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Ideal mortar composition with rice husk ash addition and addictive for maximum mortal strength

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Abstract.
The intensity of earthquakes increases from time to time both in number and in strength; recently, in Indonesia, damage to buildings by earthquake acceleration usually begins with damage to walls. Besides having a function as a barrier between spaces in construction, walls also have an essential role in increasing a building structure's rigidity. Mortar, which is usually used as a wall and plastering, has a role as a binder between the walls themselves' components so that quality mortar will help the walls be stronger. This research aims to produce the ideal mortar mixture with low price, high quality, and easy to obtain material. The proposed added composition was husk ash and Fosroc SP 337 additive, varied based on cement's weight. The yield of mortar with added ingredients will be compared with ordinary mortar without added ingredients. The specimens' manufacture used 20 samples of 5cm x 5cm x 5cm cubes with five variations of mortar composition, and mortar compressive strength testing was carried out at 7, 14, and 28 days of age. The maximum compressive strength obtained for mortar with the addition of 15% rice husk ash, 1% fosroc sp 337, and the combination of the two experienced an increase in the compressive strength value, the ratio of the average compressive strength of the mortar, the highest average compressive strength results in the mixture 1 PPC cement: 4 Sand with the addition of 15% rice husk ash: 1% fosroc sp 337 with an average compressive strength yield of 116.6 kg / cm² at the age of 7 days, 145.6 kg / cm² at the period of 14 days and 154.6 kg / cm² at the age of 28 days.

Keywords: Compressive Strength, Rice Husk Ash, Earthquake Intensity

I. INTRODUCTION

Indonesia is a country that is passed by the world's ring of fire with the potential for earthquakes and tsunamis. The Indo-Australian plate movement in the western part of Indonesia is 7mm / year, and the movement of the Pacific plate in Eastern Indonesia is 12mm / year[1]. This movement's magnitude indicates that each plate is moving actively, with the number of earthquakes that occur per year is 1200 times with an intensity> 4 on the Ritcher scale.[2].

West Sumatra is one of the provinces located in Indonesia's western part. Geographically, West Sumatra province has three earthquake sources that can generate large-scale earthquakes that can cause tsunamis at sea. On the mainland of West Sumatra's island, a fault line is known as the faulth line that runs from Singkarangk, Padang Panjang, Padang, and Painan along 500 km [3][4]. Earthquake data from 1779-2019 shows that the characteristics of the earthquake that occurred were earthquakes with large magnitude because this earthquake was a shallow earthquake such as in 1928 (Mw8.4), 1933 (Mw9.3), 1981 (Mw8.1), and 2007 (Mw8. 4). One of the major earthquakes that occurred in the last ten years was an earthquake that occurred in 2009 with a magnitude of 7.9 on the ritcher scale at a depth of 71 km southwest of the city of Padang. This earthquake incident caused 1117 victims died, 2 people were missing, and 1214 people were seriously injured [5].

Building damage due to earthquake vibrations is influenced by building blocks themselves, namely the walls. Walls have a vital role both as non-structure and structure, namely increasing structural strength [6], good quality mortar dramatically affects the strength of the walls, strong walls will increase the rigidity of the building structure because it functions as a binder for the walls [7][8].

The ideal composition innovation for the quality of the mortar is always carried out, such as the addition of UHPC material [9], foam agent [10], bagasse silica[8], and coconut shells[11]. This

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research proposes the ideal mixture composition for mortar using additives that are inexpensive, easy to obtain, and have high compressive strength. The proposed solution's composition uses added materials, namely husk ash and additive Fosroc SP 337, which is varied based on the weight of cement. Manufacturing and testing procedures follow existing standard specifications[12]

I.1 Mortar

Mortar is a mixture of fine aggregate (sand) materials, adhesive material (clay, lime, portland cement), and water with a specific composition either with added or without added ingredients. The following is the mortar used in the construction world, such as brickwork adhesives in walls, adhesive or plastering, and tile installation. The quality of the constituent materials influences the mortar's quality, the excellent quality of mortar must follow the standards for material selection and manufacturing standards [13] [14].

The following are the building blocks of the mortar used in this study:

1. Composite Portland Cement (PCC)
   The composite Portland cement used is the cement production of Padang cement, which has the specifications for Padang cement that meet the SNI 15-7064-2004 requirements [15].
2. Fine Aggregate
   In this study, the fine aggregate was used sand from the Nagari Buayan river flow, Batang Anai District, Padang Pariaman Regency, West Sumatra Province.
3. Add Materials
   a. Chemical Additives
      The added chemical material used is the type SP 337, which aims to increase the workability of the mortar and optimal compaction, provide higher strength without increasing cement content or reducing workability, reduce shrinkage cracking due to lower water-cement ratio and improve the durability and impermeability of the mortar.
   b. Natural Additives
      The natural added material used is rice husk ash taken from the KUD in Padang. Rice husk ash is perfect as an added material because it is dominant silica. The addition of rice husk ash aims to increase the strength of the mortar [16][17][18].
4. The water used is water that meets colorless, smelly, and tasteless requirements. The water used is taken from the building materials laboratory and the Padang State University road.

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I.2 Rice Husk Ash and Additives *SP 337*

Rice husk ash is the final rice product, which results from agriculture. Rice husk ash has a high silica content, which is very suitable for mortar additive [17][18]. The silica (SiO2) content in rice husk ash is 80.4% [19]; the utilization of silica content in rice husk ash has long been used as an added material or as a substitute for cement as Portland in the manufacture of mortar and concrete [18]. Rice husk ash will react with cement to improve the mortar's quality and reduce the cement reaction temperature [19]. Additive SP 337 is a chemical mixture used as an additive to speed up the response so that it is expected to obtain the desired quality at the beginning of the cement binding period.

Some of the implementation procedures in this study are as follows: 1. The material mixture proportion for the test object refers to the number of samples to be made for each test age., 2. Mixing mortar., 3 The ingredients for the mortar are mixed and stirred with a standard mixer ASTM C 305 for about 3-5 minutes., 4. Water retention according to ASTM C 91, for mortar made in the laboratory must be the same material and mixture for construction purposes., 5. Compressive strength mortar must consist of ingredients in the mixture proportion to be used in the construction with an adequate amount of mixing water to result in discomfort (110 ± 5)%.

The calculation of the compressive strength of the mortar is obtained based on the formula:

$$f'c = \frac{P}{A}$$

Where :
$f'c$ = the compressive strength of the mortar, in MPa
P = total maximum load, in N
A = area of the loaded surface, in mm²

II. METHOD

The research procedure used is as follows (Figure 1).

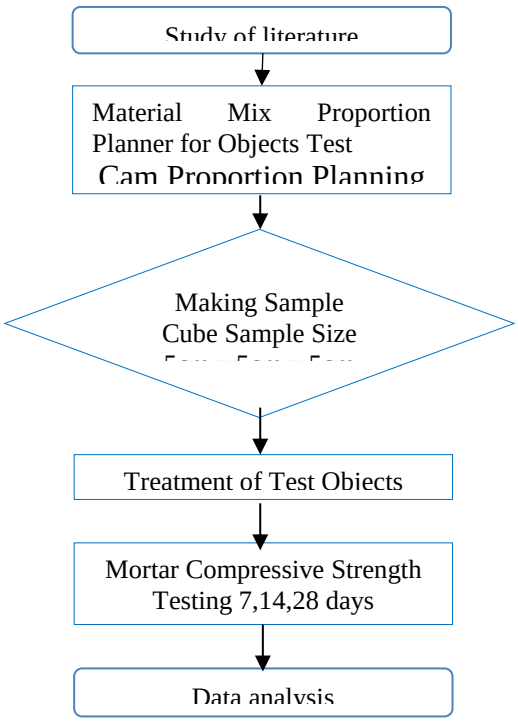

Figure 1. The flow of Research Procedures

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The research was conducted at the Building Materials Laboratory, Department of Civil Engineering, Padang State University. The composition of the mixture used is in table 1.

Table 1. Research Sample

Mixed Proportion Type
1 PCC Cement: 4 Sand (without additives)
1 PCC Cement: 15% Rice Husk Ash: 4 Sand
1 PCC cement: 1% Fosroc SP 337: 4 Sand
1 PCC Cement: 15% Rice Husk Ash: 1% Fosroc SP 337: 4 Sand

Making mortar specimens using cube molds with a size of 5 cm x 5 cm x 5 cm of 20 pieces, the number of samples for each composition is five samples of objects and tested at 7, 14, and 28 days.

The mold's opening is carried out after 24 hours, the treatment of the test object (curing), the treatment of the mortar is done by immersing it in a tub filled with water. Treatment of mortar specimens aims to keep moisture and heat constant during hydration. After soaking, the test object is removed from the soaking tub and placed in a humid place 24 hours before the test, which is at the planned age of the mortar compressive strength test at 7, 14, and 28 days.

Mortar compressive strength testing was carried out at the age of 7, 14, and 28 days using a universal testing machine (UTM). The test results on each day for mortar with additives will be compared with mortar without added ingredients as a comparison.

III. RESULTS AND DISCUSSION

The mixture's composition is calculated according to the plan for the mortar's desired quality without added ingredients or with added ingredients. The following is the composition of a mortar mixture consisting of a comparison mortar without added ingredients and a plan mortar with added ingredients. The composition of each mortar is as follows:

Table 2. Comparator standard mortar (without added ingredients)

	PCC cement	Sand
Proportion to volume	1	4
Load weight (kg / m3)	1250	1400
Modifying factors	0.446	0.446
Material Weight (g)	558	2498

Table 3. Mortar with added materials of Fosroc SP 337)

	PCC cement	Fosroc SP 337	Sand
Proportion to volume	1	1%	4
Weight is i (kg / m3)	1250	1250	1400
Modifying factors	0.446	0.446	0.446
Material Weight (g)	558	5,575	2498

Table 4. Mortar with added ingredients (Rice Husk Ash)

	PCC cement	Rice Husk Ash	Sand
Proportion to volume	1	15%	4
Weight is i (kg / m3)	1250	1250	1400
Modifying factors	0.446	0.446	0.446
Material Weight (g)	558	187.5	2498

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Table 5. Mortar with added material (Fosroc SP 377: Rice Husk Ash).

	PCC cement	Fosroc SP 337	Rice Husk Ash	Sand
Proportion to volume	1	1%	15%	4
Load weight (kg / m3)	1250	1250	1250	1400
Modifying factors	0.446	0.446	0.446	0.446
Material Weight (g)	558	5,575	187.5	2498

Making the test object using a cube molding with a size of 5 cm x 5 cm x 5 cm as much as 20 with a specification of the proportion of the mixture of materials for the test object (gram / l). Curing or treatment is carried out until the test life. The compressive strength test is carried out at the age of 7, 14, 28 days to determine the maximum strength for each day; the test results are as follows:

1. Compressive strength of control mortar

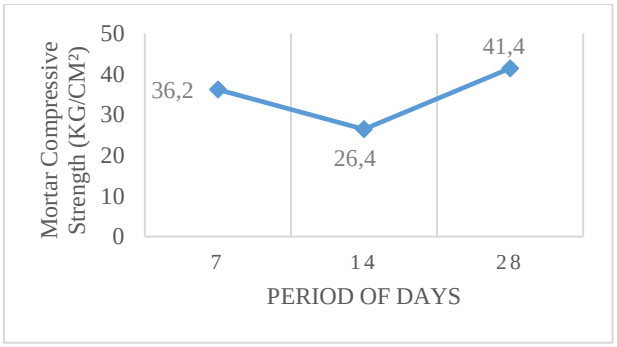

Figure 2. Average compressive strength of control mortar vs concrete age.

Based on the results of data analysis (Figure 2) from the compressive strength test with a mixture of 1 cement PCC: 4 sand, it was obtained that the average compressive strength was 36.2 kg / cm² at the age of 7 days, 26.4 kg / cm² at the age of 14 days and 41.4 kg / cm² at 28 days of age. The average compressive strength decreased at the period of 14 days of mortar, where the compressive strength at the age of 14 days should be higher than at the age of 7 days.

The graph (figure 3) shows that the compressive strength with a mixture of 1 PPC cement: 15% rice husk ash: 4 Sand results in average compressive strength of 43.6 kg / cm² at the age of 7 days, 54 kg / cm² at the period of 14 days and 69.2 kg / cm² at the age of 28 days.

2. The compressive strength of the mortar is 15% rice husk ash

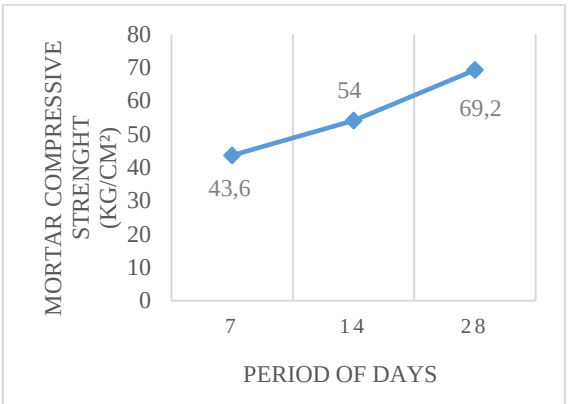

Figure 3. The average compressive strength of mortar 15% rice husk ash vs mortar age.

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3. The Compressive strength of mortar 1% Fosroc SP 377.

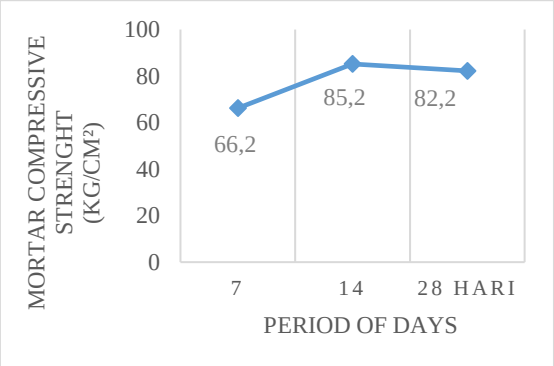

Figure 4. The average compressive strength of 1% Fosroc SP 337 mortar vs mortar age.

Based on the results of data analysis (Figure 4) from the compressive strength test with a mixture of 1sement PPC: 1% fosroc sp 337: 4 Sand, it was obtained that the average compressive strength was 66.2 kg / cm² at the age of 7 days, 85.2 kg / cm² at the age of 14 days and 82.2 kg / cm² at the period of 28 days.

Graphs (Figures 2, 3, 4, and 5) obtained the average compressive strength of control mortals aged seven days, namely 36.2kg / cm², age 14 days, namely 26.4 kg / cm², and 28 days of age, namely 41.4 kg / cm². The average compressive strength of mortar with 15% added material of rice husk ash at the age of 7 days was 43.6kg / cm², 14 days is 54 kg / cm², and the period of 28 days is 64.2 kg / cm². The average compressive strength of the mortar uses added ingredients1% Fosroc SP 337 at the age of 7 days was 66.2 kg / cm², at the period of 14 days was 85.2 kg / cm² and at the duration of 28 days was 82.2 kg / cm². The average compressive strength of the mortal with the added material is 15% husk ash rice and 1% Fosroc SP 337 at the age of 7 days was 116.6 kg / cm², age 14 days is 145.6kg / cm², and the age of 28 days is 154.6kg / cm².

4. The compressive strength of mortar is 15% rice husk ash + 1% Fosroc SP 337

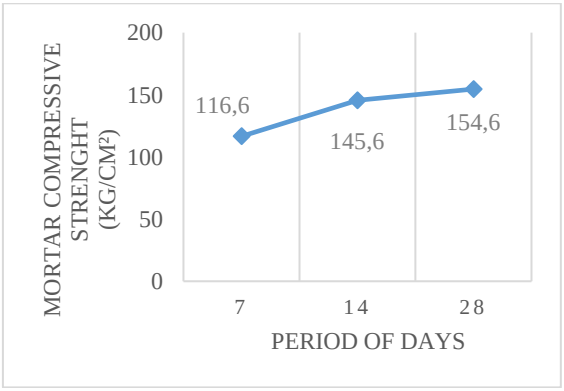

Figure 5.The average compressive strength of mortar 15% rice husk ash + 1% fosroc SP 33

Based on the mortar compressive strength test results with a mixture of PCC cement, rice husk ash, fosroc sp 337, and sand, it was found that the variations in the results from 4 different specimens obtained good results. In this test, before making the test object, the mixture's proportion of ingredients is calculated first. The calculation of the ratio of the mix of ingredients is carried out to ensure that the materials used are in accordance with the plan for the mixture of components to be made in the manufacture of mortar. After calculating the proportion of the mixture, the test object is created.

The addition of rice husk ash and fosroc sp 337 can be used as a reference for other researchers because it can improve the quality of mortar both at the age of 7, 14, and 28 days. Incorporation of

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added materials fosroc sp 337 and husk ash is recommended because it has water control properties to regulate the rapid absorption of water.

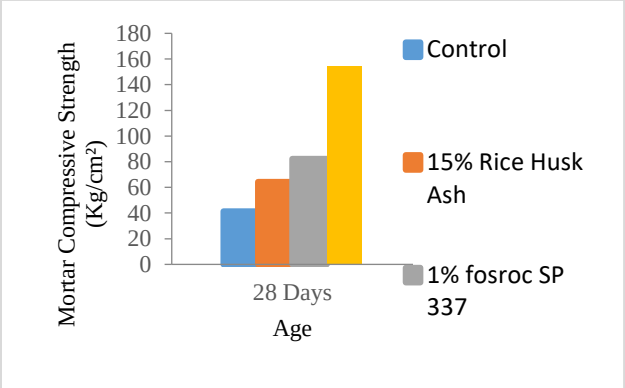

Figure 6. Graph of Comparison of Mortar Compressive Strength to Mixture Proportion

Based on the comparison of compressive strength from 4 different variations of specimens, the compressive strength of the control mortar was 41.4 kg / cm², the addition of 15% rice husk ash obtained a compressive strength value of 64.2 kg / cm². Furthermore, the addition of 1% fosroc sp 337 obtained a compressive strength value of 82.2 kg / cm² and mixing 15% rice husk ash with 1% fosroc sp 337 received a compressive strength value of 154.6 kg / cm². Thus the proportion of a mixture of mortar constituents is good to use one cement PCC: 15% rice husk ash: 1% fosroc sp 337: 4 sand.

IV. CONCLUSION

In the compressive strength research carried out on mortar with the addition of 15% rice husk ash, 1% fosroc sp 337, and the combination of the two experienced an increase in the compressive strength value, the ratio of the average compressive strength of the mortar, the highest average compressive strength results in the mixture 1 PPC cement: 4 Sand with the addition of 15% rice husk ash: 1% fosroc sp 337 with an average compressive strength yield of 116.6 kg / cm² at the age of 7 days, 145.6 kg / cm² at the period of 14 days and 154, 6 kg / cm² at 28 days of age.

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