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Increasing Compressive Strength of The Red Brick with Fly Ash and Rice Husk Ash

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Abstract. Red brick is a building material widely used in Indonesia as a non-structural separator wall of a building. Soil is the main material in the production of red bricks. The soil used for the main material of red brick is sandy clay soil. The advantage of red brick is that it is resistant to hot weather or fire because it has undergone the combustion process. However, new innovations are necessary for the red brick manufacturing process due to the reduced soil. The innovation carried out in this study was adding the main material with fly ash and rice husk ash. The purpose of this study was to obtain red brick mixture fly ash and rice husks with increased compressive strength than normal red bricks. The research method used is an experimental method with the addition of fly ash and rice husk ash by 4%, 8%, and 12% of the soil weight. The results obtained from this study are red bricks with fly ash and rice husk ash produced the highest value in the fly ash mixture of 12% (in sample D2) content of 75.07 Kgf / cm² so as to improve the quality of conventional red bricks.

Keywords: Compressive Strength, Fly Ash, Red Brick, Rice Husk Ash, Soil Classification

INTRODUCTION

Red brick is a building material widely used in Indonesia as a non-structural separation wall of a building[1].The building material of red brick is soil. Soil is an important component in development because the soil has a function for construction buffers. Soil consists of several aggregates (granules) of solid minerals and relatively loose deposits that are in bedrock. (Bedrock) [2]. The soil used for the main material of red brick is sandy clay soil. The advantages of red brick are resistant to hot weather or fire because it has undergone a combustion process [3].

The disadvantage of red brick is that it has a low compressive strength and is relatively expensive than light brick which is an alternative to wall making. This makes red bricks less desirable by the community. Therefore, there is a need for innovation in the addition of other materials to get greater compressive strength such as fly ash and rice husk ash. Fly ash is the remaining coal burning ash and contains Silica such as Aluminum, Fe (iron), Ca (Calcium) and Mg (Magnesium), S (Sulfur), Na (Sodium) [4][5]. Rice husk ash is the remaining ash from burning rice husks for the process of burning red bricks.

Some research on the addition of rice husk ash and fly ash material for the manufacture of red bricks. Previous study by [6] shows that the results advocate the use of fly ash as a complementary material to the soil by reducing soil consumption in brick making towards efforts to maintain ecological balance through the development of sustainable natural resources. In previous studies for the highest compressive strength using fly ash 2% [7], 10% [8] and rice husk ash 2% [9]. The method used in this study was an experimental method with the addition of fly ash and rice husk ash of 4%, 8%, and 12% of the soil weight. The importance of finding the best quality in a strong red brick press with various experiments with the addition of materials to the process of making red bricks. With the addition of this material, it is expected to add compressive strength that exceeds the strength of conventional / normal red brick.

METHODOLOGY

Research Methodology

This research employed the experimental method of red bricks with the addition of rice husk ash and fly ash with a percentage of 4%, 8%, and 12%. Test objects in the form of blocks with a size of 23×11.5×5cm or like the shape of bricks sold in the community. The purpose of this research method was to examine the influence of the addition of rice husk ash and fly ash material to the red brick based on previous research theory studies.

Materials

Red brick is made of clay and sandy soil, water with or without mixture [10].The material must meet the material requirements such as soil classification testing. To meet the material requirements, material testing was carried out at the Civil Engineering Laboratory of Kadiri University.

1. Soil

Soil is a material in the form of solid mineral granules that are not cemented. The soil consists of a wide variety of different sizes of particle, can be classified into four groups such as gravel, sand, silt, and clay[11]. One of the problematic soil in the field of construction is clay soil. Clay or clay soil is the result of weathering hard rocks (igneous rocks) that occur naturally during the physical and chemical weathering stages [12]. Clay soil is a type of soil that has certain particles that can produce plastic soil when the soil is mixed with water, generally clay soil measuring less than 0.002 mm[13][14]. Clay soil becomes the basic material for making red bricks with plasticity and dry shrinkage properties. The plastic properties of clay soils are very important to facilitate the process of making bricks. However, if the clay soil is too plastic, it will result in the red brick formed affecting the strength, and the result of burning the red brick. Clay soil is declared suitable for red brick materials when the soil crushed with water is not chewed after being stored for 24 hours without exposure to sunlight, and the soil that is red when burned is very good for red brick materials [15].

FIGURE 1. Soil

2. Fly Ash

Fly ash is a byproduct produced by stone-fired power plants this is considered a clay additive to enhance the effective impact response. [16][6][17]. Silikon dioksida (SiO_2), aluminium Oksida (Al_2O_3), Ferioksida (Fe_2O_3), Kalsium Oksida (CaO), dan Magnesium Oksida (MgO) is the content of fly ash [18][6]. Fly ash and bottom ash are two types of ash derived from the process of burning coal in the steam generation unit (Boiler). [4]. Fly ash can be used as its own material on concrete or as a component of cement mixtures to improve the properties of concrete. Fly ash used is fly ash type F derived from burning from coal bitumen that has pozzolanic properties. [19]. This type of fly ash was chosen because it has a low calcium content and does not interfere with polymerization press. [20].

FIGURE 2. Fly Ash

3. Rice Husk Ash

Burning rice husks produces a chaff ashes that become an increased material for making red bricks. [6][21]. Silica amorphous comes from burning rice husks at temperatures ranging from 400° - 500 °C and turns into crystalline silica at temperatures above around 1000 °C. [9][22][23]. Rice husk ash has a chemical content consisting of 50% cellulose, 25- 30% lignin, and 15-20% silica. [22][6][24]. The binding material and filling of pores to be mixed with other materials is the property of rice husk ash, so that rice husk ash can be used as a binding material in the manufacture of red bricks. [6]. The rice husk ash used comes from burning rice husks produced as factory and power plant rice grates. [24][25].

FIGURE 3. Rice Husk Ash

Job Mix Design Bricks

The provision of proportions and the amount of red brick mixture becomes one of the elements that exist in the process of preparing materials. Red brick should be mixed so that it has the desired consistency and working capabilities. Every variation was present in this study with the addition of fly ash and rice husk ash at levels of 4%, 8%, and 12%.

Compressive Strength

Compressive strength is a test used to obtain the press value of each test object. The red brick's compressive strength is its maximal compressive strength per unit of loaded surface area. [24][25][27]. Compressive strength is sometimes described as a material's resistance to forces that are parallel or perpendicular to its compressive qualities. The formula used to calculate the compressive strength is as follows:

Compressive Strength (Fc') = P/A (1)

Information:

P = Press Force of Machine (Div)

A = Press Field Area (P x l)

FIGURE 4. Universal compressive Test Machine

RESULTS AND DISCUSSION

The results of the study obtained the results of soil classification, strong results of press red brick every percentage

Soil Classification

Soil classification testing is used to obtain the desired type of soil. The results of soil classification testing are obtained as in Table 1.

TABLE 1. Sieve Gradation Analysis

No. Sieve	Diameter Sieve	Retained Soil Mass (gr)	Percentage Held (%)	Percentage of Escape (%)
1,5	38,1	0	0	100
1	25,4	0	0	100
4	4,75	74	7,41	93
10	2,00	210	21,02	72
20	0,84	173	17,32	54
30	0,59	87	8,71	46
50	0,297	248	24,82	21
100	0,149	47	4,70	16
200	0,074	64	6,51	10
Pan	0,04	95	9,51	0
Sum		999		
Soil lost during testing		1		gr

Source: Research Results Data

Table 1. shows the calculation results from the sieve gradation test performed. This table is used to determine the percentage of granules so that data can be obtained from the classification of soil types. From the results of the tests, the amount of soil lost during testing is 1 Kg. The soil classification can be found on the following results:

Based on the data above, soil classification is found based on the USCS (Unified Soil Classification System), soils can be grouped as follows:

Gravel Ø 76,2 s/d 4,75 (mm)	7,41	%
Sand Ø 4,75 s/d 0,075 (mm)	76,58	%
Smooth (Silt and Clay) < 0,075 (mm)	16,02	%
Total	100,00	%

In the USCS classification of soils, based on the percentage of granules that are more than 12% passed the sieve No.200, it was found that the classification of symbols of the group was GC.

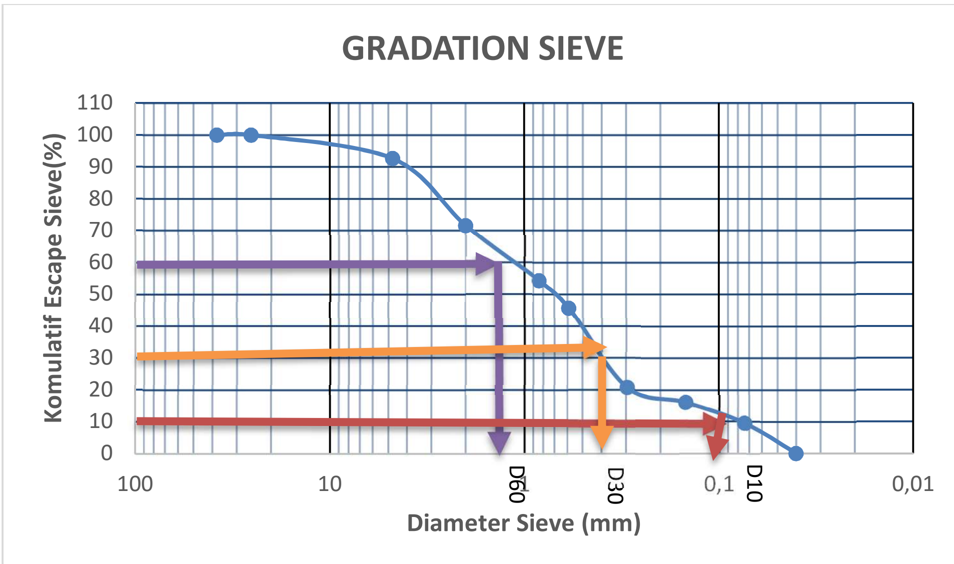

FIGURE 4. GC Soil Sieve Gradation Analysis Graph (Gravel Clay)

Figure 4 shows that the graph of the analysis of the GC (Gravel Clay) soil sieve gradation. It shows the results of D60, D30 and D10 to further calculate the value of the uniformity coefficient (Cu) and the gradation coefficient (Cc) is as follows:

Coefficient Uniformity (Cu) = D60/D10 = 1,10/0,08 = 14.67
Coefficient Gradation (Cc) = D30/(D10×D60) = $0{,}40^2$/ (0,08 × 1,10) = 1,94

From the calculation of the Coefficient of Uniformity (Cu) produces a value of 14.67. And for the calculation value of the Gradation Coefficient (Cc) is 1.94. From these results, obtained the classification of soil USCS, based on the Soil Classification, can be concluded for the value of the group symbol is GC.

Job Mix Design

Job mix design was completed to obtain a proportion of red brick mixture with increasing materials, specifically fly ash and rice husk ash, by 0%, 4%, 8%, and 12%. Job mix design was obtained from the results of research for one sample.

TABLE 2. Mix Design Proportion Bricks with Fly Ash

SAMPLE	SAMPLE RATE	CLAY (gram)	FLY ASH (gram)	WATER (gram)
A	0%	2000	0	270
B	4%	2000	87	270
C	8%	2000	173	270

D	12%	2000	260	270

Source: Data Processed

TABLE 3. Mix Design Proportion Bricks with Rice Husk Ash

SAMPLE	SAMPLE RATE	CLAY (gram)	RICE HUSK ASH (gram)	WATER (gram)
A	0%	2000	0	280
E	4%	2000	87	280
F	8%	2000	173	280
G	12%	2000	260	280

Source: Data processed

From Table 2 and Table 3 shows that the red brick job mix design uses soil with an amount of 2000grams and to get the percentage of the percentage of the increasing material of each sample multiplied by the weight of the soil used.

Result Red Bricks Press Strength Test

Red bricks that have been burned will go through the last process, which was the test process of strong press with normal red brick samples (A), red brick fly ash mixture 4% (B), red brick fly ash mixture 8% (C), red brick mixed fly ash 12%(D), red brick mixed rice husk ash 4% (E), red brick mixed rice husk ash 8%(F), red brick rice husk ash mixture 12%(G).

1. The compressive strength of Red Brick Mixed Fly Ash

The compressive strength test of the red brick press was carried out at the Civil Engineering Laboratory of Kadiri University using the Universal Testing Machine tool. The samples tested were normal red brick, fly ash mixed red brick 4%, 8%, 12% with sample count of 4 test objects.

TABLE 4 Strong Result Press Normal Red Brick and Fly Ash Mixture (4%, 8%,12%)

No	Name Sample	Lengthy (cm)	Width (cm)	Height (cm)	Load (Div)	Surface Area (cm²)	Compressive Strenght (Kgf/cm²)	Compressive Strength Mean
1	A1	11,50	11,50	10,50	7	132,25	52,91	59,33
2	A2	11,50	11,50	10,40	9	132,25	68,03	
3	A3	11,50	11,50	10,30	8,3	132,25	62,73	
4	A4	11,50	11,50	10,50	7,1	132,25	53,66	
5	B1	11,50	11,60	10,80	7	133,4	52,45	54,45
6	B2	11,50	11,60	10,80	7	133,4	52,91	
7	B3	11,50	11,60	10,40	7	133,40	52,00	
8	B4	11,50	11,60	10,80	8	133,4	60,47	
9	C1	11,50	11,70	10,80	4	134,55	30,23	39,13
10	C2	11,50	11,70	10,80	5	134,55	37,15	
11	C3	11,50	11,70	11,40	6	134,55	44,20	
12	C4	11,50	11,70	10,80	6	134,55	44,96	
13	D1	11,50	11,60	10,40	8	133,4	60,47	**62,53**
14	**D2**	**11,50**	**11,60**	**10,80**	**9,5**	**133,4**	**75,07**	
15	D3	11,50	11,60	10,80	7	133,4	55,31	
16	D4	11,50	11,60	10,80	7,5	133,4	59,26	

Source: Data processed

Results of the test calculation of standard red brick compressive strength and fly ash combination of 4%, 8%, and 12% are shown in Table 4. From the results of each data, the 4 samples obtained the largest compressive strength result on the 12% mixed red brick of 62.53 Kgf/cm2. The results of Table 4 are outlined on the following compressive strength graph.

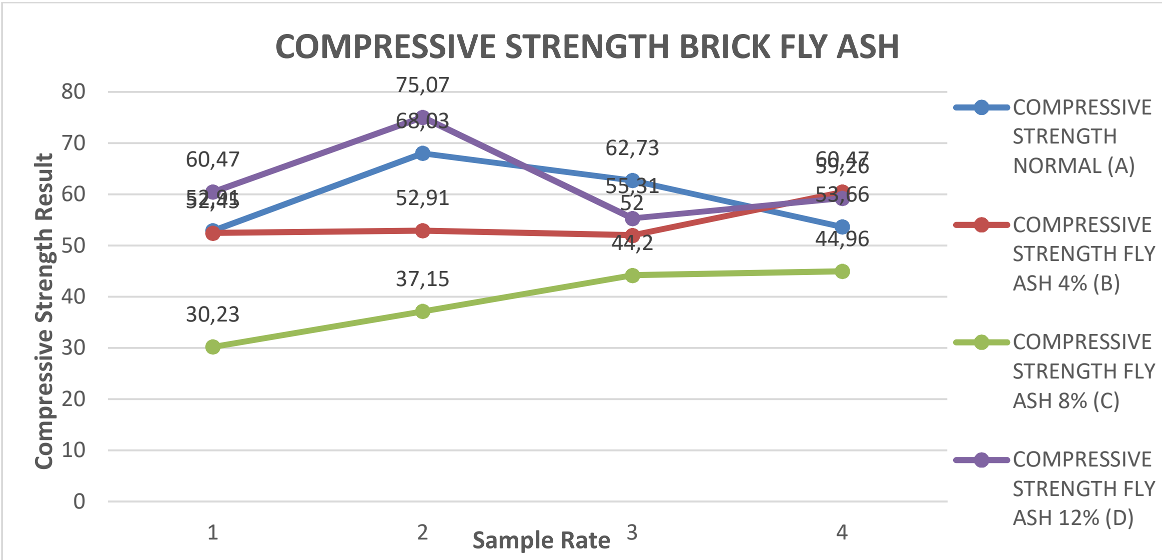

FIGURE 5. Compressive Strength Graph of Red Brick Mixed Fly Ash 0%,4%,8%,12%

Figure 5 shows a graph of the test results of the compressive strength test. The highest value that occurs in the D2 test object is 75,07 Kgf/cm².

FIGURE 6. The compressive strength of Fly Ash Mixed Red Brick

2. The Compressive Strength of Red Brick Mixed Rice Husk Ash

The compressive strength test of the red brick press was carried out at the Civil Engineering Laboratory of Kadiri University using the Universal Testing Machine tool. The sample tested was a normal red brick, a mixed red brick rice husk ash 4%, 8%, 12% with a sample number of 4 test objects.

TABLE 5. Strong Results Press Normal Red Brick and Rice Husk Ash Mixture (4%, 8%,12%)

No	Name Sample	Lengthy (cm)	Width (cm)	Height (cm)	Load (Div)	Surface Area (cm²)	Compressive Strenght (Kgf/cm²)	Compressive Strength Mean
1	A1	11,50	11,50	10,50	7	132,25	52,91	**59,33**
2	**A2**	**11,50**	**11,50**	**10,40**	**6**	**132,25**	**68,03**	
3	A3	11,50	11,50	10,30	8,3	132,25	62,73	
4	A4	11,50	11,50	10,50	7,1	132,25	53,66	

5	E1	11,65	11,50	10,50	6	133,975	44,77	39,17
6	E2	11,65	11,50	10,30	7	133,975	52,23	
7	E3	11,65	11,50	10,30	3	133,975	22,38	
8	E4	11,65	11,50	10,50	5	133,975	37,31	
9	F1	11,65	11,50	10,50	6,50	133,98	48,50	44,58
10	F2	11,65	11,50	10,50	6,50	133,98	58,20	
11	F3	11,65	11,50	10,50	6,50	133,98	29,84	
12	F4	11,65	11,50	10,50	6,50	133,98	41,78	
13	G1	11,50	11,50	10,50	5	132,25	37,31	26,11
14	G2	11,50	11,50	10,50	3	132,25	22,38	
15	G3	11,50	11,50	10,50	4	132,25	29,84	
16	G4	11,50	11,50	10,50	2	132,25	14,92	

Source: Data processed

The results of the test for the compressive strength of a 4%, 8%, or 12% mixture of rice husk ash and a standard red brick press are shown in Table 5. From the results of each data, the 4 samples obtained the largest average compressive strength result on normal red bricks 59,33 Kgf/cm^2. The results of Table 5 are presented on the following compressive strength graph.

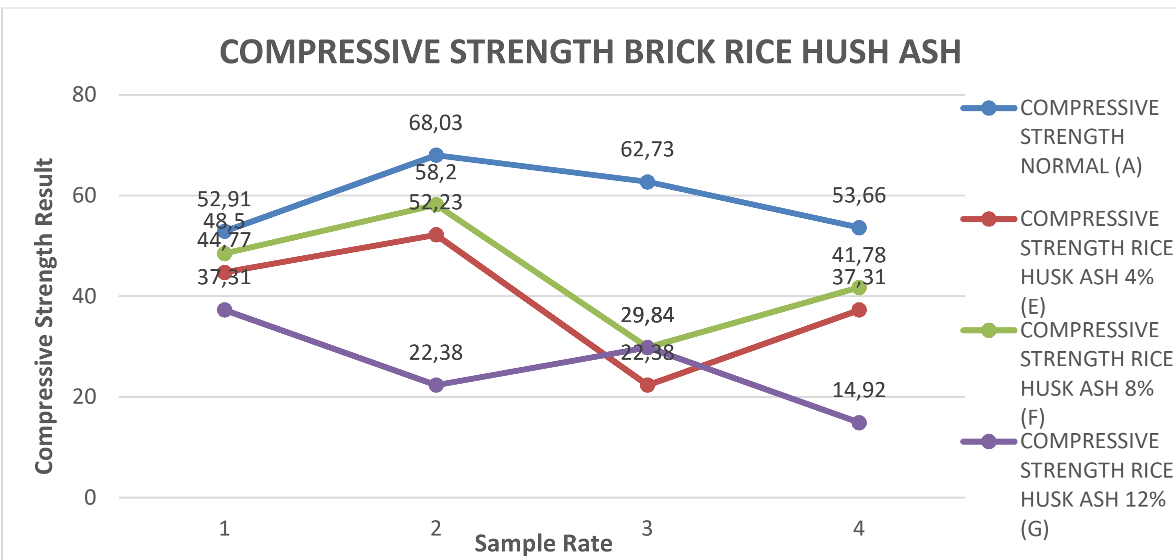

FIGURE 7 Compressive Strength Graph of Red Brick Mixed Rice Husk Ash 0%,4%,8%,12%

Figure 7 shows a graph of the test results of the compressive strength test. The highest value that occurs in the A2 test object is 68,03 Kgf/cm².

Figure 8. The compressive strength of Red Brick Mixed Rice Husk Ash

CONCLUSION

According to the study's findings, a red brick mixture with fly ash and rice husk ash produced strong results, with the fly ash mixture having the highest value at 12% (Sample D2) at 75.07 Kgf / cm2 to enhance the quality of traditional red bricks and provide another option to the mixed material used to make red bricks.

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