THE EFFECT OF USING HIGH VOLUME FLY ASH (HVFA) ON THE PROPERTIES OF FRESH MORTAR

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Abstract: This study aims to understand the effect of using High Volume Fly Ash (HVFA) on the properties of fresh mortar. Mortar properties such as cement paste setting time, fresh mortar flow value, and mortar compressive strength were tested in this study. The results showed that the higher the fly ash content used in the mixture, the longer the paste setting time occurred. The initial bonding time of the cement paste with the control specimen, fly ash content of 0, 50 and 75% occurred at the 131st minute, 17.5th minute, 15th minute and 28th minute, respectively. The final binding time of the control sample cement paste, fly ash content of 0, 50 and 75% occurred in the 210th minute, 50th minute, 70th minute and 95th minute, respectively. The results showed that the use of High-Volume Fly Ash (HVFA) could increase the workability of fresh mortar. This is evidenced by the use of fly ash 50% causes an increase in flow value as much as 20.5% and the use of fly ash 75% causes an increase in flow value as much as 42.7%. Research proves that the higher the fly ash content used in the mixture, the lower the compressive strength value produced by the mortar. The results of the compressive strength test of HVFA mortar with control sample specimens, fly ash content of 0, 50 and 75% respectively were 16.6 Mpa, 6.3 Mpa, 5.2 Mpa, and 4.5 Mpa.

Kata Kunci: HVFA, fresh mortar, setting time, compressive strength

1. INTRODUCTION

Along with population growth in Indonesia, the need for housing is increasing which causes the need for building materials to also increase. The most commonly used construction is concrete construction, which in its application uses a large amount of cement. This causes an increase in air pollution caused by the release of CO_2 gas during the cement production process.

In this study, the authors will use fly ash as an additive to mortar mix using the High-Volume Fly Ash (HVFA) method which was first introduced at the Canadian Center for Mineral and Energy Technology (CANMET) in 1985 (Malhotra & Mehta, 2002). High Volume Fly Ash (HVFA) is a method of mixing concrete or mortar with a fly ash content of 50% or more of the amount of cement used.

SNI 2460:2014 defines fly ash as a fine residue resulting from burning or crushing a type of coal. The use of fly ash as an additional construction material is useful for reducing the use of cement and reducing the environmental impact of waste disposal. High Volume Fly Ash (HVFA) as a mixture of concrete or mortar has the potential to save waste treatment costs and can increase the workability, strength, durability of concrete or mortar (Kurniawati & Sofianto, 2019).

The results of the Naibaho & Rahman (2020) study used variations in fly ash levels of 0, 25, 50, 75 and 100%, only variations of fly ash 0, 25 and 50% that could be tested for compression. The specimens with 75% and 100% fly ash variations failed the compression test because they were destroyed during the curing process. The value of the compressive strength of mortar at the age of 7 days with a variation of 0% as much as 19.36 Mpa, a variation of 25% as much as 20 Mpa, and a variation of 50% as much as 10 Mpa. Research and observations carried out by Sengkey, S.L; Irmawati, R;

Hustim (2020) proved that the flow mortar value decreased with the higher molarity of NaOH and Na2SiO3 ratio and the lower the ratio of activator/fly ash.

In this study, fly ash will be used as a substitute for cement in the mortar composition. The activator used is 3M NaOH solution. The levels of use of fly ash are 0%, 50% and 75% of the total weight of cement. The tests carried out were testing the bonding time, mortar workability (flow) and compressive strength.

SNI 03-6825-2002 states that portland cement mortar is made from a certain ratio of quartz sand, distilled water, and portland cement. The quartz sand used must comply with ASTM C-190 which contains a silica mineral content of at least 90 percent. Water distillation is the process of removing impurities from water by heating it to a sufficiently high temperature.

The purpose of mortar is to increase bonding and bond resistance between various building components. Mortar is used in masonry, plastering, ceramic tiling, and other building construction applications. Cement mortar has a volume ratio of cement and fine aggregate between 1: 2 to 1: 8. Determination of the ratio of the cement mortar mixture is determined by the conditions or parts of the construction to be built. Mortar must have a standard thickness in order to withstand the compressive force caused by the weight of the load (Mulyono, 2005).

2. METHOD

2.1 Material

The materials for the mortar in this study used Tiga Roda brand PCC cement, Lumajang sand, 3M NaOH solution activator from PUDAK SCIENTIFIC powder NaOH dissolved in distilled water, class C fly ash from PT. Gresik Petrochemicals. The results of the XRF (X-Ray Fluorence) fly ash test conducted by Sari, et al in 2016 in Maulidiyawati (2017) stated that the content of SiO2 + Al2O3 + Fe2O3 in fly ash PT. Petrokimia Gresik is as much as 64.27%. So that the fly ash belongs to class C.

2.2 Sample Making and Testing

The initial stage of making the test object is to prepare the materials that will be used in the test. Followed by basic tests such as mud content, sieve analysis, specific gravity of aggregates, and also testing the normal consistency of cement. Testing of basic materials needs to be carried out to ensure that the materials to be used for research are in accordance with the provisions of SNI.

The manufacture of mortar samples begins with the manufacture of 3M NaOH solution, where the weighed NaOH powder is put into a glass beaker and then dissolved with distilled water of the total volume of the solution to be made. Then the concentrated NaOH solution was put into a volumetric flask and distilled water was added until the volume was 1000 ml and stirred until dissolved and then allowed to stand for 24 hours in the volumetric flask. After 24 hours, the volume of the solution is checked whether it is 1000 ml exactly, if the volume of the solution is shrinking it is necessary to add water. After ascertaining the appropriate volume, the solution is stored in a closed container.

The procedure for making samples for the setting time test is carried out based on SNI 2049:2015 regarding portland cement. The prepared cement paste is then shaped into a ball and thrown six times with a distance of about 15 cm from one hand to the other. Then the paste ball was inserted into the vicat ring and flattened, then allowed to stand for 30 minutes before penetrating the vicat needle every 15 minutes.

The procedure for making samples for the test of fresh mortar and mortar compressive strength is carried out based on SNI 03-6825-2002 regarding the method of testing the compressive strength of portland cement mortar for civil works. The fresh mortar test is carried out by filling the melt ring with mortar until it is completely filled. The filling is carried out in two layers, each of which is compacted 20 times with a compactor. The melting ring is slowly removed and the melting table is vibrated 25 times for 15 seconds. The mortar diameter was then measured in four different places and the average mortar diameter and mortar flow value were calculated.

Making cube specimens for compressive strength testing is done by pouring mortar into a mold that is smeared with lubricant. The mold is filled in two layers, each of which is compacted 32 times with four rotations within 10 seconds, then the specimen is allowed to stand for 24 hours. After 24 hours the cube mold can be removed and the test object is immersed in clean water for 7 days. When going to be tested, the test object is drained for 15 minutes and the surface is dried with a cloth then the dimensions and weight of the test object are measured. The test object is placed on a pressing machine, and pressed with a constant force until the test object breaks. The maximum compressive force acting when the specimen breaks is measured, then the density and compressive strength of the specimen are calculated, and finally averaged.

Table 1. Komposisi Campuran Mortar

No	Sample Code	Percentage Fly Ash	Cement	Fly Ash	Sand	Water	NaOH 3M	Quantity of Samples
			(gram)	(gram)	(gram)	(ml)	(ml)`	
1	P	0	450	0	1350	225	-	6
2	P0	0	450	0	1350	-	225	6
3	P50	50	225	225	1350	-	225	6
4	P75	75	112,5	337,5	1350	-	225	6
Total of Samples								24

3. RESULTS AND DISCUSSION

3.1 Setting Time Test Results

The setting time test was carried out on three variations of the fly ash mixture and one control variant. Based on SNI 2049:2015, the initial binding time occurs when the decrease is 25 mm and the final binding time occurs when the vicat needle is not immersed in the paste. The data on the results of the binding time test are presented as follows:

Table 2. Setting Time Recapitulation

Sample Code	Initial Setting Time (minutes)	Final Setting Time (minutes)
P	131	210
P0	17,5	50
P50	15	70
P75	28	95

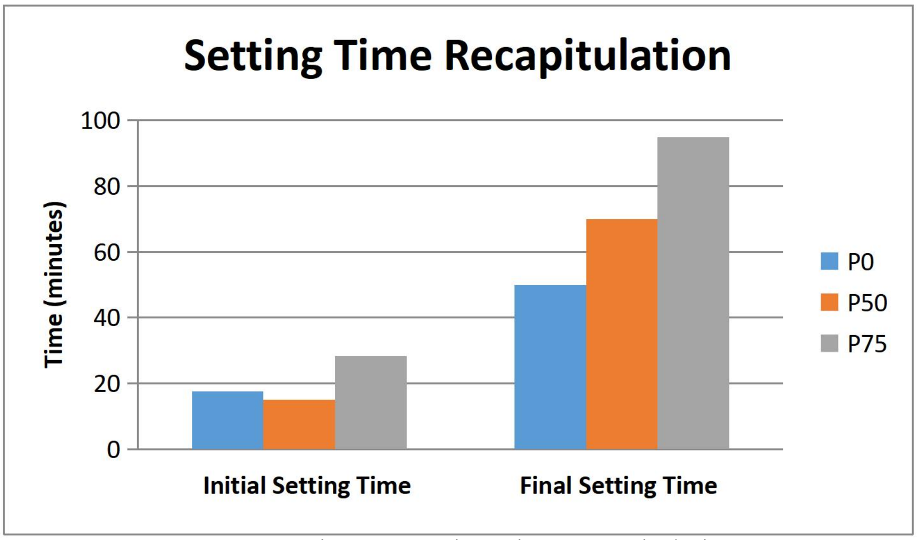

Figure 1. Diagram Setting Time Recapitulation

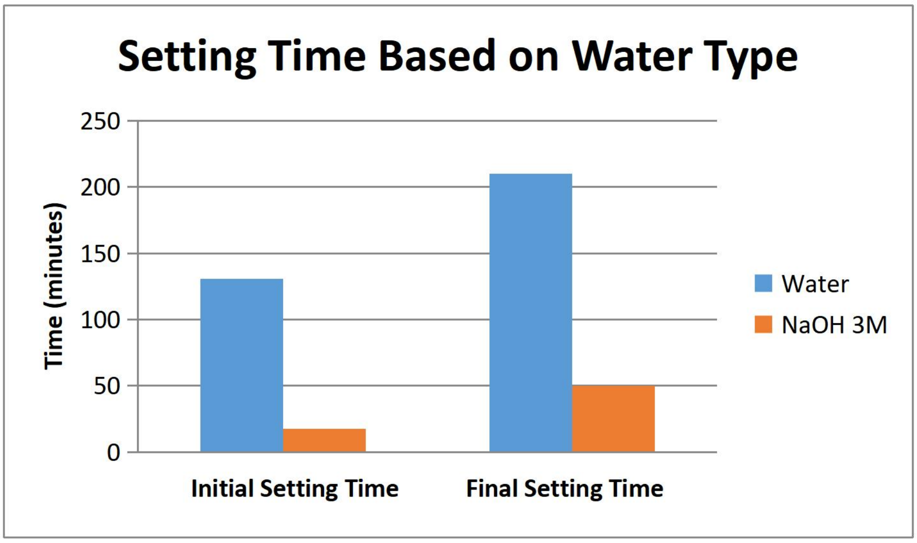

Figure 2. Diagram Setting Time Based on Water Type

Judging from the diagram in Figure 1, it can be concluded that the more fly ash used from the total weight of cement, the longer it takes for the paste to harden. Based on the diagram in Figure 2, it can be concluded that the initial setting time and the final setting time of the paste with a mixture of 3M NaOH solution occurred 81.4% faster than the paste with a mixture of plain water. This is because NaOH is an alkaline activator that can stimulate the reaction of silica compounds in the binder so as to speed up the hardening time of the paste (Ghosh & Ghosh, 2012).

3.2 Fresh Mortar Testing Result (Flow Test)

Fresh mortar testing (flow test) was carried out on three variations of the mortar mixture and one control variant. The properties of fresh mortar are determined from the value of workability or workability of the mortar carried out by the flow test. Where mortar workability is the ease with which a mortar mix can be worked. The requirement for flow value is between 1.05 - 1.15 or experiencing a widening of 105% - 115% (SNI 03-6825-2002).

Table 3. Fresh Mortar Testing Result (Flow Test)

Sample Code	P	P0	P50	P75	Unit
Initial Diameter (D_0)	9	9	9	9	cm
Diameter 1 (D_1)	12,5	12	12,7	13,2	cm
Diameter 2 (D_2)	12,9	11,9	12,5	13	cm
Diameter 3 (D_3)	12,6	11,8	12,5	13,2	cm
Diameter 4 (D_4)	12,5	12	12,4	13,3	cm
Average Diameter (D_5)	12,63	11,93	12,53	13,18	cm
Flow = $(D_5 - D_0)/(D_0) \times 100\%$	40,28	32,50	39,17	46,39	%

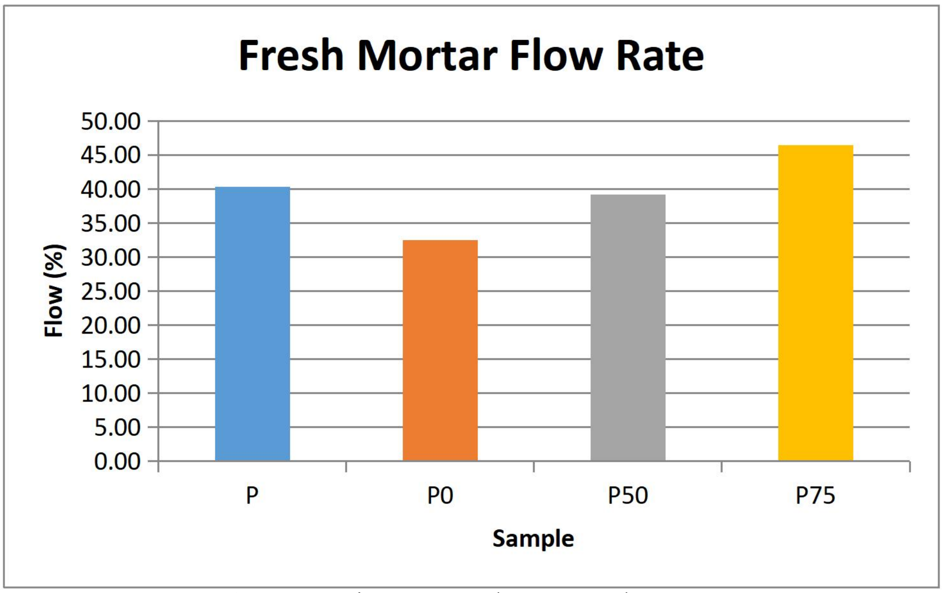

Figure 3. Diagram Fresh Mortar Flow Rate

Judging from the diagram in Figure 3, it can be concluded that the higher the fly ash content used from the weight of the cement, the smoother the mortar mixture will be. The use of fly ash 50% causes an increase in the flow value as much as 20.5% and the use of fly ash 75% causes an increase in the flow value as much as 42.7%.

However, it is necessary to pay attention to the processing time if an activator such as NaOH is added to the mixture, because the addition of NaOH concentration will accelerate the mortar hardening time so that the flow value decreases (Sengkey, S.L; Irmawaty, R; Hustim, 2020). So to facilitate the implementation in the field, it is necessary to add admixture to slow down the hydration process.

3.3 Mortar Compressive Strength Test Results

The compressive strength test of mortar was carried out on three variations of the mortar mixture and one control variant, where each variant amounted to 6 test objects. The compressive strength test of mortar was carried out at the age of 7 days with a cube-shaped sample measuring 50 x 50 x 50 mm. The mortar compressive strength test step refers to SNI 03-6825-2002.

Table 4. Average Compressive Strength and Mortar Density Test Results for Each Variant

Sample	**P**	**P0**	**P50**	**P75**
Compressive Strength (f_c), MPa	16,6	6,3	5,2	4,5
Density (ρ), g/cm^3	2,161	2,167	2,153	2,151

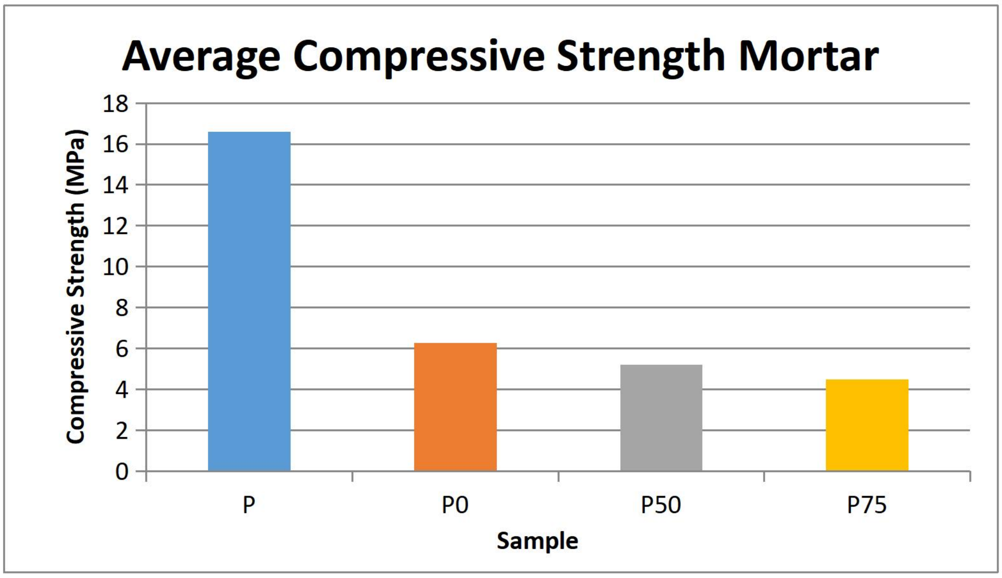

Figure 4. Diagram Average Compressive Strength Mortar

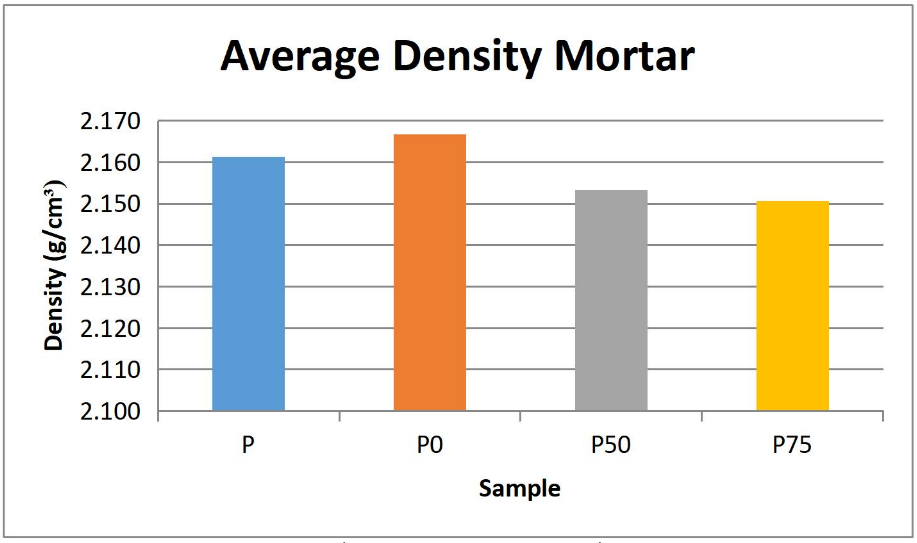

Figure 5. Diagram Average Density Mortar

Based on the diagram in Figure 4, the relationship between fly ash content and the compressive strength of mortar is presented. The fly ash content is inversely proportional to the compressive strength value. The greater the level of fly ash used, the smaller the value of the resulting compressive strength. This is evidenced by the difference in the compressive strength of mortar between 0% and 50% levels, which is 1.1 Mpa, and between 50% and 75% levels, which is 0.7 Mpa.

From Figure 4, it is known that mortar with a mixture of plain water has a compressive strength value of 7 days greater than the mortar with a mixture of NaOH solution. This should not happen because the addition of NaOH should accelerate mortar pavement. Judging from the density, it can be seen in Figure 5 that the density of each variant does not have much difference.

Another possibility that causes a decrease in the compressive strength of mortar with a mixture of NaOH solution is the occurrence of errors during the process of making NaOH solution. In this study, before being tested for compression, the test object was not coated with a cap first. This can cause the pressure obtained by the mortar to be uneven because the surface of the test object is uneven so that the results are less accurate.

4 CONCLUSION

Based on this research, it can be concluded that the use of High Volume Fly Ash (HVFA) affects the properties of fresh mortar and its compressive strength. The higher the fly ash content in the mixture, the longer the bonding time will occur. The initial setting time of the HVFA cement paste from the four test specimens with the control sample, fly ash content of 0, 50 and 75%, respectively, occurred at the 131st minute, 17.5th minute, 15th minute and 28th minute. The final setting time of cement paste with the control sample, fly ash content of 0, 50 and 75% occurred in the 210th minute, 50th minute, 70th minute and 95th minute, respectively.

The use of High Volume Fly Ash (HVFA) can increase the workability of fresh mortar. This is evidenced by the addition of 50% fly ash causing an increase in flow value as much as 20.5% and the use of fly ash 75% causing an increase in flow value as much as 42.7%.

The higher the fly ash content used in the mixture, the lower the compressive strength value produced by the mortar. The results of the test of the compressive strength of the HVFA mortar with the four control samples, fly ash content of 0, 50 and 75%, respectively, were 16.6 Mpa, 6.3 Mpa, 5.2 Mpa, and 4.5 Mpa.

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