PHYSICAL AND MECHANICAL PROPERTIES OF GEOPOLYMER SYNTHESIZED FROM ALTERNATE SOURCE LATERITE

ABSTRACT

Procurement and development of materials are essential facts of structural engineering practice. This study seeks to understand potential of laterite deposit in Ado-Ekiti metropolis for development as source material for geopolymer for engineering applications. Scooped laterite from alternate sources of Ekiti Parapo Pavilion and Federal Polytechnic Gate deposits were calcined at 750°c thereafter pulverized. The metallic oxide of the pulverized samples were determined. Alkaline activator solution of NaOH and $NaSi0_3$ while maintaining NaoH at 8M, with sodium hydroxide - sodium silicate- sterile water ratio of 7:3:3. The alkaline activator with the source material at ratio of 0.45 mixed was used to produce 50×50×50mm³ specimen cubes based on the alternate geopolymer source materials. Sets of the specimen were cured respectively at 27°c (room temperature), oven temperature 50°c and 90°c respectively for 28days, 72hours and 72hours. To evaluate physical and mechanical properties of the specimens, density, porosity and comprehensive strength of the specimens were determined. Result shows that the specimen density decreases with increase of cure temperature while porosity increases with increase cure temperature. Specimen density ranges from 2.16g/cm³-2.4g/cm³ and Porosity ranges from 8.8%-17.64%. Specimen comprehensive strength increases with cure temperature with strength value ranges from 1.74N/mm³-7.24N/mm³ for geopolymer based on Ekiti parapo laterite. The trend for density, porosity and comprehensive strength for the specimen were similar for geopolymer based on the Polytechnic Gate laterite except that the comprehensive strength were relatively lower with minimum value ranges from 0.58N/mm³- 3.80N/mm³.

Keywords: Geopolymer, material, density, porosity, strength

INTRODUCTION

The demand for cementitious materials has increased considerably in recent years. Ordinary Portland cement, OPC is normally considered as the main material for construction purposes. Cement as binder is a key constituents of concrete apart from Fine Aggregate, Coarse Aggregate and Hydrating water(Gagg 2014). However, the Portland cement production has a severe impact on the environment due to the huge amount of greenhouse gases emitted to the atmosphere. The production of 1 ton cement requires about 2.8 tonnes raw materials (including fuels and other materials), 5 to 10% of these materials are dust out of the dryers, mills, kilns, coolers and transportation facilities (Cement, 2012). Moreover, the production of OPC triggers stronger CO_2 emissions (8% of global CO_2 emissions) Kamal et al, (2018). The global standards of the modern construction industry imply the commitment to abate greenhouse gas emissions and decrease the energy-consuming process produced by OPC. The invent of geopolymers has been subjected to have low carbon footprint.

In the early 80 s geopolymers were introduced as alternative construction materials with a lower environmental impact. The geopolymer binder is synthesized by mixing materials rich in silica and amorphous alumina with a strong alkaline activator. High proportion of industrial by-products such as fly ash (FA), coal ash and blast furnace slag were readily available in develop countries for geopolymer production Orji, et al., (2017).

This term has no scientific association. In reality, the terminology used to describe geopolymer molecules has no connection to biology, such as poly (sialate)/polysialate or poly (sialate-siloxo). Therefore, the use and promotion of this terminology will continue without any limitations Raijiwala et al., (2010).

Geopolymers, which are made from natural materials such as fly ash and slag, are effective in treating water and wastewater due to their ability to adsorb and exchange ions Rajini et al (2014). They have been successfully used to remove heavy metals, organic pollutants, and bacteria from water and wastewater Oke & Ayeni (2019). Geopolymers have also been used to remove organic pollutants and inactivate bacteria, making them useful for disinfection. Overall, the use of geopolymers in water and wastewater treatment has the potential to improve the quality of these resources Abdullah et al., (2007).Geopolymer materials can effectively adsorb heavy metals, dyes, and other radioactive pollution, which is very beneficial to society's future development Matsimbe et al, (2022b). The strength of the unary or blended geopolymer product is dependent on the composition and properties of the polymeric gel Matsimbe et al, (2022a) and this is bound to be so for divergence of source materials applicable for geopolymer gel. Geopolymers are imagined for use in nearly every field of technology today because they are regarded as versatile materials that have attracted attention in numerous environmental applications. Matsimbe et al, (2022a) supports need for increasing study. Most study on Geopolymer are arbitrary on mix and methodology because of multiplicity of the source material Cong and Cheng, (2021). Increasing study will be required to address several gaps in large-scale civil engineering application and implementation, Matsimbe et al (2022b). Nikoloutsopoulos et al, compared strength properties of Fly Ash Geopolymer concrete to Portland Cement Concrete with report of better performance of fly ash Geopolymer concrete in compressive strength and thermal resistance. Standardization however still remains a challenge in applications of geopolymer.

There is a lack of clarity on definitions and mix design methods to achieve the best of various properties due to the varying scientific approaches to geopolymers and alkali-activated materials.

Geopolymer proponents are subjected that geological material rich in silica and alumina can serve as a source material for geopolymer. Thus, developing and under developing countries can consider development of geopolymer from readily available local materials from geological and agricultural source. This study is therefore geared at determination and comparison of physical and mechanical properties of geopolymer gel produce from geological source of laterite from two alternative sources in Ado-Ekiti, Ekiti state, Nigeria.

MATERIALS AND METHODS

Materials for this study include laterites extracted freely from deposits located at Ado Ekiti, Ekiti State Nigeria. 10kg of laterites scooped was spread in the atmosphere after 48hrs to reduce the moisture content. The air-dried laterites were introduced to the burning furnace and calcined for 2hrs at 750^0C was ground to increase the surface reaction and alkaline activator. A little of the calcined laterite of about 100g were subjected to hydrometric gravitation to analyze elements and metallic oxides in the laterites. 8M of NaOH was mixed with Na_2SiO_3 and sterile water at ratio of 7:3:3. Homogenous mix was obtained by applying heat to the alkaline solution mix by applying heat at a temperature of 110^0C in the oven. The alkaline activator was applied within 3hrs after cooling to the required pulverized calcined laterite at activator to source material ratio of 0.45. The thorough mix activator and source materials were placed in a wooden mold of 50 by 50 by 50 mm for 24hrs after which three sets of specimens prepared respectively were cured at room temperature, 50^0C, and 90^0C respectively in the air and electric Oven. Specimens cured in the air were cured for 28 days. Oven - cured specimens lasted for 72hrs with an intermittent break of power supply.

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 has been obtained were subjected to compressive strength test with the comprehensive test machine available in the concrete laboratory of Afe Babalola University Ado-Ekiti.

RESULTS AND DISCUSSION

Table 1 shows the metallic oxides constituents of laterite deposits at Ekiti Parapo Pavilllion and Federal Polytechnic gate Ado Ekiti, Nigeria. The pavilion laterite is constituted of SiO_2 and aluminum oxide of 34.51 and 12.80% of the sample respectively. While the polytechnic gate laterite sample is constituted of silicon oxide and aluminum oxide respectively of 12.72 and 10.26%. Other metallic oxide like Fe_2O_3 are similar in percentage content for the respective samples.

Table 1: Chemical Composition of Pavilion and Polytechnic gate laterite

Metallic oxides	Na_2O	CaO	KaO	MgO	Fe_2O_3	Al_2O_3	SiO_2	MnO_2
% Ekiti Parapo	0.112	0.392	0.132	3.150	42.16	14.44	34.51	0.083
% Poly	0.170	0.304	0.152	2.10	44.62	10.26	12.80	0.100

Table 2 present physical and mechanical properties of geopolymer gel cube specimen synthesized with the alternative laterite sources. The density of the specimen base on the alternate laterite sources decreases with increasing cure temperature. Even though the Ekiti parapo specimen generally manifest higher densities comparatively. Density of Pavilion specimen range from 2.1600-2.4600 for cure temperature for 90°c-27°c respectively.

Density of polytechnic gate laterite based specimen ranges from 2.03-1.80g/c³.

The specimens base on the alternative sources increases in porosity as the specimen cure temperature increases.

Pavilion-based geopolymer gel specimen porosity varied from 5.32 - 15.43% while the geopolymer gel specimen associated with the poly gate laterite had its porosity varied from 8.83 - 17.64%.

At corresponding cure temperature polytechnic gate specimens manifest higher porosity than specimens based on pavilion laterite.

The compressive strength of the specimens increase with increase cure temperature. The pavilion geopolymer specimen compressive strength increases from 1.74 N/mm² at cure temperature of 27°c (ambient) to 7.240N/mm² at 90°c cure temperature. Poly gate geopolymer specimen compressive strength increases from 0.57N/mm² at room temperature to 3.79N/mm² at 90°c cure temperature respectively. Pavilion laterite base specimen generally show for corresponding cure temperature superior compressive strength capacity over corresponding specimen at similar cure temperature over polytechnic gate laterite geopolymer specimen.

Table 2: Cure temperature and Properties of Geopolymer Specimens of Pavilion and Polytechnic Laterite Deposits.

Cure Temperature (^0C)	Ekiti Parapo Specimens			Poly Specimens		
	Density (%)	Porosity (%)	Compressive Strength (N/mm^2)	Density (Kg/M^3)	Porosity (%)	Compressive Strength (N/mm^2)
27	2.4600	8.833	1.736	2.0325	5.32	0.5678
50	2.3300	15.696	6.728	1.8672	11.46	1.2115
90	2.1600	17.643	7.240	1.8096	15.43	3.7997

CONCLUSION

This study successfully examine the relationship between the porosity, density, and compressive strength of geopolymer gel in another word alkaline cement specimens synthesized from 8M of alkaline activator solution with the pavilion and Polytechnic gate laterite cured at ambient temperature(27°C), 50°C and 90°C. The study confirms that porosity and density decreases with increasing cure temperature, even though the compressive strength increases with increasing cure temperature.

This phenomenon was similar to the two categories of specimen from the alternative sources. It was obvious that the set of specimen with higher silicone to aluminum ratio in the source material constituents correspondingly manifest higher strength at different cure temperatures.

The outcome of this study can find use in solutions to the cementitious material needs for environmental problems.

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