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The Influence Sugarcane Bagasse Ash and Metakaolin on Mechanical Properties Fly Ash Geopolymer Paste

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ABSTRACT— ***This paper present an optimization of sugarcane bagasse ash and metakaolin on fly ash geopolymer paste with sea water treatment. Mechanical properties were assessed by compressive strenght test (SNI 03-1974-2011), UPV test (ASTM C597 – 16), and porosity test (ASTM C642-90). Na_2SiO_3 (Sodium Silicate) and NaOH (Sodium Hydroxide) with concentration of 12 Molar were used as alkali activators with ratio activator of 2,5. Percentage of fly ash and alkali used is 70% and 30%. Compressive strength test was conducted on binder 5cm x 5cm x 5cm with the age of 7, 14, 28 days, while UPV and Porosity test was performed in 28 days. Based on the compressive strength of 7-day-old concrete paste. It was found that the compressive strength of concrete paste used as a control was 21.3 MPa, V1 was 24.7 MPa, and V5 was 22.1 MPa. While at the age of concrete pasta 28 days. It was found that the compressive strength of the control was 49.6 MPa, V1 was 34.1 MPa, and V5 was 39.3 MPa. So it is assumed that those with the greatest compressive strength and the most stable are the controls (100% FA), V1(80% FA : 20% SGBA) and V5 (80% FA : 20% Metakaolin).***

Keywords— geopolymer, fly ash, sugarcane bagasse ash, metakaolin

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1. INTRODUCTION

In Jokowi president era Indonesia is developing infrastructure development in the maritime field to make Indonesia the maritime axis of the world. One of the factors in realizing the maritime axis is the improvement of sea transportation, including in port development. Concrete is an important component in the port building structure. In the process of making concrete is required the most important component of cement as a binder of other materials that provide strength and durability of concrete against all environmental situations.

Concrete is a durable construction material and highly reliable in the construction of building structures. In addition to water, cement is a material mostly used in the manufacture of concrete [1]. The cement used in the manufacture of concrete in the sea is type II cement concrete, where type II cement is very rare and the price is very expensive [2].

Material experts began to think about finding concrete without using cement. One developed is Geopolymer Concrete. Using natural silica and alumina source with alkaline activator [3]. Sources of Alumina Silica used is the product of by-product synthesis such as fly ash, mill scale, glass, blast furnace slag, rice husk ash, and many contain Silica and Aluminum [4]. Most of these byproducts are thrown away in nature that can cause environmental damage, as well as the disposal of fly ash which can lead to contamination of water, soil and air even in small quantities, fly ash contains some toxic elements such as arsenic, vanadium, antimony, boron and chromium [5].

Fly Ash-based geopolymer concrete is formed from polymeration reactions due to the alkali-aluminisilicate reaction resulting in strong structured materials such as Zeolite [4]. Geopolymer concrete is an eco-friendly concrete that does not release CO_2 emissions into the atmosphere as it is formed from chemical reactions rather than hydration reactions. Geopolymer concrete has good resistance to corrosion of sea water caused by micro compact geopolymer, aluminosilicate geopolymeration in contrast to the hydration of cement concrete that greatly affects sea water [6].

Ashes of bagasse ash from the ashes of combustion of bagasse as a byproduct of agro-industrial by-product (agro-industrial by-product) which is in abundance but its utilization is lacking. Ashes of bagasse contain SiO_2 and Al_2O_3 of 72.95% and 1.68% [12] where in the manufacture of geopolymer concrete sources of silica and alumina are required.

2. MATERIALS AND RESEARCH METHOD

2.1 Materials

Fly ash (FA) from PT. Jawa Power, PLTU Paiton, Indonesia were used in this research. Table 3 shows the chemical composition of fly ash using X-ray fluorescence (XRF). Sugarcane bagasse ash (SGBA) was collected during the cleaning operation of a boiler operating in PG Toelangan, sidoarjo, Indonesia. Table 4 shows the chemical composition of sugarcane bagasse ash. Metakaolin (MK) is a product from dehydroxylation of a clay mineral, kaolinite, which is very fine powder prepared by firing in a muffle furnace from room temperature up to 750^{o}C for 3 h. The chemical composition of Metakaolin using X-ray fluorescence (XRF) showed in the table 5.

Alkali activator is required in order to produce geopolymer binder. Alkali activator sodium hydroxide (NaOH) with concentration 12 Molar and ratio between sodium silicate (Na_2SiO_3) and sodium hydroxide (NaOH) 2.5 is recommended.

figure 1. A. Fly ash, B. Sugarcane Bagasse ash, C. Metakaolin

Table 1. Mix Proportion

Materials	Mix Proportion (% by weight)
Fly ash, Sugarcane bagasse ash, and metakaolin	70
Activator	30

Experiments conducted in the form of making concrete paste geopolymer by using several variations of the mixture that is

Table 2. Experiment Varation

No	*Material Variation*			*code*
	Fly Ash	*Sugarcane Bagasse Ash*	*Metakaolin*	
1.	100%	-	-	Control
2.	80%	20%	-	V1
3.	80%	15%	5%	V2
4.	80%	10%	10%	V3
5.	80%	5%	15%	V4
6.	80%	-	20%	V5

The steps undertaken in this study include the examination of ingredients composition which aims to get the material with good quality, followed by doing a mixture design inspection in order to get the right composition. Continued to the stage of making concrete paste with square mold with size 5cm x 5cm x 5cm, after that done the treatment period of 7 days, 14 days and 28 days. Treatment conducted during the treatment period is a test object placed into the sea water on the kenjeran beach Surabaya. After that done some testing with test specimens as many as 90 pieces with the kind of testing that is, Test Pressure, Ultra Plus Velocity Test and Porosity Test.

figure 2. Concrete Paste 5cm x 5cm x5cm

3. RESULTS AND DISCUSSION

The test material is done by XRF and SEM test to see the existing content in the material to be used, so that the material can be classified based on the existing standard and can be known the quality of the material.

Table 3. Fly Ash XRF Result

	SiO_2	Al_2O_3	Fe_2O_3	Cr_2O_3	K_2O	CaO	MgO	MnO_2	TiO_2	Na_2O	SO_3	LOI
Oksida	26,48%	13,01%	13,19%	0,01%	0,98%	18,41%	8,31%	0,17%	0,59%	2,69%	1,84%	13,72%

According to ASTM C618 Fly Ash can be classified with calculation of $SiO_2 + Al_2O_3 + Fe_2O_3$ more than 50% for type C and more than 70% for type F, after calculation got fly ash including type C with result 52,68%.

Table 4. Sugarcane Bagasse Ash XRF Result

	SiO_2	Al_2O_3	Fe_2O_3	P_2O_5	K_2O	CaO	CuO	MnO	TiO_2	ZnO	SO_3	LOI
Oksida	65%	2,10%	10,90%	2,90%	5,80%	10,90%	0,19%	0,68%	0,50%	0,33%	0,69%	0,01%

Above is the result of XRF test of bagasse ash, if using the same standard with Fly Ash it is found that ash bagasse used with result of calculation $SiO_2 + Al_2O_3 + Fe_2O_3$ is 78% can be said that bagasse ash is equivalent to fly ash type F.

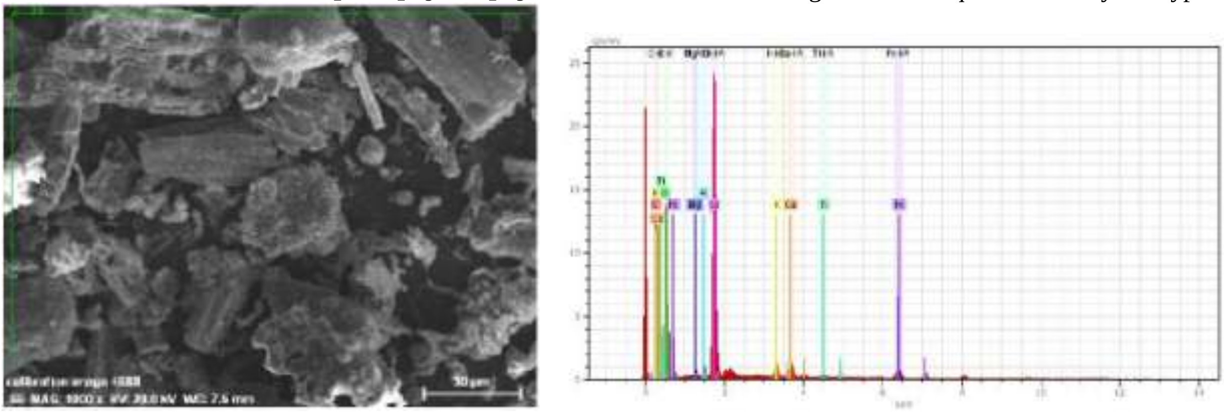

figure 3. SEM-EDX 1000x Sugarcane bagasse ash

Table 5. Metakaolin Ash XRF Result

	SiO_2	Al_2O_3	Fe_2O_3	P_2O_5	K_2O	CaO	V_2O_5	MnO	TiO_2	Nb_2O_5	Rb_2O	LOI
Oksida	58%	36%	2,10%	0,77%	1,26%	0,64%	0,02%	0,02%	0,85%	0.03%	0.02%	0,01%

Above is the result of XRF Kaolin test, if using same standard with Fly Ash hence obtained that metakaolin which used with result of calculation $SiO_2 + Al_2O_3 + Fe_2O_3$ is 96,1% can be said that metakaolin equal to fly ash type F.

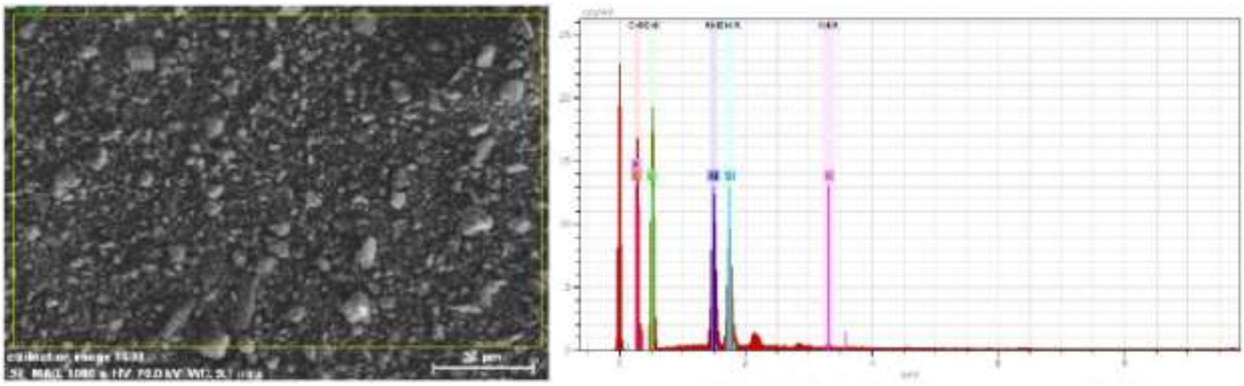

figure 4. SEM-EDX 1000x Metakaolin

After the material tested, do the manufacture of the test object for subsequent next process done, after made the first test object is done is a compressive strength test with the following results

Table 6. Compressive Strenght Test Result

No.	***Code***	***Results (MPa)***		
		7 days	***14 days***	***28 days***
1.	Control	21,3	34,9	49,6
2.	V1	24,3	26,5	34,1
3.	V2	16,4	29,5	32,0
4.	V3	14,3	27,1	35,1
5.	V4	14,5	26,8	32,4
6.	V5	22,1	27,2	39,3

It can be seen that the increase of compressive strength of concrete from age 7 days to 28 days with sea water environment condition which can damage the concrete got high enough increase, at 100% fly ash condition resulted compressive strength equal to 49,6 MPa become highest compressive strength and As a compressive force of control, in Variation 6 with V6 code, a compressive strength of 39.3MPa is almost equal to the strength of the control of geopolymer concrete with the addition of metakaolin of 20%, and in the 4th variation with the V3 code the result is 35.1 MPa with the addition of 10% Bagasse and 10% metakaolin, and the lowest compressive strength obtained in variation V2 with a compressive strength of 32.0 MPa with the addition of 15% bagasse ash and 5% metakaolin.

This the result of Ultra Pulse Velocity test, It was a type of testing without damaging the concrete (Non-Destructive) for the purpose of estimating the quality of concrete based on the relationship UPV wave velocity through the medium of concrete at 28 days.

Table 7. UPV Test Result

Code	***Average Results of UPV test, V (m/sec)***
Control	2763,33
V1	2566,67
V2	2563,33
V3	2543,33
V4	2566,67
V5	2546,67

Porosity test results were a type of testing without damaging the concrete (Non-Destructive) in order to measure the durability of the concrete structure of the clamshells waste. This test showed the percentage of free space on concrete or porous levels which became the major factor in influencing the quality of concrete at 28 days.

Table 8. Porosity Test Result

Code	***Average Results of Porosity test (%)***
Control	16,35
V1	16,67
V2	13,60
V3	14,95
V4	17,74
V5	16,03

4. CONCLUSION

From the result of UPV (Ultrasonic Pulse Velocity) test, the optimum density of the concrete paste is on the test specimens used as control with an average of 2763.3 m/s. While among the specimens which has the biggest density from the variation specimens is V1 with an average of 2586.7 m/s.

In the result of the compressive strength test of 7 days old concrete paste was obtained that the biggest compressive strength is on the V1 and followed by V5 with an average compressive strength of V1 is 24.3 MPa, and V5 is 22.1 MPa.

But, from the result of compressive strength test of 28 days old concrete paste was obtained that the biggest compressive strength is on the control specimens and followed by V5 with an average compressive strength of control specimens is 49.6 MPa and V5 equal to 39.5 MPa.

From the porosity test. Porosity of paste made from a mixture of fly ash, sugarcane bagasse ash, and metakaolin is not very influential on compressive strength.

So, it can be concluded that the optimum paste to be used for concrete is control, V1 and V5 concrete paste.

5. ACKNOWLEDGEMENT

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