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The Effect of Acidic to the Fly Ash Based Geopolymer Artificial Aggregate

A. Alida, A.M. Mustafa Al Bakri, H. Kamarudin, C.M. Ruzaidi, M.A.A. Mohd Salleh, Khoo Hooi Chin

Center of Excellence Geopolymer and Green Technology (CEGeoGTech), School of Materials Engineering, Universiti Malaysia Perlis (UniMAP), D/A Pejabat Pos Besar, 01000, Kangar, Perlis, Malaysia.

Abstract: The Ordinary Portland Cement (OPC), which is widely used materials not only consumes significant amount of natural resources and energy but also pollutes the atmosphere by the emission of CO_2. Hence, reduce this ill effect, the search for alternative result is geopolymer concrete. This experiment research focused on utilizing fly ash as source material. Fly ash is receiving more attention now since their uses generally improve the properties in construction industry, cost saving and reduction of negative environmental affects. Three different molarity of paste has been tested to acidic environment to determine the effect of acidic to the fly ash based geopolymer artificial aggregate. The geopolymer paste samples were cured at 70°C for 1 day and keep in room temperature until the testing days. The compressive strength and acid resistant testing was done at after 28 days. The result showed that the geopolymer paste with NaOH concentration of 12 M produced maximum strength.

Key words: Fly ash, acid resistant, geopolymer, artificial aggregate and compressive strength.

INTRODUCTION

Concrete is one of the most widely used in construction industry since many decade ago, it is usually associated with ordinary Portland cement as the main component for making concrete. The demand for concrete as a construction material is on the increase. Because of this, the natural sources became less in our world. The use of recent day cement releases to two billion tonnes of Carbon Dioxide (CO_2) annually into the atmosphere, which makes it in the third largest man-made source of CO_2. General consumption of natural sources, massive amount production of industrial wastes and environmental pollution require new solutions for a more sustainable development (Rangan, 2008).

Generally, the raw material used in the manufacture of artificial aggregate is pulverised fuel ash (fly ash). This is the waste material produced from electricity production in coal-fired power stations. Synthetic artificial aggregate produced from environmental waste, like fly ash, is a viable new source of structural aggregate material. Fly ash is a residual material of energy production using coal, which has been found out have a few advantages for use in the concrete to reduced permeability, increased ultimate strength, reduced bleeding, better surface finish and reduced heat of hydration (Davidovits, 1988).

According to fly ash's property which has strong silica alumina glassy chain, it has been used as supplementary cementing material to substitute Ordinary Portland Cement (OPC). Portland cement is the most used material in the worldwide construction industry but it also has a high level of CO_2. Its use tends to become less competitive compared to alternative ecological new binders like geopolymers (Davidovits, 1991 and Mustafa, 2011).

In this kind of issue the geopolymer technology is the process of strong alkali activators are used to break the sturdy silica alumina chain to enhance polymeric process of fly ash to form cementations binder. This geopolymer technology could reduce approximately 80% of CO_2 emission contributed by the cement and aggregate industry. Unlike conventional Portland cement, geopolymeric cements do not rely on lime and are not dissolved by acidic solutions which are the Portland based cements will be destroyed in acidic environment (Davidovits, 1991).

MATERIALS AND METHODS

Materials:

Fly ash is the residual from the combustion of pulverized coal which was collected by mechanical or electrostatic separators from the flue gases of thermal power plants. The most important characteristics of fly ash will be the spherical form of the particles. The purpose of this shape of particle is to improve the flow ability and reduces the water demand (Yudthana, 2009 and Sathish Kumar, 2012).

Corresponding Author: A. Alida, Center of Excellence Geopolymer and Green Technology (CEGeoGTech), School of Materials Engineering, Universiti Malaysia Perlis (UniMAP), D/A Pejabat Pos Besar, 01000, Kangar, Perlis, Malaysia.
E-mail: alida@unimap.edu.my

Sodium Hydroxide is also generally used as an alkaline activator in geopolymer production. While it does not maintain the level of activation as a K^+ ion, sodium cations are smaller than potassium cations and can migrate throughout the paste chain with much less effort promoting better zeolitization (Vijaya, 2006)

Sodium Silicate is also known as water glass or liquid glass, available in liquid (gel) form. Sodium or potassium silicates are manufactured by fusing sand (SiO_2) with sodium. Sodium silicate solution is commercially available in different grades, but it should be noted that powdered water glass leads to lower performance compared to the liquid form (Kong, 2008).

Experimental Procedure:

The alkaline activator solutions were prepared by the dissolution of sodium hydroxide in one litter of distilled water in a volumetric flask to obtain various molarity which are 10 M, 12 M and 14 M. Alkaline activator, which consisted of the combination of the NaOH and Na_2SiO_3, was prepared just before it was to be mixed with the fly ash.

The fresh fly ash base geopolymer as artificial aggregate is dark in colour which is due to the dark color of the fly ash. The sodium hydroxide available in pellets form it is dissolved in water. Morality to use in the artificial aggregate is 10 M, 12 M, and 14 M then will be leave it at room temperature around 24 hours then after that can be start to mix with sodium silicate accordingly to each concentration around 3 minutes. The alkaline solution was added to the geopolymer precursor which is fly ash and mixed for 20 minutes to obtain a homogeneous mixture, which is then allow to stand at room temperature for a few hours.

Before doing the curing process then we need to shape in sphere shape by hand from the geopolymer paste then place on the tray. The geopolymer specimens are keep inside the heat curing chamber at 70 degree and temperature indicator is also placed outside the set up. The canvas should be so tight such that the heat is cannot come out of the heat curing set up. The samples are cure for 24 hours.

RESULT AND DISCUSSION

Compressive Strength:

The main objective which is the effective of varied concentration of alkaline solution on the strength characteristics of the aggregate with based geopolymer. Figure 1 showed that 12 M of NaOH is the optimum compressive strength compared to 10 M and 14 M. Mustafa et. al also found that the fly ash geopolymer with 12 M had contributed the maximum compressive strength (Mustafa, 2011).

Geopolymer with ratio 1.5 for each concentration showed high compressive strength and it can be conclude as the concentration in 12 M with activator-to-fly ash ratio 1.5 is the most suitable mixture portion in making fly ash artificial aggregate. This result was contradicted from Mustafa et.al where they found that the best ratio was 2.0 for geopolymer cube paste (50 mm x 50 mm x 50 mm) (Mustafa, 2012). This difference may due to different size of sample. Figure 1 showed that the optimum activator-to-fly ash ratio is in 1.5. As the amount of activator content ratio increased up to 1.5, the compressive strength of fly ash artificial aggregate also increased. Sathia *et.al* stated that the compressive strength increase with an increasing of fly ash and activators. This is due to the high amount of sodium oxide content, which is mainly required for the geopolymerization reaction (Thokchom, 2010).

However, when additional activator content is added, increasing the activator-to-fly ash ratio to 0.3 the compressive strength is decrease. This might be due to excess of OH^- concentration, which will decrease the strength of fly ash aggregate with based geopolymer. It is because the excess sodium content can form sodium carbonate by atmospheric carbonation and may disrupt the polymerization process (Bakharev, 2005).

The compressive strength decrease when geopolymer ratio increase to 3.0 due to an excess of fly ash, not have enough liquid which is alkaline activator to mix the geopolymer homogeneously. The use of high concentration of sodium hydroxide leads to greater dissolution of the initial solid material and increase geopolymerization reaction and hence higher compressive strength is achieved. However, an increase in the sodium hydroxide concentration up to 12 M caused negative effect on the geopolymerization present in lower compressive strength of aggregate (Yang, 1996).

Acid Resistant Test:

The microstructure of geopolymer with different molarity of NaOH are shown in Figure 2 (a,b and c). From the microstructure in Figure 2 (b) which is less pores and less crack compare to Figure 2 (a and c). Hence, from the result can be known that the 12 molarity NaOH is the most strength when exposed in acid with 28 weeks compared to 10 M and 14 M.

Pores as indicated on the figures by arrow sign, and cracks which could limit the strength of geopolymer also found in the matrix in Figure 2(a) and Figure 2(c) that leads to lower compressive strength. The result obtained suggested that the composition of aluminosilicate gel formed by the reaction between fly ash and alkaline activator is variable and depends on the reactivity and concentration of activators (Yang, 1996).

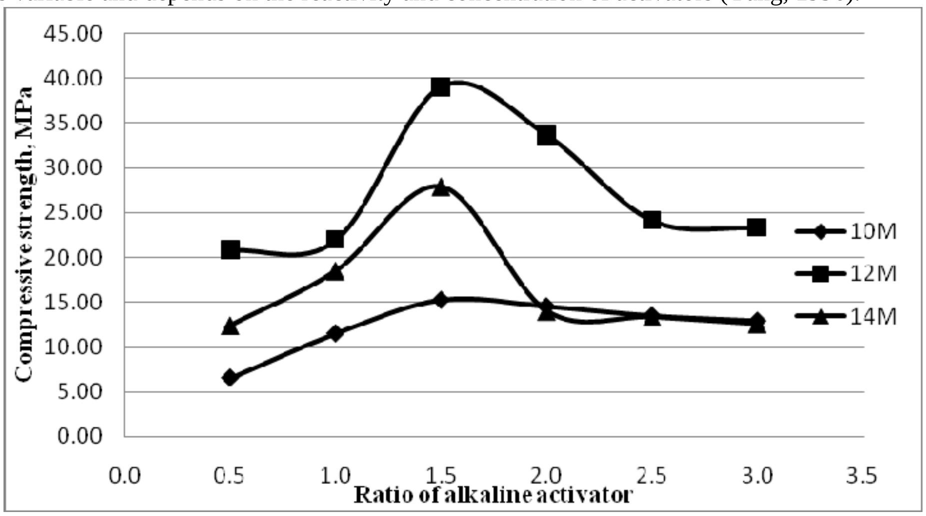

Fig. 1: Compressive strength of artificial aggregate with geopolymer based for 10 M, 12 M and 14 M.

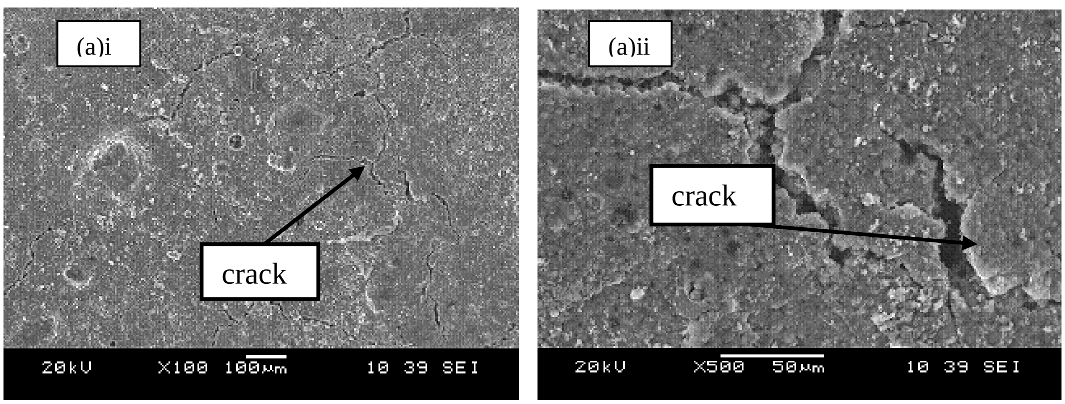

Fig. 2: a) (i) 10 M with magnification x100; (ii) 10M with magnification x500.

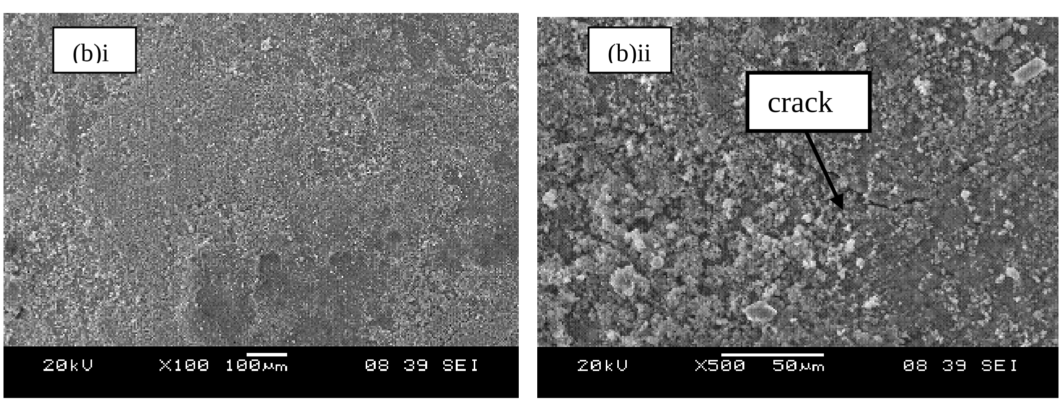

Fig. 2: (b) (i) 12 M with magnification x100; (ii) 12M with magnification x500.

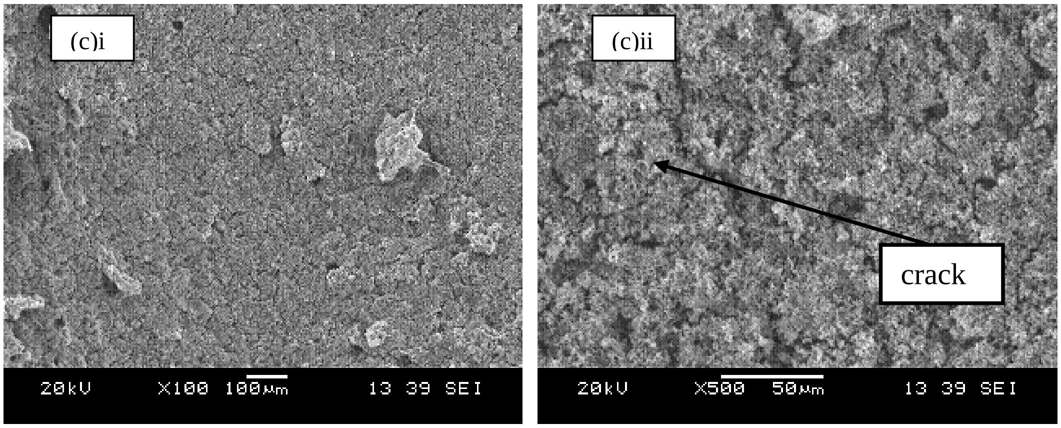

Fig. 2: (c) (i) 14 M with magnification x100; (ii) 14M with magnification x500.

Conclusion:

In summary, it was found that the ratio of Na_2SiO_3/NaOH influence the strength of geopolymer paste and the concentration of the NaOH also has influence the strength of geopolymer paste. The compressive strength of fly ash based geopolymer as artificial aggregate was improved to a certain extent increasing the alkaline activator solution. The activator-to-fly ash ratio at 1.5 produced the optimum compressive strength with the molar concentration in 12 M which is 39.06 MPa.

From the result of acid resistant, it can be concluded that the molar concentration NaOH in 12 M is the most better compared to molar 10 M and 14 M when immersed in 3 % acid sulfuric. Regarding the microstructure showed that in molar 12 M the surface of aggregate is not much appear of cracking and pores. Moreover, at activator-to-fly ash ratio `1.5 is also the better compared to the other ratio when immersed in acid sulfuric. It is because, from the optical microstructure there showed that less corrosive and cracking on the surface of aggregate.

Fly ash from power station mixture with sodium hydroxide, NaOH and sodium silicate, Na_2SiO_3 as geopolymer can be enhanced to use of the ordinary Portland cement which often used in construction due to the high compressive strength produced. Fly ash based geopolymer artificial aggregate with 12 M NaOH and activator-to-fly ash ratio at 1.5 shows optimum results with high compressive strength which is 39.06 MPa of the testing and has great acid resistant properties. The microstructure of the optimum strength geopolymer appears to be homogeneous and contain minimum proportion of unreacted fly ash microspheres, with continuous matrices of aluminosilicate and microcracks.

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