VOL. 15, NO. 5, MARCH 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

CORRELATION OF NaOH COMPOSITION AND ALKALI MODULUS TO COMPRESSIVE STRENGTH ON GEOPOLYMERS MORTAR

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ABSTRACT

Fly ash is a side waste from the cement industry that can damage the environment. Fly ash has the potential as an essential material in making geopolymers. The study discusses how the relationship of the use of activator composition with the compressive strength of geopolymer mortar using fly ash. The sample uses activator sie NaOH and Na_2SiO_3. The sample uses several variations of NaOH composition and alkali modulus. NaOH variations consist of 13 M, 14 M, 15 M, and 16 M. Variations in alkali modulus include 1.5, 1.75, 2.00, 2.25, and 2.50. Treatment of samples according to room temperature and compressive strength testing was carried out at 7, 14, 28, and 56 days. Research has shown that the correlation between NaOH and alkali modulus on mortar strength is very significant. The highest compressive strength occurs at 14 M of all variations. The relationship of activator composition and compressive strength form 2nd polynomial equation order and NaOH optimum composition occurs between 14 and 15 M.

Keyword: fly ash, mortar, geopolymer, compressive strength, NaOH, alkali modulus.

1. INTRODUCTION

The cement industry generally uses coal as an energy source. Besides Industry produces main products of cement also produces by-products in the form of waste. This waste product produced affects the environment. The impact produced is fly ash and bottom ash waste. Both residues damage the environment. Fly ash has an excellent size so that it can fly into the air, which has the potential to damage the air environment. Air contaminated with fly ash can cause humans to breathe so that it can damage breathing. Bottom ash accumulates, and it has contaminated with soil, which can cause the life of organisms in the soil disturbed, or the cycle is interrupted to extinction.

Geopolymer concrete is concrete that has made without using cement. Geopolymer concrete generally uses fly ash as an adhesive. Fly ash is a material derived from the combustion of coal. Fly ash can be used as a source of content to make binders needed in concrete mixtures. As the research of Adam et al. (2009, a, b) explains that fly ash, which is a waste from a steam power plant, it has excellent potential as a basis for geopolymer. The fly ash can replace Portland cement in producing mortar and concrete.

The process of chemical reactions in geopolymer concrete is different from normal concrete hydration reactions occur. (Davidovits, 1999). The geopolymer concrete reaction is the polymerization action between the fly ash and the activator used.

Geopolymer concrete activator must be following the compounds contained in the fly ash. Also, the composition must use the right form so that the reaction and polymerization bond occur correctly. Activators commonly used are Sodium Hydroxide 8M to 14M and Sodium Silicate (Na2SiO3) with a ratio between 0.4 to 2.5. (Wang H., H. Li & F. Yan (2005).

Research on the factors that influence the polymerization reaction on mortar has been widely carried out by researchers. Many factors can influence the response of geopolymer bond formation. Temperature, duration of curing time, and molarity affect geopolymer bonding and strength of geopolymer material (Adam A and Harianto, 2014; Pradnya K. Jamdade, 2016; Budh and Warhade, 2014).

E. Bachtiar *et al*. (2018a) have researched the development of fly ash-based geopolymer mortar strength. The study uses variations of curing, namely the type of fly ash, oven temperature curing, and room temperature curing. The results showed the development of concrete strength increased with age. Besides, the results of research that curing and type of fly ash much affect the strength of geopolymer mortar.

Aravindan S. *et al.* (2015) have also researched the strength comparison of conventional concrete and fly ash-based geopolymer concrete. The results of his research found that traditional concrete has lower strength compared to fly ash geopolymer concrete.

Geopolymer concrete is an environmentally friendly concrete because it does not use cement but uses fly ash waste, which damages the air and soil environment. The strength and durability of the concrete depending on the quality of the concrete itself. Concrete strength is closely related to the porosity value of the concrete itself, the higher the porosity of the concrete, the lower the strength value (Erniati *et al*. 2015a, 2015b). In addition to porosity, treatment after solidified concrete is very important to note, especially curing, which affects the strength of concrete without curing concrete that can reduce its strength (E. Bachtiar, 2018b).

The strength of geopolymer concrete materials varies significantly due to many factors; primarily fly ash has different chemical content, shape, and size. So that until now, there has been no standard composition in the making fly ash-based geopolymer concrete-like regular concrete using cement. This geopolymer mortar study is a continuation of previous studies. The basis of the researchers' research is that one of the factors affecting geopolymer material is the activator composition. Activators used are NaOH and Na_2SiO_3. The purpose of this study discusses explicitly how the correlation of NaOH and alkali modulus on the strength of mortar using fly ash.

2. RESEARCH METHODS

This research is using an experimental method. There are several stages of research, namely preparation of materials and tools, fine aggregate and fly ash material characteristics, mix design mortar composition, sample making, curing, and testing. Making and testing samples based on the Indonesian National Standard (SNI).

This research uses local materials. Making samples using several elements, namely fine aggregate, fly ash, and activators. The aggregate has a smooth modulus of 3.06, a specific gravity of 2.76, and a volume weight of 1.76. Fly ash comes from a steam power plant in Jenneponto, South Sulawesi. From the results of previous studies, fly ash has the characteristics of type C (E. Bachtiar et al. 2018)

Mortar design uses SNI 03-6825-2002 standard. The ratio of fly ash to sand is 1: 2.75. The Air Binder Factor (FAB) is 0.3. Sample variation uses three sample variations, namely differences in age, NaOH composition, and alkali modulus. Alkali modulus is the ratio between Na_2SiO_3: NaOH. NaOH composition uses four structures, namely 13 M, 14, M, 15 M, and 16 M, while the alkali modulus uses five variations, namely 1.50, 1.75, 2.00, 2.25, and 2.50. Curing the sample with room temperature is done with several varieties of age, namely 7 days, 14 days, 28 days, and 56 days.

3. RESULTS AND DISCUSSIONS

A. Increased compressive strength of geopolymers mortar due to the composition of NaOH and Alkali Modulus

In general, the compressive strength of mortar or concrete material has the property of increasing strength with age. Figure-1, Figure-2, Figure-3, Figure-4, and figure-5 show the results of research on improving the strength of geopolymer mortar.

Figure-1 illustrates the increase in the compressive strength of geopolymer mortars using 1.5 alkali modulus and variations in NaOH composition. Of all the differences in the form of NaOH has the same pattern of increasing compressive strength. The highest compressive strength occurs in the formation of 14 Molar. In the 13 M composition, there is a lower compressive strength than other NaOH compositions. At the age of 28 days and 56 days, the use of the formation of NaOH, which has a compressive strength from the highest to the low, respectively, is 14 M, 15 M, 16, and 13 M.

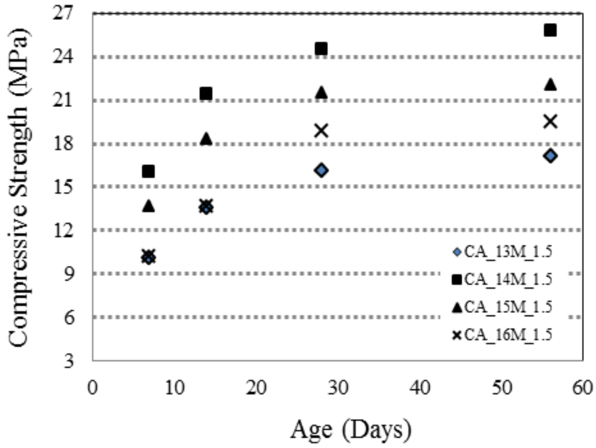

Figure-1. Increased compressive strength of Mortar Geopolymers in the Modulus Alkali 1.5 variation.

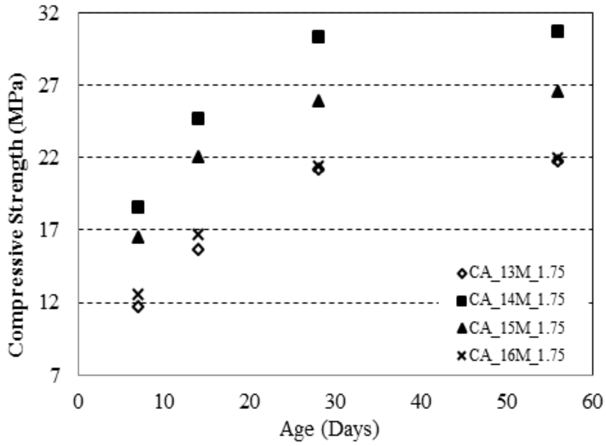

Figure-2. Increased compressive strength of Mortar Geopolymers in the Modulus Alkali 1.75 variation.

Figure-2 illustrates the increase in the compressive strength of geopolymer mortars using 1.75 alkali modulus and variations in NaOH composition. Of all the changes in the form of NaOH has the same pattern of increasing compressive strength, the compressive strength increases with age. The highest compressive strength occurs in the composition of 14 Molar. At the period of 28 days and 56 days, the use of the structure of NaOH which has a compressive strength from the highest to the lowest is 14 M, 15 M, 16 and 13 M. The use of compositions of 13 M and 16 M produces almost the same compressive strength. In mortars that use the form of 16 M and 13 M NaOH, there is very little difference in compressive strength at the age of 28 days and 56 days that is equal to 0.22 MPa and 0.21 MPa.

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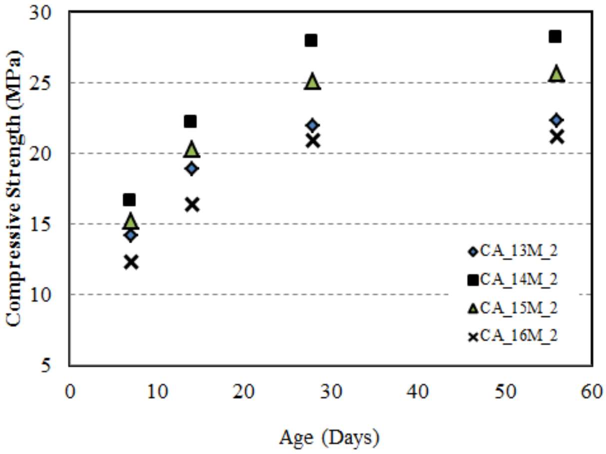

Figure-3. Increased compressive strength of Mortar Geopolymers in the Modulus Alkali 2.00 variation.

Figure-3 illustrates the increase in the compressive strength of geopolymer mortars using two alkali modulus and variations in NaOH composition. Of all the differences in the formation of NaOH has the same pattern of increasing compressive strength, the compressive strength increases with age. The highest compressive strength occurs in the composition of 14 Molar. At 16 M composition, the lower compressive strength occurs compared to 14 M, 15 M, and 13 M. At the age of 28 days and 56 days, the use of the composition of NaOH, which has a compressive strength from the highest to the low is 14 M, 15 M, respectively, 13 and 16 M.

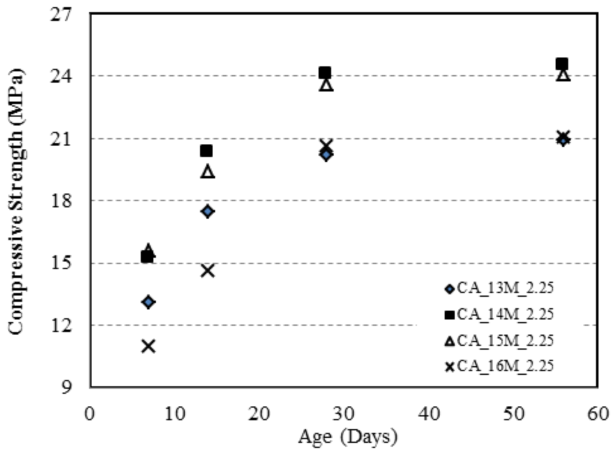

Figure-4. Increased compressive strength of Mortar Geopolymers in the Modulus Alkali 2.25 variation.

Figure-4 illustrates the increase in the compressive strength of geopolymer mortars using 2.25 alkali modulus and variations in NaOH composition. Of all the differences in the formation of NaOH has the same pattern of increasing compressive strength, the compressive strength increases with age. The highest compressive strength occurs in the composition of 14 Molar. In the form of 13 M, the lower compressive strength occurs compared to 14 M, 15 M, and 16 M. At the age of 28 days and 56 days, the use of the composition of NaOH which has a compressive strength from the highest to the low respectively are 14 M, 15 M, 16 and 13 M. Besides that at 14 M and 15 M NaOH has a slight difference in compressive strength of mortar around 0.50 MPa. In mortars that use the composition of 16 M and 13 M NaOH, there is very little difference in compressive strength that is equal to 0.40 MPa.

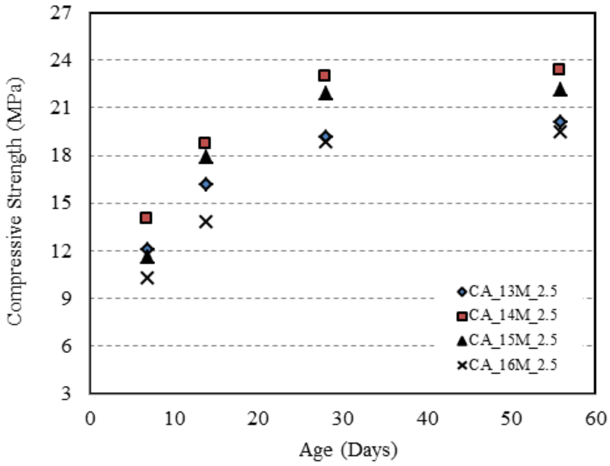

Figure-5. Increased compressive strength of Mortar Geopolymers in the Modulus Alkali 2.25 variation.

Figure-5 illustrates the increase in compressive strength of geopolymer mortar using 2.5 alkali modulus and some variations of NaOH composition. Of all the changes in the formation of NaOH has the same pattern of increasing compressive strength, the compressive strength increases with age. The highest compressive strength occurs in the composition of 14 Molar. At the age of 28 days and 56 days, the compressive strength of mortar from highest to low is the use of NaOH at 14 M, 15 M, 13 and 16 M. In mortars that use the composition of 13 M and 16 M NaOH there is a slight difference in the same compressive strength with 0.32 MPa. In 2.25 alkali modulus, the compressive strength of mortar that uses 16 M is slightly higher than 13 M, while in the mortar that uses the alkali modulus of 2.5, the opposite occurs.

Of the five variations of alkali modulus used in mortars, the highest average compressive strength occurs in variations of the composition of 14 M NaOH and subsequently 15 M NaOH. The details are shown in Figure-1, Figure-2, Figure-3, Figure-4, and Figure-5.

B. Correlation of NaOH composition and compressive strengthon geopolymer mortar

Research on the relationship between activator and compressive strength of mortar has been widely carried out. However, this research cannot yet become a reference for activator composition if fly ash is different. Activators used in this study are NaOH and Na2SiO3. C. Relationship of NaOH composition with Geopolymer Mortar Compressive Strength with an alkali modulus that continues to occur nonlinear relationship, as shown in Figure-6, Figure-7, Figure-8, Figure-9, Figure-10, and Figure-11.

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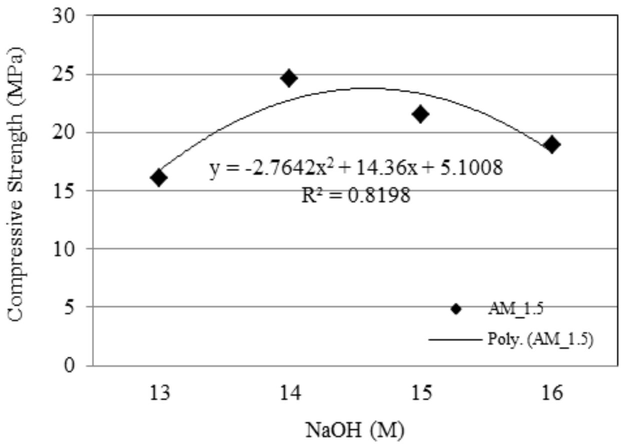

Figure-6. Correlation between NaOH and Mortar Compressive Strength using 1.5 Alkali Modulus.

Figure-6 shows the relationship of NaOH composition with compressive strength on the alkaline modulus 1.5 formed nonlinear polynomial equation. This relationship forms the polynomial equation y = -2.7642x2 + 14.36x + 5.1008 and the correlation value R = 0.905. The relationship of NaOH composition with mortar strength is very significant because the correlation value is close to 0. The optimal value of NaOH occurs between 14 M and 15 M.

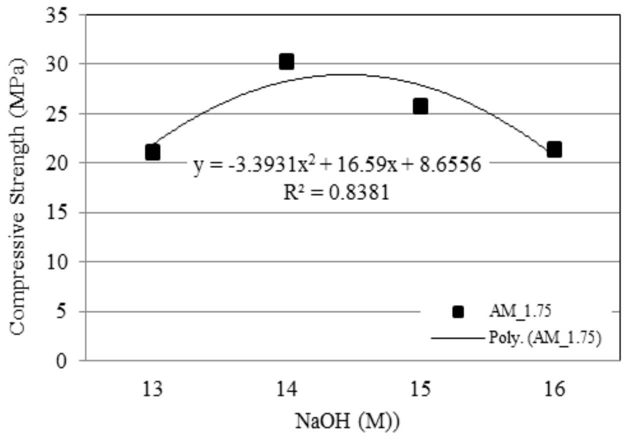

Figure-7. Correlation between NaOH and Mortar Compressive Strength using 1.75 Alkali Modulus.

Figure-7 shows the relationship of NaOH composition with compressive strength on the 1.75 alkaline modulus of the nonlinear polynomial equation. This relationship forms the polynomial equation y = -3.3931x2 + 16.59x + 8.6556 and the correlation value R = 0.915. The relationship of NaOH composition with mortar strength is very significant because the correlation value is close to 0. The optimal value of NaOH occurs between 14 M and 15 M.

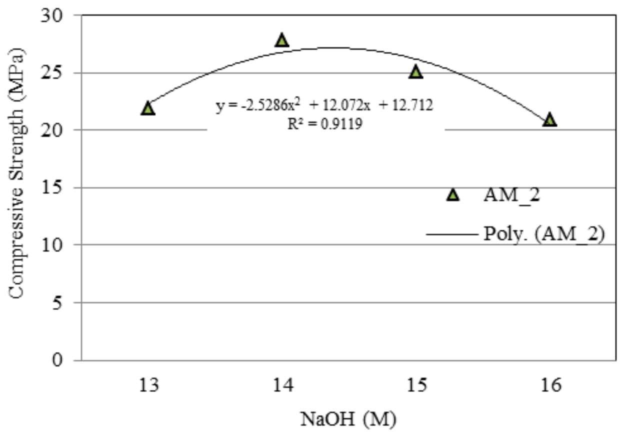

Figure-8. Correlation between NaOH and Mortar Compressive Strength using 2.00 Alkali Modulus.

Figure-8 shows the relationship of NaOH composition with compressive strength on the 1.75 alkaline modulus of the nonlinear polynomial equation. The relationship forms the polynomial equation y = -2.5286x2 + 12.072x + 12.712 and the correlation value R = 0.945. The relationship of NaOH composition with mortar strength is very significant because the correlation value is close to 0. The optimal value of NaOH occurs between 14 M and 15 M.

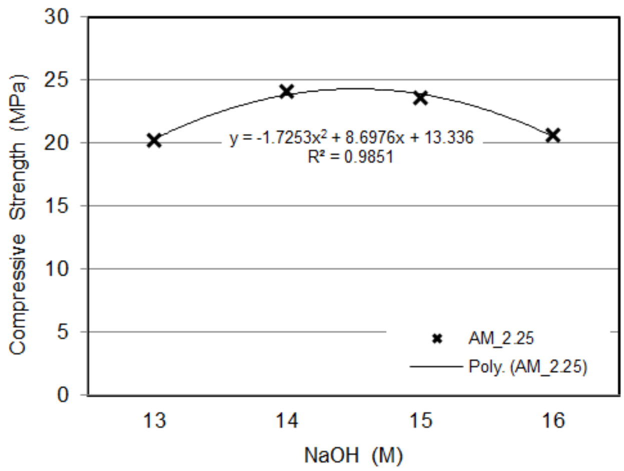

Figure-9. Correlation between NaOH and Mortar Compressive Strength using 2.25 Alkali Modulus.

Figure-9 shows the relationship of NaOH composition with compressive strength in the 1.75 alkaline modulus of the nonlinear polynomial equation. This relationship forms the polynomial equation y = -1.7253x2 + 8.6976x + 13.336 and the correlation value R = 0.993. The relationship of NaOH composition with the strength of mortar is very significant because the correlation value is close to 0. The optimal value of NaOH occurs between 14 M and 15 M.

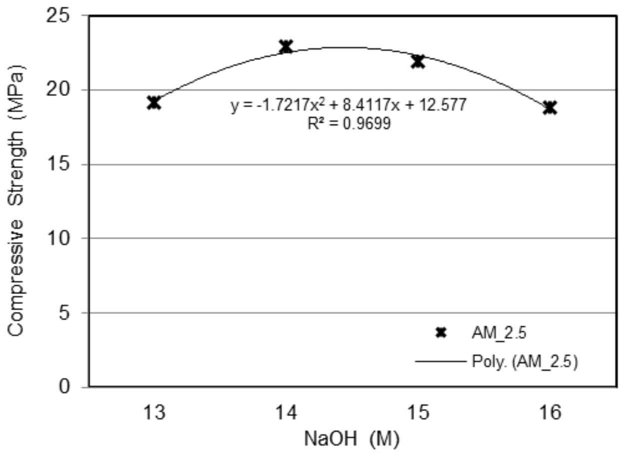

Figure-10. Correlation between NaOH and Mortar Compressive Strength using 2.50 Alkali Modulus.

Figure-10 shows the relationship of NaOH composition with compressive strength in the 1.75 alkaline modulus of the nonlinear polynomial equation. This relationship forms the polynomial equation y = -1.7217x2 + 8.4117x + 12.577 and the correlation value R = 0.985. The relationship of NaOH composition with mortar strength is very significant because the correlation value is close to 0. The optimal value of NaOH occurs between 14 M and 15 M.

Of the five variations of alkaline modulus, the correlation between NaOH composition and compressive strength of geopolymer mortars is very significant. Where the five variations have the same pattern of forming a 2nd order polynomial equation, the correlation value approaches 1, and the optimal NaOH value is between 14 and 15 M.

4. CONCLUSIONS

The conclusions from the results and discussion are as follows:

a) Fly ash geopolymer mortar with different variations of NaOH and alkali modulus has the same pattern of increasing compressive strength, and the highest compressive strength occurs in the NaOH14M composition.
b) In geopolymer mortar using the alkali modulus of 1.5 and 1.75, at 28 days and 56 days, the use of NaOH composition, which has compressive strength from the highest to the low is 14 M, 15 M, 16 and 13 M.
c) In geopolymer mortar using modulus alkali 2, at the age of 28 days and 56 days, the use of NaOH composition, which has compressive strength from the highest to the low is 14 M, 15 M, 13 and 16 M.
d) In geopolymer mortars using alkaline modulus 2.25, at 28 days and 56 days, the use of NaOH compositions which have compressive strengths from the highest to the low is 14 M, 15 M, 16 and 13 M. The uses of 13 and 16 M NaOH produces almost the same compressive strength.
e) In geopolymer mortars using 2.5 alkaline modulus, at 28 days and 56 days, the use of NaOH compositions, which have compressive strengths from the highest to the lowest, is 14 M, 15 M, 13 and 16 M. Use 13 and 16 M NaOH produces almost the same compressive strength.
f) The correlation value between NaOH composition and compressive strength of geopolymer mortar is very significant. The relationship forms the same pattern that forms the 2nd order polynomial equation, the correlation value approaches 1, and the optimal NaOH value averages between 14 and 15 M.

ACKNOWLEDGMENT

Thanks to the Ministry of Research, Technology, and Research in Higher Education, the Directorate General of Research and Development Strengthening has funded Basic TA Research 2019 based on SK No. T/140/E3/ RA.002/2019 and contract No. 1/AI /LPPM/ -UNIFA/IV/ 2019.

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