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Submission date: 12-Sep-2018 01:15PM (UTC+0700)
Submission ID: 1000566354
File name: the_compressive_strength.docx (177.04K)
Word count: 2062
Character count: 10895

THE COMPRESSIVE STRENGTH OF BAGGASE ASH-BASED GEOPOLYMER CONCRETE

(BM-040)

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1. INTRODUCTION

In this decades, concrete becomes a famous material for building construction. There are several reasons to use concrete as a material for building, such as (1) easily to make because the material for making concrete are not so difficult to find; (2) easily to form in the mould as we desire to make it; (3) the cost of maintenance is very low as long as the procedure in making concrete is in the proper way. Generally, conventional concrete composes of ordinary portland cement as a primary binder, water, fine aggregates, and coarse aggregates. Sometimes were added with other material such as fiber, fly ash, silica fume in order to get a specific properties of the concrete.

Currently, conventional concrete has been discussed by researchers who care in environmental issues. This issue is related to carbon dioxide as a side effect in the producing of ordinary portland cement. According to Roy (1999), in producing 1 ton ordinary portland cement will produce 1 ton carbon dioxide that releases to the air and gives contribution to global warming. Geopolymer concrete becoming as a green concrete to reduce global warming, because geopolymer concrete does not use ordinary portland cement for binder, but uses natural material such as fly ash and rice hush ash as a binder. Davidovits (1994) stated that natural materials for replacing ordinary portland cement in geopolymer concrete must contain high of silica and alumina. These elements will react with alkaline liquid to make polymerisation process in geopolymer concrete. Hardjito and Rangan (2005) had developed geopolymer concrete by using low calcium fly ash (fly ash type F which contains 80 to 85 % of silica and alumina).

Baggase ash is one of the waste of sugar industry. As the waste of sugar industry, the baggase ash is useless material and just put in the area around the sugar industry and made pollution. In the present, the baggase ash has been developed to be a potentially material and used as pozzolan for concrete. Wibowo and Hatmoko (2001) carried out research to make high strength concrete using baggase ash for partial replacing of ordinary portland cement. This research stated that replacing 10 % and 20 % of ordinary portland cement can increase compressive strength 16.16 % up to 23.01 %. In this research also found that the optimum burning of baggase ash is 500^0 Celsius during 25 minutes. In this research, the compressive strength of concrete using baggase ash for partial replacing of ordinary portland cement can reach up to 39.7 MPa.

When this research began, the published literature regarding to the use of baggase ash in geopolymer concrete was not available. So, this research try to make baggase ash-based geopolymer concrete and this research is preliminary research for the basis of the future research to develope baggase ash-based geopolymer concrete.

2. METHODOLOGY

Materials

Fine aggregates were taken from Krasak River, Muntilan which located in the North of Yogyakarta Province. The properties and gradation of fine aggregates can be seen in Table 1 and Table 2, respectively.

Table 1. Properties of fine aggregates

Properties	According to ASTM	Result
Bulk specific grafity	C. 127 - 79	2.6645
Bilk specific grafity SSD (saturated surface dry basic)	C. 127 - 79	2.7412
Apparent specific grafity	C. 127 - 79	2.8860
Absorbtion (%)	C. 127 - 79	2.8807
Unit weight SSD : a. rodded b. shoveled	C. 29 – 78T	1.5653 1.3275

Table 2. Gradation of fine aggregates

Sieve size	Percentage retained in the sieve	Total percentage retained in the sieve	Total percentage passing the sieve	According to ASTM C.33-82
50	-	-	-	-
37.5	-	-	-	-
25	-	-	-	-
19	-	-	-	-
12.5	-	-	-	-
9.5	-	-	100	100
4.75	1.64	1.64	98.36	95 - 100
2.36	5.46	5.46	94.54	80 - 100
1.18	17.46	22.92	77.08	50 - 85
0.6	34.64	57.56	42.44	25 - 60
0.3	23.18	80.74	19.26	10 - 30
0.15	12.18	92.92	7.08	2 - 10
0	5.44	-	-	-
Total	100	261.24	-	-
Fineness modulus of fine aggregates = 2.6124				

It can be seen that the gradation of fine aggregates comply with the grading requirement for fine aggregates in accordance with ASTM C.33-82.

Coarse aggregates were taken from Clereng, Kulon Progo which is located in the West part of Yogyakarta Province. The properties and gradation of coarse aggregates can be seen in Table 3 and Table 4.

Table 3. Properties of coarse aggregates

Properties	According to ASTM	Result
Bulk specific grafity	C. 127 - 81	2,5304
Bilk specific grafity SSD (saturated surface dry basic)	C. 127 - 81	2,7996
Apparent specific grafity	C. 127 - 81	2,7233
Absorbtion (%)	C. 127 - 81	2,8000
Unit weight SSD : a. rodded b. shoveled	C. 29 – 78T	1,5653 1,3669

Table 4. Gradation of coarse aggregates

Sieve size	Percentage retained in the sieve	Total percentage retained in the sieve	Total percentage passing the sieve	According to ASTM C.33-82
37.5	-	-	-	-
25	0	0	100	100
19	3,72	3,72	96,28	90 - 100
12.5	20,07	23,79	76,21	-
9.5	49,34	73,13	26,87	20 - 55
4.75	22,56	95,69	4,31	0 - 10
2.36	2,05	97,74	2,26	0 - 5
1.18	1,81	99,55	0,45	-
0.6	0	-	-	-
0.3	0	-	-	-
0.15	0	-	-	-
0	0.45	-	-	-
Total	100	-	-	-

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Table 5 shows that the gradation of coarse aggregates comply with the grading requirement for fine aggregates in accordance with ASTM C.33-82.

Material of baggase ash was taken from Madukismo Sugar Mill which is located in the South part of Yogyakarta Province. Baggase ash is waste of sugar mill, and had been used to burn molasses in sugar mill. Wibowo and Hatmoko (2001) stated that these baggase ash has very low silica and needs to be burned to increase the contain of silica. Deposit of baggase ash in the area around sugar mill can be seen in the Figure 1.

Figure 1. Deposit of baggase ash.

According to Wibowo and Hatmoko (2001) that the optimum burning temperature is 500^0 Celsius during 25 minutes, where the contain of SiO2 + Al_2O_3 + Fe_2O_3 can reach 85.21 % (the chemical composition see Table 5).

Table 5. Chemical composition of baggase ash burning in temperature of 5000 Celsius during 25 minutes. (Wibowo and Hatmoko, 2001)

Chemical element	Content (%)
SiO2	64.110
Al_2O_3	15.110
Fe_2O_3	5.990
SiO2 + Al_2O_3 + Fe_2O_3	85.210
Lost of ignition	0.440
CaO	5.810
MgO	2.260
SO_3	0.000
K_2O	3.620
Na_2O	2.660
H_2O	0.050

In this research the baggase ash was also burned at temperature of 500^0 Celsius during 25 minutes. After the burning process, the baggase ash must be sieved passing through No. 200 sieve (75 μm). The baggase ash after burning and passing through No. 200 sieve can be seen in the Figure 2.

Figure 2. The baggase ash

Mix Design of Geopolymer Concrete.

According to Vijai et al. (2010) in the design of geopolymer concrete mix that the coarse and fine aggregates were taken as 77 % of entire mixture by mass, and the fine aggregate was taken as 30 % of total aggregates. Vijai et all also stated that from the past literature the average density of fly ash-based geopolymer concrete is similar to that of Ordinary Portland Cement concrete. In this research, it was also assumed that the density of baggase ash-based geopolymer concrete is similar to the density of Ordinary Portland Cement concrete. By knowing the density of concrete, the combined mass of alkaline liquid and baggase ash can be arrived. Assuming the ratios of alkaline liquid to baggase ash as 0.4, mass of baggase ash and mass of alkaline liquid were found out. To obtain mass of sodium hydroxide and sodium silicate solutions, the ratio of sodium silicate solution to sodium hydroxide solution was fixed as 2.5. Concentration of NaOH solution was taken as 8M. The mix proportion of baggase ash-based geopolymer concrete can be seen in the Table 6.

Table 6. Details of proportion baggase ash-based geopolymer concrete

Alkaline Liquid to Baggase Ash Ratio	Baggase Ash (gr)	Fine Aggregate (gr)	Coarse Aggregate (gr)	NaOH (gr)	Na_2SiO_3 (gr)	Water (gr)	Total Solids (gr)	Water to Solid Ratio
0.4	1875	2636.4	6151.6	214.3	535.7	787.5	2625	0.3

Preparation of Specimen.

To make sodium hydroxide solution of 8 molarity (8M), take 320 grams of sodium hydroxide flakes was dissolved in one litre of water. After sodium hydroxide was dissolved with water, then keep it at least one day before mix with sodium silicate solution. The sodium hydroxide solution is mixed with sodium silicate solution one day before mixing the concrete to get the alkaline solution. To make baggase ash-based geopolymer concrete in this research follow the procedure in the research done by Vijai et al. (2010). First the baggase ash and the aggregates were dry mixed in the pan mixer for about three minutes. Second, after dry mixing, alkaline solution was added to the dry mix and wet mixing was done for 4 minutes. After that casting the cylinder specimens. In this research, cylinder with diameter of 70 mm and height of 140 mm was used to make specimen of cylinder. After casting the specimens, the cylinders specimens were kept for five days before demoulding. After demoulding, the specimens were kept for curing at room temperature.

3. RESULTS AND DISCUSSION

Density of Geopolymer Concrete

Density of baggase ash-based geopolymer concrete can be seen in Table 7.

Table 7. Density of baggase ash-based geopolymer concrete

Type of Curing	Density (kg/m^3)			
	14 Days	Average	28 Days	Average
Room Temperature	1940.64	1984.11	1988.01	2001.13
	1999.44		1992.73	
	2012.24		2022.64	

Table 7 shown that the density of baggase ash-based geopolymer concrete in the range of 1940.64 kg/m^3 and 2022.64 kg/m^3. The average density of 14 days and 28 days are 1984.11 kg/m^3 and 2001.13 kg/m^3, respectively. It was found that the density of baggase ash-based geopolymer concrete is lower that the density of Ordinary Portland Cement concrete. So, for future research it is better to make the mix design of baggase ash-based geopolymer concrete by using the density result of this research.

Compressive Strength

The compressive strength at 14 and 28 days is presented in Table 8.

Table 8. Compressive strength of geopolymer concrete at 14 and 28 days.

Specimen	Compressive Strength (N/mm^2)			
	14 days	Average	28 days	Average
1	0.336	0.325	0.366	0.344
2	0.425		0.329	
3	0.213		0.336	

Table 8 shows that the average compressive strength of baggase ash-based at 14 days and 28 days are 0.325 N/mm^2 and 0.344 N/mm^2, respectively. It can be seen that the compressive strength of 28 days is only about 1.06 times of 14 days compressive strength. Because of the cylinders in this research used size of (70 mm x 140 mm), so according to Troxell and Davis (1956), the results must be converse by the factor 0.86. Hence, the average compressive strength of 14 days and 28 days are 0.2795 N/mm^2 and 0.2958 N/mm^2, respectively.

4. CONCLUSION

Base on the result of experimental program, it can be drawn that the density of baggase ash-based geopolymer concrete is little bit lower than density of Ordinary Portland Cement concrete. The average density of baggase ash-based geopolymer concrete at 28 days is 2001.13 kg/m^3. The compressive strength of room temperature cured of baggase ash-based geopolymer concrete has not increased after 14 days, The average compressive strength of baggase ash-based geopolymer concrete at 28 days is only 0.2958 MPa. Therefore, it needs to be developed for the next research to get higher the compressive strength than this results.

5. ACKNOWLEDGEMENT

The outhors would like to thanks to University of Atma Jaya Yogyakarta for the granted of this research. The outhors also thanks to the Head and Staffs of Laboratory of Structures and Materials, Civil Engineering Department, Faculty of Engineering, University of Atma Jaya Yogyakarta, especially to Sukaryanto, Beni Antana, Tami and Evan for their help during the experimental program was conducted. The outhors also would like to thanks to Dr. Djwantoro Hardjito for personal communication and suggestion during the research was conducted.

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