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Evaluating Impact of Corn Cob Ash Additives on IRE Clay Geopolymer Concrete Cured At Room Temperature

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ABSTRACT
The purpose of this study is to investigate the effect of CCA on agricultural waste used as compressive strength additions in Ire Clay geopolymer concrete. Cassava was obtained, sun-dried, and ashed at 650oC for two hours in the furnace of the glass technology department, federal polytechnic, Ado-Ekiti. Ire Clay was similarly obtained, air-dried, and calcined in a furnace at 750° for two hours. Pulverized calcined clay as the raw material for the geopolymer containing 12M of NaOH and Na_2SiO_3. 2:5 ratio of NaOH to Na_2SiO_3The 1:2:3 mix ratio for geopolymer concrete utilized river sand and 12mm granite aggregate size as filler. The geopolymer concrete mixes for various specimens and maturities of 7, 14, and 28 days contained CCA in mass percentages of Ire Clay ranging from 0.75 to 15%.

Keywords: Geopolymer, Clay, Maturity, Ash, Additives

I. INTRODUCTION

Due to their low cost, outstanding mechanical and physical qualities, minimal energy consumption, and reduced "green house emissions" during production, geopolymers have garnered great interest. As Geopolymer concretes do not contain Portland cement and the powder binder is often an industrial waste or little processed natural material, they can be promoted as environmentally benign and have lower carbon dioxide emissions than conventional concrete. However, despite the release of carbon becoming the main factor used in the assessment of environmental impacts, there are also other components that harm the environment, such as fresh water and marine ecotoxicity, human toxicity, ozone depletion, acidification, and eutrophication.

Davidovits [1988] proposed that an alkaline liquid could be used to react with the silicon (Si) and the aluminium (Al) in a source material of geological origin or in by-product materials such as fly ash and rice husk ash to produce binders. Because the chemical reaction that takes place in this case is a polymerization process, he coined the term „Geopolymer" to represent these binders. Geopolymer concrete is concrete which does not utilize any Portland cement in its production. Geopolymer concrete is being studied extensively and shows promise as a substitute to Portland cement concrete. Research is shifting from the chemistry domain to engineering applications and commercial production of geopolymer concrete.

Corn cob is the hard core portion of the corn and base of the kernel The corn cob is generally used as fire wood in various industries. The ash generated from this corn cob is then dumped in low-level arrears or land filling which causes the environmental problems particularly the habitat in nearby areas. Corn Cob Ash (CCA) is one among the agricultural by-products.

This can be considered for recycling or reusing in to various ways. One of the opportunity is reusing as pozzolanic material in cement or concrete.It is rich in silica similar to BA and RHA and can be used as SCM in cement and concrete. The CCA was considered as pozzolanic material during manufacturing of blended cement by adding with cement clinkers during grinding process and also added as partial replacement of OPC while making concrete or mortar expressing it in another way, it can be said that 7% of the world's carbon dioxide emission is attributable to Portland cement industry (Olutoge et al, 2010). Because of the significant contribution to the environmental pollution, to the high consumption of natural resources like limestone and the high cost of Portland cement etc., we cannot go on producing more and more cement. There is need to economize the use of cement. One of the practical solutions to economize cement is to replace cement with supplementary cementitious materials like corn cob ash, coal fly ash (aka pulverized fuel ash or PFA), ground granulated blast furnace slag (GGBS), silica fume, metakaolin (calcined clay), rice husk ash, palm kernel shell ash. However, the significance of this research is to help reduce the cost of concrete production arising from the rising cost of cement, and reduce the volume of solid waste generated from corncob using this waste-to-wealth initiative. Corncob is the hard thick cylindrical central core of maize (on which are borne the grains or kernels of an ear of corn). Raheem A.A. (2010) described Corncob as the agricultural waste product obtained from maize or corn; which is the most important cereal crop in sub-Saharan Africa. There had been various research efforts on the use of corncob ash (CCA) and other pozzolan as a replacement for cement in concrete. Olutogeet al (2010); presented a comparative study on fly ash and ground granulated blast furnace slag (GGBS) high performance concrete, Ogunfolami (1995); considered mixing of the CCA with Ordinary Portland cement at the point of need (i.e. on site). Adesanya and Raheem (2010); studied the workability and compressive strength characteristics of Corn cob ash (CCA) blended cement concrete. Adesanya and Raheem (2009); also assessed the development of Corncob ash (CCA) Blended Cement. This present while investigating the strength of corncob ash concrete, also attempted an examination of split tensile and high strength properties of such concrete.

Alkaline activator solutions and silicon (Si) and aluminum (Al)-rich source materials are the primary components of Geopolymer. Natural minerals such as kaolinite and clays, as well as industrial byproducts such as rice husk ash, GGBFS, fly ash, silica fume, and red mud, could be used as Geopolymer's raw materials. The alkaline liquids employed as an activator in the geo-polymerization process can be a solution of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate (Na2SiO3). In a geopolymer mixture, water plays no significant role in the chemical reaction and contributes in the production of a workable mixture (Sreevidya 2014).

The kind and nature of the raw materials, alkaline activators, and curing conditions are highlighted as the most influential aspects of geo-polymerization. Typically, silica- and alumina-rich raw materials are utilized. Controlling the leaching of alumina and silica from raw material is largely dependent on the alkali concentration. The activation of silicates enhances the solubility of raw materials and generates advantageous mechanical characteristics. Different curing conditions are recorded for different raw materials and activators (Bagchiet al., 2018).

II. MATERIALS AND METHOD

3.1 Source Material

Calcined clay (CC) was made by calcining natural kaolin clay at 750 °C for two hours in a furnace. As activators, sodium hydroxide (NaOH) and sodium silicate (Na2SiO3) were chosen since they are the most common and easiest alkali materials to manipulate (2013).

This project uses locally sourced fine aggregates (river sand). It was subjected to a physical laboratory test known as particle size distribution, also known as sieve analysis, because it appeared to be free of debris and clay. Fine aggregate is a necessary component of concrete made from natural sand or crushed stone. The quality of S has a significant effect on the qualities of hardened concrete. If fine aggregate is selected based on grading zone, particle form and surface texture, abrasion and skid resistance, and absorption and surface moisture, the concrete or mortar mixture will be more durable, stronger, and less expensive.

Coarse aggregate is the component of geopolymer concrete that consists of the larger stones incorporated inside the mixture. It was gathered from a quarry site in Ekiti State, Nigeria, and has an aggregate size of 12mm, passing through sieve sizes of 12mm downward to the smallest sieve, which is 4mm. It was also subjected to a laboratory physical test known as a particle size distribution test. Aggregate retained on each sieve ranging from 12 mm to 4 mm in size when employed.

Corn cobs gathered locally in Ijan are the agricultural waste material utilized in this study. Before it was reduced to ash in the Glass and Ceramic Technology department of the Federal Polytechnic Ado-Ekiti, it underwent a preliminary treatment consisting of sun drying. This agricultural waste was utilized as an addition in the manufacturing of geopolymer concrete. In order to obtain silica in amorphous form, it was burned and ground into fine ash particles at 650°C for two hours, with the amount of gas in the combustion chamber carefully regulated. The hydrometer test was conducted to ascertain the grain size distribution of the raw material and additives. Utilizing a pyrometer, the temperature was

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measured (RT Series). At the conclusion of each experiment, the kiln was cooled to room temperature before the removal of the ash. The ashes were sieved using a 75um sieve to remove any foreign matter and larger ash particles; only the fine ashes that passed through the 75um sieve were collected. Further chemical analysis of the additives was conducted in a chemistry laboratory to determine their chemical composition.

The alkaline solution employed as an activator for the geopolymer gel consists of Sodium Silicate (Na_2SiO_3) and Sodium Hydroxide (NaOH) at a ratio of 2:5, with NaOH having a molarity of 12M. To dilute Alkaline to the necessary molarity, distilled water was utilized.

The recommended mix ratio of 1:2:3 geopolymer concrete by mass, in which geopolymer gel is one part, fine aggregate is two parts, and coarse aggregate is three parts. CPA was added in proportions of 0%, 7.5%, and 15% to several batches of the mixture as an additive.
Three test samples were cast for varying maturities of 7, 14, and 28 days. The 50mm x 50mm x 50mm sample was cured at room temperature to the appropriate degree of maturity.

Table 1: Mix Proportion Ratio Table

%	Alkaline mix (cm3)	S.M ash (g)	F.A	C.A	additives
0%	96.3	316.5	632.7	949.2	0
7%	96.3	316.5	632.7	949.2	23.73
15%	96.3	316.5	632.7	949.2	47.5

Compressive Strength Test

Geopolymer concrete was tested for its compressive strength at the Department of Civil Engineering Laboratory at AfeBabalola University. The compressive strength test was conducted utilizing a wizard basic compression test machine that was operated electronically. The specimens were placed in the hydraulic testing frame and a force was applied until the specimens fractured. The prism halves were centered to the machine's platens within 0.5 mm laterally and longitudinally so that the end face of the prism overhangs the platens by approximately 10 mm. The greatest force exerted and specimen dimensions were then recorded, and the specimen's compressive strength was computed. The results for compressive strength were determined using the arithmetic mean of the measurements of six separate test samples.

III. RESULTS AND DISCUSSION

Physical Properties

The specific gravity, particle size distribution, and color of the additive and source are shown in Table 2. Specific gravity will have an effect on the sample's bulk density, particle size distribution will have an effect on the reaction, and color is an indicative of the predominant pigment of the constituent materials.

Table 2: Physical properties of geopolymer base material and additives.

Properties	**IRE CLAY**	**CCA**
Specific gravity	2.57	1.75
Grain size	-	-
Colour	Reddish brown	Reddish

Chemical Composition

Table 3 displays the chemical composition of Ire clay is composed of 58.96% silicon oxide and 19.85% aluminium oxide. CCA, on the other hand, consists of 66.78 percent Silicon Oxide and 9.42 percent Aluminium Oxide. SiO_2 has a CPA that is approximately 73.8% higher than Al_2O_3.

Table 3: Chemical composition of geopolymer base material and additives.

Oxide Composition	Na_2O	CaO	K_2O	MgO	Fe_2O_3	Al_2O_3	SiO_2	MnO_2	P_2O_5	CuO	LOI
Ire Kaolin	1.92	0.36	0.23	0.38	3.31	19.85	58.96	0.01	0.11	0.21	11.26
Corn Cob Ash	1.36	11.21	0.2	1.96	5.66	9.42	66.78	0.01	0.04	0.06	4.82

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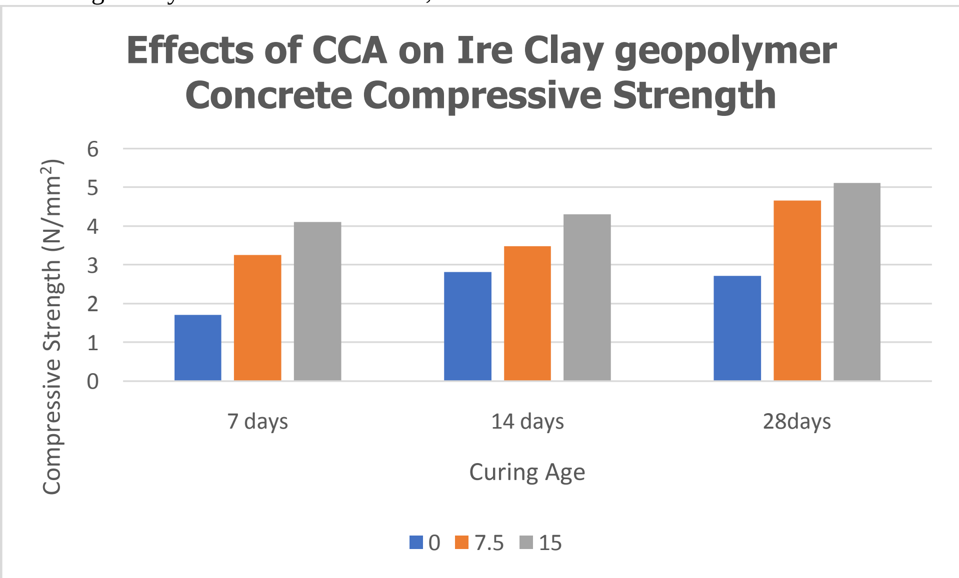
4.3. Compressive Strength

Fig. 1 depicts the compressive strengths of Ire clay geopolymer concrete samples with CCA as an additive that have matured for 7, 14, and 28 days at room temperature and in the open air. The compressive strength of the samples improved with age; samples without additives demonstrated a 38.9% rise in compressive strength from 7 to 28 days, from 1.71 to 2.82 N/mm^2.

CCA additions of 7.5% and 15% increased compressive strength by 120% and 195%, respectively, at 7-day maturity. At 14 days of maturation, a 7.5% CCA addition increased compressive strength by 133%, and a 15% CCA addition increased strength by 150%. At 28 days maturation, the addition of 7.5% CCA and 15% CPA increased the compressive strength by 152% and 167%, respectively. Increasing percentages of CCA as additives have a positive impact on the compressive strength gain of geopolymer concrete as it ages.



IV. CONCLUSIONS

Increasing percentages of CCA as additives have a good effect on the maturity of geopolymer concrete at room temperature, as measured by the increase in compressive strength. This is edging geopolymer adaptation and application toward utilization in developing and under-developing nations for the suggestive viability of Ire clay as a geological source for geopolymer and agricultural waste of CCA as additives boosting the compressive strength of created geopolymer samples.

The activator concentration of Sodium hydroxide NaOH and its ratio to Sodium silicate $NaSi_3$ for the activation of calcined Ire Clay-derived materials need additional investigation. Other Additives may be utilized for enhancing the compressive strength of Ire Clay geopolymer concrete for extensive structural applications.

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