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The Effect of Baggase Ash on Fly Ash-Based Geopolimer Binder

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Abstract. Geopolymer concrete is an environmentally friendly concrete. However, the geopolymer binder has a problem with setting time; mainly the composition comprises high calcium fly ash. This study utilized bagasse ash to improve setting time on fly ash- based geopolymer binder. The characterization of bagasse ash was carried out by using chemical and phase analysis, while the morphology characterization was examined by scanning electron microscope (SEM). The setting time test and the compressive strength test used standard ASTM C 191-04 and ASTM C39 / C39M respectively. The compressive strength of the samples determined at 3, 28 and 56 days. The result compared the requirement of the standards.

1. Introduction

The green concept for ordinary cement Portland industry today is to substitute separately and replace it entirely using environmentally local materials. The fact shows the cement industry contributes CO_2 emissions close to 8% of the total emissions in the world.

This phenom is caused a ton of cement production produces a ton of CO_2 emissions in the air, and this contributes to global warming [1]. Davidovits [2] defines that the natural ingredients to replace portland cement in concrete high geopolymer should contain silica and alumina. These elements will react with the liquid alkali such as Na_2SiO_3 and NaOH to make the process of polymerization in geopolymer concret.

Therefore, geopolymer concrete is now a popular material to develop continuously in Indonesia since approximately since 2010[3-6]. The main problem of geopolymer concrete in Indonesia is the quality of fly ash which is so varied that it causes problems to its setting time.

Therefore, this study to reduce the dominance of fly ash on geopolymer binder by substituting fly ash with local material of alumina silicate [10]. While, many challenges need to be solved, such as setting time for high calcium fly ash for geopolymer binder and geopolymer concrete. Previous study [7-11] explored the bagasse ash (AAT) on normal concrete.

The bagasse has great potensial to improve the properties of normal concrete still slightly reviewed in geopolymer concrete. Because of that, this study to explore the bagasse ash to reduce the domination of fly ash in binder geopolymer.

2. Methodology

Experimental laboratory used to answer this research. Bagasse ash from PG. Toelangan PTPN X-Sidoarjo. The fly ash samples were collected from Paiton steam power plant in Probolinggo, East Java, Indonesia. To determine the chemical composition contained in the waste bagasse ash and fly ash, tests will be conducted SEM-EDX, 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 12 M. Table 1 showed eight different geopolymer binder compositions used during this experiments. Those are including the variation on alumina and silica material composition. The ratio between activator solution of NaOH and Na_2SiO_3 were 0.5 and 1.5. The binder sample prepared by mixing the materials then casting the sample into the mould. During this process, the setting time used the ASTM [12]. The sample harden by itself and followed by curing process afterwards. The curing process were monitored at the age of 3, 28 and 56 days. Then we can continue to test the sample's compressive strength by using the ASTM[13] standard code.

Table 1. Geopolymer Binder composition.

No	Binder code	Information
1	AAT12- 0.5	AAT 100%, NaOH 12M, Na_2SiO_3/NaOH = 0.5
2	FA12 - 0.5	FA 100%, NaOH 12M, Na_2SiO_3/NaOH = 0.5
3	50AAT+50FA12 - 0.5	AAT 50% + FA 50%, NaOH 12M, Na_2SiO_3/NaOH = 0.5
4	20AAT+80FA12 - 0.5	AAT 20% + FA 80%, NaOH 12M, Na_2SiO_3/NaOH = 0.5
5	AAT12- 1.5	AAT 100%, NaOH 12M, Na_2SiO_3/NaOH = 1.5
6	FA12 - 1.5	FA 100%, NaOH 12M, Na_2SiO_3/NaOH = 1.5
7	50AAT+50FA12 - 1.5	AAT 50% + FA 50%, NaOH 12M, Na_2SiO_3/NaOH = 1.5
8	20AAT+80FA12 - 1.5	AAT 20% + FA 80%, NaOH 12M, Na_2SiO_3/NaOH = 1.5

3. Result and discussion

Some results from baggase ash and fly ash test physically and chemically are presented in the Figure 1-6 and the table 2 and 3 below:

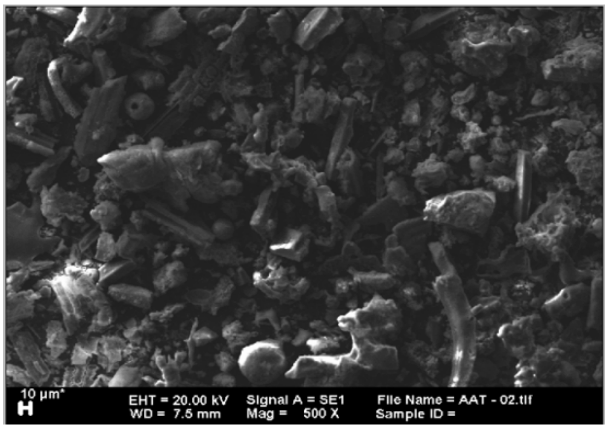

Figure 1. Baggase Ash in magnification of 500x.

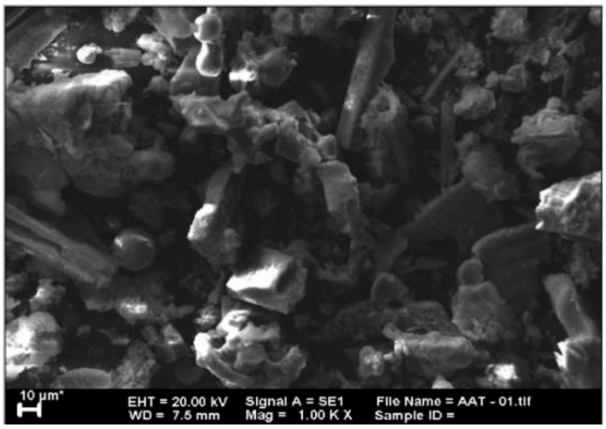

Figure 2. Baggase Ash in magnification of 1000x.

The test results SEM fly ash has a relatively round grain shape so it is more easily oxidized than baggase ash shaped like coral. The faster the oxidation process faster binding occurs.

This test is used to determine the elemental composition of the material analysis. From the test results XRF known that fly ash used in this study is Si + Al + Fe> 70%. CaO content of fly ash used in this study was 5.83%, according to ASTM [12] fly ash which has a CaO content of less than 10% are classified into type F fly ash.

Figure 7 presented the test results of setting time. This figure described the fastest setting time occurred in the composition of FA 100%, NaOH 12M, Na_2SiO_3/NaOH = 0,5. The longest setting time was showed the binder composition of AAT 20% + FA 80%, NaOH 12M, Na_2SiO_3/NaOH = 0,5.

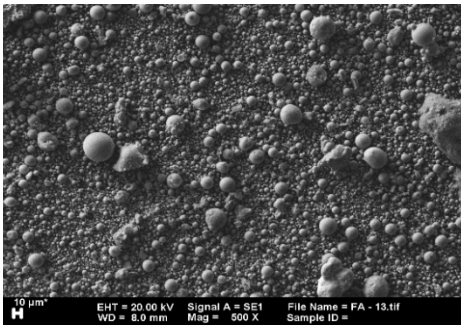

Figure 3. Fly Ash in magnification of 500x.

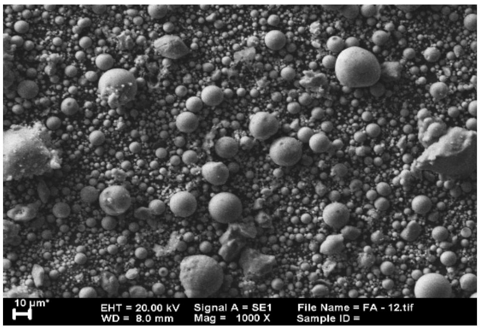

Figure 4. Fly Ash in magnification of 1000x.

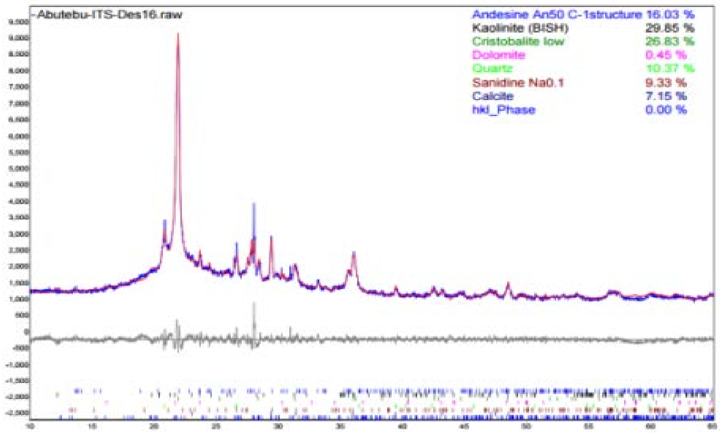

Figure 5. The XRD Test Result of Baggase Ash.

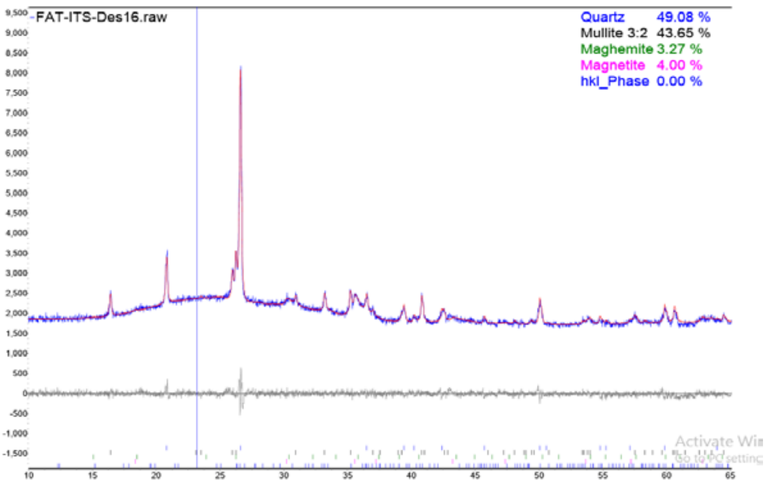

Figure 6. The XRD Test Result of Fly Ash.

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XRD test results, the highest intensity on bagasse ash highest intensity occurred in 9100 while in fly ash occurs at an altitude of 8,100.

The compressive strength test was shown Figure 8. There were two highest compressive strength presented the binder composition. The composition were FA 100%, NaOH 12M, Na_2SiO_3/NaOH = 1,5 and AAT 20% + FA 80%, NaOH 12M, Na_2SiO_3/NaOH = 1,5 at the 56 days 42.52 MPa and 42.32 MPa, respictively.

Table 2. The XRF Test Result of Baggase Ash.

No	**Code sample**		**Results analysis (%)**
	Coumpound	Name of chemical	
1.	Silica dioxide	SiO_2	72.14
2.	Fery oxide	Fe_2O_3	7.75
3.	Corundum	Al_2O_3	4.86
4.	Calcium dioxide	CaO	7.13
5.	Magnesia	MgO	1.63
6.	Sodium oxide	Na_2O	0.46
7.	Potassium oxide	K_2O	3.6
8.	Manganese oxide	MnO	0.32
9.	Iron oxide	ZnO	0.15
10.	Lead oxide	Ti_2O	0.31
11.	Phosphate	P_2O_5	1.27

Table 3. The XRF Test Result of Fly Ash.

No	**Code sample**		**Results analysis (%)**
	Coumpound	Name of chemical	
1.	Silica dioxide	SiO_2	47.10
2.	Fery oxide	Fe_2O_3	16.07
3.	Corundum	Al_2O_3	24.25
4.	Calcium dioxide	CaO	5.83
5.	Magnesia	MgO	2.62
6.	Sodium oxide	Na_2O	0.65
7.	Potassium oxide	K_2O	1.64
8.	Manganese oxide	MnO	0.10
9.	Iron oxide	ZnO	0.29
10.	Lead oxide	Ti_2O	1.16
11.	Phosphate	P_2O_5	0.18

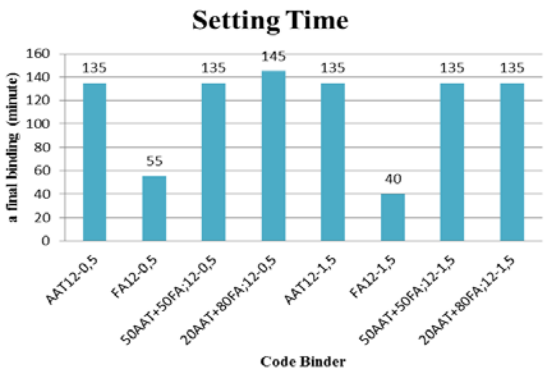

Figure 7. The Setting Time Test Result.

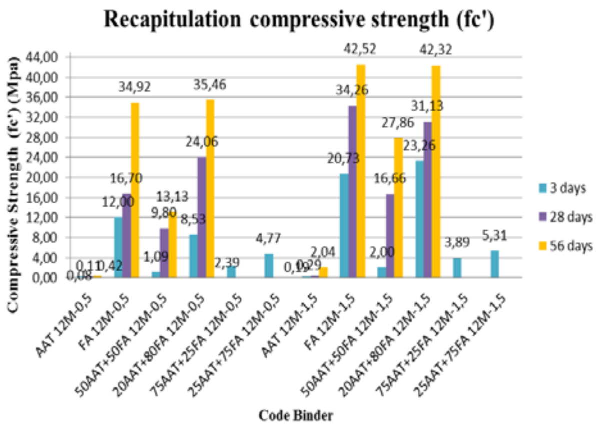

Figure 8. The Compressive Strength Test Result.

4. Conclusions

The bagasse ash could be able to improve its performance to substitute fly ash in a geopolymer binder mixture. The properties chemical and physical of bagasse ash adequate to work together with fly ash. The Baggase ash in the low NaOH molar could increase the setting time of geopolymer binder. However, the bagasse ash required higher NaOH molar to produce better compressive strength.

5. References

[1] Bilodeau A and Malhotra V M 2000 *Materials Journal* **97**(1) 41-48
[2] Davidovits J 1984 *Synthetic mineral polymer compound of the silicoaluminates family and preparation process* Google Patents
[3] Ekaputri J J, Maekawa K and Ishida T 2010 *The use of geopolymerization process for boron fixation in fly ash* in *Jinan, China: Proceeding the 7th International Symposium on Cement& Concrete (ISCC2010) and the 11th International Conference on Advance in Concrete Technology and Sustainable Development*
[4] Ekaputri J J, et al 2015 *Applied Mechanics and Materials* Trans Tech Publ
[5] Bayuaji R, et al 2015 *Applied Mechanics and Materials* Trans Tech Publ
[6] Dwijayanti L Y, Ekaputri J J and Bayuaji R 2016 *Lightweight geopolymer binder with abaca fiber in different curing* in *Materials Science Forum* Trans Tech Publ
[7] Wani A H, Sharma S and Siddique R 2018 I*nternational Journal of Civil and Environmental Engineering* **5**(3)
[8] Rajasekar A, et al 2018 *Construction and Building Materials* **171** 350-356
[9] Moretti J P, Nunes S and A Sales 2018 *Construction and Building Materials* **172** 635-649
[10] ASTM-C191-13 2013 *Standard Test Methods for Time of Setting of Hydraulic Cement by Vicat Needle*
[11] Burduhos Nergis D D, Abdullah M M A and Vizureanu P 2017 *European Journal of Materials Science and Engineering* **2** 111-118
[12] Popovici A, Corbu O, Popita GE, Rosu C, Proorocu M, Sandu AV and Abdullah MMAB 2015 *Materiale Plastice* **52(4)** 588-592
[13] ASTMC39/C39M-18 2018 *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*
[14] ASTM-C618-03, *Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete* Annual Book of ASTM Standards, **4-2** , ed ASfTa Materials 2003, Philadelphia,USA

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