The Effect of Rice Husk Ash

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The Effect of Rice Husk Ash and Sulfatic Acid Solutions on The Setting Time and Compressive Strength of Mortar

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Abstrak. This study aims to determine the effect of rice husk ash (RHA) as an ingredient added to mortar to the setting time and compressive strength of mortar. The article also studies about the effect of the sulfuric acid solution on the setting time and compressive strength of mortar. Quantitative research using an experimental approach to making mortar samples at various RHA levels is 0%, 3%, 6%, 9% and 12%, each of the 16 test objects. The mortar properties tested setting time and compressive strength. The results of the analysis show that the using of RHA in mortar production caused the shorter of setting time. The compressive strength of mortar at 6% variation produces optimal results. The compressive strength of ordinary mortar at 28 days was 6 MPa, while the maximum compressive strength of 6% variation was 6.25 MPa. The use of pH4 a water causes differences in setting time and mortar compressive strength. The acidity of the mixing water causes the cement to bind faster but causes a decrease in the compressive strength of the mortar.

Keywords: setting time, compressive strength, cement substitution

1. Introduction

The construction industry in Indonesia is developing along with the development of science and technology. Building construction serves as an essential role in human life with the construction of housing, offices, factories, buildings, hotels, and hospitals. One proof of the progress of the construction industry is the optimal use of materials in economic aspects. Therefore, there are various efforts to utilize waste material as a primary material for composing concrete. One such waste material is rice husk ash (RHA) as a residual material in rice production.

Indonesia as an agrarian country where the majority of the population make rice as a staple food, and rice production is evenly distributed throughout the homeland. Rice production in 2015 amounted to 75.40 million tons of dry grain or increased by 4.55 million tons (6.42%) compared to 2014. The increase in production was driven by the expansion of harvested land covering an area of 379.18 thousand ha (3.22%). In the rice milling process, there was a waste in the form of rice husk ash. Based on data on the amount of rice production, it is predicted that the volume of waste in the form of rice husks is 15 million tons per year [1][2].

Rice husk ash, is the result of the residual combustion of rice husk, has a dominant silica content of 93% and almost the same silica content found in factory-made micro silica. It is usually used as rubbing ash in the washing of household appliances, carbon sources, filter media, porous media, and hydroponic plant media. During the process of changing rice husks to ash, burning removes organic substances and leaves silica-rich leftovers [3]. RHA utilization can reduce Portland cement use. Rice husk ash with silica contents (SiO_2) has the same characteristic as Portland cement. Rice husk ash is beneficial to increase mortar quality because it has pozzolanic properties, namely silica. Having a useful element to improve the quality of concrete, contains very prominent silica, and if this element is mixed with cement will produce a higher strength.

Mortar which is a mixture consisting of fine aggregate, adhesive material (rice husk ash, Portland cement) and water. The mortar function is as a matrix binder of the part of a construction such as on a split stone pair for a pair of foundations or a pair of bricks for filler walls. Quality mortars have strength and durability and become a protective concrete (structure) to water [4]. Also, the quality of mortar can be reduced due to acid attack from the environment. Therefore, this study describes the quality of mortar using RHA by simulating the presence of acid disturbances from the environment. This study aims to determine the effect of rice husk ash (ASP) as an added mortar material on the binding time and compressive strength of mortar. Furthermore, making mortar samples also by using the maximum pH water to the binding time and compressive strength of mortar.

2. Research Method

The study is an experimental study supported by laboratory test results. The study was conducted at the Structure and Material Laboratory of the Department of Civil Engineering and Planning, Faculty of Engineering, Universitas Negeri Makassar. Mortar maker components are cement and rice husk ash as binding material, fine aggregate (sand) and water. Cement used is Portland Cement Composite (PCC) locally produced medium cement RHA composition as much as 0%, 3%, 6%, 9% and 12% of the weight of cement. Fine aggregate in the form of sand comes from Bili-bili, Gowa Regency, as a result of a sieve with a No. 4 sieve (4.8 mm). Aggregate testing refers to the American Society for Testing Materials (ASTM). Mixing water in the process of making mortar is clean water that does not contain oil, alkaline acids, salts, organic substances that can damage mortar and paste. The sulfuric acid to determine the effect of acid condition on mortar compressive strength.

Mixed design method (mix design) used by standard mix for mortar method, namely; Japanese Industrial Standard (JIS) R 5201 Physical Testing Methods for Cement. Furthermore, the process of mixing mortar forming material is carried out using a mortar mixer. The specimen consists of variations in rice husk ash substitution namely; 0%, 3%, 6%, 9% and 12% based on testing for 7 days, 14 days, 21 days and 28 days. Test object in the form of cubes with a size (5x5x5) cm. Substitution variations and time periods which are the matrix of the number of samples in this study can be shown in Table 1, and the heavy composition of mortar constituents is presented in Table 2.

Table 1. Number of mortar test items with the treatment of RHA

Age (days)	Number of samples				
	0% RHA	3% RHA	6% RHA	9% RHA	12% RHA
7	4	4	4	4	4
14	4	4	4	4	4
21	4	4	4	4	4
28	4	4	4	4	4
Sub-total	16	16	16	16	16
Total			80		

Table 2. The composition of mortar constituents according to mortar material

Material	Percentage of RHA				
	0% RHA	3% RHA	6% RHA	9% RHA	12% RHA
Portland cement	43	43	43	43	43
RHA	-	1.29	2.58	3.87	6.45
Sand	215	215	215	215	215
Water	219	219	219	219	219

The setting time test aims to determine the time needed for cement material to harden, starting from starting to react with water and becoming a cement paste until the cement paste is rigid enough to withstand pressure. The setting time of cement is divided into 2, namely the initial setting time and the setting time. The normal consistency value is when the penetration needle reaches ten ± 1 mm while the initial setting time is 25 ± 1 mm.

Testing the compressive strength of mortar aims to determine the compressive strength of mortar in a cube or cylinder. The compressive strength of mortar is the ratio of the load to the cross-sectional area of the mortar, carried out using compressive strength with a capacity of 1000 kN. Measuring the compressive strength of mortar is done by applying pressure to mortar and paste specimens in the form of cubes (5x5x5) cm. Maximum compressive load when the test specimen is broken is divided by the cross-sectional area of the test object is the value of the compressive strength of the concrete expressed in units of Mpa or N mm^{-2}. The compressive strength test was carried out at the age of 7, 14, 21, and 28 days. The formula for calculating compressive strength is used as follows:

$$F' = \sigma = P/A$$

Information:

- F' = Compressive strength of mortar (Mpa)
- σ = Strength (Mpa)
- P = Pressure load (N)
- A = Mortar cross-sectional area mm^2

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3. Result and Discussion

3.1 Setting a time test

Testing of setting time was done by using the Vicat test tool, intended as a reference to determine the consistency of mortar. The time of mortar binding is carried out every 15 minutes and until the mortar undergoes final binding to produce an appropriate proportional variation of the mixture used [5]. The setting time test results with various RHA variations are presented in Figure 1.

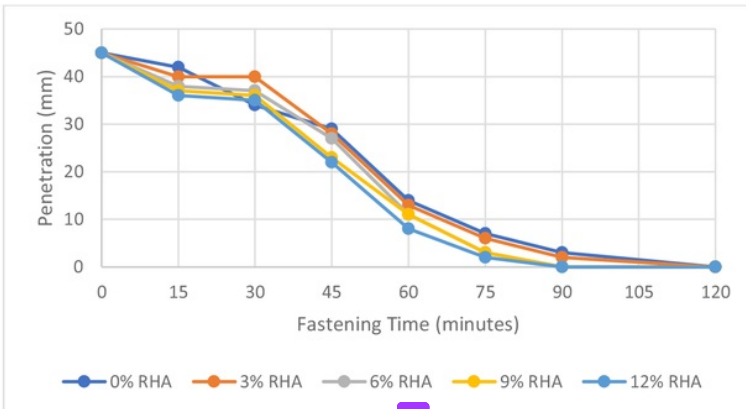

Figure 1. Test results for setting time of mortar

The results of the setting time test result in the penetration depth of the Vicat tool needle. The final tie time is marked by the penetration depth of 0 mm. The testing results of the setting time for 9% RHA and 12% RHA were 90 minutes while 6% RHA was 105 minutes. In the 0% sample and 3% RHA, the setting time value is 120 minutes. The setting time testing results indicate that the addition of RHA causes a difference in the bonding time of mortar. The binding time increases due to the addition of rice husk ash due to the presence of silica in rice husk ash.

3.2 Mortar compressive strength test

The results of mortar compressive strength testing with a percentage variation of RHA are presented in Table 3.

Table 3. Results of mortar compressive strength test

RHA (%)	Compressive strength (MPa)			
	7 days	14 days	21 days	28 days
0%	4.25	5.0	5.75	6.0
3%	4.25	5.0	6.00	6.20
6%	4.50	5.25	6.25	6.25
9%	4.25	4.75	5.75	5.75
12%	3.75	4.00	5.50	5.00

Table 3 shows that mortar samples without RHA material produced compressive strength at 28 days 6 MPa. Variations in the addition of 3% rice husk ash (RHA3) obtained mortar compressive strength 6.20 MPa, 6% (RHA6) obtained 6.25 MPa, 9% (RHA9) obtained 5.75 MPa and 12% (RHA12) obtained 5 MPa. Optimal use of RHA is obtained in the composition of 6% RHA or with the highest compressive strength.

3.3 Variation of 6% RHA and sulfuric acid water pH 4 on the setting time of mortar

The simulation of an acid attack against mortar is done by making 6% RHA mortar samples and pH4 mixing water. The results of the setting time test on 6% variation of rice husk ash using pH four water can be seen in Figure 2.

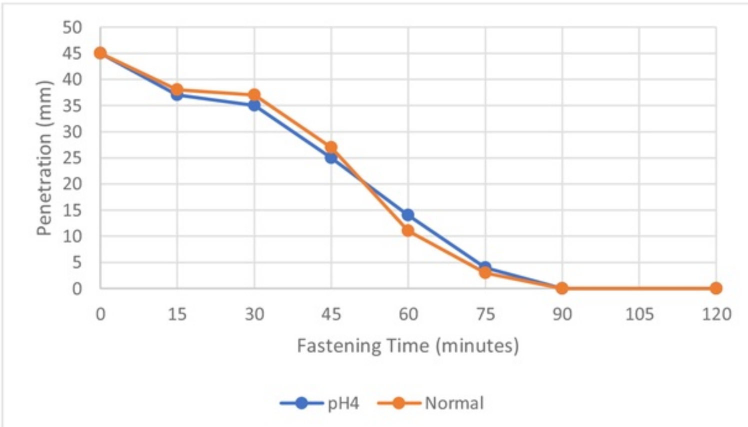

Figure 2. The results of the comparison of the setting time mortar with regular water and pH4 water

Figure 2 shows that mortar with 6% RHA produces penetration differences at minute 60. The use of pH four water causes faster cement binding compared to a mortar with ordinary water. The time of mortar binding is influenced by the quality of the material including the use of water which must be conditional as a concrete material.

3.4 The compressive strength of mortar in 6% RHA with sulfuric acid water pH 4

Test the compressive strength of mortar with pH4 mixing water compared to a mortar with ordinary water is presented in Table 4.

Table 4. Comparison test of the compressive strength of mortar (6% RHA) at the pH4 water and regular water

Mortar age (days)	Compressive strength mortar with regular water	Compressive strength mortar with pH 4 water
7	4.50	4,5
14	5.25	5,20
21	6.25	5,70
28	6.25	6,10

The compressive strength of mortar with PH4 shows lower compressive strength compared to a mortar with regular water. The use of water with high acidity causes a decrease in concrete compressive strength. The acidity of the water causes a weakening of the cement matrix bond and affects its compressive strength. Rice husk ash is pozzolan that contains silica minerals. With these properties, the RHA which acts as a cement substitute can improve mortar performance. The use of waste in mortar production supports carbon reduction that occurs in the cement industry. This type of mortar is categorized as green concrete.

4. Conclusion

The use of RHA in mortar production causes changes in the setting time of mortar. The higher the percentage of RHA causes an earlier setting time or mortar or harden faster. The compressive strength of mortar at 6% variation produces optimal results. The compressive strength of ordinary mortar at 28 days was 6 MPa, while the maximum compressive strength of 6% mortar was 6.25 MPa. The use of pH 4 mixing water causes differences in mortar setting time and concrete compressive strength. The acidity of the mixing water causes the cement to bind faster but causes a decrease in the compressive strength of the concrete.

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