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CHARACTERISTICS OF THE NEW MATERIAL GEOPOLYMER BINDER COURSE FLY ASH AND BOTTOM ASH

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ABSTRACT

Selection of concrete specifications is something that must be done according to needs. The use of concrete as a building material is efficiency and effectiveness in terms of processing and supply. The increase in fly ash and bottom ash waste will affect new innovations for new materials in construction. The purpose of this study was to determine the characteristics of the new material geopolymer binder course fly waste and bottom ash whether it complies with standards and is suitable for use as a construction material or for making roads. This research was carried out experimentally in the laboratory to check whether the characteristics of the material used met the standards or not. The results obtained were that the best mixture for the new material was between (FA+BA) with a compressive strength of 5.15 MPa and (FA+PS) with a compressive strength of 25.6 MPa at 28 days old with a mixture composition of 1 : 1.5. As for the mixed wear value (FA+BA) has a wear value of 76% while (FA+PS) has 39% wear. The new material resulting from the wear level can be used as a base course material.

Keyword: *base course, bottom ash, concrete specifications, fly ash, new material*

1. INTRODUCTION

Infrastructure development and housing demand demand accelerated innovation in structural design, particularly in building material technology. The realized innovation aims to obtain a structural material composition with a good category by using effective and efficient stages. The most common or most frequently used building material in construction is concrete. Concrete is a solid object that is formed from several material compositions to form a high solidity. Structural concrete is a type of concrete that functions to support structural loads in buildings. Architectural concrete can be defined as concrete with a minimum compressive strength of 17 MPa at 28 days of age. Whereas concrete as a building construction contains various sizes of mixtures, among others those that function as fillers are sand or fine aggregate and gravel or coarse aggregate, as well as fillers, as well as a mixture of water and cement which functions as a binding material.

Selection of concrete specifications is something that must be done according to needs. The use of concrete as a building material is efficiency and effectiveness in terms of processing and supply. In general, concrete aggregates are made from natural materials or industrial processes that have a level of ease of obtaining and processing (workability), as well as having the required durability and strength for the structure. The advantages of good quality concrete are that it has a high level of strength, is resistant to rust or damage due to environmental influences, and is impermeable to atmospheric substances. However, concrete also has disadvantages: it is compressed, expands and contracts with changes in temperature, is difficult to completely seal and is brittle.

The increase in fly ash and bottom ash waste materials at PLTU Tanjung Jati B Jepara requires management and recycling that has economic value. The goal is to reduce existing waste, because it accumulates in landfills. This excessive accumulation of waste creates overcapacity meaning that new areas have to be developed. Fly ash and bottom ash are wastes from burning coal in the PLTU power generation process. Fly ash is in the form of fly ash but bottom ash is in the form of sand-like crumbs, but weighs less. Generally, fly ash formed from burning coal is divided into two types, namely type F

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and type C[1][2]. A distinction is made between the two on the basis of differences in chemical concentrations. Fly ash and slag waste are classified as non-B3 waste according to existing regulations. Contains fly ash Silicon dioxide (SiO2), aluminum (Al2O3), iron (Fe2O3) and calcium (CaO) oxides and Sodium, Potassium, Sulfur and Titanium. This explains that fly ash can be recycled as a substitute for cement in the concrete production process[3][4]. Structural concrete consisting of fly ash and bottom ash has a strength of 36.6 MPa [5]. In addition, research on the use of deep slag mortar without the addition of fly ash indicates a decrease in quality, if more and more bottom ash is used with increased use of bottom ash, bottom ash is also used in making cement blocks[6][7].

Many studies have examined the use of fly ash as a substitute for cement and slag as a substitute for sand [8][9]. However, this waste has not been utilized optimally, especially as a new material in construction. This is because the right ratio has not been obtained when using fly ash and bottom ash. Even though it is very necessary to reduce the amount of waste, especially at PLTU Tanjung Jati B Jepara. Therefore, it is necessary to conduct research on the characteristics of new materials as a substitute for natural materials which are increasingly depleting as geopolymer binders made from fly ash and bottom ash waste. The aim of the research was to obtain the characteristics of the new material geopolymer binder course, fly waste and bottom ash, whether it complies with the standards and is suitable for use as a construction or road construction material. The results of this research provide guidance for the community in utilizing fly ash and bottom ash as new materials in construction and reducing the amount of existing waste.

2. RESEARCH METHODOLOGY

The methodology used in this study is an experimental method in which the method used in this study aims to find the effect of certain treatments on concrete [10][11][12]. In this study, the percentage variation of the mix between (fly ash + bottom ash) and (fly ash + sand) per sample required for geopolymer mortar samples with the percentage variation of fly ash being a substitute benchmark for the volume weight of cement with a FAS of 0.5. Making geopolymer mortar samples as a test material will be made of coarse aggregate having mold dimensions of 5 cm x 5 cm[13][14][15]. The molarity used in the variation of the geopolymer mortar mix is 10 Mol with a ratio (1: 2) for NaOH and Waterglass with a total sample of 115 samples taken from the best variation combination between fly ash + bottom ash geopolymer mortar and fly ash + sand with a test period of 28 days on concrete.

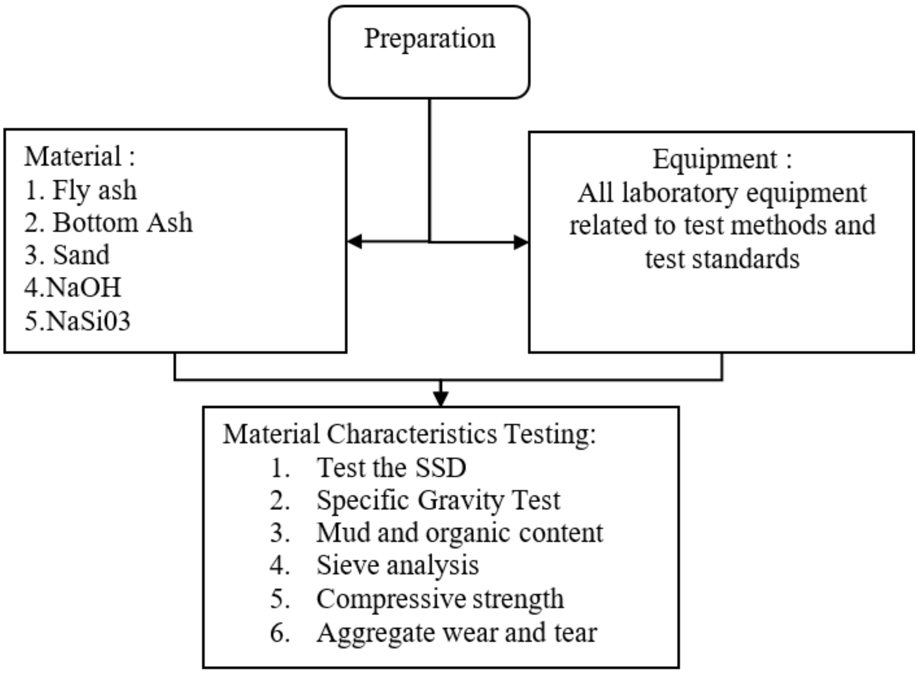

Figure 1. Research flowchart

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3. ANALYSIS DAN RESULT

3.1. Saturated Surface Dry Test

The Saturated Surface Dry test is used to determine the condition of the material used, especially related to the water content contained in the expansion material from wet conditions, SSD, and dry conditions. The characteristics of the materials tested are fly ash, bottom ash, and sand with table 1 as follows:

Table 1. Saturated Surface Dry Test Results

No	Condition	Moisture Content of Test Material (%)		
		Fly Ash	Bottom Ash	Sand
1	Wet	6,72	7,29	6,75
2	SSD	3,15	3,51	3,34
3	Dry	0	0	0

Source: Analysis Results, 2023.

These results indicate that each material has a different level of water content with the order from the highest water content in each condition being bottom ash, sand and fly ash.

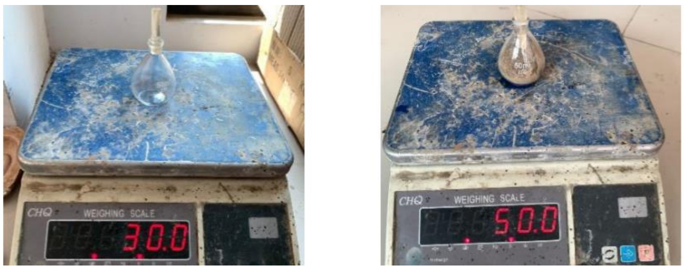
3.2. Specific Gravity Testing

This test was carried out on fly ash, bottom ash, and sand that met the standards and specific gravity requirements as shown in table 2 below:

Table 2. Specific gravity test results

No	Test Objects	Specific gravity	Condition	Information
1	**Fly Ash**	2,20	1,9-2,55	Fulfil
2	**Bottom Ash**	2,51	2,3-2,9	Fulfil
3	**Pasir**	2,20	1,2-2,8	Fulfil

Source: Analysis Results, 2023.



Source: M. Farich Azka documentation, 2023

Figure 2. Picnometer weighing in the specific gravity test

3.3. Sludge and Organic Testing

Three aggregates were tested in this test including fly ash, bottom ash and sand. The following is information about the results of the three aggregate tests:
Table 3 shows that according to the requirements for a maximum silt content in sand of 5%, fly ash and bottom ash meet the requirements because they have a silt content of 0% and 3.96%.

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Table 3. Specific gravity test results 1

No	Data	Unit	Test Objects		Sludge levels	Organic Content	
			1	2			
1	High Fly Ash + Mud	cc	135	135	0%	Clear	
	Fly Ash Height	cc	135	135			
	Mud Height	cc	0	0			
2	Bottom Ash + Mud Height	cc	135	134	3,96%	Golden Yellow	
	Bottom Ash's height	cc	129	130			
	Mud Height	cc	6	4			
3	High Sand + Mud	cc	143	143	8,30%	Brownish Yellow	
	Sand Height	cc	131	131			
	Mud Height	cc	12	12			

Source: Analysis Results, 2023.

As for the sand used, it does not meet the requirements because it is 8.30% which exceeds 5%. The results of testing the organic matter content of fly ash with NaOH obtained a clear color while the results of testing the sludge content of bottom ash organic matter with NaOH obtained a golden yellow color, and the results of testing the sludge content of sand organic matter with NaOH obtained a brownish yellow color. All tests met the standards seen from the allowable color of NaOH, namely from clear to dark yellow and when viewed from the sludge content, they met the requirements

3.4. Fine Aggregate Sieve Analysis

Screening analysis was carried out using two comparison samples and a dissipation factor of not more than 1%. The test results are displayed according to table 4 below:

Table 4. Fine Aggregate Sieve Test Results

No	Test Objects	Loss Percentage	Fineness Modulus(mm)	Condition	Information
1	**Bottom Ash**	0,3%	3,60	2,3-2,9	Fulfil
2	**Sand**	0,2%	2,70	1,2-2,8	Fulfil

Source: Analysis Results, 2023

In this study, it was found that the fineness modulus (FM) of bottom ash was 3.60 mm and that of sand was 2.70 mm so that it was included in the group with the degree of fineness at the required limit of 1.5-3.8 according to (SK SNI S-04-1989-F).

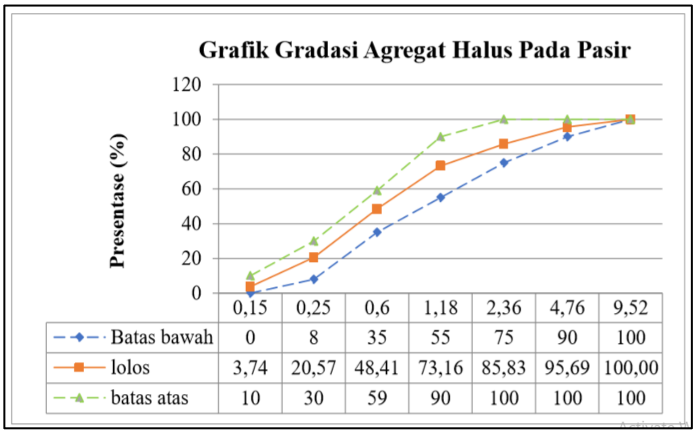

Figure 3. Graph of fine aggregate gradation in sand

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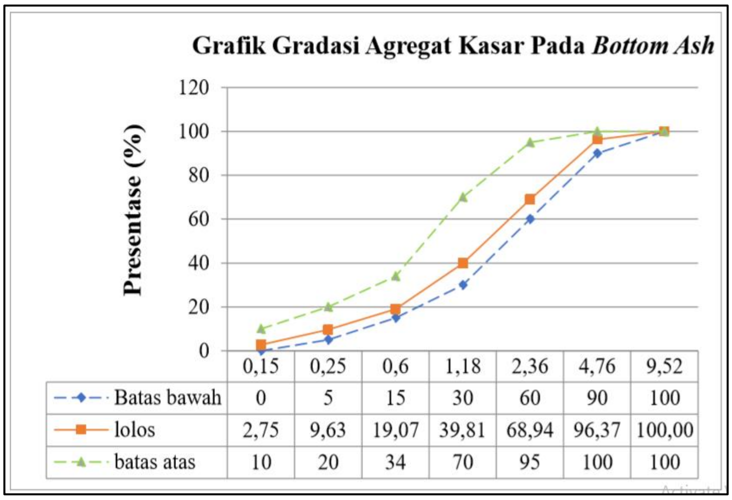

Figure 4. Graph of fine aggregate gradation on bottom ash

3.5. Compressive Strength of Geopolymer Mortar

The compressive strength of the mortar in this study has 2 different types of aggregate mortar with 3 different comparisons.

a. Fly Ash and Bottom Ash Aggregate Mortar

The results of the standard deviation between samples in the compressive strength test with fly ash and bottom ash aggregates are shown in table 5 below:

Table 5. Standard deviation of FA+BA aggregate mortar

No	Mixture	Standard Deviation			Information
		7 Day	14 Day	28 Day	
1	**FA+BA (1:1,5)**	0,27	0,21	0,35	Perfect
2	**FA+BA (1:2)**	0,24	0,15	0,45	Perfect
3	**FA+BA (1:2,5)**	0,38	0,23	0,87	Perfect

Source: Analysis Results, 2023

Based on table 5, it can be seen that the standard deviation for each FABA aggregate mortar variation has a different value. The standard deviation for variation (1 : 1.5) was 0.27 at 7 days, 0.21 at 14 days, and 0.35 at 28 days. The standard deviation for variation (1 : 2) was 0.24 at 7 days, 0.15 at 14 days, and 0.45 at 28 days. The standard deviation for variation (1 : 2.5) was 0.38 at 7 days, 0.23 at 14 days, and 0.87 at 28 days. Based on the test results show that all variations are categorized into perfect working conditions because they have a standard deviation value of less than 3.

The compressive strength values of fly ash and bottom ash aggregate mortar can be seen graphically in Figure 3.

Based on Figure 5, it can be seen that the compressive strength of mortar aggregate fly ash + bottom ash (FABA) variation (1: 1.5) aged 7 days is 2.2 MPa, aged 14 days is 3.1 MPa, and aged 28 days is 5.15 MPa. As for the other variations, the compressive strength decreased because the more comparisons to the bottom ash aggregate, the less activator was added. This makes the mortar lighter due to the lack of a binder which results in a lower compressive strength value.

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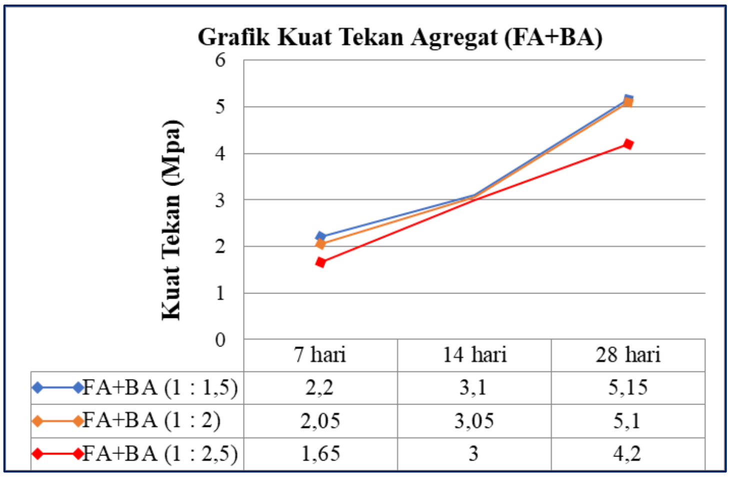

Figure 5. Graph of Compressive Strength of Aggregate Mortar FA+BA

b. Aggregate Mortar Fly Ash and Sand

The standard deviation graph of FA+PS aggregate mortar can be seen in Figure 6.

Table 6. Graph of FA+PS Aggregate Mortar Standard Deviation

No	Mixture	Standard Deviation			Information
		7 Day	**14 Day**	**28 Day**	
1	**FA+PS (1:1,5)**	1,20	0,90	2,20	Perfect
2	**FA+PS (1:2)**	2,30	1,20	1,90	Perfect
3	**FA+PS (1:2,5)**	0,50	2,80	3,20	Not good

Source: Analysis Results, 2023

Seen in table 6. the standard deviation for each variation of FA+PS aggregate mortar has a different value. The standard deviation for variation (1 : 1.5) at 7 days is 1.20, 14 days is 0.90 and 28 days is 2.20. The standard deviation for variation (1 : 2) is 2.30 at 7 days, 1.20 at 14 days, and 1.90 at 28 days. The standard deviation for variation (1 : 2.5) at 7 days was 0.50 MPa, 2.80 at 14 days, and 3.20 at 28 days. Based on the results obtained, it can be concluded that almost all variations are categorized into perfect working conditions because they have a standard deviation value of less than 3. However, the standard deviation of the FA+PS mortar variation (1 : 2.5) aged 28 days is included in good working conditions because it has a standard deviation value between 3.5 - 4.

The compressive strength values of fly ash and sand aggregate mortar can be seen graphically in Figure 6.

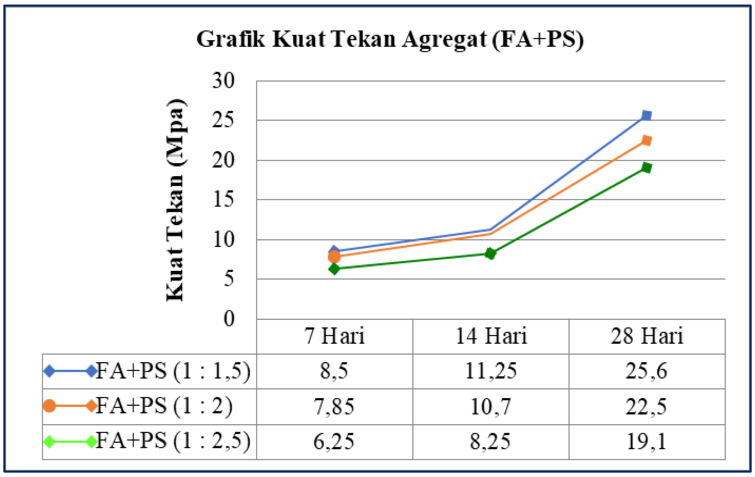

Figure 6. Graph of Compressive Strength of FA+PS Aggregate Mortar

Seen in Figure 6, it is known that the compressive strength of mortar aggregate fly ash + sand (FA+PS) variation (1: 1.5) at 7 days is 8.5 MPa, 14 days is 11.25 MPa, and 28 days is 25.6 MPa. As for the other variations, the compressive strength decreased because the more comparisons to the sand aggregate, the less the addition of the activator. This makes the mortar lighter due to the lack of a binder which results in a lower compressive strength value.

3.6. Coarse Aggregate Wear

The best mixture between (FA+BA) and (FA+PS) with a mixture composition of 1: 1.5 was then carried out a wear test on the artificial material with the result that (FA+BA) has a wear value of 76% while (FA+PS) has 39% wear

Source: M. Farich Azka documentation, 2023

Figure 6. Wear test of coarse aggregate

This proves that artificial aggregate (FA+PS) with a mixture of 1: 1.5 aged 28 days fulfills the appropriate requirements (SNI 03-2471-1991) and is declared suitable for a construction if it has a wear value of less than 40%. However, artificial aggregate (FA+BA) with a mixture of 1: 1.5 aged 28 days was declared not suitable for construction because it had a wear value of more than 40%.

4. CONCLUSSION

From the research results it can be concluded that the characteristics of the new material geopolymer binder course waste fly and bottom ash are as follows :

1. The SSD test results show that each material has a different level of water content with the order of the highest water content in each condition being 3.51% bottom ash, 3.34% sand, and 3.15% fly ash.
2. The specific gravity of the material used is fly ash 2.20, bottom ash 2.51 and sand 2.20. Whereas the mud content of fly ash and bottom ash meets the requirements for building materials because it is less than 5%, but for sand it does not meet the requirements because it is obtained 8.30%.
3. The fineness modulus (FM) of bottom ash is 3.60 mm and that of sand is 2.70 mm so that it is included in the group with a degree of fineness at the allowable limit of 1.5-3.8 according to (SK SNI S-04-1989-F)
4. The best mixture for new materials is between (FA+BA) with a compressive strength of 5.15 MPa and (FA+PS) with a compressive strength of 25.6 MPa at 28 days of age with a mixture composition of 1 : 1.5. As for the mixed wear value (FA+BA) has a wear value of 76% while (FA+PS) has 39% wear.

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