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UTILIZATION OF FLY AND RICE HUSK ASHES WASTE IN THE MAKING OF LIGHTWEIGHT BRICK IN SUPPORTING CONSTRUCTION MATERIALS IN BANYUWANGI

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Abstract. The high specific gravity of concrete, which ranges around 2400 kg/m³, will affect the loading of relatively large and heavy structures. This will affect the total weight of the building which can lead to wasteful dimension of foundations which tend to affect the structural behavior in high earthquake areas; the more the weight of the structure, the greater the effect of the earthquake for the building. One alternative material to reduce the weight of the building is lightweight building materials, such as light brick. This study aims to determine the characteristic properties of mortar which is the lightweight brick base material by using the proportion of fly ash and rice husk ash as a substitute for heavy cement with the addition of aluminium powder and when the duration of steam curing is 6 hours at 60oC. The results of the maximum mortar compressive strength occur in a mixture of PC90%: Psr100%: FA10%: AP0%, which is equal to 13.5 MPa. As for the mortar with added ingredients in the form of aluminium powder, the maximum compressive strength of the mixture of PC90%: Psr100%: FA10%: AP0.2%, which is equal to 5.1 MPa. The correlation between specific gravity and compressive strength of mortar can be seen from the low value of specific gravity and high value of compressive strength on the mortar occurring in a mixture of PC90%: Psr100%: PS10%: AP0% with a value of 1.6 kg / cm2 and 5.1 MPa.

Keywords : Aluminium Powder, Specific Gravity, Compressive Strength, Light Mortar, Steam Curing

1. INTRODUCTION

The weight of big building can result in the dimension of foundation that tends to be wasteful and affect the structural behavior in high earthquake areas: the more the weight of the structure, the greater the effect of the earthquake for the building based on the concept of static earthquake in SNI 03-1726-2002 [1]. Therefore, There are many researches on lightweight concrete to reduce the specific gravity of concrete so the concrete will be lighter and reduce the risk of earthquake. One alternative material to reduce concrete weight is by adding developer substance namely Aluminium Powder, because by adding Aluminium Powder to the mixture, it will occur chemical reaction releasing some gas, and after the mixture hardens, porous structure will be formed so that it will become lighter (Scheffler and Colombo, 2005, in Shofi'ul's research.) [2].

Until now, there have been more innovations developed in making concrete; one is by utilizing waste which is not maximally utilized as the additional substances for concrete such as fly ash and husk ash. The substances in fly ash and husk ash have pozzolan characteristics. It is hoped in this research that the waste used to substitute some of the cement weight can increase the compressive strength of lightweight mortar.

In this research, lightweight concrete will be made into concrete in form of mortar since based on its constituent materials, aerated concrete can be categorized as mortar because lightweight concrete does not use coarse aggregate and with the purpose to get good basic composition so that it can be used later as lightweight concrete brick to be put on the walls.

The treatment process of this lightweight mortar applies steam curing, namely a treatment using water vapor because it can be beneficial in keeping the heat of hydration of the mortar. The purpose of the use of water vapor is to get high initial strength (Paul and Antoni, 2007) [3]. The process of steam curing lasts for 6 hours by the temperature of 60ºC.

2. METHODS

Literature study is done by reviewing journals, books, news, and other sources related to this research, so it can be used as basis of this research as well as references to get expected results. Besides, it is also to learn how to test materials. The examination is carried out in several stages including:

Study on Materials Preparation

This stage is to prepare the material so that research is ready to be carried out. The materials needed for the research are fine aggregate, cement (PC), water, fly ash, husk ash, and aluminium powder.

Test on Materials Characteristics

On the test of materials characteristics, it is carried out specific gravity test and volume weight test for cement (PC); specific gravity test, infiltration water test, mud content test, and sand gradation analysis for fine aggregate; meanwhile for materials like fly ash, husk ash, it is only carried out specific gravity test and gradation analysis.

The Making of Test Specimens

Test specimens are made by using cube in size of 5x5x5 cm. The composition of materials used in making test specimens is in accordance with the planned composition. The composition of lightweight mortar uses the ratio of cement and fine aggregate 1:2,75 with the substitution of some of the cement weight using three kinds of waste and aluminium powder as additional material. The mixture proportion used in making lightweight mortar can be seen in table 1, with the description as follows:

PC= Cement
Psr= Sand
AP= Aluminium powder
FA= Fly Ash
AS= Husk Ash

Table 1: Proportion of Mortar Mixture

Mixture	Code
Normal	A
$PC_{80\%} : Psr_{100\%} : FA_{20\%} : AP_{0\%}$	B
$PC_{80\%} : Psr_{100\%} : FA_{20\%} : AP_{0,2\%}$	C
$PC_{80\%} : Psr_{100\%} : AS_{20\%} : AP_{0\%}$	D
$PC_{80\%} : Psr_{100\%} : AS_{20\%} : AP_{0,2\%}$	E

Treatment of Lightweight Mortar

Treatment of test specimens is done by applying curing steam method. This method is applied by using water vapor which is beneficial in maintaining hydration heat in concrete by reducing hydration heat resulted from chemical reaction between cement and other mortar materials. The treatment is done for 6 hours at temperature of 60^0C.

Lightweight Mortar Test

The tests done on mortar are tests on mortar content weight, specific gravity, and compressive strength.

Analysis of Test Result and Discussion

Results of test on the specimens are noted and it will be discussed the effects and behavior of the lightweight mortar by using fly ash and husk ash as substitution for some of cement weight and the addition of aluminium powder with steam curing treatment at temperature of 60^0C for 6 hours.

3. RESULTS AND DISCUSSION

Results of Material Characteristics Testing

Results of material characteristics testing can be seen in Table 2.

Table 2: Results of Material Characteristics Testing

Material	Characteristic Test	Test result
Fine aggregate	Specific gravity	2,39 gr/cm^3
	Sand Infiltration	3,27 %
	Cleanliness of the mud in a dry manner	4,1 %
	Filter Analysis	Zona 1
Fly Ash	Specific gravity	2,3 gr/cm^3
Fly Ash	Specific gravity	1,79 gr/cm^3

Table 2 shows the testing results of the characteristics of material used as mortar mixture. The value of sand specific gravity is 2,39 gr/cm³. The requirements of aggregates used to make concrete based on SNI-04-1989-F [4] is that the specific gravity of fine aggregate is 2,5-2,7 gr/cm³ so it can be concluded that the sand does not fulfill the requirements. However, this sand is still used as a material in lightweight mortar mixture. Based on the testing of water absorption, the sand does not fulfill the requirements because the good value of water absorption based on ASTM C-128 is maximally 2%. Meanwhile in the testing of dry cleaning sand against mud, the level of mud contained in fine aggregate must not more than 5%, so it can be concluded that the fine aggregate used meet the standards.

The Making of Lightweight Mortar Test Specimen

In this research, mortar was made of the mixture of light pasta + fine aggregate (sand in Setail river, Banyuwangi) with 6 specimens in form of 5x5x5cm-sized cubes for each variant. The test was carried out in the age of 7, 14, 21, and 28 days. Mortar treatment uses steam at the temperature of ±60ºC for 6 hours. The steps of making are as follows:

1. Prepare materials such as fine aggregate, cement, waste, and aluminium powder. Based on SNI 03-6882-2002 [5], the calculation of material needed to make lightweight mortar in form of 5x5x5cm-sized cube for 6 specimens is:
    1. Cement: 0,5 kg
    2. Sand: 1,375 kg
    3. Water: 242 ml

    For the substitution of some of cement weight by using waste, the mixture proportion is in accordance with Table 2.
2. After that, it is done the making of mortar, in accordance with the planned mixture proportion.
3. After the materials are stirred evenly, the mixture then is put into the mold with the amount based on the research needs and is placed in dry place. Then after 24 hours, the mortar is put into steam machine and treatment (curing) is done at the temperature of ±60ºC for 6 hours. The result is visually presented in Figure 1.

Figure 1: The result after the mixture is put into the mold and left for 24 hours.

Making mortar with the addition of aluminium powder will make it expands in ±40 minutes after being put into the mold.

4. The next step is removing the specimen from the mold after it is cold, and the next treatment is by wrapping and soaking it in water. For the specimens which use aluminium powder before the wrapping process, expanded parts are scrapped so that the specimen can be precise. Steamed and wrapped mortar can be seen in Figure 2.

Figure 2: Steamed and wrapped mortar

In picture 2, it is seen hollow and non-hollow mortar surface. Hollow surface mortar is resulted from the effects of the addition of expander material (aluminium powder) which gives air inside. The smaller and more equal the hollow will give the mortar more stable and better value of its compressive strength and weight.

Testing of Lightweight Mortar Characteristics

The testing of lightweight mortar characteristic done is testing of content weight, specific gravity, and compressive strength of mortar. The result recapitulation of content weight testing can be seen in Figure 3.

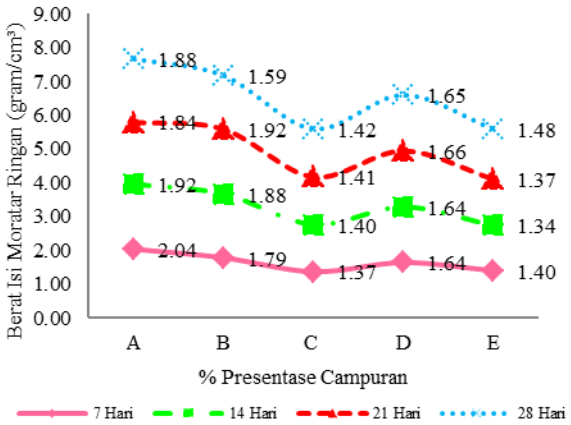

Figure 3: Graphic of Result Recapitulation of Mortar Content Weight Testing

Picture 3 shows the testing result of lightweight mortar content weight is increased and decreased. The decline of the value of mortar content weight occurs in the mixtures containing aluminium powder; they are mixture C and E. The decline in mixture C is 21,96% of the content weight of mortar mixture B and in mixture E is 15,24% of the content weight of mortar mixture D. This is because the usage of additional material in form of aluminium powder will create air bubbles in cement mixture which is called aerated concrete. This is in accordance with statement in a research (Scheffer and Colombo, 2005; in the research of Shofi'ul, et.al. 2014) that by adding aluminium pasta into the mixture, there will be a chemical reaction releasing some gas, and after the mixture hardens, porous structure will be formed so that it will be lighter [2]. Recapitulation of the result of mortar specific gravity testing can be seen in Table 3.

Table 3: Recapitulation of the Result of Mortar Specific Gravity Testing

Mixture	28 Days Testing	
	(gr/cm^3)	(kg/m^3)
Normal (A)	1.91	1910
$PC_{80\%}$: $Psr_{100\%}$: FA $_{20\%}$: AP $_{0\%}$ (B)	1.89	1890
$PC_{80\%}$: $Psr_{100\%}$: FA $_{20\%}$: AP $_{0,2\%}$ (C)	1.49	1490
$PC_{80\%}$: $Psr_{100\%}$: AS $_{20\%}$: AP $0_{\%}$ (D)	1.86	1860
$PC_{80\%}$: $Psr_{100\%}$:AS $_{20\%}$: $AP_{0,2\%}$ (E)	1.59	1590

Table 3 shows the recapitulation of the result of mortar specific gravity testing for testing age of 28 days. The difference of the value of specific gravity is because the mixture used is different. The greatest decline in the result of specific gravity value testing happens in the mixture of $PC_{80\%}$: Psr $_{100\%}$: FA $_{20\%}$: AP $_{0,2\%}$ (C). Lightweight mortars with the additional material in form of aluminium powder (mixture C and E) have fulfilled minimum requirements for the specific gravity of lightweight brick since the value of specific gravity <1800 kg. Meanwhile based on the survey on the specification of lightweight brick at market, from some of lightweight brick producer such as PT. Citicon Bata, PT.Primacon Bangun Persada, CV. Anugrah Ajitama and PT. Facon Interlite have specific gravity value of 550-650 kg/m^3, so it can be concluded that the value of specific gravity produced by lightweight mortar is not in accordance with the value specification of lightweight brick specific gravity at market. Recapitulation of testing result of mortar compressive strength can be seen in Table 3. In table 4, type of mortar compressive strength is based on SNI 02-6825-2002 [6] for testing age of 28 days. Lightweight mortar mixture C and E belongs to mortar category O. This is because the compressive strength value of mixture C and E >2,4 MPa, meanwhile for mixture A, B, and D for testing age of 28 days are in order belongs to N, S, and N types of mortar category. The best quality is dominated by mixture B which uses fly ash since the fly ash which is hydraulic can react by binding free calcium released by cement during hydration process and the effects of lightweight mortar treatment using steam curing so the mixture can get high initial strength. This is proved by mixture A that is treated without using steam and get lower compressive strength value.

Table 4: Result Recapitulation of Mortar Compressive Strength Testing

Mixture	Day Testing (MPa)			
	7	14	21	28
Normal (A)	7.8	8.7	10.1	10.7
$PC_{80\%}$: $Psr_{100\%}$: $FA_{20\%}$: AP $_{0\%}$ (B)	8.7	9.1	12.4	13.5
$PC_{80\%}$: $Psr_{100\%}$: $FA_{20\%}$: $AP_{0,2\%}$ (C)	3.2	4.8	5.1	5.1
$PC_{80\%}$: $Psr_{100\%}$: $AS_{20\%}$: AP $0_{\%}$ (D)	6.5	6.5	6.6	7.4
$PC_{80\%}$: $Psr_{100\%}$: $AS_{20\%}$: $AP_{0,2\%}$ (E)	2.3	2.9	3.1	4.9

Based on survey on the specification of lightweight brick in the market, the bricks produced by some producers such as PT. Citicon Bata, PT. Primacon Bangun Persada, CV. Anugrah Ajitama, and PT. Facon Interlite have compressive strength values from 3,5 MPa to 4,5 MPa. So it can be concluded that the value of compressive strength produced by lightweight mortar already fulfills the specification of compressive strength value of lightweight brick in the market, but the value of specific gravity does not meet the specification. Therefore, lightweight mortar with additional material in form of aluminium powder is still poor in quality. So it is needed the constituent materials of mortar with lighter specific gravity such as fine aggregate.

4. CONCLUSION

The utilization of fly ash and husk ash waste as substitution for cement and the addition of aluminium powder in making lightweight mortar can affect the value of mortar characteristic in testing age of 28 days, in which the values are 1.56 g/cm^3, 1,59 g/cm^3, 1,58 g/cm^3 for specific gravity and 4,2 MPa, 5,1 MPa, 4,9 MPa for compressive strength. So, from the result of the research, it is known that the higher the value of mortar specific

gravity, the higher the value of compressive strength produced. The maximum compressive strength value occurs in the mixture of FA+AP which is equal to 5,1 MPa. In terms of the compressive strength, based on SNI 03-6882-2002 about mortar specification, lightweight mortar belongs to O type since the value of compressive strength is <5,2 MPa.

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