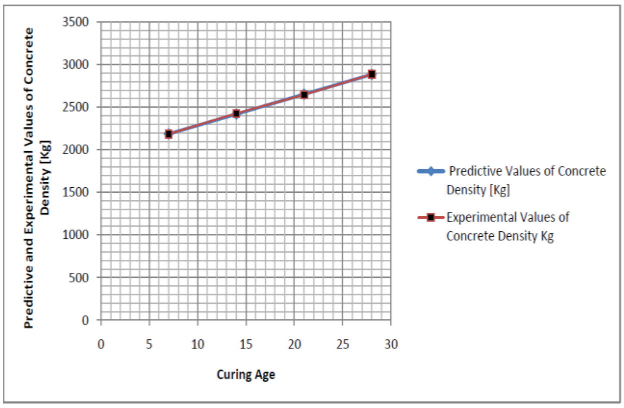

Figure6. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

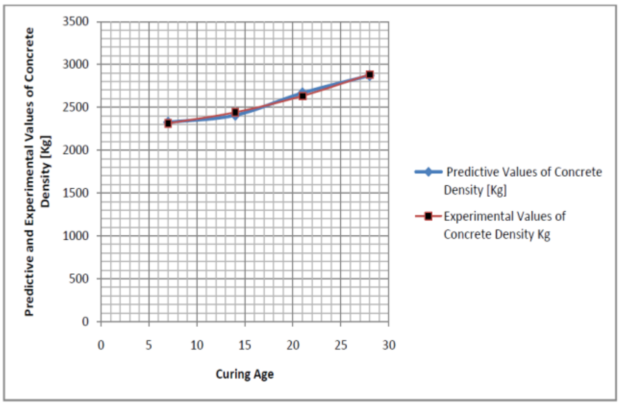

Figure7. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

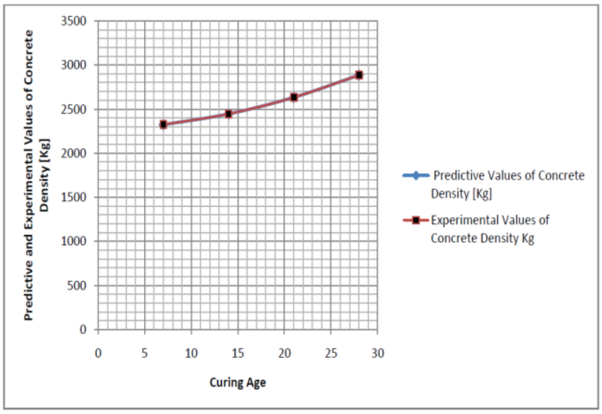

Figure8. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

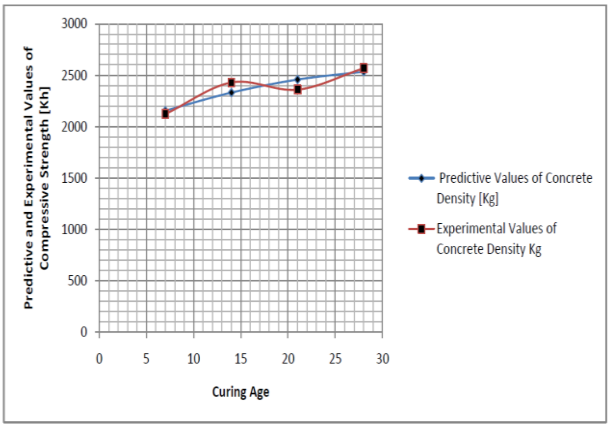

Figure9. *Predictive and Experimental Values of Concrete Density at Different Curing Age*

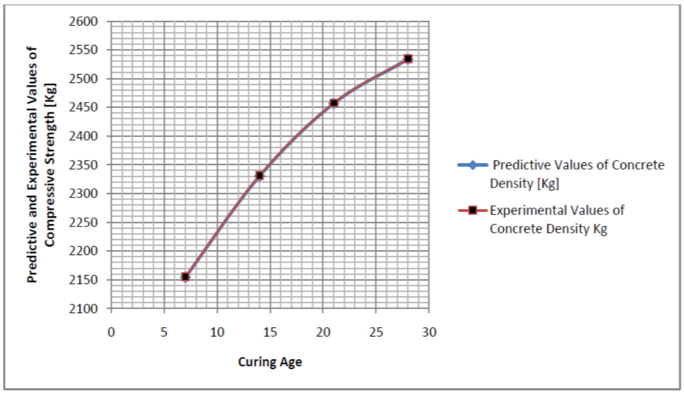

Figure10. *Predictive and Experiential Values of Concrete Density at Different Curing age*

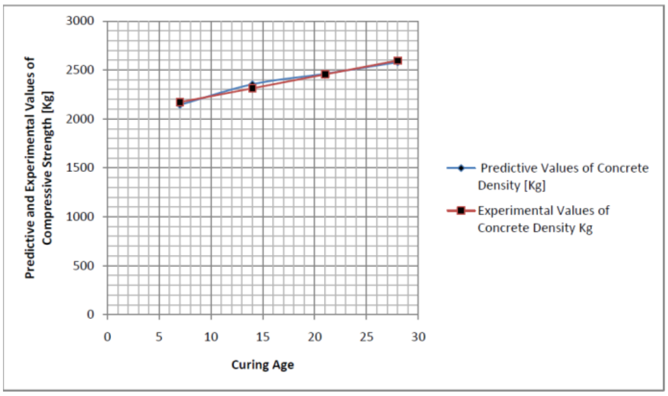

Figure11. *Predictive and Experimental Values of Concrete Density at Different Curing age*

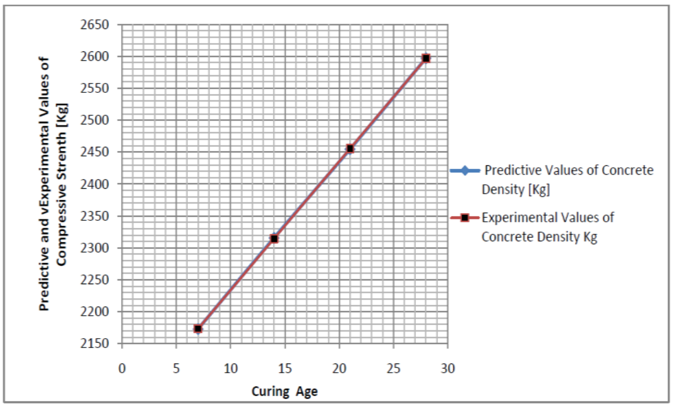

Figure12. *Predictive and Experimental Values of Concrete Density at Different Curing age*

RESULT AND DISCUSSION

The figures from 1-12 shows the variations on concrete density, these are based on variation of mixed design including some chemical attack, fluctuation were observed in some part of the figures, while linear trend were observed in most part of the figures, this show some mixed proportion that express that express homogeneous state of increase in density, optimum rate of density were experienced at twenty eight days of curing, some of the vacillation experienced from the concrete densities are based on heterogeneous concrete characteristic's that were involved that may have inappropriate in its production as its affect the rate of porosity and void deposition in concrete formation, the behavior of the growth rate of density on some of the figure describe the variation of mechanical properties of the concrete as it is influenced by these conditions.

The rate of permeability variation were also observed to influenced these density of the concrete, these were experienced in some figures from the graphical representations, the fluctuation observed the rate of mechanical properties in different mixed production which affect some of the growth rate of concrete densities. The study applying deterministic concepts were subjected to model validation, the predictive values were compared with experimental data, and both values developed better correlations.

CONCLUSION

Concrete are known to be as non-natural conglomerate stone that are produced from made Portland cement, water, and aggregate, the study discusses about the concrete densities with slight modifications, the developed concrete strength were observed to generate fluctuation densities to the optimum values recorded at different curing age. Studies have express that denser concrete normally delivers higher strength and less amount of voids and porosity. This implies that smaller the voids in concrete will definitely generates less permeable to water and soluble elements.

Therefore the rate of water absorption will also be less, these will generate better durability as it is expected from any proper mixed designed type of concrete. The study developed a model to monitor the variation of concrete densities at different curing age with slight modifications, the result expressed vacillations in some figure through graphical representations and linear trend were observed in few figures, these monitoring express the behavior of concrete densities through its of rate mechanical properties applied in the concrete. Simulation carried out generated predictive values, these parameters were subjected to model validation, better correlations were observed from the model validation

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Citation: *Mr. Eluozo, S.N., Dimkpa, K. ,"Development of Mathematical Model to Predict Concrete Density with Slight Modification with Ordinary Portland cement" Journal of Architecture and Construction, 2(2), 2019, pp. 30-37.*