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# Effects of Alkaline Activator Molarity and cure Temperature on Properties of Geopolymer Synthesized from the Federal Polytechnic Gate Laterite Deposits

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**Abstract- Geopolymer is involved in study and application for its proclaimed advantages over Portland cement. Studies of factors affecting the physical and mechanical properties of geopolymer materials is critical to impending requirements for standardization and regularization of applications of the materials. Materials are mostly described by their physical and mechanical properties when they are deployed for structural development. However, to understand the properties in design and deployment, the parameter affecting the property needs to be understood. This study aims to investigate the impact of alkaline activator concentration and cure temperature on geopolymer specimens produced based on geologically sourced material deposits near the Federal Polytechnic Gate. Alkaline activator solution was composed of NaOH of varied molarity (8, 10, and 12 with Nasio3 and sterile water in ratio of 7:3:3, respectively. The activator was applied to pulverized calcined laterite sourced near the federal polytechnic main gate. The activator to geopolymer sourced material ratio was maintained at 0.45 for all specimen mixes, thoroughly mixed to produce 27 geopolymer gel cubes. 3 sets Specimens of the same alkaline activator concentration were respectively cured at 27°c (room temperature) and oven temperatures of 50°c and 90°c for respective maturities of 28 days and 72 hours. Density, porosity, and comprehensive strength tests were conducted, and their respective outcomes were related to specimens' molarity and cure temperature. Specimen density ranges from 1.81g/cm³-2.32g/cm³, Porosity ranges from 5.32% to 26.08%, and Compressive strength ranges from 0.5 N/mm² - 6.9N/mm².**

**Keywords- Materials, Activator, Porosity, Geopolymer, Alternative .**

## I. INTRODUCTION

Geopolymerization is a direction of scientific development for the treatment of solid waste and by-products Matsimbe*et al,* (2022). It provides sophisticated and cost-effective solutions to many of the challenges associated with the handling and storage of hazardous waste in critical environmental conditions. Geopolymers contain silicates and aluminates, which are byproducts of the geopolymerization process Castillo *et al,* (2021): Essam*et al,* (2008)]. Castillo *et al,* (2021) studied highlight factors which may affect properties of geopolymer.

Geopolymer is gaining attentions for studies and applications for its perceived environmental and cost advantage over Portland cement Castillo *et al,* (2021). It is environmentally friendly and requires moderate energy to produce. Some reviews consider it as an ideal factor influencing the properties of Geopolymer. The relative value of the environment, low energy requirements for production, variety of raw materials, diversity or processing and variety of raw materials are research centers with increasing needs for understanding and regulation. The literature shows that certain mix compositions and reaction conditions such as $Al_2O_3/SiO_2$, alkali concentration, curing time versus curing temperature, water/solid ratio, and pH can affect geopolymer formation and properties. It has been reported that geopolymers can reach 70% of their final strength within the first 3-4 hours of curing.

Generally, geopolymers are inorganic synthetic polymers formed by the reaction of aluminosilicate material with alkaline agents to form a semi-crystalline amorphous material after curing Wang et al. (2005). Zannerni*et al.,* (2020) stated that the curing reaction can occur at both elevated temperature and room temperature, depending on the composition of the geopolymer. A wide range of aluminosilicate reagents have been developed for the production of geopolymers. The most common sources of aluminosilicates used in geopolymer production are metakaolin and by-products from other industries such as fly ash, mine tailings, red mud, and slag. Zhang, (2021): Khan *et al.,* (2021): Farhan *et al.,* (2020): Li *et al.,* (2019): Sun *et al.,* (2019)]. Studies of volcanic ash-based geopolymers are also available, Centinta*et al.,* (2018).

The alkaline activator causes the raw materials to dissolve Rifaai*et al,* (2019). It is recommended to choose it carefully because its composition has different effects on the properties of fresh geopolymer paste and the development of mechanical strength in hardened geopolymers Nadoushan&Ramezanianpour, (2020). The most common are alkali hydroxide and silicate solutions. The product resulting from the reaction between the source of aluminosilicate and the alkaline activator is an amorphous substance consisting of solid phases of aluminosilicates built on the basis of compounds of $SiO_4^{4}$- and $AlO_4^{5}$- in the form of tetrahedrons forming a 3D structure. A number of researchers have suggested that the synthesis of geopolymers consists of three steps in the following order: the dissolution of aluminosilicate materials, which include silicate and aluminate monomers, the gelation process, which involves the conversion of monomers active in geopolymer fragments of Bound aluminosilicate oligomers and geopolymer gel formation by crystallization and polymerization chain reaction

| Parameters (%) | School Gate |
|---|---|
| $Na_2O$ | 0.170 |
| Cao | 0.304 |
| $K_2o$ | 0.152 |
| Mgo | 2.100 |
| $Fe_2O_3$ | 44.620 |
| $Al_2O_3$ | 10.260 |
| $Sio_2$ | 12.800 |
| $Mno_2$ | 0.103 |

Zhang *et al.,* (2011). Geopolymer concrete (GPC) is estimated to reduce the carbon footprint in construction projects by 80% compared to regular Portland cement, Khale& Chaudhary (2007). To construct a geopolymer with good compressive strength, the design must take into account several variables, such as the type of aluminosilicate source, the composition, composition and concentration of the alkali activator, the amount of water to be used, if cured at room temperature or higher temperatures. The current study is to compare the effects of Sodium Hydroxide and Sodium Silicate as alkaline activators concentration or molarities and cure temperature on mechanical and physical properties of geopolymer specimens produced from geological source materials at the Federal Polytechnic Gate laterite deposits at Ado Ekiti, Ekiti State South Western Nigeria.

## II.MATERIALS AND METHODS

The Geopolymer source material for this study is laterite obtained from the laterite deposit near the Federal Polytechnic School main gate at Ado-Ekiti. Sodium Hydroxide and Sodium Silicate solutions were adopted as activator solution. The Sodium hydroxide concentration is varied to alter the activator solution concentration. Concentration of Sodium Hydroxide in the activator solution is varied as 8M, 10M and 12M with comparative adjustment with Sodium Silicate and activator solution mixed sterile water to ratio 7:3:3 (Xiang 2018).

Prepared alkane activator solution was applied to the source material at ratio of 0.45. Properly mixed gel of the activator and source material were cast and de-molded after 24 hours and thereafter set specimens were subjected to different cure temperatures at room temperature (27ºC), Oven Temperature at 50ºC and 90ºC. Cure duration at room temperature was 28 days, while at accentuated oven temperatures, cure duration was 72 hours. The Geopolymer specimens were weighed for density evaluation. Saturated specimens and the dry weight in the air were evaluated for percentage porosity of the specimens. The specimens which density and porosity as obtained were subjected to compressive strength test with Universal Testing Machine.

## III.RESULTS AND DISCUSSION

### 1.Chemical Compostion

Chemical Composition result for this study is an adoption from Oluborode *et al.*$SiO_2$ and Al02 were established key relevant constituents of geopolymer source material. Table 1 presents the $SiO_2$ and $Al_2O_3$ to be 12.8% and 10.26% respectively

Table 1 Chemical Composition of Federal Polytechnic Ado Ekiti school gate Laterite.

### 2.Impact of Molarity and CURE temperature on specimen density:

Density determines the robustness or lightness of materials as it may be required for different purpose in design and construction. Table 2 indicates that the density of the specimens varies depending on the activator molarity and cure temperature. At the lowest molarity of 8M, the density ranges from 2.0325 g/cm³ at 27°C to 1.8096 g/cm³ at 90°C. At the highest molarity 12M, the density ranges from 2.3275 g/cm³ at 27°C to 1.9803 g/cm³ at 90°CAs activator Molarity increases from 8 to 12M at different cure temperatures the density increases. Nevertheless, the higher the cure temperature the density decreases.

Table 2: Effects of Activator Molarity and Cured temperature on Density of the specimens.

| Molarity | 27$^{O}$C | 50 $^{O}$C | 90 $^{O}$C |
|---|---|---|---|
| 8M | 2.0325 | 1.8672 | 1.8096 |
| 10M | 2.3051 | 1.9897 | 1.8448 |
| 12M | 2.3275 | 2.1616 | 1.9803 |

### 3.Impact of Molarity and CURE temperature on specimen porosity:

Porosity describes the total pore distribution of the specimen; this usually have implication on other properties of the specimen Table 3 shows that the porosity of the specimens varies related to the activator molarity and cure temperature. 8M for specimen activator at 27°C cure temperature has the lowest porosity value of 5.32%. 12M for specimen activator at 90°C cure temperature with highest porosity of 26.08%As activator Molarity increases from 8 to 12M at different cure temperatures the porosity increases generally from 5.32% to 26.08% and as cure temperature increases the porosity increases correspondingly for instance at 12M the porosity increases from 12.52% to 26.08% corresponding to cure temperature at 27°C and 90°C respectively.

Table 3: Effects of Activator Molarity and Cured temperature on Porosity of the specimens.

| Molarity | 27 $^{O}$C | 50 $^{O}$C | 90 $^{O}$C |
|---|---|---|---|
| 8M | 5.32 | 11.46 | 15.43 |
| 10M | 11.61 | 19.12 | 22.59 |
| 12M | 12.52 | 25.75 | 26.08 |

**3.Impact of Molarity and CURE temperature on specimen compressive strength:**

Compressive strength is a measure of the geopolymer specimen to resist compressive load. Table 4 that the compressive strength of the specimens varies depending on the activator molarity and cure temperature. 8M at 27C has lowest porosity at 5.32 and 12M at 90C with highest porosity of 26.08C as activator Molarity increases from 8 to 12M at different cure temperatures the porosity and as cure temperature increases the porosity increases correspondingly.

Table 4: Effects of Molarity and Cured temperature on Compressive strength of the specimens.

| Molarity | 27• C | 50• C | 90• C |
|---|---|---|---|
| 8M | 0.5768 | 1.2115 | 3.7997 |
| 10M | 0.9595 | 2.8367 | 4.1364 |
| 12M | 1.4061 | 3.9992 | 6.9013 |

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