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Assessment of Compressive Strength of Major Brands of Cement in Enugu Urban Markets.

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Abstract

Cement as a binder is the world's most utilized construction material. There are so many brands of cement in production today that many are confused on which brand to use during construction work. Contractors generally choose any brand of cement for use based on their own personal and previous experiences from past works but since construction works are different, it is necessary to make a clear finding on which brands should be preferably used for given projects. This cannot be done successfully without carrying out as many laboratory tests as possible to establish a scientific position for each brand based on research. The aggregates and other ingredients of the concrete were initially characterized to determine the properties. Despite minimal variation in the compressive strength values of concretes produced with different brands of Portland cement, the average compressive strength of the concrete cubes indicated that BUA cement exhibited the highest values across all curing ages, closely succeeded by Dangote cement, while Unicem cement recorded the lowest values. The exponential function-based model developed adequately predicted the experimental observed compressive strength with high accuracy.

Keywords: Cement, compressive strength, brands, model, assessment.

1. Introduction. Since cement is essential to the binding of various components to produce concrete, it is practically important to humanity for the provision of shelter. One of the most common building materials for conceptual ideas known as structures is concrete. Ordinary Portland Cement (OPC) is the most widely utilized cementitious material in the Nigerian building industry. Based on their chemical makeup, the three cement brands chosen for the study naturally differ from one another in terms of quality. Nwankwojike et al. (2014) assessed several physical properties of Portland cement brands in the Umuahia Industrial Market Region, Nigeria, to identify the underlying reason of the elevated incidence of story building collapses in Umuahia. The study selected Dangote 42.5 Portland cement, Ibeto 42.5 Portland cement, Unicem 32.5 Portland cement, Elephant 32.5 Portland cement, and Atlas 32.5 Portland cement as the brands of Portland cement.

They discovered that every sample had a fineness rating that was acceptable because their consistency was within the standards' range. After evaluating the strength characteristics of five distinct cement brands, Bamigboye et al. (2015)

concluded that Ibeto cement had the greatest compressive strength values, followed by Elephant cement, and Unicem cement had the lowest. According to Akanni et al. (2014), who examined the chemical composition of several cement brands that are primarily utilized in Southwest Nigeria, Purechem cement has the lowest amount of free lime. The strength development rate of concrete produced with specific Nigerian cement brands was studied by Anejo et al. (2017). According to their findings, for the majority of cement brands, 85% of the strength was developed at 21 days. Solitari et al. (2019) focused on assessing the mechanical and physical properties of concrete produced with various brands of Portland cement.

They contrasted the findings of tests on the compressive and tensile strengths of four distinct cement varieties that are sold in the Sindh province market. It was discovered that Lucky cement outperformed other brands in terms of both tensile and compressive strength. Various groups in the building business have conducted subjective and unverified evaluations comparing the available cement brands based on factors including compressive strength, fineness, workability, and setting time. Therefore, proper independent academic research to determine the qualities of each of the various cement brands is long overdue. Therefore, this study will assess the impact of certain Portland cement brands on the mechanical properties of concrete in order to address the disparity in concrete compressive strength produced by different cement producers. Investigating the compressive strength of concrete made with the main brands of Portland cements in the city of Enugu is the study's main goal.

2.0 Material and methods

BUA 42.5 Portland cement, Dangote 42.5 Portland cement, and Unicem 42.5 Portland cement are used as the main binding agent.These brands of cement are readily available in major markets in Enugu and their properties conform to BS 12, 1996. The fine aggregate used were sourced from a river in Akpugo in Enugu state. This river called Nyaba is the major source of fine aggregates (sharp sand) for construction purposes around Akpugo. The granite aggregates were sourced/ procured from crushed rock quarry in Abakaliki in Ebonyi state. The coarse aggregates (granite) were of high quality with maximum size of 20mm. Pipe borne water fit for drinking was used as the mixing water. The water is clean, colourless and odorless water that is free from organic materials that may affect the quality of the concrete.

With the three brands of cement selected, fine and coarse aggregates specified or chosen, and using mix ratio of 1:2:4, a total of 60 cubes of concrete of size (150x150x150) mm, which makes 20 cubes for each brand of cement and 5 cubes for each of the crushing days. The 5 cubes cast for each brand of cement cubes were cured and crushed at the ages of 7, 14, 21, 28 days respectively.

Bulk density of the compacted fresh concrete was conducted according to BS 1881 pt. 107, 1983, Equation (1) was used to calculate the density.

$$\rho = \frac{W2 - W1}{V} \quad (1)$$

Let W1 denote the mass of the empty cylinder (in kg), W2 represent the mass of the cube and sample (in kg), V signify the volume of the cylinder (in m^3), and ρ indicate the bulk density (in kg/m^3).The sieve analysis, or particle size distribution test, was conducted in accordance with BS 812 pt. 103.1, 1985.Furthermore, compressive strength tests were conducted on the various cubic specimens in accordance with BS 1881 pt. 110, 1983; the formula is represented as Equation (2). A uniform water-to-cement ratio of 0.6 was utilized, and batching was conducted by weight.

$$Compressive\ Strength = \frac{Crushing\ load\ (N)}{Cross\ sectional\ area(mm^2)} \quad (2)$$

2.1 Model Development

To forecast the compressive strengths of concretes made with three distinct cement brands—BUA, UNICEM, and DANGOTE—at different curing ages of 7, 14, 21, and 28 days, models based on exponential functions were created. Concrete's compressive strengths at different curing ages were predicted using an exponential function model, as shown in Equation 3

$$.F = \beta_1 e^{\beta_2 t} \quad (3)$$

F is the compressive strength (N/mm^2), t is the curing age (Days), β_1 and β_2 are constants.
When the natural logarithm is applied to both sides of Equation 3.1, we get:

$$lnF = ln\beta_1 + \beta_2 t \quad (4)$$

$lnF \equiv Y, ln\beta_1 \equiv a, t \equiv x,$ and $\beta_2 \equiv b.$

$$\therefore Y = a + bx \quad (5)$$

The constants a and b can be found by calibration.

2.2. Statistical Assessment

The models' correctness and dependability were assessed using appropriate statistical evaluation criteria, specifically the Coefficient of Determination (R2) and the Coefficient of Correlation (CRR).

3.0 Results and Discussions

The particle size distribution of the fine aggregate used for the study in Figure 1 shows size range from 0.08mm with percentage passing of 3% to 4.75mm with percentage passing of 95%, this is an indication that the fine aggregate used for the study belong to Zone IV according to BS. 882, 1973. The particle size distribution of the coarse aggregate used for the study in Figure 2 shows size range from 4.75mm with percentage passing of 3% to a maximum aggregate size of 25mm.

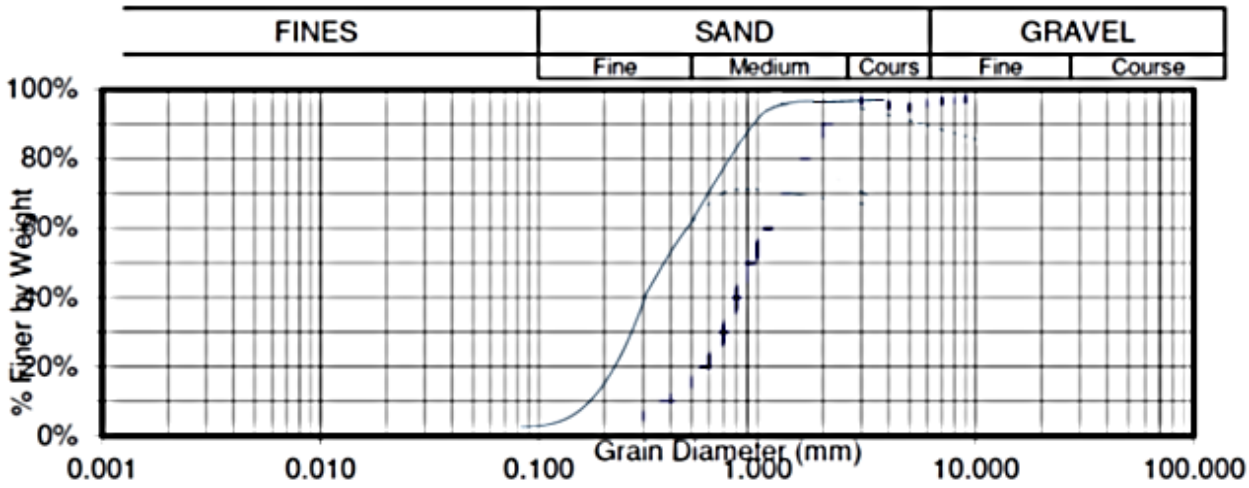

Figure 1: Particle size distribution curve of the fine aggregate

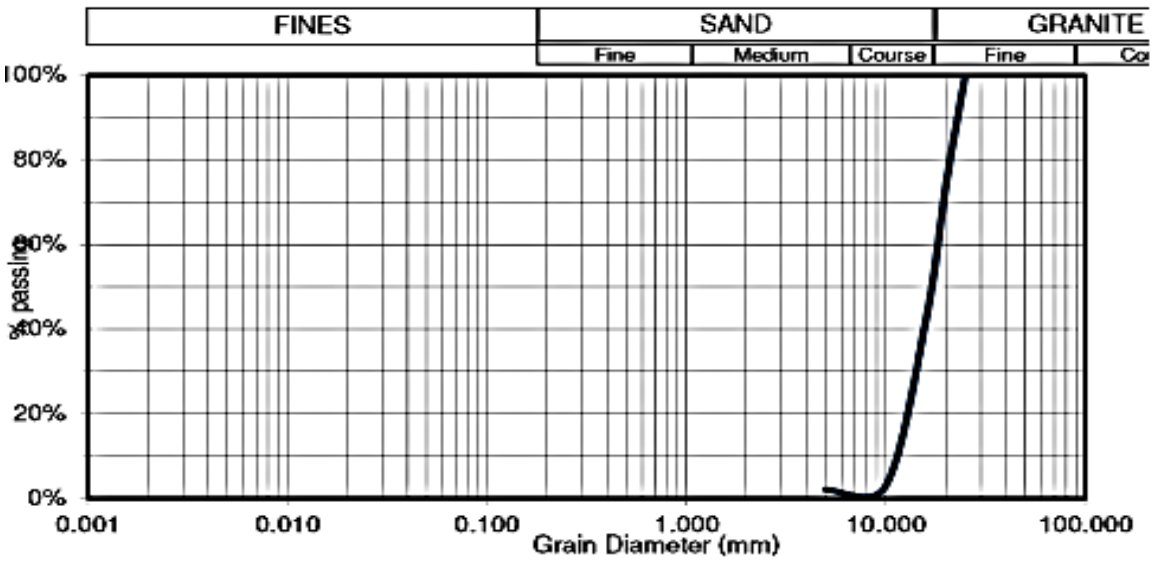

Figure 2: Particle size distribution curve of the coarse aggregate

Figure 3 displays the wet density of concrete cubes made using different Portland cement brands. The Unicem brand exhibited the highest average wet density at 7 days of curing, measuring 2518.52 kg/m3. The Dangote brand had the greatest average wet density (2494.808 kg/m3) after 14 days of curing. The BUA brand exhibited the highest average wet density at 21 days of curing, measuring 2521.478 kg/m3. The Dangote brand exhibited the highest average wet density at 28 days of curing, measuring 2527.408 kg/m3. For all curing ages, the concrete cubes made with BUA cement had the highest average compressive strength values, closely followed by those made with Dangote cement. Conversely, the concrete cubes made with Unicem cement had the lowest average compressive strength values.

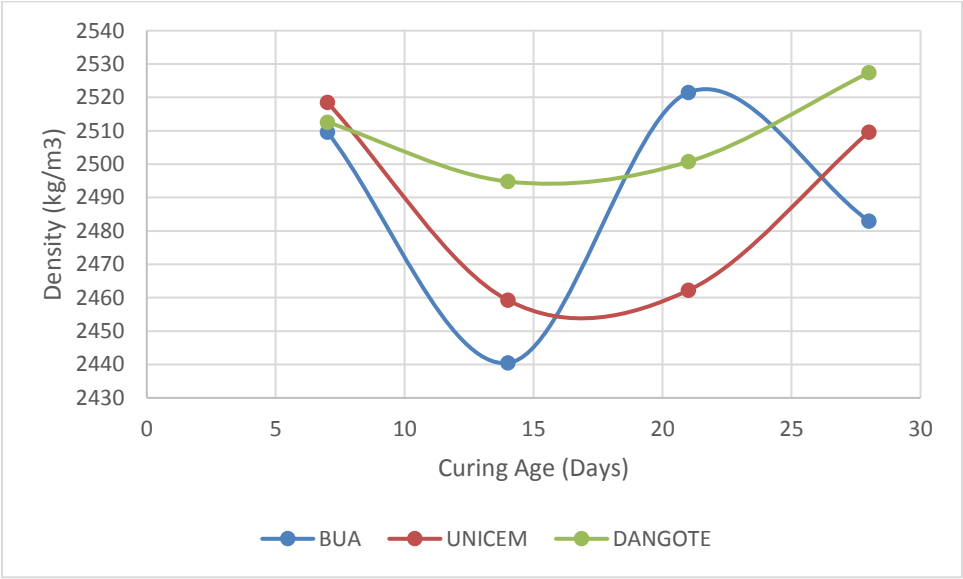

Figure 3: Wet density at various curing ages of the concrete cubes.

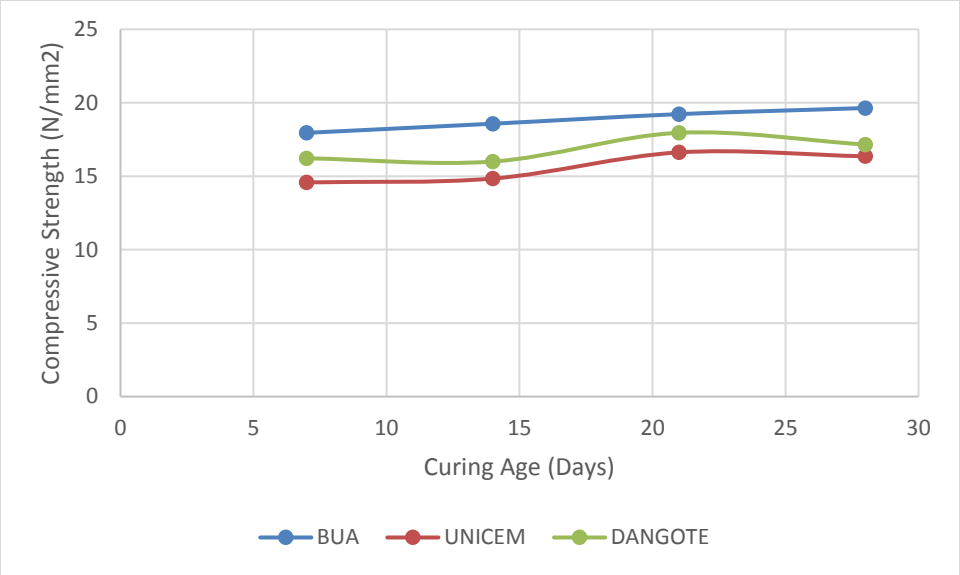

Figure 4: Compressive strength of cubes against curing ages

3.1. Model Verification

Figure 5 compares the average compressive strength vs curing age plots for concretes made using BUA cement that were seen in the laboratory and those that were projected using the model in Equation 6. With lab to model values ranging from 19.64 N/mm2 to 18.99 N/mm2, it is evident that the model accurately predicted the average strength. As seen in Figure 6, the statistical evaluation of the model's accuracy yielded a coefficient of determination (R2) value of 1.00, which in turn produced a coefficient of correlation (CORR) value of 1.00.

$$F_{CB} = 17.46e^{0.0043t} \quad (6)$$

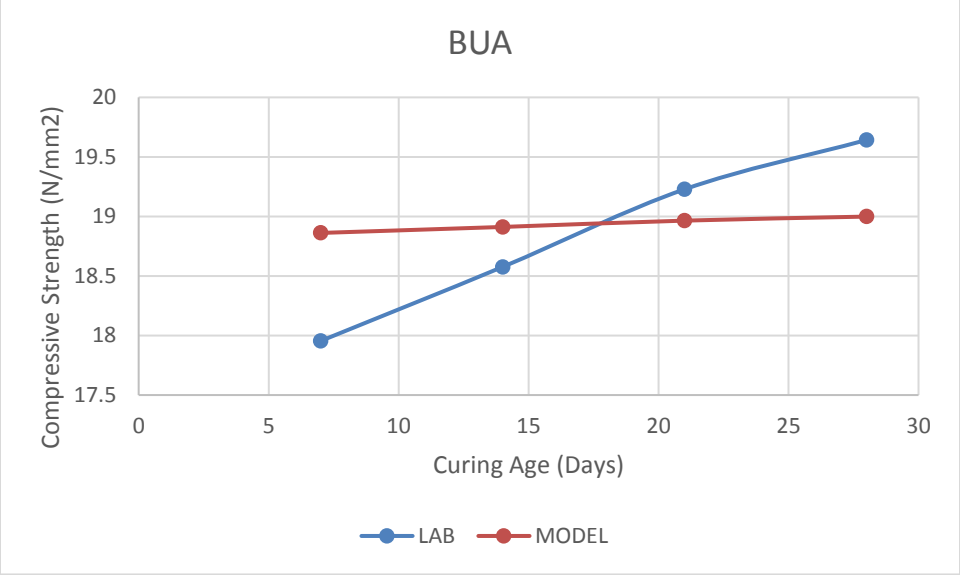

Figure 5: Model verification of compressive strength against curing age for BUA cement

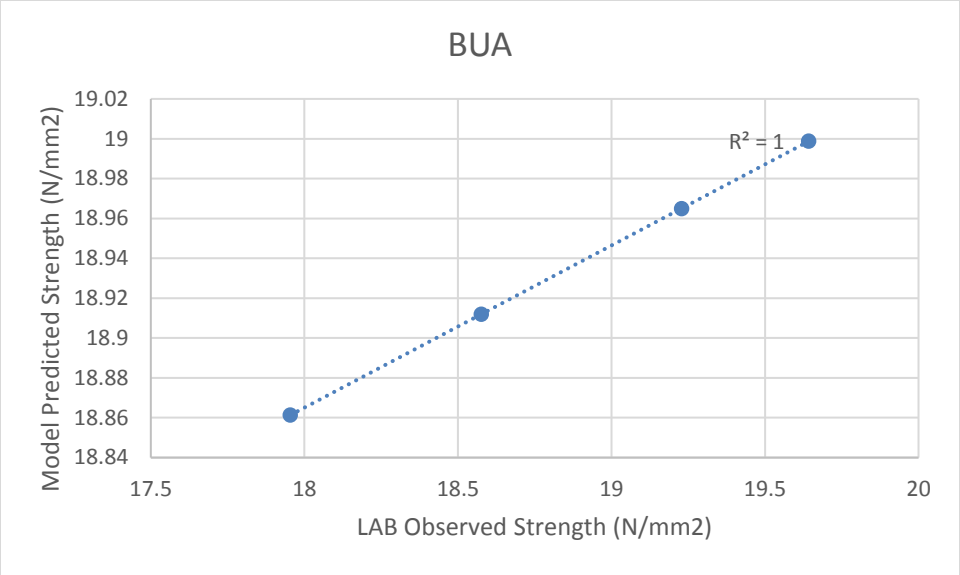

Figure 6: Coefficient of determination of model for BUA cement.

Figure 7 juxtaposes the average compressive strength against curing age graphs for concrete produced with UNICEM cement, as observed in the laboratory, against those forecasted by the model in Equation 7. The model's estimated average compressive strength, with laboratory values ranging from 16.34 N/mm² to 15.45 N/mm², demonstrates a commendable level of accuracy. Figure 8 demonstrates that the statistical assessment of the model's accuracy produced a coefficient of determination (R2) of 1.00, resulting in a coefficient of correlation (CRR) of 1.00. F_CU denotes the compressive strength of concrete formulated with UNICEM cement.

$$F_{CU} = 13.888e^{0.0065t} \quad (7)$$

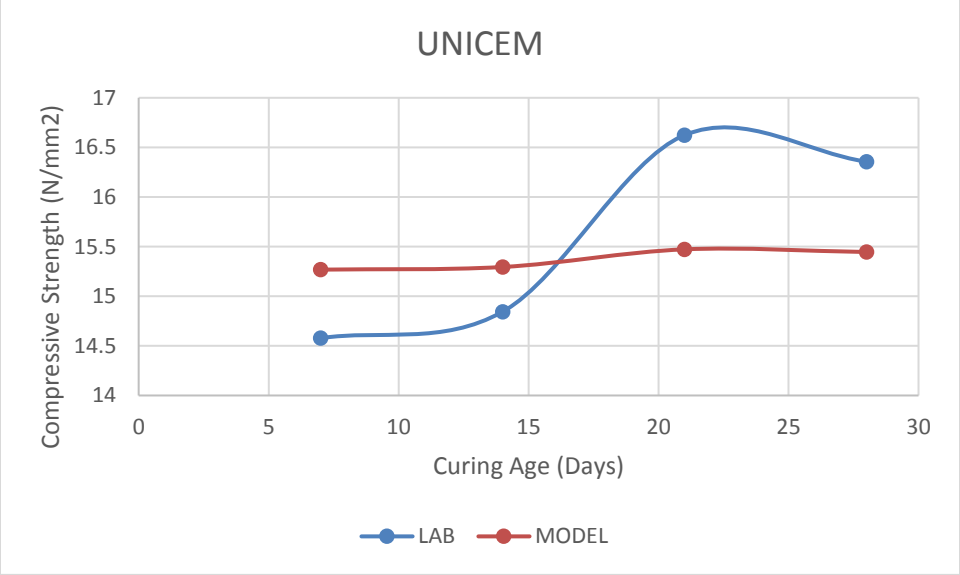

Figure 7: Model verification of compressive strength against curing age for UNICEM cement

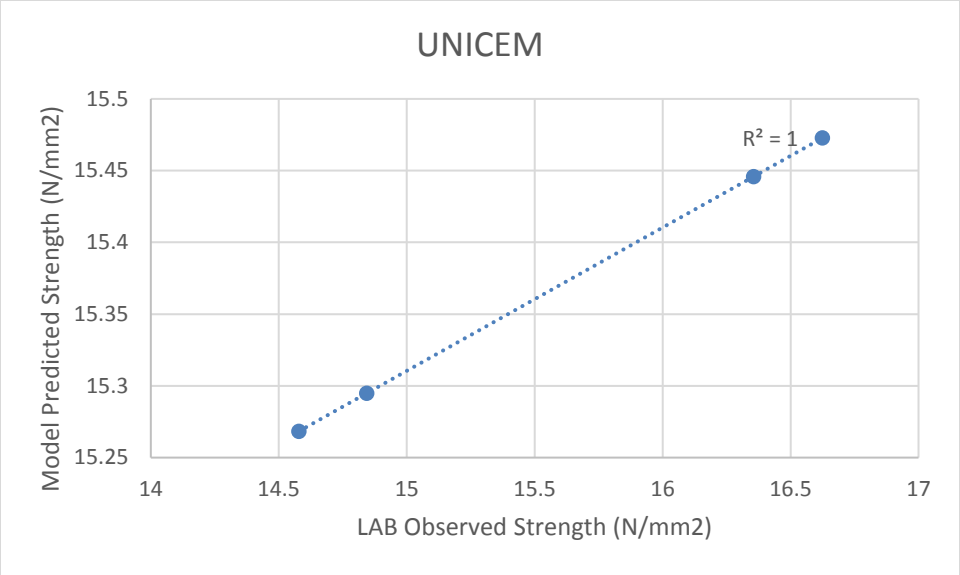

Figure 8: Coefficient of determination of model for UNICEM cement.

Figure 9 compares the average compressive strength vs curing age plots for concretes made using Dangote cement that were seen in the laboratory and those that were predicted using the model in Equation 8. With lab to model values ranging from 17.16 N/mm2 to 16.81 N/mm2, it is evident that the model accurately predicted the average strength. As seen in Figure 10, the statistical evaluation of the model's accuracy yielded a coefficient of determination (R2) value of 1.00, which in turn produced a coefficient of correlation (CORR) value of 1.00.

$$F_{CD} = 15.665e^{0.0041t} \quad (8)$$

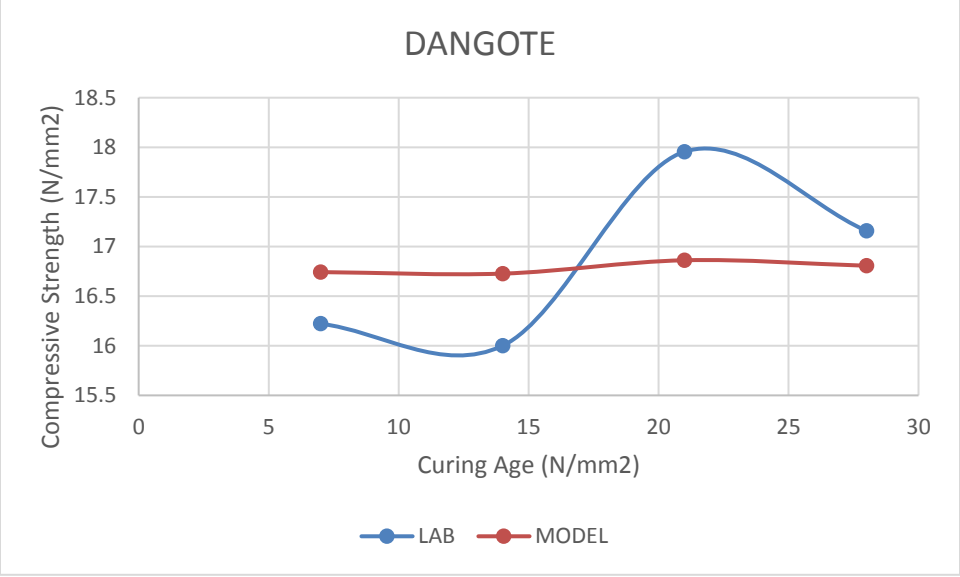

Figure 9: Model verification of compressive strength against curing age for DANGOTE cement

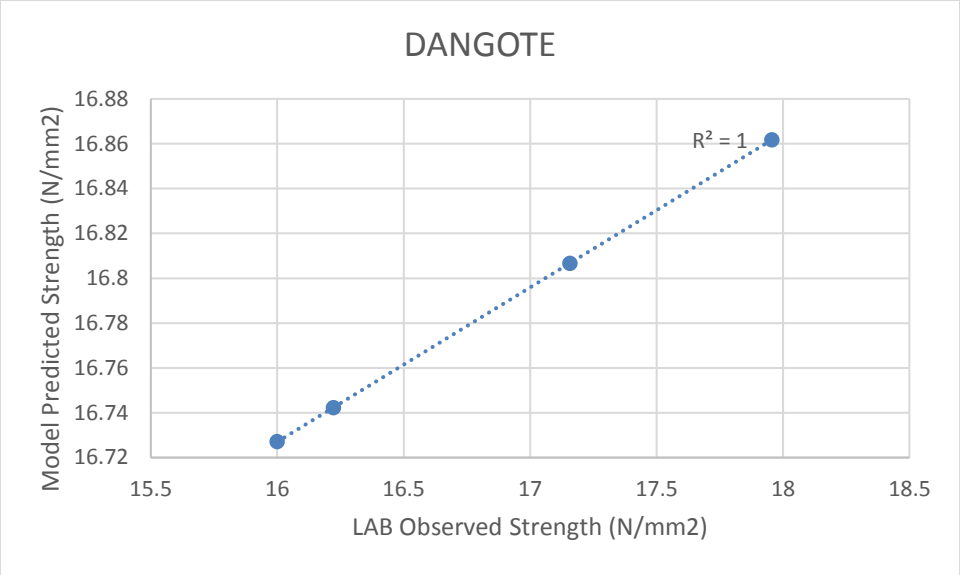

Figure 10: Determination coefficient of model for DANGOTE cement.

4.0. Conclusion

The classification of the aggregates utilized in the study found fine aggregate from sand Zone IV. A maximum coarse aggregate size of 25 mm was used for the study. No identifiable pattern or trend was observed in the wet densities of the concrete cubes produced with various cement brands during all curing ages. During all curing periods, concrete cubes produced with BUA cement had the highest compressive strength, while those prepared with Dangote and Unicem cement demonstrated the lowest strength values. Nevertheless, there is minimal variance in the compressive strength ratings of concretes produced with various cement manufacturers. The developed model, founded on exponential functions, precisely forecasted the average compressive strength recorded in the experiment.

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