MATEC Web of Conferences **97**, 01020 (2017) DOI: 10.1051/matecconf/20179701020
ETIC 2016

The Effect of High Temperature on Compression Strength of Geopolymer Paste

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Abstract. This research has a purpose to confirm the resistance of geopolymer concrete towards high temperature. This high temperature becomes the issues in material structure defense due to the danger of fire. Therefore, this research is done on geopolymer paste, the main binding ingredient from fly ash as local industry waste material. The method that is used in order to achieve the objective is done experimentally in laboratory with the geopolymer testing paste constructed of type C fly ash. Fly ash was obtained from PT. Petrokimia Gresik. The activator alkali sodium hydroxide (NaOH) was designed 6, 10, and 14 Molar. The dimension of specimen shape was cylinder 2.5 cm × 5 cm. The maintenance of specimen done in a room temperature (27±3°C) until testing period 28 days and proceeded by test item burning process on 200°C and 600°C for 4 hours. The testing of the test item that is done includes the pressure strength test according to SNI-1974-1990. The result of this research shows that the pressure strength of geopolymer paste with NaOH 6, 10, and 14 molar at 200°C temperature has a better pressure strength than room temperature geopolymer paste.

1 Introduction

Population growth in Indonesia and the acceleration of infrastructure are not balanced, especially in urban areas. It raises unawareness, one of which is the threat of fires in the building. Fires often cause damage to elements of the structure. Research on the building on the Makasar mall temperature recorded due to the fire can reach 1400°C.

On the other hand, the current global research directed toward the mindset of green environment, how the reduction of primary material partly or entirely of building materials and structures that are cementitious. Portland cement concrete as the main adhesive ingredient reaps a lot of attention because of greenhouse gas emissions (carbon dioxide) generated in the cement production process. The combustion process requires energy to the transformation temperatures of up to 1400°C, for 1 ton of cement produces 0.55 tonnes of CO_2 [1].

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One of the innovations to reduce the 100% cementitious material is the technology of geopolymer concrete, in which its binding material consists of material with pozzolan characteristics, generally have significant silicate oxide substance and alumina oxide[2]. Examples of geopolymer concrete raw materials derived from coal combustion waste (fly ash). Utilization of industrial waste material and non industry are the other reason why geopolymer concrete worth the continued research [3-10] to support environmental researches.

This research focuses on those two main things, the threat of fire and waste utilization by formulation of the problem, to which extent the effect of temperature towards the strength of geopolymer concrete paste as the primary binding material for geopolymer concrete.

2 Methodology

Research method that is used to answer this research is by experimental laboratory. Fly ash used in this study as the basic material for the manufacture of geopolymer from PT. Petrokimia, Gresik. To determine the chemical composition contained in the fly ash, tests will be done in XRD (X-Ray Diffraction) and XRF (X-Ray Fluorescence). Activators for alkaline solution used is sodium silicate (Na_2SiO_3) and sodium hydroxide (NaOH) with molarity 6, 10 and 14. For the manufacture of test specimens using a cylinder with a diameter of 2.5 cm × 5 cm.

After the specimen is manufactured it will be tested as, firing test done by furnace for 4 hours in temperature of 200°C, 600°C, and 1000°C then the binder is rested until it is cooled off for the next testing process.

Test on the test object is the compressive strength test with the standard ISO-1974-1990. The age compressive strength test binder geopolymer concrete is done at the age of 28 days. For each test compressive strength, used 3 specimens of each combustion temperature condition.

3 Result and discussion

Some of the results from fly ash testing were presented on Figure 1, Table-1 and Table-2: This test is used to determine the elemental composition analysis in the ingredients. From the test result of XRD is known that fly ash used in this study is amorphous SiO_2 + Ca (FeO_3) 58% so as to the fly ash that is used is a type C. CaO content of fly ash used in this study is 10.74%, according to ASTM C 618-84 fly ash which has a CaO content of more than 10% are classified into type C fly ash.

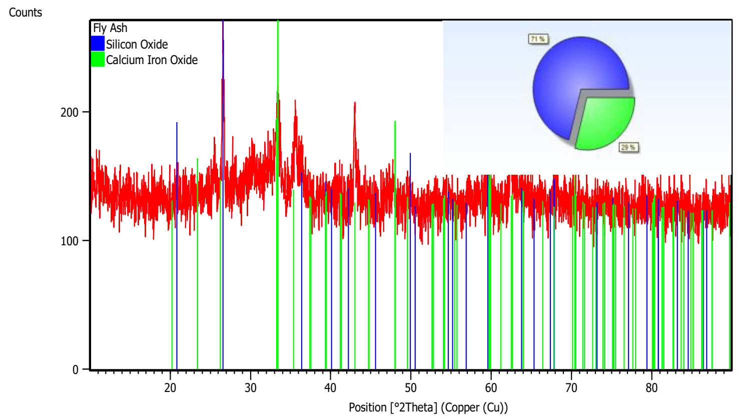

Fig. 1. X-Ray Difraction Test Result

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Table 1. Fly Ash content based on XRD test

Score	Compound Name	Displacement [°2Th.]	Scale Factor	Chemical Formula
38	Silicon Oxide	0.124	0.992	Si O_2
20	Calcium Iron Oxide	-0.171	0.467	Ca (Fe O_3)

Table 2. XRF Test Result

Component	iO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	TiO_2	$Ca(FeO_3)$	SO_3	P_2O_5	MnO	SrO
Percentage (%)	18,32	6,74	10,74	2,28	0,27	1,2	0,68	20,62	0,94	0,17	0,1	0,51

Compressive strength testing is conducted on Material and Building Structure Laboratory, FTSP Civil Engineering ITS. Here are the results of compressive strength testing. For the test result of the geopolymer concrete are described on Figure 2 to Figure 4. From figure 2, it is known that the average compressive strength of geopolymer paste test specimens treated with the room temperature compressive strength will increase if molar activator is enlarged. The increase in 6 molar to 10 molar by 9% and 10 molar to 14 molar increased 13%. The highest compressive strength at room temperature is 14 molar. From figure 3, it is known that the average compressive strength of geopolymer paste test specimens treated with burnt 200°C temperature compressive strength will have different patterns with the normal temperature. At 6 molar to 10 molar compressive strength decreased by 7% and 10 molar to 14 molar increased 3%. The highest compressive strength a temperature of 200°C was 14 molar. From figure 4, it is known that the average compressive strength of geopolymer paste test specimens treated with burnt 600°C temperature compressive strength will increase if molar activator is enlarged. At 6 molar test specimens were broken and could not be tested and 10 molar to 14 molar increased 68%. The highest compressive strength 600°C temperature is 14 molar. The highest compressive strength on geopolymer paste was caused the heat effect during curing system. The heat curing generated the water was expelling from the geopolymer matrix, causes discontinuous nano-pores within matrix, which increases the strength of geopolymers[11].

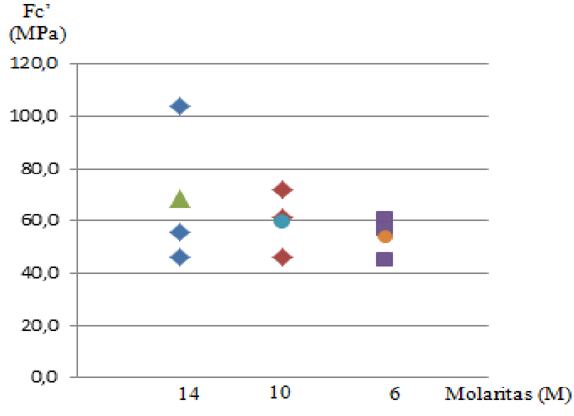

Fig. 2. Compression strength of room temperature geopolymer paste from different molarities

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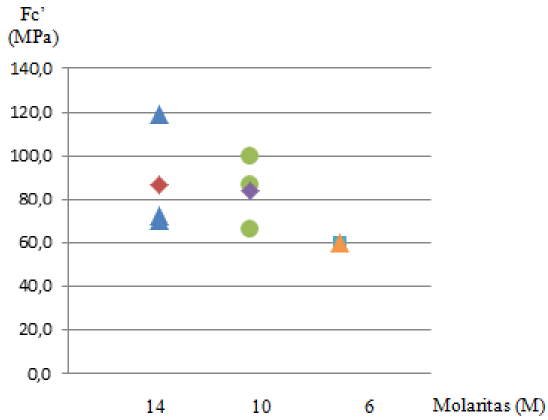

Fig. 3. Compression strength of 200°C geopolymer paste from different molarities

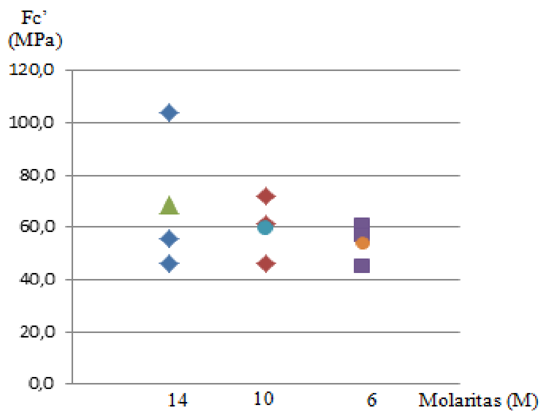

Fig. 4. Compression strength of 6000C geopolymer paste from different molarities

4 Conclusion

From the research with cylindrical test specimen, it can be concluded that, geopolymer paste (6, 10 and 14 molar) at normal temperature resulted the higher the molar would have increased compressive strength, the axis also lowered if the molar is enlarged. However, unlike UPV experiment, the result of experiment on 10 molar UPV is greater than 14 molar. Compressive strength of geopolymer paste (6, 10, and 14 molar) at a temperature of 200° C increased, decreased at a temperature of 600° C. The highest compressive strength is the specimen with 14 molar and burned at a temperature of 200° C (14-200).

The authors would like to thank RISTEK-DIKTI and LPPM ITS for provided financial assistance to complete this laboratory research grants. In addition, the support of Laboratory of Testing Materials of Diploma Civil Engineering Program ITS is greatly appreciated.

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