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Application of Regression Model in Predicting Compressive Strength of Concrete Incorporating Aloe Vera Gel as Admixture

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ABSTRACT

This research examined the impact of aloe vera gel (AVG) as an admixture on the compressive strengths of concrete and to model these properties with Ibearugbulem's Approach using Visual Basic program. Data used for the model were obtained experimentally. The fresh and hardened properties of AVG-concrete were determined at 7, 14, 21, and 28 curing days with a water-binder ratio of 0.6 and AVG content varying at 0.5% increasing dosage of cement weight up to 5%, using mix ratios of 1:1.5:3 and 1:3:5. Grain size analysis, specific gravity tests, workability tests, setting-time tests, compressive strength' test were carried out. A total of two hundred and sixty-four 150 × 150 × 150 mm' concrete cubes were made for compressive strength test. Ibearugbulem's concept was adopted to develop a model for prediction and strength-optimization of AVG-cement concrete. For the quantity of the constituent ingredients, the response function is expressed as a multivariable function, with respect to the spatial-domain for individual concrete mix content. Response function was formulated within the distinguished spatial-domain and was optimized with the variational approach. The results reveal that mix ratio of 1:1.5:3 is more workable than those made with the ratio of 1:3:5 and slump values increased as the addition of AVG content increased from 0.5 to 5. For mix ratio of 1:1.5:3 and 1:3:5, the optimum experimental and model compressive strength was 31.42 N/mm2 and 33.23N/mm2, 31.78 N/mm2 and 34.83 N/mm2 respectively at 28 curing days and 2.0% AVG inclusion. At 0.60 water-cement ratio, it is recommended to use aloe vera gel not exceeding 2.0%. wt. of cement. The Student's T-test statistical tool which was employed to evaluate the model performance at a 0.95 confidence status, affirmed that the model herein is reliable and apt for AVG-concrete.

1.Introduction

Concrete utilization in the building industry is escalating daily and has placed much demand and expending of concrete constituents. Concrete is a composite-substance made of three components: the cement matrix, water, fine and coarse aggregates. Admixtures are extra materials incorporated into the concrete mix during or immediately before its mixing, to modify the behaviour of concrete [1-6].

Mineral and chemical admixtures are largely the main categories of admixtures. Water-soluble compounds that can be introduced to cement to improve the properties of concrete are considered as chemical admixtures, which include accelerating, water-reducing, retarding admixtures and those combining two or more. While mineral-admixtures are inorganic supplementary cementitious materials that possess pozzolanic ability and can help improve important properties of concrete, such as durability, strengths and permeability. Mineral admixtures include ground granulated blast furnace slag, sawdust ash, rice husk ash, silica fume, cassava peel ash, coconut husk ash, cow dung ash, periwinkle shell ash [7-11].

Investigations on adoption of naturally occurring admixtures have accelerated due to the need to minimize reliance on chemical-admixtures as well as the problem of their accessibility and expense in developing regions. Naturally-occurring admixtures such as cassava starch, maize starch, corn starch, black liquor, Gum Arabic Karroo and broiler hen egg, are abundantly available, cost-effective, eco-friendly and can be locally produced [5, 12-16]. The study on aloe vera gel is validated by the need for more research on local-alternative materials.

The aloe vera gel which is a locally available material, can be considered as a substitute for chemical admixture in concrete, particularly in regions with suitable climates for aloe vera cultivation. Aloe vera gel (AVG) is a bio-based admixture collected from the field, thoroughly cleaned under moving water. The green layer is peeled off and the white part grained to a gel. The gel is added to concrete during fresh mixing at the percentage weight of cement [17-19].
Several authors have employed aloe vera gel to modify concrete properties. Shalini *et al.* [20] employed Aloe vera gel as an admixture to investigate the compressive strength of concrete. The authors adopted concrete of M35 Grade with ratio of 1:1.6:2.9 and added aloe vera juice in varying proportions of 0.5 %, 0.7 % and 1 % of cement weight respectively. Their study showed that at 0.5% proportion of the admixture, there was a high compressive strength of 34.63N/mm^2 at 28 curing days but there was a slight and steady reduction in strength as the concentration of the admixture increased.

The properties of pervious concrete with aloe vera and marble waste powder as partial replacements for cement are investigated by Oggu and Madupu [17]. Aloe vera pulp was used as a water replacement at 60%. The authors tested the permeability, compressive strength and tensile strength of the porous concrete.

Ahmed and Memon [19] used aloe vera gel in concrete at the proportion of 0% ,0.5%,1% ,1.5%,2%,2.5% to analyze its promising effects on workability and compressive strength of concrete. Mixture of AVG had positive outcome on workability and compressive strength at 2.5% addition. Concrete slump up to 57% with 10% rise in compressive-strength. 2.5% dosage of AVG was recommended for adoption in congested reinforcement structure.

Nyabuto *et al.*, [18] employed aloe vera mucilage (AVM) as a bio-admixture in dosages of 2.5% up to 10% to investigate its effects on the fresh properties and mechanical performance of ordinary Portland cement and limestone calcined clay cement in producing self-consolidating concrete. Their study showed the effect of AVM as a set-retarder as the setting time increased with the percentage dosage of AVM. The authors considered 7.5wt.% of AVM inclusion to concrete for anticipated consistency and mobility as well as allowable concrete strength.

A new regression model is developed in this study to circumvent the problem of time-consumption and cost-effect associated with laboratory mix proportioning techniques with respect to the exigency to produce quality and workable concrete with the desired strength. The distinctive aspect of this study is the optimization of aloe vera gel dosage on consistency, mobility, stability, finishability, setting-time and compressive strength of concrete. In addition, it explored the impact of AVG on two different mix ratios: 1:1.5:3 and 1:3:5 for M20 and M10 grades of concrete respectively for reliable domestic and commercial strong floorings.

2. Materials and Methods

2.1 Materials

The materials adopted herein are locally available and they are Portland cement, nanosized aloe vera gel (AVG), drinkable water, fine and coarse aggregates. These materials are discussed below.

2.1.1 Portland cement

The Superset brand of Portland cement in accordance with the specification of BS 12 [21] was used. The Superset cement is a CEM II type of OPC of 42.5 R strength-grade. It was procured from the Watt market in Calabar south, Cross River State.

2.1.2 Aloe Vera Gel (AVG)

The aloe vera plant was obtained from rural farmers in Calabar Municipal, Cross River State. The aloe vera pulp consists of the cell walls, the degenerated organelles and the viscous liquid contained within the cells. The pulp from aloe vera plant was scrapped and the gel extracted by scooping it with a spoon. Then it was grinded and soaked in distilled water for 2 days to separate the fiber and the filament. This extracted gel was then measured using a measuring jar in 0.5% increasing dosage of cement weight up to 5% and applied to the concrete matrix.

2.1.3 Aggregates

The coarse and fine aggregates used herein are locally available. The granite was of angular-shape. The maximum size of the granite used for this work was 20mm diameter, which conformed to the requirements of BS 882 [22]. Sharp river sand was sieved through 10mm British Standard test sieve to eliminate cobbles to satisfy the requirements of [22].

2.1.4 Water

The water used for the experiment during mixing and curing operation was fit for drinking and it conformed to the stipulations in BS 3140 [23]. The water was obtained from the concrete laboratory, Civil Engineering Department, University of Cross River State.

2.2 Methods

2.2.1 Experimental Method

Batching of the constituent materials which include cement, fine aggregate, and coarse aggregate was done by weight and the mix ratio for this experiment was 1:1.5:3 and 1:3:5 and water cement ratio of 0.6. The AVG was added 0.5% to 5% by weight of cement employing 0.5% increasing dosage. For each mix ratio, a total of 132 concrete cubes were prepared.

The concrete constituents were thoroughly and uniformly mixed before the addition of water. The homogenized mixture was poured into 150 mm ×150 mm × 150 mm metal moulds; in three layers and compacted with the tamping rod 25 stroke per layer and the top finish with the trowel and label accurately conforming to BS 1881 [24]. For identification purpose, the cubes were marked at their tops after a while. The concrete was de-moulded after 24 hours. The concrete specimens were cured for 28 days and tested afterward.

2.2.2 Derivation of fundamental equation of the mathematical model

The mix quantity (x_i) of each component on a particular observation point was determined by dividing the individual component (s_i) by the sum of the components (S) as shown in equation 1 and 2.

$$x_i = \frac{s_i}{S} \quad (1)$$

$$S = s_1 + s_2 + s_3 + s_4 \quad (2)$$

In this work, the spatial domain in which the model was restricted to are mix ratio domains given as equations 3 to 6:

$$s_{1min} \leq s_1 \leq s_{1max} \quad (3)$$

$$s_{2min} \leq s_2 \leq s_{2max} \quad (4)$$

$$s_{3min} \leq s_3 \leq s_{3max} \quad (5)$$

$$s_{4min} \leq s_4 \leq s_{4max} \quad (6)$$

From Equation 1,

$$s_i = x_i \, . \, S \qquad [where \; 1 \leq i \leq 4\,] \quad (7)$$

Substituting Equation 7 into Equation 2 gives the sum of all the mix quantities to be unity as:

$$x_1 + x_2 + x_3 + x_4 = 1 \quad (8)$$

The relationship between S and x_1 is shown in equations 9a and 9b:

$$S = \mathbf{-4536.8}x_1^3 + \mathbf{1946.1}x_1^2 - \mathbf{313.04}x_1 + \mathbf{22.38} \quad (9a)$$

$$S = \mathbf{-33528}x_1^3 + \mathbf{8722.7}x_1^2 - \mathbf{851}x_1 + \mathbf{36.9} \quad (9b)$$

Equations 9a and 9b is obtained from the third-degree-polynomial Trendline equation from the Microsoft Excel line graph of the variation of X_1 against S using the experimental data. Equations 9a and 9b is for mix ratios 1:1.5:3 and 1:3:5 respectively. The response function to be adopted herein is a quadratic function of the component proportions given as:

$$y = a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5{x_1}^2 + a_6{x_2}^2 + a_7{x_3}^2 + a_8{x_4}^2 + a_9x_1x_2 + a_{10}x_1x_3 + a_{11}x_1x_4 + a_{12}x_2x_3 + a_{13}x_2x_4 + a_{14}x_3x_4 \quad 9c$$

That is:

$$y = [x_i]\,[a_i] \quad 9d$$

Equation 9d was used to obtain the array response equation for the set of mix ratios used in the formulation as:

$$[y^k] = [{x_i}^k]\,[a_i] \quad 9e$$

Where k denotes the mix number (or observation point number); $[a_i]$ is the coefficient vector, and $[x_i]$ is the shape function vector. They are:

$$[a_i] = [a_1\ a_2\ a_3\ a_4\ a_5\ \ a_6\ a_7\ a_8\ a_9\ a_{10}\ a_{11}\ a_{12}\ a_{13}\ a_{14}]^T \quad 10$$

$$[x_i]\ = [x_1\ \ x_2\ \ x_3\ \ x_4\ \ {x_1}^2\ \ {x_2}^2\ \ {x_3}^2\ \ {x_4}^2\ \ x_1x_2\ \ x_1x_3\ \ \ x_1x_4\ \ x_2x_3\ \ x_2x_4\ \ x_3x_4] \quad 11$$

Pre-multiplying both sides of Equation 9c with a weighting function (transpose of the shape function) for the set of mixes for the formulation gives the weighted response equation (WRE) as:

$$[{x_i}^k]^T[y^k] = [{x_i}^k]^T.[{x_i}^k]\,[a_i] \quad 12a$$

This multiplication did not change the generality of the regression function as the weighting function can easily cancel out from both the left and right hand sides of Equation 12a. It is clear from here that the approach used in the original work of Ibearugbulem model (Ibearugbulem et al., 2013) is weighted response approach (WRA).
The weighted response equation (Equation 12a) can be rewritten as:

$$[F] = [CC]\,[a_i] \quad 12b$$

Where the weighted response vector, F and CC matrix are defined as:

$$[F] = [{x_i}^k]^T[y^k] \quad 13$$

$$[CC] = [{x_i}^k]^T.[{x_i}^k] \quad 14$$

[CC] is the matrix whose arbitrary element CC_{ij} is obtained by array multiplication of transpose of Column "i" with Column "j" of the shape function vector.

3. Results and Discussion

3.1 Properties of Concrete Constituents

The sharp sand has coefficient of uniformity and curvature values of 2.16 and 0.82 respectively obtained from Figure 1. The coarse aggregate has coefficient of uniformity and coefficient of curvature values of 2.46 and 0.77 respectively obtained from Figure 2. The grain-size analysis was conducted as stipulated in BS EN 933 [25] and the grading limits was ascertained based on BS EN

882 [22] as shown in Figures 1 and 2. The coefficient of curvature for both aggregates were affirmed to be close to 1 which indicates that the samples were well-graded, while the coefficient of uniformity of less than or equal to 4, which implies that they were uniformly-graded. The results of the specific gravity of the river sand and granite were 2.55 and 2.65; which are within the acceptable limits for aggregates ranged from 2.30 to 2.90. The aggregates are apt for concrete making.

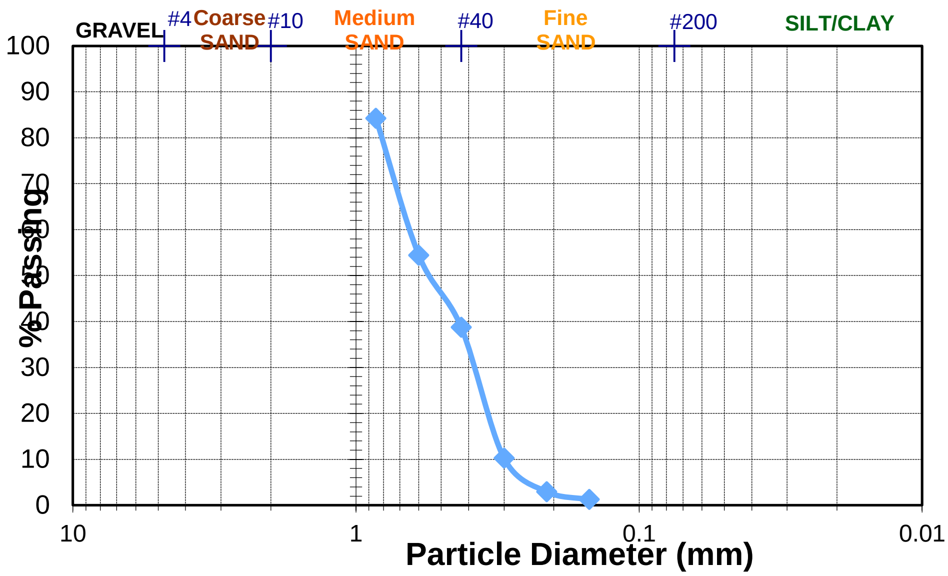

Figure 1. Particle size distribution curves for fine aggregate

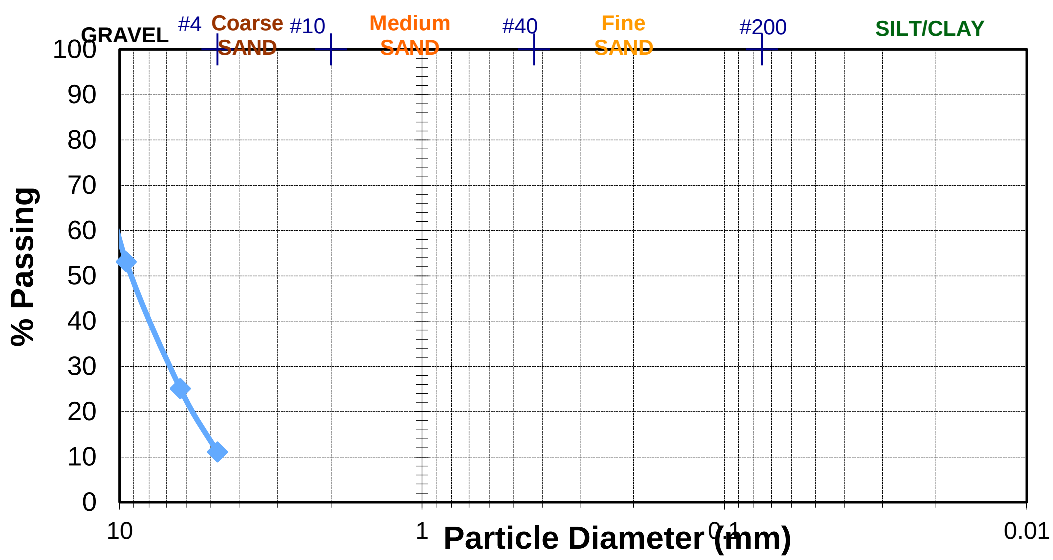

Figure 2. Particle size distribution curves for coarse aggregate

3.2. Slump Test

The test was done in accordance with BS EN 12350-2 [26]. It can be seen from Figures 3 and 4, that the slump increased as the addition of AVG content increased from 0.5 to 5. For mix ratio 1:1.5:3, At 1.5% AVG inclusion, the slump had an increased percentage difference of 4.57 while it had a decreased percentage difference of 1.05 at of 2.5 % AVG inclusion. For mix ratio 1:3:5, At 1.5% AVG inclusion, the slump had an increased percentage difference of 14.47 while it had a reduced percentage difference of 0.66 at of 2.5 % AVG inclusion. This implies that AVG-cement concrete produced with mix-ratio of 1:1.5:3 is more workable. The increased workability of AVG-concrete is traceable to the water content of aloe vera gel. As the internal-friction of the cement-paste within the concrete reduced, there was an increased mix flowability. The slump values showed that they have improved degree of workability which is attributed to the polymer molecules in aloe vera gel. Figures 3 and 4 indicates that AVG-concrete is suitable for manually compacted slabs, normal reinforced concrete works and mass concrete jobs.

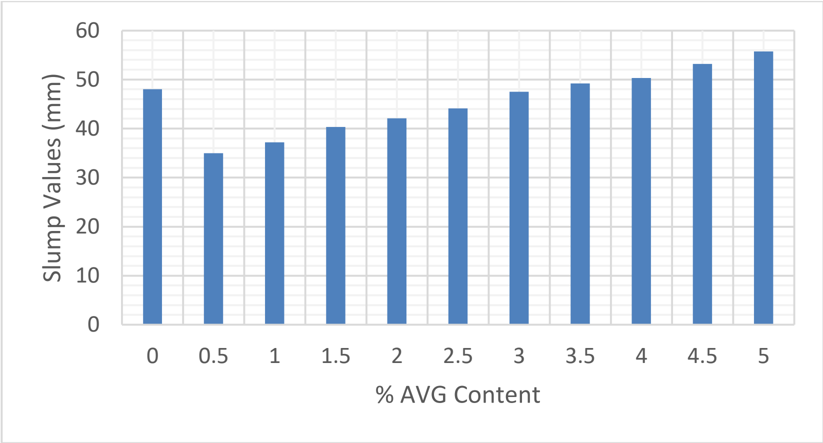

Figure 3. Variation of slump values with % AVG Content for 1:1.5:3 Mix ratio

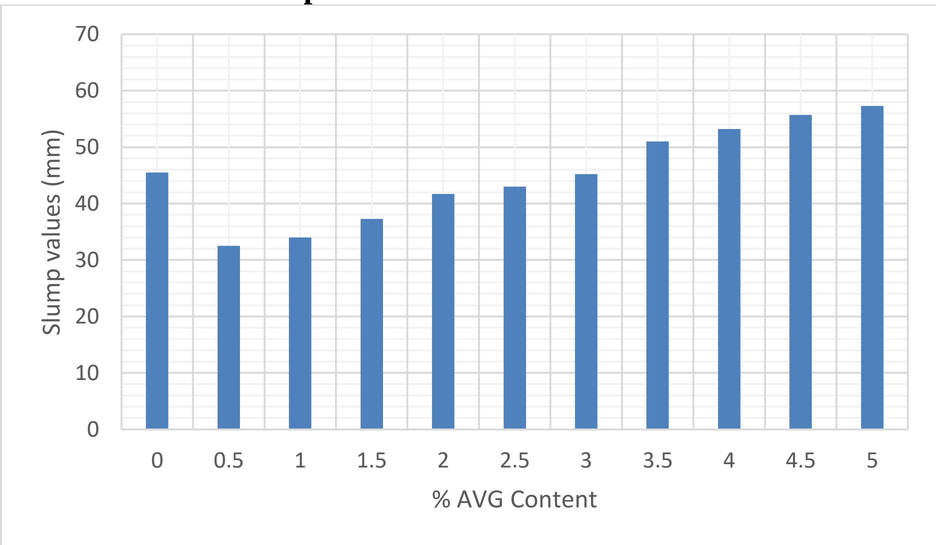

Figure 4. Variation of slump values with % AVG Content for 1:3:5 Mix ratio

3.3 Setting time test

The setting time was measured by the guidelines in BS 4550: Part 3 [27]. The outcome of the setting time tests shown in Figure 5 reveals a progressive increase in the setting time with the inclusion of aloe vera gel admixture. Initial and final setting times for the control mix were 83 and 125 minutes and gradually increased to 203 and 352 minutes, respectively, with the addition of AVG up to 5.0% by weight of cement. The increase in the initial and final setting times for 1.5%, 2.5% and 5% percentage inclusion of AVG over the control are 20 minutes and 62 minutes, 41 minutes and 100 minutes, 120 minutes and 227 minutes respectively.

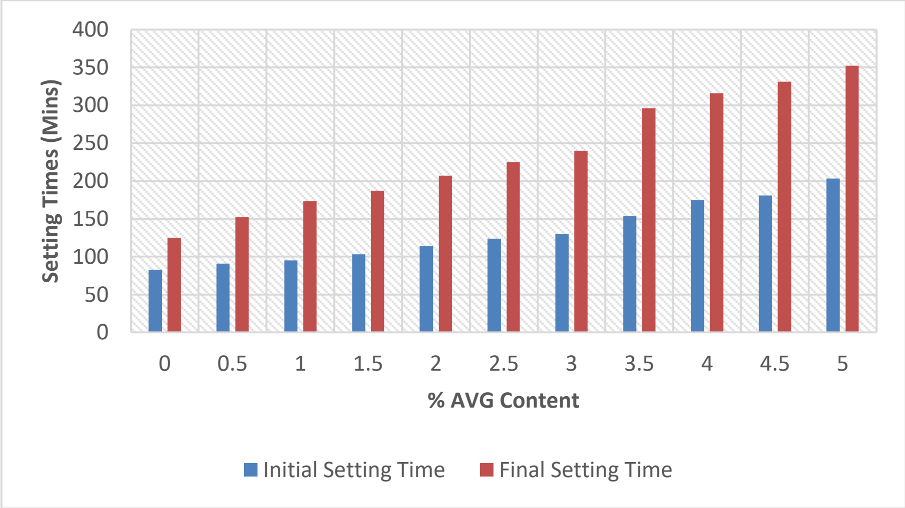

Figure 5. Variation of setting times with % AVG content

3.4 Compressive strength of AVG-cement concrete
3.4.1 Experimental Outcome

The compressive strength of different specimens after 7 days, 21 days, and 28 days were shown presented on figures 6 and 7. It is evident that all the cubes produced with aloe vera gel admixture gave strength that are greater than the control mix for all the mix ratios. It is also observed that AVG-Concrete with mix ratio of 1:3:5 had higher compressive strength than those produced with mix ratio of 1:1.5:3.

For both mix ratios, the compressive strength increased as the curing days increased. Strength also increased with AVG addition and dropped after 2.0% inclusion. This outcome is in agreement with the findings of Ahmed and Memon (2022) that aloe vera gel increases the strength of concrete. The result also shows slow early strength gain of AVG- concrete and improved compressive strength after 28 days of curing.

Figure 6 showed that AVG-concrete produced with 2.0% addition of AVG admixture gave the highest strength of 26.03 N/mm2, 30.24 N/mm2 and 32.34 N/mm2 for 7 days, 21 days and 28 days, respectively for mix ratio of 1:1.5:3. Figure 7 showed that AVG-concrete produced with 2.0% addition of AVG admixture gave the highest strength of 28.34 N/mm^2, 32.10 N/mm^2 and 33.76 N/mm^2 for 7 days, 21 days and 28 days, respectively for mix ratio of 1:3:5.

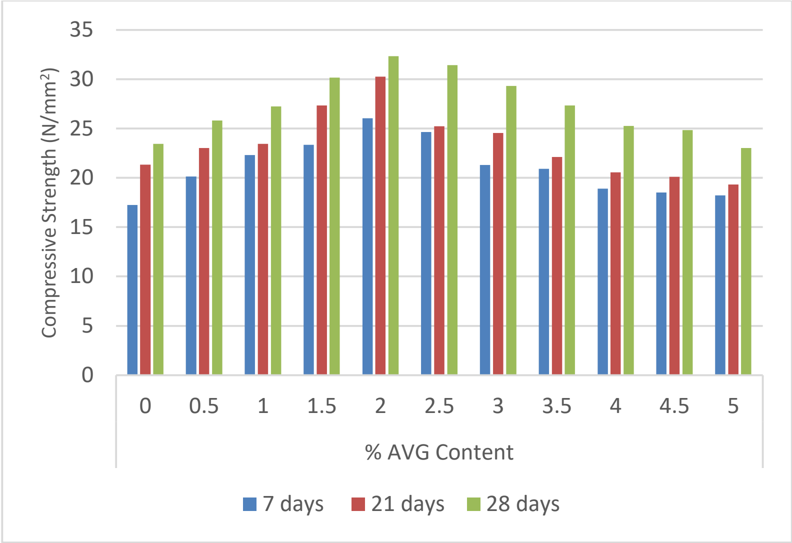

Figure 6. Variation of Compressive strength with different Curing periods for different percentage content of AVG-cement concrete at mix ratio of 1:1.5:3

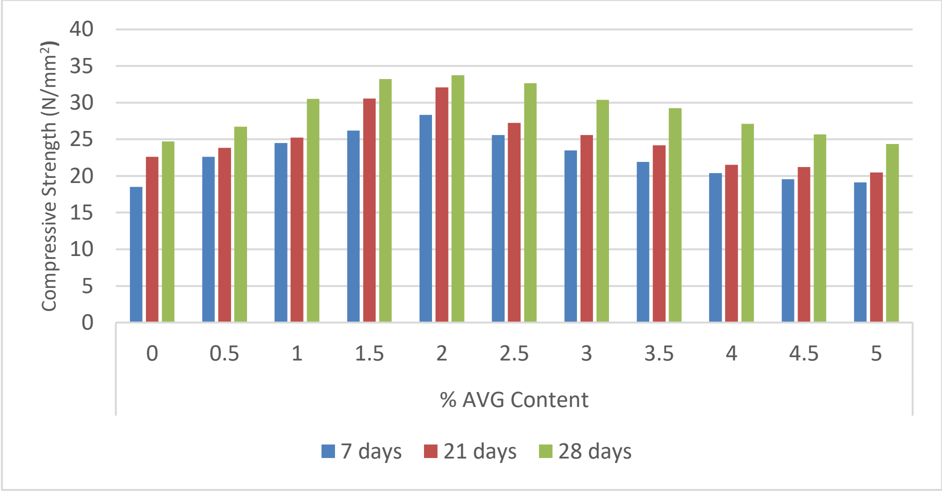

Figure 7. Variation of Compressive strength with different Curing periods for different percentage content of AVG-cement concrete at mix ratio of 1:3:5

3.4.2 Fitting the model with the mixes used herein

The mix proportion containing the values of quantities of mix components, x_1. x_1 was normalized and approximated at four decimal places such that condition of Equation 8 was not violated. The summation of x_1 in each mix ratio obtained from Table 1, was ensured to be equal to unity (in accordance with Equation 8). The values of x_1 obtained from Table 1 were used to determine the shape function and weighted response.

The transpose of the response of the odd number mix ratios is taken directly from mix proportions and is given as:

$[y^k]$ = [28.43 27.24 32.24 29.31 25.26 23.02]

The shape function for the 6 mixes (mix C1, C3, C5, C7, C9 and C11) was taken from mx proportions and substituted into Equations 1 and 2.

The transpose of the shape function is:

$[x^k] =$

5.57	0.108	0.271	0.621	0.000	0.012	0.073	0.386	0.000	0.029	0.067	0.000	0.168	0.000	0.000
5.58	0.108	0.271	0.62	0.002	0.012	0.073	0.384	0.000	0.029	0.066	0.000	0.168	0.000	0.001
5.59	0.107	0.27	0.619	0.004	0.011	0.073	0.383	0.000	0.029	0.066	0.000	0.167	0.001	0.002
5.6	0.107	0.269	0.618	0.005	0.011	0.072	0.382	0.000	0.029	0.066	0.000	0.166	0.001	0.003
5.61	0.107	0.269	0.617	0.007	0.011	0.072	0.381	0.000	0.029	0.066	0.000	0.166	0.002	0.004
5.62	0.107	0.269	0.616	0.009	0.011	0.072	0.379	0.000	0.029	0.066	0.001	0.166	0.002	0.005

The shape function and its transpose were substituted into Equation 14 to obtain CC matrix. In the same manner, the transpose of the shape function and the response vector from the first ten mixes were Substituted into Equation 13 to obtain the weighted response vector. The CC matrix and the weighted response vector are respectively presented as:

CC Matrix =

0.06913	0.17378	0.39832	0.00289	0.00730	0.04669	0.24634	0.01000	0.01868	0.04261	0.00011	0.10744	0.00064	0.00161
0.17378	0.43687	1.00136	0.00727	0.01835	0.11738	0.61928	0.01000	0.04695	0.10713	0.00027	0.27011	0.00162	0.00404
0.39839	1.00136	2.29527	0.01667	0.04206	0.26905	1.41948	0.01000	0.10762	0.24555	0.00062	0.61913	0.00370	0.00926
0.00289	0.00727	0.01667	0.00018	0.00030	0.00195	0.01029	0.01000	0.00078	0.00178	0.00001	0.00449	0.00004	0.00010
0.0073	0.01835	0.04206	0.00030	0.00077	0.00493	0.02602	0.01000	0.00197	0.00450	0.00001	0.01135	0.00007	0.00017
0.04669	0.11738	0.26905	0.00195	0.00493	0.03154	0.16639	0.01000	0.01262	0.02878	0.00007	0.07258	0.00043	0.00108
0.24633	0.61928	1.41948	0.01029	0.02602	0.16639	0.87787	0.01000	0.06656	0.15186	0.00038	0.38289	0.00229	0.00572

0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.01000	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
0.01868	0.04695	0.10762	0.00078	0.00197	0.01262	0.06656	0.01000	0.00505	0.01151	0.00003	0.02903	0.00017	0.00044
0.04261	0.10713	0.24555	0.00178	0.00450	0.02878	0.15186	0.01000	0.01151	0.02627	0.00007	0.06623	0.00040	0.00100
0.00011	0.00027	0.00062	0.00001	0.00001	0.00007	0.00038	0.01000	0.00003	0.00007	0.00001	0.00017	0.00000	0.00001
0.10744	0.27011	0.61913	0.00450	0.01135	0.07258	0.38289	0.01000	0.02903	0.06623	0.00017	0.16701	0.00100	0.00249
0.00064	0.00162	0.00370	0.00004	0.00007	0.00043	0.00229	0.01000	0.00017	0.00040	0.00000	0.00100	0.00001	0.00002
0.00161	0.00404	0.00926	0.00010	0.00017	0.00108	0.00572	0.01000	0.00044	0.00099	0.00001	0.00249	0.00002	0.00006

Weighted Response Matrix, F

F =

17.23487
43.33508
99.33661
0.71439
1.81727
11.64621
61.43542
0
4.6574
10.62303
0.02302
26.79328
0.15821
0.39599

Substituting the model coefficients into equation (9c) gives the response function for the mix ratios used herein as

$$y_1 = 132.30x_1 - 436.95x_2 + 581.17\, x_3 - 212.94\, x_4 + 645.85\, {x_1}^2 + 378.03{x_2}^2 - 663.44{x_3}^2 + 0.30\, {x_4}^2 + 153.99x_1x_2 + 621.13\, x_1x_3 - 820.80\, x_1x_4 - 325.59\, x_2x_3 - 74.70\, x_2x_4 - 7.79\, x_3x_4 \quad (16)$$

$$y_2 = -6.30x_1 + 35.24x_2 - 1.29\, x_3 - 5.13\, x_4 - 1.20\, {x_1}^2 + 16.49{x_2}^2 + 88.11{x_3}^2 - 15.48\, {x_4}^2 + 63.17\, x_1x_2 - 167.62\, x_1x_3 + 15.80\, x_1x_4 - 45.55\, x_2x_3 - 8.92\, x_2x_4 + 18.63\, x_3x_4 \quad (17)$$

Equation 16 and 17 are the models for prediction of 28days' of compressive strength of AVG concrete for mix ratio 1:1.5:3 and 1:3:5 respectively

3.4.3 Test of adequacy of the model

The developed model was further examined for adequacy using the student's t-test as shown in Tables 1 and 2. A two-tailed student's T- test was done and the computations presented in Tables 3 and 4. The property of AVG-concrete used for this model validation is the compressive strength because the quality of concrete is largely determined by its compressive property. Prediction and optimization of this property is needed for the performance and sustainability evaluation of concrete. The maximum percentage difference between the laboratory results and model outcome of the compressive strength obtained with mix ratio 1:1.5:3 was 18.93%, 17.10%, and 3.19% at 7, 21 and 28 curing periods. The computed T-value of the model was -0.79 which is less than the standard T-value of 2.78 obtained from the standard statistical tables. The optimum percentage difference between the laboratory results and model outcome of the compressive strength obtained with mix ratio 1:3:5 was -2.02%, -0.74%, and 0% at 7, 21 and 28 curing periods. The computed T-value of the model was -2.75 which is less than the standard T-value of 2.78 obtained from the standard statistical tables. The adequacy test confirms that the result from model are reliable and could be used to predict the 7, 21 and 28 compressive strength of AVG-concrete at 95% confidence level. This proves that Ibearugbulem's model is reliable and worthy of adoption for strength prediction.

Table 1: Comparison of Experimental Results against Ibearugbulem Model Prediction for the Compressive Strength of AVG Concrete of Mix ratio 1:1.5:3 using Percentage Error Method.

S/N	Compressive Strength (N/mm²) 7 days			21 days			28 days		
	Lab	Model	% difference	Lab	Model	% difference	Lab	Model	% difference
1	20.12	21.15	4.87	23.01	24.32	-5.39	25.80	26.21	-1.56
2	23.35	20.54	13.68	27.32	23.32	17.10	30.15	31.78	-5.13
3	24.63	20.71	18.93	25.21	23.49	7.32	31.42	30.45	3.19
4	20.9	20.57	1.60	22.10	23.13	-4.45	27.33	26.46	3.29
5	18.51	20.24	-8.55	20.10	22.43	-10.39	24.82	27.33	-9.18

Table 2: Comparison of Experimental Results against Ibearugbulem Model Prediction for the Compressive Strength of AVG Concrete of Mix ratio 1:3:5 using Percentage Error Method.

S/N	Compressive Strength (N/mm²) 7 days			21 days			28 days		
	Lab	Model	% difference	Lab	Model	% difference	Lab	Model	% difference
1	22.61	24.65	8.28	23.82	24.71	3.60	26.72	27.23	2.23
2	26.20	26.74	2.02	30.56	31.65	3.44	33.23	33.23	0
3	25.60	27.45	6.74	27.23	28.24	3.58	32.66	34.83	6.23
4	21.90	22.79	3.91	24.17	24.35	0.74	29.26	30.35	3.59
5	19.87	20.01	0.70	21.84	22.65	3.58	25.62	27.74	7.64

Table 3: Statistical student's T-test for Ibearugbulem's model validation using the 28 day' compressive strength of mix ratio 1:1.5:3

S/No.	E_x	N_p	$D_i=E_x-N_p$	$D_A=(\sum D_i)/N$	D_A-D_i	$(D_A-D_i)^2$
1	25.80	26.21	0.41	0.54	0.13	0.02
2	30.15	31.78	1.63	0.54	1.09	1.19
3	31.42	30.45	0.97	0.54	1.51	2.28
4	27.33	26.46	0.87	0.54	1.41	1.99
5	24.82	27.33	2.51	0.54	1.97	3.88

Table 4: Statistical student's T-test for Ibearugbulem's model validation using the 28 day' compressive strength of mix ratio 1:3:5

S/No.	E_x	N_p	$D_i=E_x-N_p$	$D_A=(\sum D_i)/N$	D_A-D_i	$(D_A-D_i)^2$
1	26.72	27.23	0.51	1.18	0.67	0.45
2	33.23	33.23	0	1.18	1.18	1.39
3	32.66	34.83	2.17	1.18	0.99	0.98
4	29.26	30.35	1.09	1.18	0.09	0.01
5	25.62	27.74	2.12	1.18	0.94	0.88

Where;
E_x = Experimental responses.
N_p=Ibearugbulem Model responses.
N = the Number of Responses = 5

For Mix ratio 1:1.5:3;
$\sum D_i = -2.71$
$\sum (D_A - D_i)^2 = 9.36$
$s^2 = [\sum (D_A - D_i)^2] / (N-1) = 2.34$
$S = \sqrt{s^2} = 1.53$

D_A x $\sqrt{N}$ = -1.21
T = [D_A x $\sqrt{N}$]/S = -0.79
Degree of freedom = N-1
5% significance for a two-tailed test = 0.05
From standard statistical table, T = $T_{(0.05, n-1)}$ = $T_{(0.05,4)}$ = 2.78

For Mix ratio 1:3:5;
$\sum D_i$= -5.89
$\sum (D_A - D_i)^2$ =3.71
$s^2 = [\sum (D_A - D_i)^2] / (N-1)$ = 0.93
S =$\sqrt{s^2}$ = 0.96
D_A x $\sqrt{N}$ = -2.64
T = [D_A x $\sqrt{N}$]/S = -2.75
Degree of freedom = N-1
5% significance for a two-tailed test = 0.05
From standard statistical table, T = $T_{(0.05, n-1)}$ = $T_{(0.05,4)}$ = 2.78

4. Conclusion

Based on the outcome of the study, the following conclusions were drawn;

i. The concrete containing aloe vera gel (AVG) as an admixture made with mix ratio of 1:1.5:3 is more workable than those made with the ratio of 1:3:5. The slump values increased as the addition of AVG content increased from 0.5 to 5. The slump values showed that they have improved degree of workability which is attributed to the molecules in aloe vera gel.
ii. AVG-Concrete with mix ratio of 1:3:5 had higher compressive strength than those produced with mix ratio of 1:1.5:3. For both mix ratios, the compressive strength increased as the curing days increased. The values of compressive strength of the concrete increased as percentage addition of the admixture increased until an optimum percentage of 2.0% AVG was attained.
iii. Adopting the Student’s T-test statistical tool at 5% significant level, the developed model was confirmed to be suitable, reliable and adequate for prediction of the compressive of the AVG-concrete

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