COMPRESSIVE STRENGTH OF GEOPOLYMER LIGHTWEIGHT CONCRETE WITH COMPARISON OF RICE HUSK ASH AND ALKALI ACTIVATOR 50% -50% IN CURING TIME VARIATIONS

Kukuh Kurniawan D.S
Civil Engineering Dept., Faculty of Engineering, Tunas Pembangunan University of Surakarta
kukuhkds@utp.ac.id

Teguh Yuono
Civil Engineering Dept., Faculty of Engineering, Tunas Pembangunan University of Surakarta
yuonoteguh.ty@utp.ac.id

Abstract

Today, concrete is a very important building material material in construction. Geopolymers are concrete technologies that utilize polymerization reactions in the binding process. The main arrangement of this geoplimer material is silica and alumina (aluminum silica hydroxide). Silica material used is derived from inorganic materials that have high silica content. Rice husk ash is one of the industrial by-products that have high silica content. Rice husk ash resulting from burning bricks reaches a temperature of 400^o C and has a silica content of around 85%. High silica content in rice husk ash can be used as a binding material in geopolymer concrete. The study carried out on lightweight geopolymer concrete rice husk ash with a ratio of rice husk and alkali activator ratio is 50%:50%, in the variation of curing time 12 hours and 24 hours. It was concluded that the compressive strength of geopolymer concrete from rice husk ash increases with the duration of curing time.

Keywords: lightweight concrete, geopolimer, rice husk ash, curing time.

I. INTRODUCTION

Today, concrete is a very important building material material in construction. Various infrastructure such as buildings, bridges, roads and other facilities using concrete as the main material. This is done because the base material of the concrete, the manufacturing process and the cost is cheaper than the other materials.

But on the other side, the concrete itself has some shortage one of which is the low strength per unit weight of the concrete resulting in the concrete becomes heavy. This effect when the concrete is used in long span structure, it will have its own grea weight.

Therefore, currently many developed concrete that has a light weight or called lightweight concrete. Lightweight concrete is usually used as a non-structural material. A concrete is said to be light if it weighs less than 1800 kg / m3. There are two methods to make lightweight concrete, first forming by using small weight aggregate with small density, called lightweight aggregate concrete. The second is to make a high pore in mortar mass, namely by adding air content into it. Lightweight concrete used as wall material, or commonly called lightweight brick.

Foaming agent is a concentrated solution of surfactant material, and in its use must be dissolved with water. One of the ingredients containing surfactants is Detergent.

According to Neville and Brooks (1993),

there are two basic methods that can be taken to produce gas/ air bubbles in concrete, one of which is by adding foam agent (liquid foam) to the mixture. Foam agent is one of the ingredients for foam making which is usually derived from protein hydrolyzed based ingredients. Foam agent forming materials can be natural and artificial. Foam agent with natural ingredients in the form of protein has a density of 80 grams/liter, while artificial ingredients in the form of synthetic have a density of 40 grams/liter. The function of this foam agent is to stabilize the air bubble during fast mixing.

With the greater consumption of concrete, the demand for cement as a base material for concrete also increases. Increased demand for cement material has an impact on the environment, due to the cement production process that explores lime.

The effort to get eco-friendly concrete is done by several methods. Concrete without cement technology began to be developed in various countries including Indonesia, by replacing the binder with environmentally friendly materials and even waste material. Concrete technology by utilizing natural silica from residual materials as a concrete binder is introduced with the term geopolymer. Geopolymers are concrete technologies that utilize polymerization reactions in the binding process. The main arrangement of this geoplimer material is silica and alumina (aluminum silica hydroxide). Silica material used is derived from inorganic materials that have high silica content.

Geopolymer concrete is a new material whose manufacturing process does not require the presence of portland cement as a binding material (Chareerat, T. et al. 2008). The binding material in geopolymer concrete is replaced with an inorganic polymer material which has the main content of silica and alumina, the concrete binding reaction is a polymerization reaction. In the polymerization reaction Aluminum (Al) and Silica (Si) have an important role in the polymerization bond because the reaction of aluminum and silica with alkaline will produce AlO_4 and SiO_4 (Davidovits, J.1994).

Sodium hydroxide is an alkaline compound that is very reactive when mixed with water. The function of this compound is to react Si and Al to produce a strong polymerization bond. Sodium hydroxide is a highly reactive alkali compound when reacted with water. Sodium hydroxide is solid as powder. The function of sodium hydroxide is to react Si and Al to produce strong polymerization bonds. While sodium silicate serves to speed up the polymerization reaction.

Rice husk ash is one of the industrial by-products that have high silica content. Rice husk ash resulting from burning bricks reaches a temperature of 400^{o} C and has a silica content of around 85%. High silica content in rice husk ash can be used as a binding material in geopolymer concrete.

Table 1. Chemical composition of rice husk ash at different temperature treatments

Temp. Bahan	Orgin° (%)	400° (%)	600° (%)	700° (%)	1000° (%)
SiO2	88.01	88.05	88.67	92.15	95.48
MgO	1.17	1.13	0.84	0.51	0.59
SO3	1.12	0.83	0.81	0.79	0.09
CaO	2.56	2.02	1.73	1.60	1.16
K2O	5.26	6.48	6.41	3.94	1.28
Na2O	0.79	0.76	1.09	0.99	0.73
TiO2	0.00	0.00	0.00	0.00	0.00
Fe2O3	0.29	0.74	0.46	0.00	0.43

Pic 1. Rice Husk Ash

Based on scanning electron microscopy on lightweight concrete geopolymer fly ash (fly ash) with heating at 60^o C has a higher density than without heating. This is because warming increases the rate of geopolymerization (Al Bakri Abdullah, M. M., Hussin, K., Bnhussain, M., Ismail, K. N., Yahya, Z., & Razak, R. A. 2012). Geopolymer concrete has mechanical properties that are not much different from ordinary concrete seen from the compressive strength and modulus of rupture values, as well as other tests (Widodo, K, 2010). Geopolymer concrete with 100% rice husk ash material as a binder has an average compressive strength of 2.58 MPa (Rihnatul, 2017).

II. MIX DESIGN

Design of lightweight geopolymer concrete mixtures by trial mix with fine aggregate and binder comparisons of 55% : 45%. Estimated weight of concrete is 1600 kg / m3. The ratio of rice husk ash and alkali activator is 50% : 50%.

Table 2. Mix Design of Lightweight Concrete Geopolymer

Fine Agr. (kg)	Water (liter)	Rice Husk Ash (kg)	Sodium Silkat (kg)	Sodium Hidroksida (kg)	Foam Agent (ml)
2.97	0.85	0.79	0.56	0.226	2.025

III. METHODOLOGY

A. Materials

1) Rice husk ash

The rice husk ash used came from by-product burning of bricks. which is refined and passed filter No. 100.

2) Water

Water is used from Laboratory of Building Materials, Civil Engineering Dept., Faculty of Engineering, Tunas Pembangunan University of Surakarta.

3) Alkali Activator

Alkali activators used in the study are sodium silicate (Na2SiO3) and sodium hydroxide (NaOH).

4) Foam Agent

This study uses foam agent type G-FOAM 1420

B. Specimens of Lightweight Concrete Geopolymer

1) Alkali Activator

The initial stages of preparation required preparation of liquid alkali activator with a molarity of 12 Moles as follows:

- Calculate the amount of Sodium Hydroxide Considering Sodium Hydroxide as needed, then put it in a measuring cup of 1 liter capacity.
- Add aquade to the measuring cup to 1 liter volumet. Stir until dissolved and let stand 24 hours.
- Combine Sodium Hydroxide and Sodium Silicate, stirring until mixed.

2) Specimens

Making geopolymer lightweight concrete with 150x150x150mm concrete cube mold with the following methods:

- Considering and preparing all material requirements to be used, including fine aggregate, rice husk ash, water, foam agent and alkali activator.
- Mix the Rice hush ask and alkaline activator into the container. Mix evenly and add water to facilitate stirring.
- Geopolymer paste mix with sand.
- Prepare foam agent.
- Then mix geopolymer mortar and foam agent.

Prepare the concrete cube mold, put the lightweight geopolymer concrete mixture into the mold.

- Cover the top of the concrete cube with plastic and tied.
- Add the mixture to the oven at 80°C for 12 hours and 24 hours.

C. Compressive Strength Test

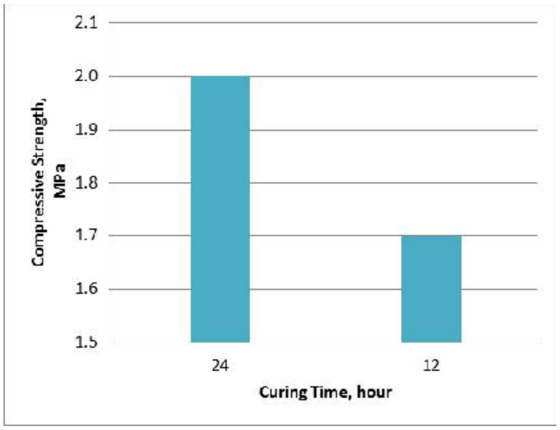
Testing of concrete compressive strength done at age 28 day.

IV. RESULT AND DISCUSSIONS

The compressive strength test of geopolymer lightweight concrete in curing time variation 12 hour and 24 hour, at 28 days was obtained as follows:

Table 3. Compressive Strength of Lightweight Geopolymer Concrete in curing time variation

Curing Time (hr)	cross section area (cm^2)	Max Load (kg)	Compressive Strength (kg/cm2)	Compressive Strength (MPa)
24	224	5,099	22.81	1.9
	222	5,608	25.26	2.1
	225	5,608	24.93	2.1
12	221	4,589	20.81	1.7
	224	4,589	20.53	1.7
	224	4,589	20.53	1.7



Pic 2. Comparison of Geopolymer Concrete Compressive Strength and Variation of Curing Time

The results of the tests showed that the variation of curing time affected the compressive strength of geopolymer concrete with rice husk ash.

Curing time for 24 hours in the oven obtained maximum geopolymer compressive strength compared to curing time for 12 hours.

V. CONCLUSIONS

From the results of testing, data processing and analysis, the conclusions are as follows:

1. Curing time of geopolymer concrete as rice husk ash in the oven can be carried out for 12 hours.
2. The compressive strength of geopolymer concrete from rice husk ash increases with the duration of curing time.

ACKNOWLEDGMENTS

This research was funded by the Ministry of Research, Technology and Higher Education of the Republic of Indonesia as part of the Beginner Lecturer Research Grant contract No. 073/LPPM-UTP/V/2018. In addition, the authors acknowledge the technical support provided by LLDIKTI region VI and Tunas Pembangunan University of Surkarta.

REFERENCES

Al Bakri Abdullah, M. M., Hussin, K., Bnhussain, M., Ismail, K. N., Yahya, Z., & Razak, R. A. (2012). Fly ash-based geopolymer lightweight concrete using foaming agent. *International Journal of Molecular Sciences*, *13*(6), 7186–7198. https://doi.org/10.3390/ijms13067186

Chareerat, T. et al.,: Composition And Microstructure Of Fly Ash Geopolimer Containing Rice Husk Ash. Technology And Innovation For Sustainable Development Conference (TISD 2008), 28-29 January 2008 (2008)

Davidovits, J.,: Properties of Geopolymer Cements. Proceeding at First International Conference on Alkaline Cements and Concretes, Scientific Research Inst. on Binders and Materials, Kiev State Techn. Univ., Kiev, Ukraine, pp. 131-149 (1994)

Kushartomo, W. (2010). Sifat mekanik beton geopolimer berbahan dasar abu terbang, *4*(KoNTekS 4), 2–3.

Neville, A. M dan J. J. Brooks,: Concrete Technology. Logman Scientific And Technical, New York (1993)

Rihnatul, I.,: The Effect of Rice Husk Ash Addition as Pozzolan on Geopolymer Binder Using Alkali Activator of Sodium Silicate (Na2SiO3) and Sodium Hydroxide (NaOH). Thesis Diploma IV Program in Civil Engineering, Institut Teknologi Sepuluh Nopember Surabaya (2017)