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WORKABILITY, COMPRESSIVE STRENGTH, AND OPTIMAL TEMPERATURE SCRUTINY OF GEOPOLYMER CONCRETE CONTAINING BESPOKE ACTIVATOR AND SUPERPLASTICIZER USING DIFFERENT PREDICTION MODELS

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Abstract
Geopolymers (GP) are novel substances made of aluminosilicate and alkaline activator that are sustainable and environmental-friendly. Geopolymers possess exceptional mechanical properties, and other admirable properties including fire and corrosion resistance. Thus, the efficiency of ash-based geopolymer was assessed. The binders include a combination of rice-husk ash (RHA), kaolin clay powder (KCP) and flyash (FA). RHA and KCP were introduced to mitigate respectively the problems of poor workability and efflorescence associated with flyash (FA) based Geopolymer concrete (GPC). A bespoke sodium silicate produced using RHA was found a more suitable alkaline activator than factory ready-made brand and was therefore utilized together with sodium hydroxide for binder activation. The activator was added at 0, 2.5, 5, 7.5, and 10% of the combined weight of the binder content. A bespoke superplasticizer produced from rice husk in the laboratory was introduced to improve workability. The GPC were cured at various temperatures. The result showed an increase in slump with the addition of the bespoke plasticizer while the compressive strength decreases at sodium hydroxide content above 2.5% of total binder weight. Fourier Transform Infrared Spectroscopy (FTIR) results show key absorbance band at the area between 949 and 3251 cm^{-1} indicating that addition of the bespoke superplasticizer to the geopolymer concrete reduced the viscosity and improved the flow characteristics. Brunauer-Emmett-Teller (BET) shows RHA, FA and KCP each has higher surface area than cement, thus they can serve as appropriate pozzolanic material and cement proxy. At temperatures above 70^0C, both compressive strength and weight decrease, for both the bespoke and ready-made sodium silicate. The optimal geopolymer product showed substantial strength and durability enhancements at 70°C, while strength and durability values decline above 70°C, indicating material deterioration. Among models used for prediction, Feret model performed best with R^2 of 0.967, indicating its excellent predictive performance.

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1.0 INTRODUCTION
Geopolymer is an expression coined to characterize the material and its chemistry [1-3]. Geopolymer materials mostly, but not absolutely, go through a geopolymerisation reaction when they are activated with a liquid substance named alkaline solution, which normally contains variable quantities of dissolved silicon [2], [4-6]. GPC is dual face materials that combine strong alkaline solutions as activator as well as aluminosilicate materials as binders [1], [7-9]. It is considered as an extremely corrosion and fire-resistant materials, shrinks below conventional

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concrete, has excellent durability, high compressive, tensile and flexural strengths [2, 6]. There are abundant raw materials which exist for the creation of geopolymers from industrial as well as laboratory-produced minerals trashes. Besides, its synthesis process guzzles much less energy, particularly those created from industrial rubbishes [10-13]. The aluminosilicates can be sourced from numerous pozzolanic materials which possess ample quantities of silica together with alumina which are mostly rubbishes from industrial or agrarian debris for instances fly ash (FA), ground granulated blast furnace slag (GGBFS), POFA (palm oil fuel ash), BA (bagasse ash), rice husk ash (RHA), Kaolin clay and that are used to lessen contaminant impact from laboratory-produced resources consumption [2], [14-16]. These agronomic and industrial debris are utilized individually or blended to serve as the aluminosilicate source in creating geopolymers for sustainable construction [17], [18]. On the other hand, alkaline activators are the second decisive constituent of GPC needed to reacts and polymerize the silicate and alumina contents presents in the aluminosilicates [18-20]. These are strong alkaline solutions like K_2SiO_3, (potassium silicate), NaOH (sodium hydroxide), as well as Na_2SiO_3 (sodium silicate), or combination of these hydroxides and silicates for reacting aluminium (Al) as well as silicon (Si) atoms. Thus, this research will solve the problems (precursors material, composition of binders ratio, optimum mix design, curing methods, alkaline to binder ratio and identification of ideal proportion of silica and alumina ratios) noticed from design and experimental studies of partial and total replacement, as well as laboratory-made super-plasticizer geopolymer concrete. Earlier researches on GP has centered on the use of alkali-activated fly ash with commercial superplasticizer as signifies in Table 1, but combination of three pozzolans derived from both agricultural and industrial wastes as binder, alkaline material and superplasticizer has not been employed and is the subject of this scrutiny.

Table 1: Various scrutiny, findings and gaps

Authors	Title	Findings	Gaps
Arum *et al.*, [3]	Strength Evaluation of Pozzolanic Concrete Containing Calcined Ceramic Waste	The results show that at maturity age of 90 days, concrete compressive strength decreased as the substitution level of CCW and WGP increased.	Though pozzolanic was securitized, but kaolin clay contents was not investigated.
Chouhan *et al.*, [16]	Rice-husk-based superplasticizer to increase performance of fly ash geopolymer concrete.	The result shows significant improvement on the workability of the GPC	Only purchased sodium silicate was utilized with the superplasticizer.
Tutal *et al.*, [25].	Effects of Bio-Based Plasticizers, Made from Starch, on the Properties of Fresh and Hardened Metakaolin-Geopolymer Mortar	The results revealed that superplasticizers improved the slump of a metakaolin-based geopolymer (MK-geopolymer) mortar while the polycarboxylate ether (PCE) investigated showed no improvement.	Metakaolin-based geopolymer with starch super plasticizers was utilized not rice husk based.
Handayani *et al.*, [26]	Synthesis of Sodium Silicate from Rice Husk Ash as an Activator to Produce Epoxy-Geopolymer Cement	The result revealed that RHA is feasible to be used as an activator in high calcium fly ash-based epoxy geopolymer cement. Also, the increase of NaOH concentration raises the silica yield strength.	Though flyash and RHA was used with epoxy, kaolin clay and waste based superplasticizer not utilized

Furthermore, this research will provide a sound platform which will reveal the full potentials of the developed GPC as novel concrete that can result in stronger and more durable concrete at different curing temperatures.

Figure 1: Laboratory-produced sodium silicate from rice husk ash after oven drying

a b c

Figure 2: a) Fly ash, b) laboratory-created superpl-asticizer and c) NaOH

2.0 MATERIALS AND TECHNIQUES

Materials utilized in this experiment were river sand, sodium hydroxide, kaolin clay, crushed granite, factory-created sodium silicate, Portland cement, laboratory-produced sodium silicate as well as super plasticizer, and potable water (Figures 1 and 2). Further, the GP concrete was thoroughly mixed before production of four of geopolymer concrete; viz: Control concrete; Partially replaced GPC; GPC using factory-produced sodium silicate and GPC using laboratory-produced sodium silicate (Table 1), before workability and strength (Compression. Split-tensile and Flexural) tests were carried out on the four categories of samplings created based on BS 8100, ASTM C597/C597M-16, BS 12350-2-2019 and ASTM C 143 codes (Table 1). The GP concrete was removed from the moulds after 24 hours and cured in water for 7 to 56 days. Chemical analysis on selected binders (kaolin clay, fly ash and rice husk ash), alkaline activators (sodium silicate and sodium hydroxide) and geopolymer concrete were carried out in the laboratory of Chemical and Material Engineering Umaru Musa Yaradua University Dutsin Ma, Kastina. Physical properties scrutiny on water used for mixing, as well as strength and durability tests on the concrete samples were done in the Nigerian Building and Road Research Institute (NBRRI) Jabi Abuja and Federal Ministry of Works (FMW), Concrete and Pavement Unit Sheda, Abuja. The design of geopolymer concrete in this research is presented in Figure 3. And the creation of laboratory – created $Na_2SiO_3$with other materials (Figures 4). BET, FTIR and XRF was investigated using Horiba SA-9600 adsorption isotherms, FTIR spectrometer (Model FTS-14 by Agilent technologies) and XRF analyzers machine respectively.

3.0 RESULTS AND DISCUSSION

3.1 Brunauer Emmett-Teller (BET) scrutiny on cement and geopolymer binders

Table 2 displays the Brunauer-Emmett-Teller (BET) analysis of the selected binders. BET is a physical categorization technique that ascertain quantitative data of the specific surface area and porosity distribution of solid materials. BET concept applies to structures of multilayer adsorption, and typically utilizes probing gases that do not chemically oxidize with material surfaces area. The surface area is an imperative property of porous materials, frequently ascertained through the BET scrutiny. That's why, standard BET scrutiny is frequently carried out at the boiling temperature of N_2. The approach is appropriate for an eclectic range of solid matrices from reagent powders to monolithic materials. The BET method was used to determine the specific surface area of cement and selected binders.

Table 1: Mix design (1:1.5:3) proportions for FA-based GPC

Mix	Molarity	Aggregate(kg/m^3)		Binders (kg)				SS/SH	Density	Water	Age (days)	Slump (mm)
Id	(M)	Fine	Coarse	Cement	Fly	RHA	KC	Ration	(kg/m^3)	(liter/m^3)	28	105
A_1	-	360	720	720	-	-	-	-	2239	184.2	28	110
A_2	12	1080	2160	320	180	120	100	2.5	2252	184.7	28	112
A_3	12	1080	2160	-	360	180	180	2.5	2257	186.2	28	112
A_4	12	1080	2160	-	360	180	180	2.5	2260	187.4	28	114

A_1 is Control concrete; A_2 is Partially replaced GPC; A_3 is GPC using factory-produced sodium silicate and A_4 is GPC using laboratory-produced sodium silicate, SS is sodium silicate and SH is sodium hydroxide

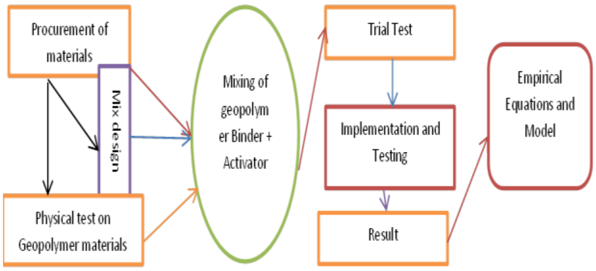


Figure 3: Design process of geopolymer concrete

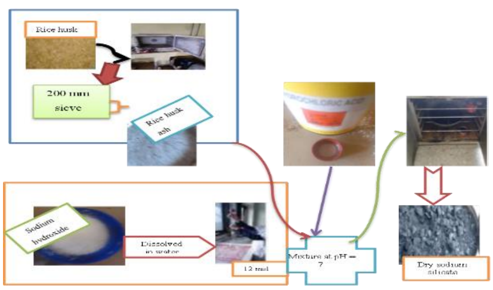


Figure 4: Preparation of laboratory-created Na_2SiO_3 from RHA

Table 2: BET outcome various binders

	RHA	Cement	FA	KC
Slope	9.99	13.28	10.622	9.809
Intercept	3.455e^{+00}	3.189e^{+00}	2.551e^{+00}	2.943e^{-01}
Correlation Coefficient	0.994	0.991	0.9906	0.9995
C constant	3.891	5.165	5.165	34.32
Surface Area	250.01m^3/g	211.5m^3/g	264.4m^3/g	344.69m^3/g

Table 2 shows that correlation coefficient of Kaolin clay (0.9995) has the extreme value. Followed by RHA (0.994), and the correlation of cement (0.991) was the lowest. Likewise, surface area values followed the same trend, kaolin clay (344.703m^3/g) was greater than RHA surface area (250.01 m^3/g), while cement (211.5 m^3/g) was the least utilized. Also, the C constant of kaolin clay was 34.3, which was the highest, cement and fly ash (5.18) are the same, and RHA values was the least. The specific surface area of kaolin clay (344.7 m^3/g), is 61.4% higher than that of cement whose specific surface area is ascertain to be 211.5 m^3/g. The intention behind the augmented surface area of kaolin clay is the coating particles applied on the kaolin clay changed the morphology of the surface from smooth to rough. The alteration in surface morphology has also elicited an improved contact interface with a polymer matrix when the selected binders utilized as a filler in the polymer matrix. The operating circumstances are analogous to those used in surface morphology analysis [4], [7-9]. Thus, all the chosen binders can serve as beneficial pozzolanic material and cement stand-in.

3.2 Outcome of Fourier Transform Infrared Spectroscopy (FTIR) Scrutiny

FTIR characterization result for binders ashes is as displayed in Tables 3(a-c). This illustrate that the fly ash has highest key absorbance band at the region between 467.9 as well as 3695.8 cm^{-1}. Then, followed by RHA with extreme band of 2084cm^{-1} and lower band of 798cm^{-1} and the lowest was Kaolin clay with greatest value of 3690 cm^{-1} and lowest value of 749 cm^{-1}. Also fly ash notable transmittance between 7.1 and 49.9% was the extreme. The results of FTIR reveal that these binders possess different functional groups namely; alkenes, amides, alkenes, alkynes, acyl chloride and alky halides. An Amine is a type of compound that is derived from ammonia (NH3), that is amines are derivatives of ammonia. The lower aliphatic amines with a fishy smell are gaseous in nature. Alkynes are traditionally identified as acetylenes, although the term acetylene also denotes C_2H_2, which is an hydrocarbons with single and double carbon-carbon bonds. Fly-ash possesses majorly; Aluminumoxide (Al_2O_3) at 23.6% as well as Silicon dioxide (SiO_2) at 52.2% and lesser quantity of Iron (III) oxide (Fe_2O_3) at 7.39%. While, kaolin clay key constituents were 52% of Silicon dioxide (SiO_2) and 35% of Aluminumoxide (Al_2O_3) together with 2% Potassium oxide (K_2O) which is insignificant quantity. Likewise, Rice husk ash shows significant amount of Silicon dioxide (SiO_2) at 93.3% together with Potassium oxide (K_2O) at 3.41% with insignificant quantity of P_2O_5at 2.1%.

Table 3a: FTIR values for kaolin clay

	FTIR Outcome Kaolin Clay	
Band (cm^{-1})	**Transmittance (%)**	**Functional group**
1982.9	101	Alkynes R-C = C-4, medium C=C stretch
3690.1	75.4	Amines – R- NH2, N-H symmetric and asym. Stretch, weak
1114.5	75.2	Akyl halides R-F, very strongs, C- F stretch
790.2	70.1	Alkenes strong, RCH = R'R C-H band
749.2	68.2	Alkyl halides R-CL, strong, C-CL stretch
909.5	30.1	Alkenes, m+s = C-H bend, RCH = CH2
998.9	25.0	Alkenes, m+s = C-H bend, RCH = CH2

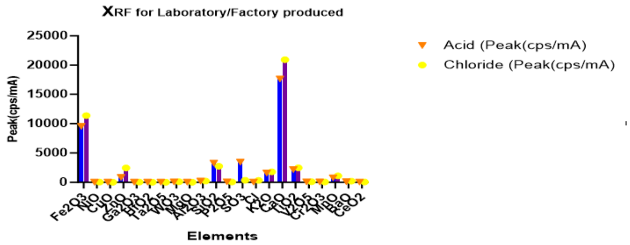
Table 3b: FTIR values for RHA

	FTIR Outcome RHA

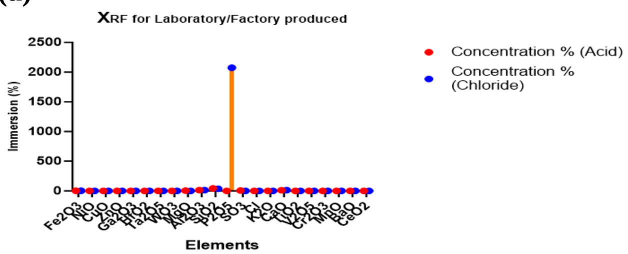
Band (cm^{-1})	Transmittance (%)	Functional group
2083.6	98.2	Alkynes R-C = C-H, medium, C= stretch
1982.9	98.0	Alkynes R-C = C-H, medium, C= stretch
1848.8	97.9	Acyl chlorides Ar – C(0) – Cl, C- 0 stretch
797.7	89.7	Alkyl halides intensity, strong, C-CL stretch
1058.6	62.4	Alkyl halides intensity, very strong, C-CF stretch

3.3 Outcome of XRF on Immersed Hardened Geopolymer Concrete

The outcome of XRF analysis on hardened concrete at 90 days immersion in acid and chloride concentration is demonstrated in Figure 5.



(a)



(b)

Figure 5: Outcome of XRF: a) peak levels, and b) concentration at 90 days for acid and Chloride immersion

From Figure 5, the highest concentration (14.076% and 11,866%) and peak values of sodium chloride and sulphuric acid immersion of 20918 cps/mA and 17633 cps/mA respectively was noticed for CaO. Fe_2O_3 of sodium chloride was at peak value of 11389 cps/mA which is above peak value of sulphuric acid of 9527 cps/mA. Concentration value of sodium chloride of 3.0611% was beyond the sulphuric acid amount of 2.5608%. Next were SiO_2 contents with sulphuric acid and sodium chloride values of 43.717% and 36.559% at peak level of 3270 cps/mA and 2735 cps/mA respectively. Likewise, alumina concentration values were 13.391% and 13.177% at peak of 209 cps/mA and 205 cps/mA for sodium chloride and sulphuric acid respectively. This result shows that various chemicals used has little or no effect pozzolanic contents and other materials in the fly ash-based geopolymer, but greatly affected by water immersion i.e water immersion decreases the geopolymer contents. These concentrations also confirm the result of SEM analysis on immersed GPC, which reveals little or no deterioration effects from the hazardous chemicals utilized for immersion. And this is in agreement with other researchers like [11-15], that also investigate behaviours of flyash based GPC in various chemicals used.

3.4 Effect of the Laboratory-produced Superplasticizer and Sodium Silicate on Geopolymer Concrete (GPC)

The compressive strength of fly-ash, kaolin clay and rice husk based geopolymer concrete activated through laboratory-produced sodium silicate (LPSS) were demonstrated in Figure 6. From the figure, the compressive strength enhances with the rising in curing days for all types of geopolymer concrete. The peak compressive strength was obtained at twenty-eight (28) curing days at for all geopolymers with a peak strength of 79.8N/mm^2 at 5% Fly-ash content for the fly-ash based geopolymer, 90.2N/mm^2 at 7.5% Kaolin clay content for the kaolin based geopolymer and 13.8N/mm^2 at 10% Rice husk ash content for the rice husk based geopolymer. The result is in accordance with that obtained from the conclusion of [16], that the compressive strength of GPC enhances with curing time due to the fact that it enhances the polymerization process, resulting in greater compressive strength. This increase can be linked to N-A-S-H and C-S-H gels formed from LPSS as well as lesser inner porosities and cracks on the surface of GPC samples.

Besides, the weight of the geopolymer concrete also increases, with the increase in curing days like the compressive strength with the peak weight obtained at 5% Fly-ash content for the fly-ash based geopolymer, 7.5% Kaolin clay content for the kaolin based geopolymer and 10% Rice husk ash content for the rice husk based geopolymer, which is the same as observed for the compressive strength. The peaks occurred at 5% fly-ash, 7.5% kaolin and 10% rice-husk ash for fly-ash based, kaolin-based and rice-husk ash geopolymer concrete respectively. However, the peak values of 99.9N/mm^2, 108.7N/mm^2 and 114.4N/mm^2 for fly-ash based, kaolin-based and rice-husk ash geopolymer concrete respectively were higher than that obtained with factory—produced silicate and therefore shows higher strength than that of the factory—produced silicate. This result is in sequence with that obtained from Fang [13], who observed steady rise in compressive strength gotten from alkali-activated fly ash slag (AAFS) concrete when the molarity of the laboratory-produced NaOH obtained from the remains of the palm oil extraction process was increased. This was interrelated to the chemical action of the inherent Si, Al as together with Ca constituents elicited via the augmented breakage of the T-O-T bonds (T = Si or Al tetrahedral atom, O = shared octahedron atom) in fly-ash. The weight of the geopolymer concrete also increases, with the increase in curing days like the compressive strength with the peak weight obtained at 5% Fly-ash content for the fly-ash based geopolymer, 7.5% Kaolin clay content for the kaolin based geopolymer and 10%Rice husk ash content for the rice husk based geopolymer, just like that obtained with the factory—produced silicate. Its peak values were also higher than that obtained from the factory—produced silicate.

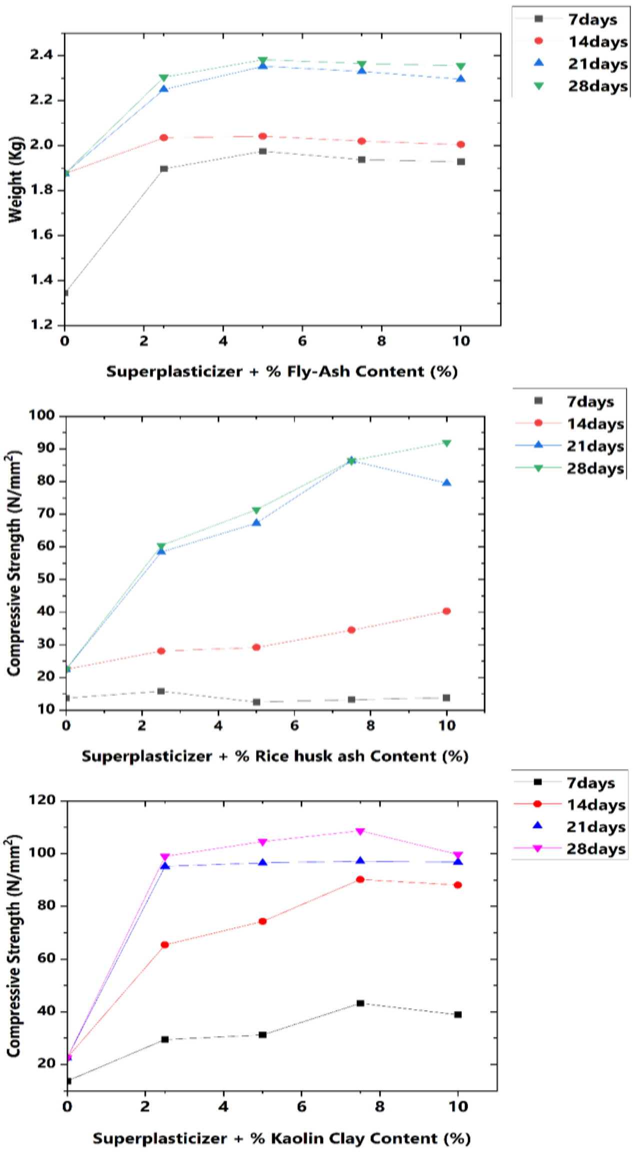
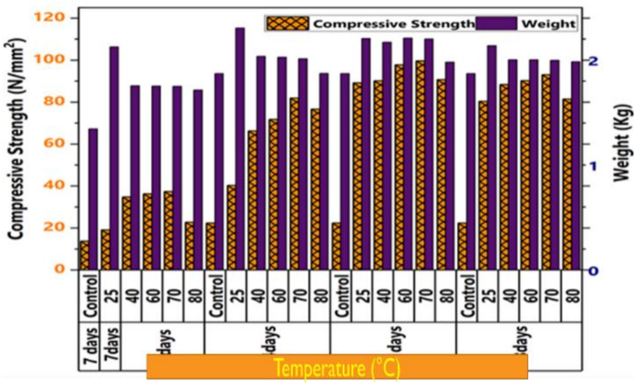


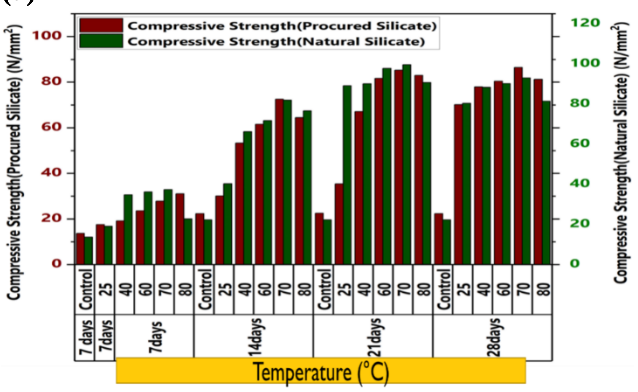
Figure 6: Characteristics of fly-ash GPC activated using factory-produced silicate

3.5 Outcome of Curing Temperature on Geopolymer Concrete (GPC)

The percentage geopolymer material content for which the optimum compressive strength was obtained for the FA-RHA based geopolymers were combined with the superplasticizer to produce geopolymer concrete activated with the laboratory-created and factory-created silicate respectively. The concrete was cured at 7, 14, 21 and 28 curing days, each at different curing temperatures of 25°C, 40°C, 60°C, 70°C as well as 80°C. Figure 7a showed the observed compressive strength and weight of the GPC for both factory-created and laboratory-created silicate. Compared to the control, the compressive strength increases steadily with increase in temperature while the weight experienced an increase to a peak before declining after the peak which on the average, occurs at the 40°c temperature mark. The peak compressive strength occurred at 28days at temperature of 70°c with a peak value of 86.47N/mm^2 for the GPC activated with the factory-created silicate while a peak value of 99.67N/mm^2 at a temperature of 70°c and at 21 curing days was obtained for the GPC activated with laboratory-produced silicate. Both peak compressive values were lower than the strength of the individual geopolymer concrete with laboratory-produced silicate. Similar trends applied to the weight, from Figure 7b, as the curing temperature was increased, both laboratory and factory produced sodium silicate also increases.



(a)



(b)

Figure 7: Characteristics of GPC with, a) Laboratory-produced Na_2SiO_3 and b) Optimum of compressive strength for ambient versus hot curing for Laboratory-produced (Natural) and Factory -made (procured) Na_2SiO_3 at different curing temperature

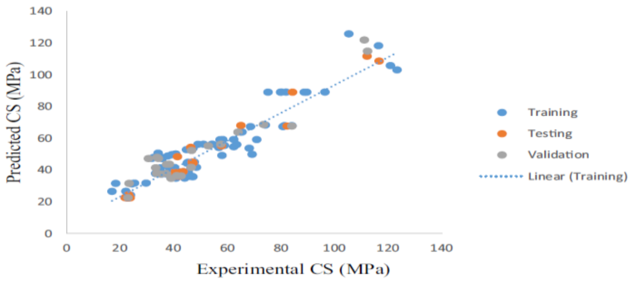
Though, the laboratory-produced silicate GPC compressive strength was higher than that of the factory—created silicate for 7, 14 and 21 curing days. Nevertheless, at 28days, the factory—created silicate compressive strength became competitively close with that of laboratory-created silicate and eventually higher at 70°c and 80°c curing temperature. This shows that the weight of the laboratory-created silicate was higher than that of the factory-produced silicate GPC, and the highest weight was at 14days and temperature of 25°C. The result is in sequence with that obtained by Pelisser et al., [11], who worked on the impact of curing temperature on compressive strength of GPC and concluded on 70°c as the optimal temperature, above which, from their studies, the compressive strength decreases. Unlike Ordinary Portland Cement concrete that obliges with low water and temperature ambient curing, GPC needs higher temperature. When GPC are cured at hot temperature, their physiognomies turn out to be like that of porcelains with numerous benefits [6], [19-20].

3.6 Predicting Performance of FA-based geopolymer

This research work adopted modified Feret model that consider necessary parameters like density, water absorption, characteristics of aggregates and mechanical properties for concrete prediction. Majorities of current formulas though followed Feret and Abrams techniques, but flout the physiognomies of aggregates in the appraisal of the strength. Since, strength of concrete cannot be predicted without knowing the properties of aggregates, because an aggregate is one of the causes of failure in concrete. Also, researchers show that the models do not suitably forecast the strength of concrete when the features of aggregate are ignored [15-18]. Thus, 5 different models, that is 3 original ((Abrams, Slater and ACI) and 2 modified (Bolomey and Feret) models were used to ascertain the compressive, split tensile and flexural strength at 7, 14, 21, 28 and 56 days of concrete made with ordinary Portland cement (OPC) as control, laboratory-produced GPC, factory-produced GPC and superplactizer based GPC, total of 180 concrete samples and compared with the experimental strength.

$$fc\ (t) = b * [\ d\ (t) + (Vgs + Vtw)a] * M \quad (1)$$

Where, (b, d) are empirical factors from the regression scrutiny of the experimental outcomes, their values are appraised statistically vain on linear curve appraisal from the SPSS-version-26; (t) is the kinetics parameter at age t, a characteristic of the geopolymer binder; (a) is the age of geopolymer concrete, age that was taken at the time fresh GPC was placed in the molds; (Vgs) is the volume of geopolymer solid (sum of volume of FA, rice husk ash and kaolin clay, volume of sodium-silicate solid together with sodium Hydroxide flakes); (Vtw) is the total volume of water, i.e water utilized for NaOH solution, Na_2SiO_3 solution and that of extra water) and (M) is the space between aggregates which is termed Utmost Paste thickness and can be ascertained via the equation. Likewise, the functionality of the models was ascertained and validated via the β (Forecast Bias), MAE, MAPE and RMSE) (Root Mean Squared Error) and coefficient of determination (R^2) metrics. MAE assesses the inaccuracies between paired observations; RMSE quantifies the spread of forecast bias (β) as well as prediction errors (residuals), and designates how greater or lesser is a projection to the real value. Likewise, to visualize the predictive performance of the developed Feret and Linear SVM model. The vertical axis epitomizes the strength anticipated via the Feret model and the horizontal axis is the perceived strength.



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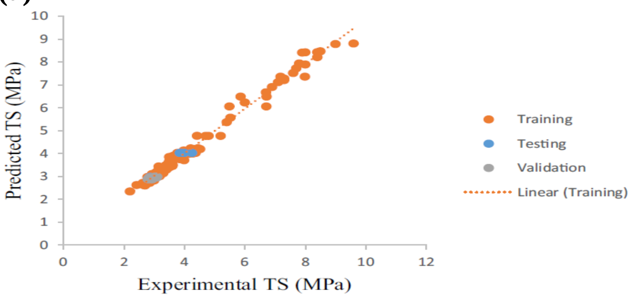
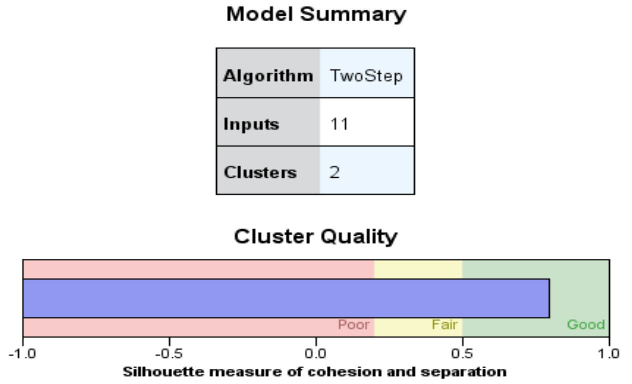


(b)

Figure 8: Comparison feret model of: a) Compressive strength, b) Tensile strength of FA-based GPC with model prediction

Largely, the data points in both training and experimental sets are grouped near the diagonal line, signifying that the model provides an exact estimation of the compressive strength. The predictive performance of the Feret and Linear SVM model is further scrutinized using the metrics [16-18].



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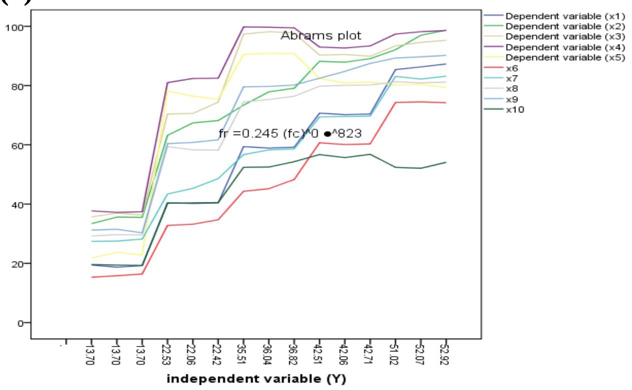

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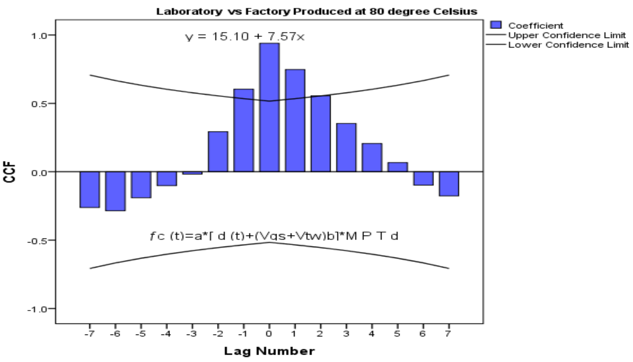

(c)

Figure 9: a) Model prediction cluster quality, b) independence vs dependence variable at various curing temperature, c) Model prediction at different lower and upper confident limit

The coefficient of determination (R^2), which is ascertained via Equation (2), is a common metric for appraising models. The value of R^2 is not beyond 1, with 1 signifying a perfect fit for the models.

$$R^2 = 1 - \{\sum_{i=1}^{N}(Predicted_i - Actual_i)^2\} - \{\sum_{i=1}^{N}(Actual_i - Actual)^2\} \quad (2)$$

$Predicted_i$ epitomizes the predicted strength of *ith* sample, $Actual_i$ denotes the actual strength of *ith* sample and *Actual* signifies the average of all specimens' actual strength.

Figures 8 and 9 show the Feret and Linear SVM model true vs predicted differences, regression model line and the residual plot respectively. The Feret, followed by the Linear SVM regression techniques had the lowest out of the five indices and is therefore the best regression model of the five (5) models considered. Regression lines' slopes for training, validation, and testing, which were 0.88, 0.78, and 0.92, respectively, prove a good connection. R-square values for the Feret was 0.967 and Linear SVM model was 0.65, while the adjusted R-squared was 0.95, mean absolute error (MAE) and root mean square error (RMSE) for Feret was 2.392 ± 0.21 and 3.459 ± 0.35, respectively. The difference between the true and predicted was minimal for all except one of the plot which shows good predictive returns. All plots were close to the predictor line that is closeness to the exact values of the predicted ones, more of the errors are close to the zero residual line, positive returns in error minimization and good predictive performances. Similarly, the experimental results are compared with the predicted values obtained from the existing relationships, and it was noticed that the experimental values are within the range of predicted values.

4.0 CONCLUSIONS

This research discusses experimental studies of laboratory-produced super-plasticizer geopolymer concrete. FTIR reveal clearly that the all binders selected have calcium, alumina and silica as vital materials and others in lesser quantities, whereas BET reveals Kaolin clay with correlation coefficient (0.9995) and surface area values of 344.703m^3/g was the highest among the binders scrutinized. The slump values increase with each percentage activation with super plasticizer (1.5%) and optimum of various binders i.e 5% FA + 7.5% KC + 10% RHA + aggregate + water. The highest compressive strength for the alkaline activated geopolymer concrete occurred at 10% NaOH activation and at 2.5% total replacement with geopolymer ash content with a strength of 33N/mm^2. Besides, the laboratory-produced silicate activated GPC showed higher strength compared to that of the factory—produced silicate. The compressive strength of the GPC increases steadily with increase in temperature The peak compressive strength occurred at 28days at temperature of 70°c with a peak value of 86.47N/mm^2 for the GPC activated with the factory—produced silicate while a peak value of 99.67N/mm^2 at a temperature of 70°c and at 21 curing days was obtained for the GPC activated with Laboratory-produced silicate. The Feret and linear regression model proved the best predictive accuracy of the eight regression models used in predicting the compressive strength of the geopolymer concrete as both closely displayed the least of the seven (7) performance error index used. The residuals and predicted vs true output plot also enunciate the supremacy of both ferret and linear SVM predictive model. Conclusively, fly ash GPC can be utilized as fireproof, thermal and acoustic insulator material for building works, rigid pavement and marine construction works because of its chemical resistance capability.

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