Effects of Gum Arabic Admixture on the Mechanical Strengths of Cement Paste and Concrete

Augustine Uchechukwu Elinwa[1]*, Muhammad Abdullahi Hazzard[1]

[1] Civil Engineering Department, Abubakar Tafawa Balewa University, Bauchi, Bauchi State, Nigeria

Email Address

auelinwa@gmail.com (Augustine Uchechukwu Elinwa)
*Correspondence: auelinwa@gmail.com

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Abstract:

The evaluation of the mechanical strengths of gum Arabic concrete (GAC) have been carried out. This was done using dosage levels of GA, 0.00 % (control) to 1.00 % as admixture, cement content of 420 kg/m3, and water-cement ratio of 0.5, to produce cement pastes and concrete specimens that were cured for 90 days in water. Results on the soundness, compressive and flexural strengths showed positive indicators for the use of GA as an admixture. An optimum dosage of 0.50 % by weight of cement was achieved. Linear regression models of Natural Log and Square Root, best described the experimental data, and parameters of interest were very significant. Response surfaces were developed showing the various levels of interactions of compressive and flexural strengths with the mix parameters.

Keywords:

Gum Arabic, Admixture, Soundness and Setting Times, Compressive and Flexural Strengths, Regression Models, Microstructure and Acid Resistance

1. Introduction

Gum Arabic (GA) is a polysaccharide and organic in nature. It is very abundant in the Sahel region. It is an important material because of its various uses and applications in the confectionary industries. This is because of its emulsifying characteristics, solubility, low viscosity, and non-toxic nature [1]. The emulsifying properties of GA are due to the arabinogalactan protein (AGP) which is linked with highly branched polysaccharide structures [2].

Figure 1. *Gum Arabic Noodles*

The use of GA in the construction industry is gaining importance because of the highlighted attributes of this material. Its use in the construction industry will equally boost the level of construction presently going on in the world and specifically, Nigeria. Not only that, the availability, easy of processing and cost, against the conventional admixtures, will make GA a more acceptable alternative. The fundamental problems however in applying GA to cement and concrete works, would be in the area of appropriate technology in its use and application. Not much in terms of literatures on like the conventional admixtures, are documented on the dosage and effects on GAC.

F. Puertas et al [3] studied the effect of a polycarboxylate (PC) admixture on the mechanical, mineralogical, structural and rheological behaviour of Portland cement pastes, using cement pastes with a w/c ratio of 0.4 and superplasticizer dosage of 0 to 1 %. The pastes were cured in chambers kept at a relative humidity of 99 % and 21 ± 2^{O}C. They concluded that the presence of PC admixture retarded the initial cement hydration reactions and, that the admixture induced microstructural modification in the pastes, which slightly reduced porosity. The admixture however, did not affect the mechanical strength of pastes at either the 2 or 28 days of hydration. The results on the rheology studies showed that low dosage of PC led to a substantial reduction (over 70 %) in the yield stress.

A study on the effects of addition of GA powder to concrete using x-ray diffraction and microstructure methods of analysis was carried out by Elinwa and Umar [4]. The characteristics of the GA nodules used have a specific gravity of 1.25, and a pH value of 5.5. The chemical composition of the GA in mg/L is: K (5.1 mg/L), Na (5.5 mg/L), Ca (4.8 mg/L), Mn (0.8 mg/L), Cu (0.2 mg/L), Zn (2.5 mg/L), Fe (4.0 mg/L). Experiments on the density, water absorption and compressive strength at 28 days of curing were done, using a mix ratio of 1: 1.7: 2.5 and a w/c ratio of 0.5. The cement content was 420 kg/m^3, and five mixes were used, labeled M-00 to M-04, containing GA of dosages from 0.0 % to 1.0 %. The x-ray diffraction and microstructure analysis were carried out using crushed samples from the compressive strength test to study the the various phase changes in the cement matrix. They concluded that the GA induced microstructural transformation in the concrete due to hydration process. Minerals like mordenite, Osumulite and wollastonite were dictated in the x-ray diffractograms and were attributed to enhanced performance of the GAC. These imparted strength to the concrete, and the maximum dosage recommended from the work was 0.50 %. Also, part of their recommendation was that GA should be used with plasticizers in addressing the issue of water absorption.

Zhoa et al [5] studied the effect of GA on the dispersion of cement pastes, and the factors influencing the holding capacity of GA in cement during hydration. Cement pastes made with gum were prepared using 200 g of ordinary Portland cement, with w/c ratio of 0.4. The dosages of the gum were from 0.02 t0 1.00 %, with a control sample of 0.00 % dosage. The rheological properties of the cement pastes such as the yield stress and plastic viscosity were determined, at different shear rates designed to increase gradually from 0 – 200 s-1 over 180 s. Tests were also run at fixed shear rates of 5 s-1 and 50 s-1 over 180 s, respectively, to assess the development of apparent viscosity of cement paste with time. Their results showed that 0.100 to 0.60 wt % of GA positively affected dispersion and that lower dosages had negligible effect. The optimum dosage of GA to achieve best disperse-holding capacity of cement paste was 0.3 wt % and the minimum water-cement ratio needed to obtain a dispersion effect was 0.28.

Chegeet et al [6] used extracts from the bark of pine (Pinus Canariensis) as an admixture to study its effect on fresh and hardened concrete properties. They used dosages of 10 % to 47.5 %, reducing the mixing water by an amount equal to the mass of the dosage, and concluded that the compressive strength was increased at 20 % level of dosage.

Mbugua et al [7] used gum from Acacia Karroo (GAK), in cement pastes and mortars. Tests conducted were the setting time and compressive strength. The samples for the compressive strength were prepared using cement content of 500 g and w/c ratios of 0.5 and 0.44, respectively. Cement mortars with 0.7, 0.8, and 0.9 % wt of cement with w/c ratio of 0.5 were used to compare that prepared using 0.44 w/c ratio, but with the same dosages. Also prepared were concrete samples with higher dosages of 1, 2, and 3 % with w/c ratio of 0.61. They concluded that there was an increase in compressive strength (9.3 %), at 28 days for cement mortar samples with 0.9 % dosage of GAK, and a reduced water-cement ratio.

Abdulabbas [8] in her work confirmed that the mechanical strengths of concrete were improved using gum Arabic. Also, the addition decreased the segregation, density and ultrasonic pulse velocity of concrete and increased the absorption.

In their work, Elah et al [9] used a GA with a specific gravity of 1.52. The chemical compositions in mg/L were given as: Mn (0.6 mg/L), Co (1.22 mg/L), Ca (ND*), K (2.87 mg/L), Na (ND*), Mg (13.4 mg/L) and Fe (2.27 mg/L). Tests were carried out on the shrinkage using dosage range of 0 % to 1.0 %. The average shrinkage ranged from 0.89 to 5.54 %. The same dosage range was used for the setting time, and the initial setting ranged from 88 min. to 387 min, and the final, from 132 min. to 562 min. For the compressive strength and durability tests, a concrete mix of 1: 2; 4 incorporating 0.0 % to 1.0 % GA, and varying w/c ratios from 0.45 to 0.65, were used. They observed an increase in both the shrinkage and setting times of concrete, but a reduced water requirement, and a decrease in compressive strength, with slight improvement in durability when used in acidic medium. They recommended a dosage of 0.2 % and 0.6 % by weight of cement in concrete.

The present study evaluates the mechanical properties of GA used for the production of fresh and hardened cement paste and concrete. The work further evaluated the sensitivity of the experimental data using the Minitab 17 Software, for possible interactions and model development. The importance of the work is that it will add information to the data bank on the use of GA as an admixture.

[***ND* is not detected***]

2. Materials and Methods

The cement used is Ashaka Portland cement and conforms to EN 197-1 [10]. The physical and chemical properties are given in Table 1. The fine aggregate is river sand with a specific gravity of 2.55, bulk density 1457 kg/m^3, and moisture content of 2.56 %. The sieve analysis of the fine aggregate is shown in Table 2 and falls under zone 2 of the classification chart. The coarse aggregate is 20 mm with a bulk density of 1552 kg/m^3, aggregate impact value (AIV) 10.8 %, specific gravity 2.84 and aggregate crushing value (ACV) of 12 %. It also falls into zone 2 of the classification chart.

The gum Arabic (GA) nodules used for this work was obtained from a local market in Bauchi, Bauchi State, Nigeria. The physical and chemical properties of the gum Arabic are shown in Table 3.

Table 1. *Physical and Chemical Properties of Ashaka Portland Cement*

Specific gravity	3.15
Loose bulk density (kg/m^3)	3150
Loss on ignition (%)	1.0
Specific surface (m^2/g)	2.30
Soundness (mm)	8.0
Chemical Properties	
Chemical Constituents	Percentage by Weight (%)
CaO	63.7
SiO_2	19.9
Al_2O_3	5.6
Fe_2O_3	2.9
SO_3	2.3
MgO	1.5
Na_2O	0,2
K_2O	0.7

Table 2. *Particle Size Distribution of the Fine Aggregate*

Sieve size (mm)	Percentage Passing (%)
6.3	100
5.0	99
4.76	98
3.35	88
2.4	60
1.2	30.5
0.6	14
0.3	6.1
0.15	0.9

Table 3. *Physical and Chemical Composition of Gum Arabic*

Composition	**Value**	
	Osman [2]	Da0ub et al [1]
Ash (%)	5.06	3.40 – 2.05 9.76 – 8.35
Moisture (%)	14.72	-
Glucouronic acid	11.96	0.243 – 1.549
Nitrogen (%)	0.2800	1.610 – 10.378
Protein (%)	1.8200	
Chemical *Composition*		
	[11] (mg/L from a solution of100 g/L)	[2] (ppm)
K	5.1	237000
Na	5.5	8400.0
Mg	2.4	38000.0
Ca	4.8	25600.0
Pb	-	6.00
Mn	0.8	106
Cu	0.2	52.0
Zn	0.1	-
Fe	2.5	128.0

2.1 Experimental set-up

The experiments were in three phases. The first phase was to characterize the cement paste, the second on the compressive and flexural strengths of gum Arabic concrete, while the third was on the microstructure and acid resistance of the gum Arabic concrete.

2.1.1 Soundness, standard consistency, and setting times of GA-cement paste

The soundness of cement is the property by virtue of which the cement does not undergo any appreciable expansion (or volume change) after it has set, thus eliminating any chances of disrupting the mortar or concrete. This was determined using the Chatterley equipment and tested in accordance to BS EN 196: Part 3 [12]. Cement paste of 85 % of standard consistency of the cement was prepared incorporating GA of proportions 0.00 % to 1.00 %, labeled as M-0.00 to M-1.00, respectively.

Consistency indicates the degree of the density or stiffness of cement and the water content of the standard paste which is between 26 – 33 %, and setting is the gradual loss of workability of concrete. For standard consistency determination, the procedure of the ASTM C 187-77 [13], was followed and for setting time determination, ASTM C 191-77 [14]. A Vicat apparatus was used for the determination of both the standard consistency and setting times of paste. Cement pastes were prepared using 400 g of cement and water of 116 g. The cement and w/c ratio were kept constant. The GA incorporated into the pastes was in proportions of 0.00 % to 1.0 % by wt % of cement, and labeled M-0.00 to M-1.00. The setting time was recorded from the moment when mixing water was added to the cement. The initial setting time is considered as the time when significant workability loss can be observed in concrete. The results are shown in Table 4.

2.1.2 Compressive and Flexural Strengths Tests of GAC

The mix used is a mix ratio of 1: 1.7: 2.5 and a water-cement ratio (w/c) of 0.5. The cement content of 420 kg/m^3 was used for the investigation. Five mixes: M-00, M-01, M-02, M-03 and M-04, were used to study the effect of gum Arabic on the mechanical strengths of concrete. The mix designations show the dosages of GA by weight of cement. The mix labeled M-00 is the control and contains 0 % of the GA while, others are having 0.25, 0.50, 0.75 and 1.0 percent respectively, by the wt of cement.

The compressive and flexural strengths tests were carried out in the hardened condition. Seventy five (75) specimens were cast and cured for 3, 7, 28, 60 and 90 days. For the cube compressive and flexural strengths tests cube moulds of 150 mm and beams of dimensions 100 mm x 100 mm x 500 mm were used respectively. The cubes were tested in accordance with ASTM C192/C192M [15], while the flexural strength test was in accordance with ASTM C78/C78M – 16 [16]. A four-point beam arrangement was used for the flexural test. The advantage of this to the two-point test is that the stress is not localized around the load point, but evenly spread between the supports. The span used was 450 mm. Five mixes were used for each of the tests on compressive and flexural strengths. The dosage of gum Arabic used was from 0 % to 1.0 %, wt % by cement. The mixes were labeled as M-0.00 to M-1.00 reflecting the dosage levels of each. The mix labeled M-0.00 was the control and contained no GA. Three specimens were tested to failure using the ELE motorized compression machine and the flexural machine as the case may be. The average of the three crushed samples recorded. The results of the various tests are shown in Table 5.

Table 4. *Consistency and setting times of GA-paste*

Mix No	Soundness (%)	Consistency (%)	Setting Times (Min.)	
			Initial	Final
M-0.00	12.3	29	45	496
M-0.25	14.5	34	185	876
M-0.50	10.3	36	300	985
M-0.75	13.7	39	490	1075
M-1.00	15.0	41	670	1100

Table 5. *Mechanical Properties of GAC beam*

Property	**Mix No**	**3 d**	**7 d**	**28 d**	**60 d**	**90 d**
Compressive Strength (kN/m^3)	M-0.00	29.2	30.1	34.4	36.6	37.0
	M-0.25	32.7	32.3	35.4	36.7	38.2
	M-0.50	40.1	42.0	46.7	47.5	47.9
	M-0.75	36.5	37.8	39.0	41.6	42.1
	M-1.00	34.0	35.2	37.7	38.0	38.9
Flexural Strength (kN/m^3)	M-0.00	4.3	5.2	5.5	5.8	6.1
	M-0.25	5.1	5.5	6.0	5.6	6.0
	M-0.50	5.9	6.3	6.4	6.4	6.4
	M-0.75	4.7	5.2	5.9	6.0	6.2
	M-1.00	5.1	5.4	5.9	5.6	6.2

2.1.3 Microstructural Test of GAC

This was done using the crushed samples from the compressive strength test after 28 days of curing. The preparation of the slides for the microstructure studies was done in the geology department of Abubakar Tafawa Balewa University; using a standard size of 72 mm x 1 mm to suit the available lapping machine, model Mod BG 150 m. The analysis of the slides was done in the Chemistry Department, using 30 samples with 6 per each dosage level. Janapol Model Polarized Microscope was used for the analysis and the minerals determined using the identification tables for common minerals in thin sections [17]. The micrographs were produced using a camera mounted on the microscope and a snap short taken under the plane polarized light with a magnification of 3.5 x 10. Results of the minerals identified are shown in Table 6, and the micrographs, in Figure 2.

Table 6. *Microstructure of Gum Arabic Concrete*

Mineral	Dosage (%)/Concentration (%)				
	0.00	0.25	0.50	0.75	1.00
Quartz	27.8	30.0	30.0	27.4	26.2
Mica	15.9	16.6	18.1	17.4	16.7
Feldspar	17.9	18.7	27.4	17.8	18.1
Opaque	11.2	10.7	10.1	10.0	8.1
Porosity	23.4	24.1	25.1	27.4	30.8

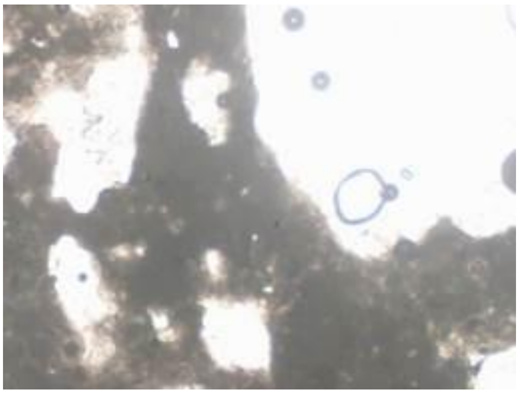

Figure 2(a). *0.00 % Dosage*

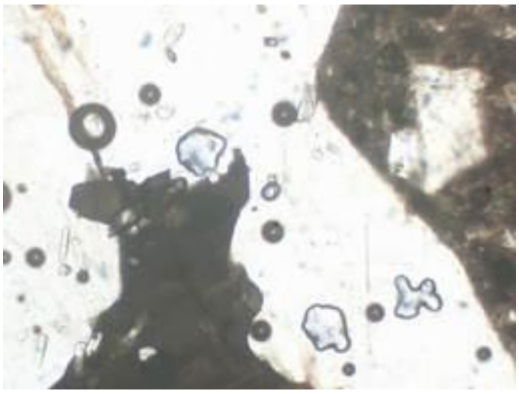

Figure 2(b). *0.25 % Dosage*

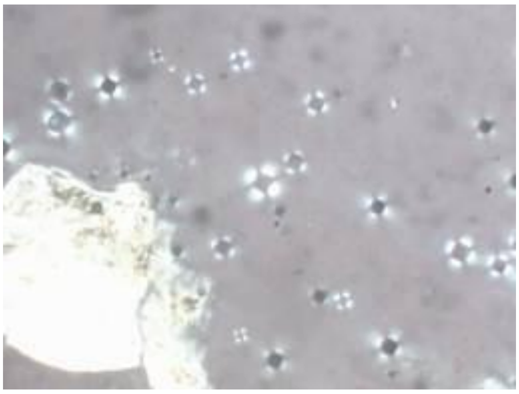

Figure 2(c). *0.50 % Dosage*

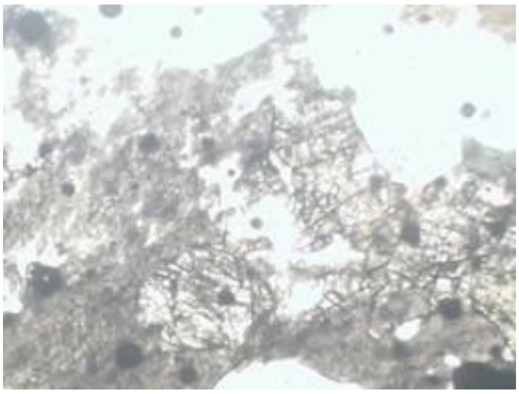

Figure 2(d). *0.75 % Dosage*

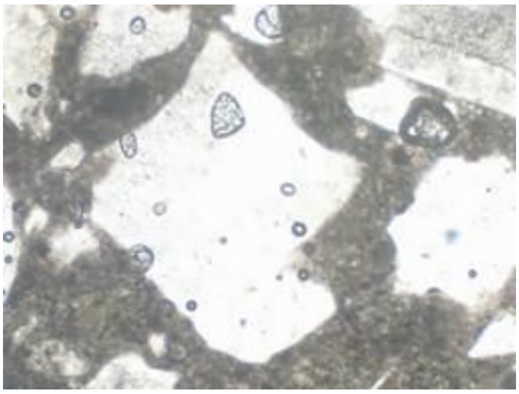

Figure 2(e). *1.00 % Dosage*
Figure 2. *Plane Polarized Micrographs of GAC*

2.1.4 Acid Resistance Test of GAC

The acid resistance tests were done with concrete cubes cast and cured for 28 days, using GA dosages of 0.00 % for control, and others at 0.25 % to 1.00 % wt. % of cement. At the end of 28 days the samples with 0.25 % to 1.00 % dosage were further cured in 20 % dilution of H_2SO_4 and HNO_3 solutions respectively, for another 28 days before testing to failure. A total of 30 samples were used and an average of three recorded. The results for the compressive strength are shown in Table? The weight loss was carried out by weighing the samples in water at the end of the 28 days curing. The samples were removed, dried and weighed before curing for further for 28 days in sulphuric and nitric acid medium, respectively. The results are shown in Table 7.

Table 7. *Acid Resistance of Gum Arabic Concrete*

Property	Mix No	Sulphuric Acid (H_2SO_4)	Nitric Acid (HNO_3)
Compressive strength (kN/m^3)	M-0.00	27.20	30.50
	M-0.25	29.30	31.70
	M-0.50	35.40	39.90
	M-0.75	33.30	35.70
	M-1.00	30.70	32.20

Table 8. *Weight Loss in Acid Medium*

Medium	Mix No	**Wt. before exposure (kg)**	**Wt. in Acid Soln. (kg)**	**Wt. Loss (%)**
H_2SO_4	M-0.00	2.59	2.26	12.74
	M-0.25	2.75	2.49	9.46
	M-0.50	2.62	2.43	7.25
	M-0.75	2.67	2.29	14.23
	M-1.00	2.63	2.20	16.35
HNO_3	M-0.00	2.52	2.29	9.12
	M-0.25	2.47	2.27	8.09
	M-0.50	2.54	2.38	6.29
	M-0.75	2.51	2.25	10.35
	M-1.00	2.52	2.21	12.23

3. Results and Discussion

3.1 Soundness of gum Arabic cement-paste (GACP)

Table 4 showed the values obtained for the soundness of GAC at dosages of 0.00 % to 1.00 %. The lowest value for GAC soundness (10.3 mm) was achieved at 0.50 % dosage. The limit of soundness for OPC is 10 mm [18]. The following parameters have been found to influence the formation of delayed ettringent (DEF) in cement composition. These are SO_3/Al_2O_3 ratio, SO_3, Na_2O, MgO, CaO, C_3A [19]. The Ashaka cement used has a SO_3/Al_2O_3 ratio of 0.85 and the MgO content, 1.5 % (< 5 %) and therefore, the issue of expansion is eliminated. Again, with the Na_2O and K_2O at 0.2 % and 0.7 %, respectively, alkali silica reaction (ASR) and change of pH in the pore solution is eliminated.

3.2 Consistency and setting times of gum Arabic cement-paste (GACP)

Table 4 also showed the results of the consistency and setting times. Consistency indicates the degree of the density, or stiffness of cement and the water content of the standard paste, which is between 26 – 33 %. Setting is the gradual loss of workability of concrete. The initial setting time is considered as the time when significant workability loss can be observed in concrete. From the results obtained, the water affinity of GACP increased as the dosages increased. With this behavior, the GA can be classified as a set-retarder and can be used for hot weather concreting [20]. The temperature effects on setting times were in the range of 30^oC to 33^oC. Khan and Ullah [21] postulated that retarding effects of a retarder depends upon a number of factors and has cited dosage of admixture as one of them. Zhao et al [5], discussed the dissolution effects of adding GA to concrete and concluded that addition of GA to OPC, decreased apparent viscosity and shear, while, the fluidity is increased.

3.3 Compressive Strength

From Table 4 the cube compressive strength showed continued increase with curing and dosage of GA. The increase in strength as the age increased is gradual but consistent. The same could be said for the dosage. The maximum strength and dosage were recorded at 0.50 %. The statistical analysis on the generated data on compressive strength test showed that a linear regression of the natural log is best option that can be used to describe adequately the behaviour of the compressive strength. This is given as $In\ (CS) = 3.3880 + 0.0321\ x + 0.0467\ x_1$, with $\sigma = 0.126441$, $r^2 = 29.50\ \%$, and the p-value (> 0.005) very significant. To further examine how well the models fit the data used, the residual and normality plots were generated for the compressive strength of the GAC model (Figure 3). As can be seen, there are few large residuals [22] and hence, limited apparent outliers [23]. This confirmed that there were no trends to show that the models are inappropriate. Figure 4 also showed the surface response plots and how the response variables (CS*)* related to the mix (x) and age (x_1) of GAC based on the model equation.

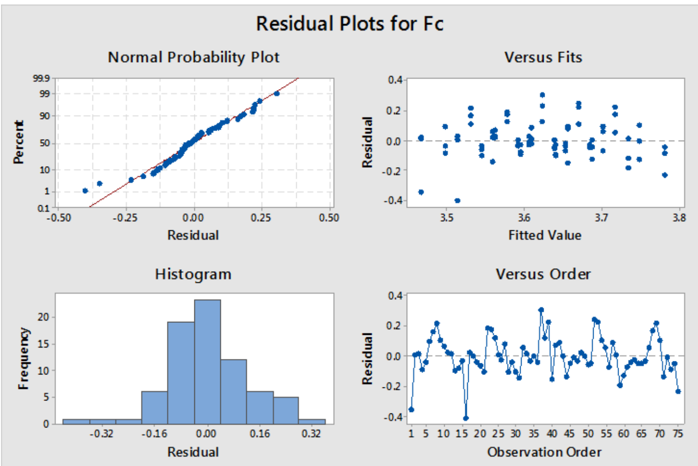

Figure 3. *Normality and Residual Plots of Compressive Strength of GAC*

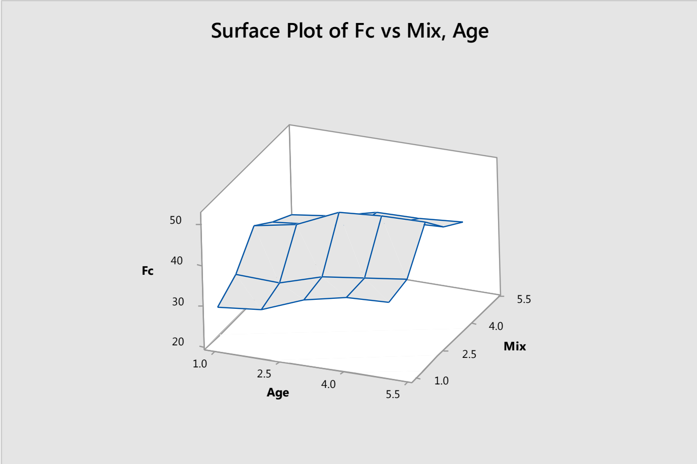

Figure 4. *Response Surface of the Compressive Strength of GAC*

3.4 Flexural Strength

The flexural strength in Table 4 followed the same trend as the compressive strength. Strength development as curing and dosage increased were gradual and the best and optimum strength and dosage were at 0.50 %. The statistical analysis on the generated data on flexural strength test showed that a linear regression of the natural log and the square root are best options that can be used to describe adequately the behaviour of the flexural strength. This is given as $In\ (MOR) = 1.5861 + 0.00514\ x + 0.04240\ x_1$, with $\sigma = 0.107615$, $r^2 = 24.76\ \%$, for the natural log, *and* $MOR^{\wedge}0.5 = 2.2112 + 0.0058\ x + 0.04973\ x_1$, $\sigma = 0.121236$ and $r^2 = 26.27$ for the square root model. The *p*-values (> 0.005) for the two models on the mix are significant but for the mix parameter, the *p*-values (> 0.005) is not significant. To further examine how well the models fit the data used the residual and normality plots were generated for the flexural strength of the GAC model (Figs. 5a & 5b). As can be seen, there are also few large residuals [22] and hence, limited apparent outliers [23]. This confirmed that there were no trends to show that the models are inappropriate. Figure 6 also showed the surface response plots and how the response variables (MOR*)* related to the mix (x) and age (x_1) of GAC based on the model equation. The relationship between the compressive and flexural strength is given by a regression model of natural log of $In\ (CS) = 2.885 + 0.0989\ MOR + 0.\ 0321\ x + 0.0256\ x_1$, with $\sigma = 0.124646$, and $r^2 = 40\ 54\ \%$. The *p*-values (< 0.005) are very significant. The response surfaces of the interaction between MOR/CS and mix (x), and MOR/CS and age (x_1), are given in Figure 6(a & b).

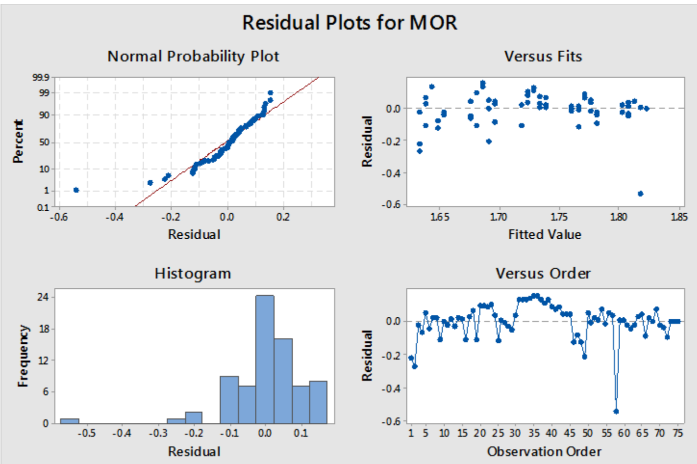

Figure 5(a). *Natural Log Model*

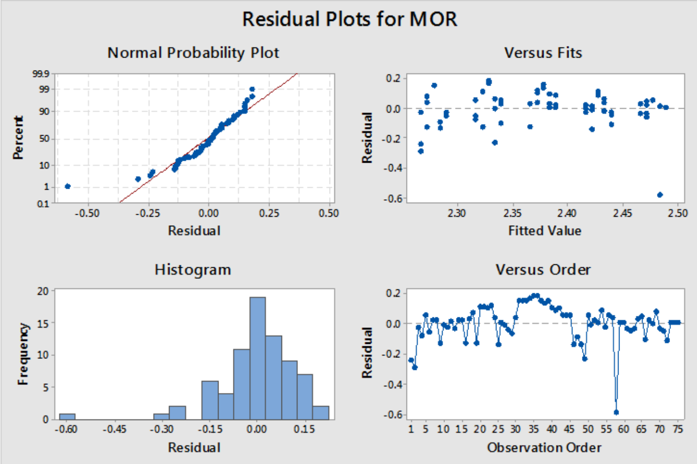

Figure 5(b). *Square Root Model*

Figure 5. *Normality and Residual Plots for Flexural Strength of GAC*

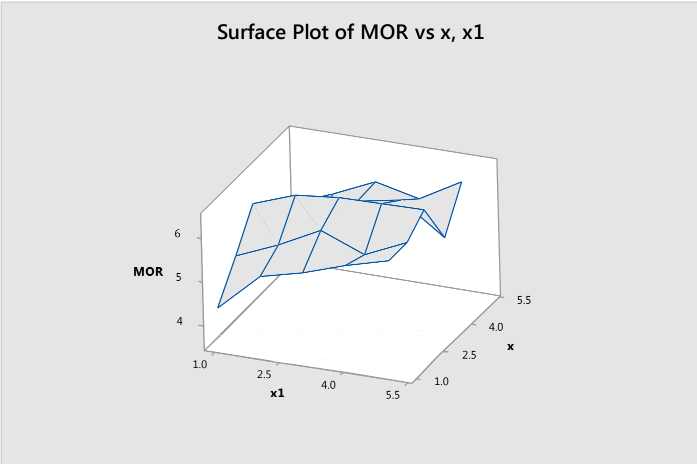

Figure 6. Response Surface of the Flexural Strength of GAC

3.5 Microstructure of GAC

Table 5 showed that the quartz, feldspar and mica minerals increased as the dosage increased and the best result was also achieved at 0.50 %. However, the opacity and porosity continued to increase as the dosage increased. Figure 2 showed the micrographs derived from the SEM analysis, at the various levels of dosages. The micrographs showed the levels of transformations that have taken place in the mineralogical and physio-chemical characteristics of GAC. These transformations are due to the interactions of GA with cement during the hydration process. The filler-effect as observed on the micrographs (Figure 2) was caused by the obstruction of the pores and voids of the finer grains during the hydration process. These transformations in GAC are shown as plane polarized micrographs of GAC at 28 days.

3.6 Acid Resistance of GAC

From Table 6 and Figure 8 the effect of acid attack on GAC is more on samples in H_2SO_4 environment than that in HNO_3. The resistance offered by the modification of microstructure of the GAC samples ranged from 7.7 % to 30.2 % in H_2SO_4 environment, and 3.9 % to 30.8 % in HNO_3 environment. Dosages at 0.50 % and 0.75 % had the best resistance to acid attack with the optimum at 0.50 %. This behaviour was confirmed in Figure 9 on weight loss. The minimum loss was recorded at 0.50 %. It can thus be adduced that adding GA to concrete mix will assist in arresting corrosion of reinforcement.

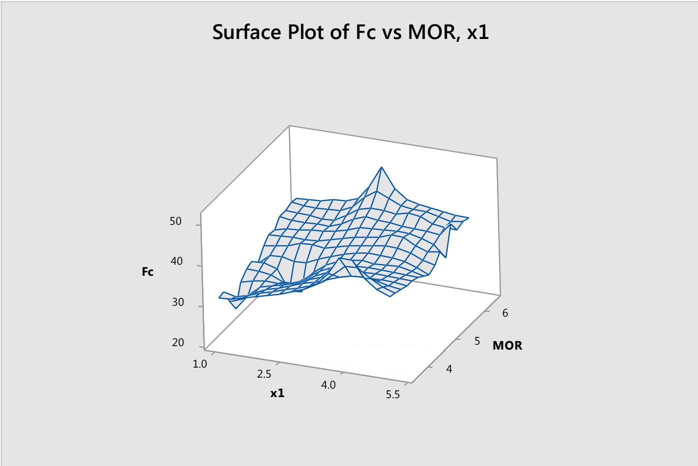

Figure 7(a). *Compressive/Flexural Strength and Mix*

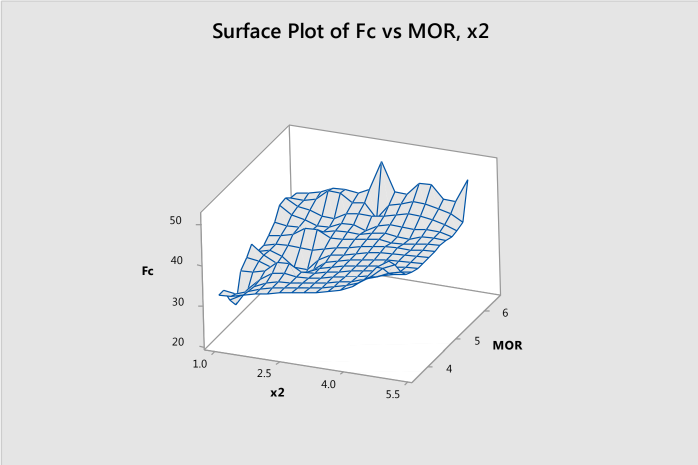

Figure 7(b). *Compressive/Flexural Strength and Age*

Figure 7. *Response Surface of the Compressive/Flexural Strength of GAC*

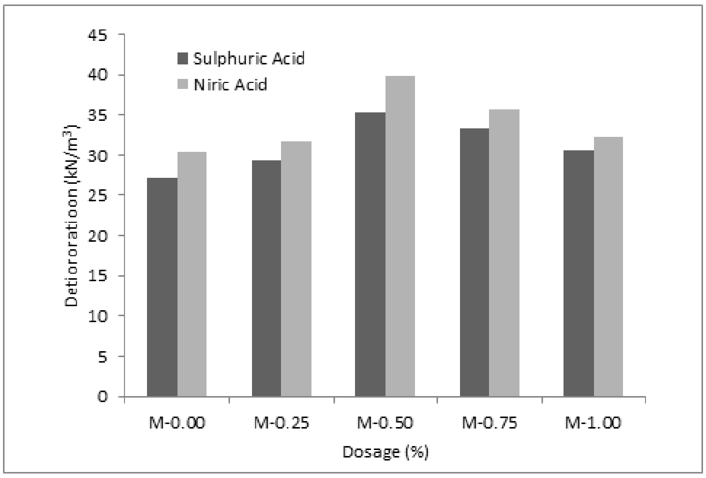

Figure 8. *Acid Resistance for GAC*

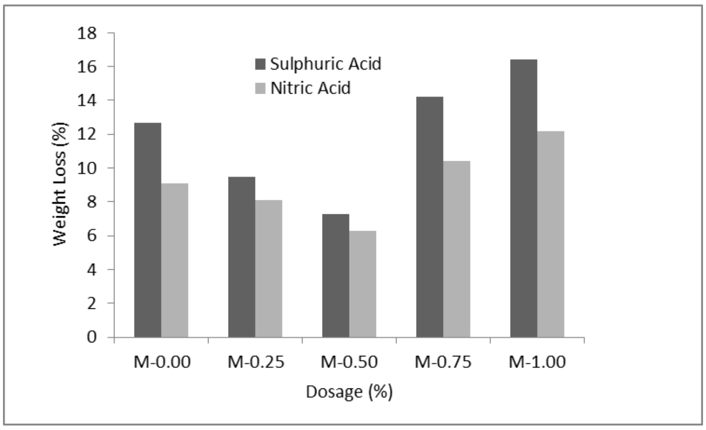

Figure 9. *Weight Loss (%)*

4. Conclusions

Evaluations of the effects of GA as an admixture have been carried out and the following are the conclusions:

i. The use of GA will lead to the production of sound concrete

ii. GA is a retarder, delaying the setting of of concrete, and therefore can be used for hot weather concreting.

iii. A maximum dosage recommended from this work is 0.50 % by weight of cement.

iv. The use of GA in concrete increased the compressive and flexural strengths of GAC, and maximum strengths are at 0.50 %, respectively.

v. A linear regression model of natural log and square root best described the experimental data on both compressive and flexural strengths.

vi. The statistical characteristics are significant at all the levels of tests.

vii. The relationship between the compressive and flexural strengths can also be represented by natural log and very significant.

viii. The response surfaces showed the degrees of interactions between the various mix parameters and compressive/flexural strengths.

ix. The GA admixture induced microstructural modification in mineralogical and physio-chemical characteristics of GAC.

x. The effect of acid attack on GAC was more in an H2SO4 environment than in HNO3 environment.

xi. The resistance offered by GA-modified concrete was higher than the plain concrete (i.e. 0.00 %).

In conclusion therefore, the use of GA for concrete production is a welcome development and a new path to concrete technology.

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