

Comparison of The Use of Type V and Type I Cement with Fly ash as Cementitious in Concrete against Chloride Ion Penetration using The Accelerated Method

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ABSTRACT

Concrete is a composite material of several rock materials glued together by a binder. Concrete is formed from mixed aggregates (fine and coarse) and added with cement paste. This research was conducted by making concrete test objects by comparing normal type I cement concrete, concrete with added materials fly ash cement type I, and normal concrete type V in the form of a cube with a size of 15 x 15 x 15 cm for testing compressive strength and a measure of 5 x 10 cm for testing chloride ion penetration also porosity testing. This study indicates that the addition of fly ash 40% (Mix II) has a compressive strength above normal type V cement concrete (Mix III), adds resistance, and reduces the passing current and the voids in the concrete are less than normal type I cement concrete. However, it is less than normal type V cement concrete (Mix III) and is more economical than normal type V cement concrete (Mix III), normal concrete of both types of cement (Mix I and Mix II).

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1. INTRODUCTION

Most of the earth's surface is the ocean. It contains enormous natural resources and means to meet human needs. It starts from food sources such as fish and marine plants and energy sources such as oil and wave power plants. The definition of an aggressive environment by [1–4] defines an aggressive environment in concrete as an environment that is prone to chemical attack, including chloride attack, sulfate attack, carbonic acid, and seawater environment. Such an environment causes abrasion of the concrete and corrosion of concrete reinforcement [5–8].

The addition of additional materials (admixture) or type V cement in concrete mixes to prevent the damage that occurs [1, 9–11]. The use of pozzolan in the form of fly ash can help control the temperature rise of the concrete at an early age. The use of this material results in the initial strength of the concrete being reduced—the use of pozzolan in the form of fly ash is influenced by differences in area and origin. Using chemical admixture can improve and control the strength value and slump loss and produce good strength, better durability, and improved workability [12].

According to Mehta [13], in principle, fly ash comes from the electric steam power plant, the raw material for pozzolan that can be used well as a component of cement mixtures in portland or as a mineral admixture in concrete. The fly ash is generally limited to 15% - 20% of the total cement mass. Usually, this amount has a beneficial effect on the workability and economic cost of the concrete but is not sufficient to increase the resistance to sulfate attacks. Thus, to produce higher durability, it is applied through high volume fly ash concrete, a concrete mixture containing more or equal to 50% fly ash of the total mass of cement with low water content [11]. Therefore, we tried to compare the use of type V and type I cement with high volume

fly ash concrete as cementitious on concrete against chloride ion penetration using the accelerated method, ASTM C 1202-91[14].

2. MATERIALS AND METHOD

The research method is a sequence of activities that include data collection, engineering process, sample testing, and continued concluding. The stages of research need to be carried out to obtain answers to the formulation of the problem from the research to be carried out in the laboratory using a flow chart to smooth the research process under the planned stages[14, 15, 24–26, 16–23].

For usage percentage of fly ash, i.e., 40% of the weight binders (cement and fly ash) and will be compared with concrete without fly ash (normal type I cement) as well as without fly ash (normal type V cement), coarse aggregate, fine aggregate. Then used, the test object was in the form of a cube with dimensions of 150 x 150 x 150 mm. The workshop location will be carried out at the PT. SCG Readymix Indonesia, in the Indonesian construction industry, makes cube test objects with a test time of 3 days, seven days, 14 days, 21 days, and 28 days then test the concrete compressive strength, chloride ion penetration, and porosity. The following research flowchart can be seen in Figure 1.

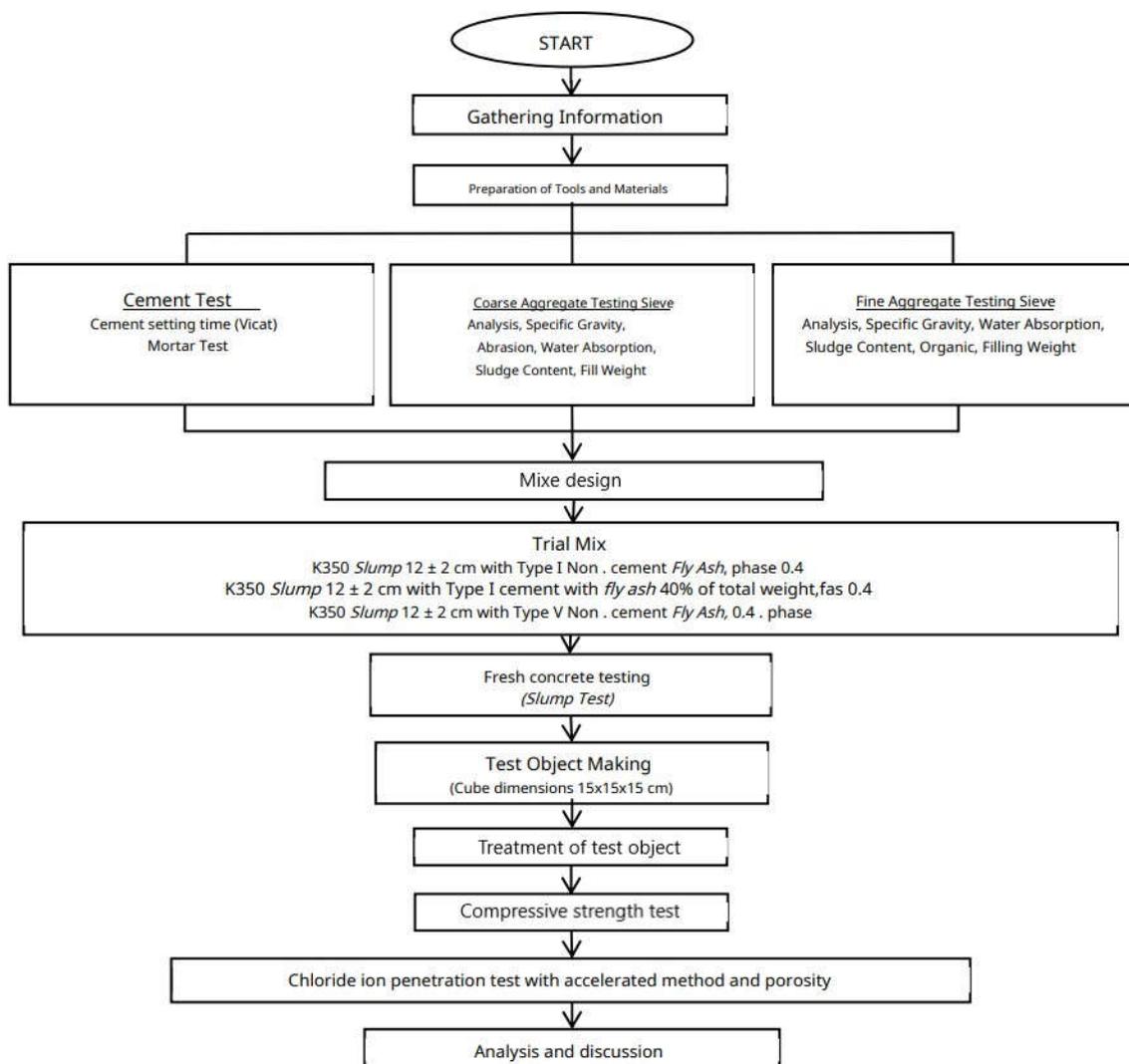


Figure 1. Research flowchart.

3. RESULTS AND DISCUSSION

3.1. Aggregate Inspection

This study has been determined in the previous chapter on fine and coarse aggregates, namely *Palangkaraya* sand and sand split *Rumpin*. The examination of each aggregate is described by the following Table 1.

Table 1. Result of aggregate inspection.

TESTING	FINE AGGREGATE (EX. PALANGKARAYA)		RUDE AGGREGATE (EX. RUMPIN)	
	Results	Standard	Results	Standard
Mud Content (%)	2,713	Max 5	0.7	Max 1
Organic Content	No.3	Max 3	-	-
Grain Hardness (%)	-	-	21,205	Max 27%
Fine Grain Modulus (FM)	2.79	2.3 – 3.1	6.55	6.0 – 7.1
Specific Gravity (SSD) (Gram/cm ³)	2,593	Min 2.5	2,602	Min 2.5
Absorption (%)	2.438	Max 5	1.377	Max 5

Source: own studied (2022).

3.2. Cement Inspection (Cement Tie Time with Vicat)

The *Gresik* and *Holcim* cement bonding times for each type and the complete type are presented in Figure 2.

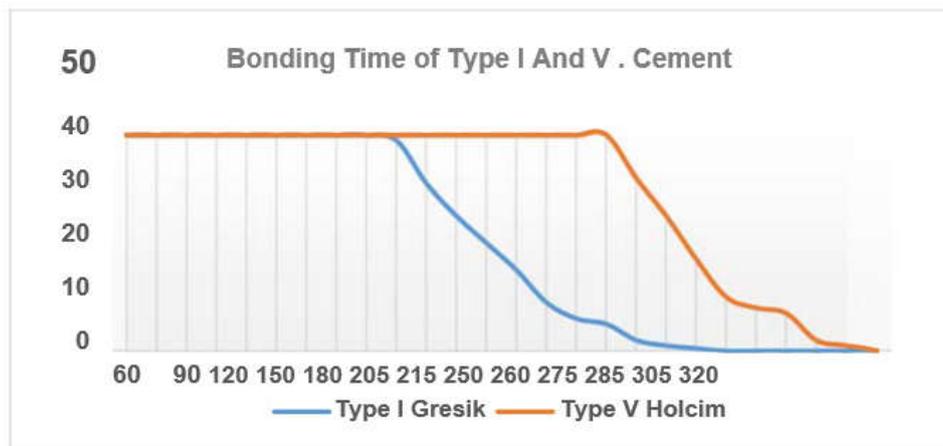


Figure 2. Result of cement inspection.

Based on Figure 2, the initial setting time for type I cement *Gresik* for 213 minutes and type V for 275 minutes, the final setting time for type I cement for 285 minutes and type V cement *Holcim* for 328 minutes.

3.3 Cement Mortar Test

For testing, the compressive strength of normal cement mortar is presented in Table 2. Based on the respective compressive strength test attachments.

Table 2. Result of cement mortar test.

Type	3 days	7 days	28 Days
NFA Type I Mortar (Non-Fly Ash)	237.2 Kg/cm ²	250.0 Kg/cm ²	325.4 Kg/cm ²
Type I FA mortar (Fly Ash) Type V	139.1 Kg/cm ²	195.1 Kg/cm ²	277.9 Kg/cm ²
FA Mortar (Non-Fly Ash)	133.0 Kg/cm ²	207.3 Kg/cm ²	281.6 Kg/cm ²

Source: own studied (2022).

3.4. Mix Design

The following Table 3 shows the result of this research's mix planning (mix design).

Table 3. Result of mixed design.

Material	Source	Mix I	Mix II	Mix III
		K350 Cement Type I Non Fly Ash (Gresik)	K350 Cement Type I Fly Ash 40% (Gresik)	K350 Cement Type V Non Fly Ash (Holcim)
Cement (Kg/m ³)	<i>Gresik</i>	460	254	497
Fly Ash (Kg/m ³)	<i>Suralaya</i>	-	169	-
Water (Kg/m ³)	<i>Bid</i>	184	169	199
Sand (Kg/m ³)	<i>Palangkaraya</i>	685	684	657
Split 4.75/25 mm (Kg/m ³)	<i>Rumpin</i>	1030	1029	989
Admixture Type D (litter/m ³)	<i>BASF</i>	1.84	1.02	1.99

Source: own studied (2022).

Based on Table 3, before the trial mix, the material was checked; namely, the water content contained in each material, which can be seen in Table 4, and the result of mix correction can be seen in Table 5.

Table 4. Water content value.

Description	Sand	Split 4.5/25 mm
	<i>Ex. Palangkaraya</i>	<i>Ex. Rumpin</i>
Absorption %	2.438	1.377
Water Content (MC) %	4048	0.624

Source: own studied (2022).

Table 5. Result of mix correction.

Material	Source	Mix I	Mix II	Mix III
		K350 Cement Type I Non Fly Ash (Gresik)	K350 Cement Type I Fly Ash 40% (Gresik)	K350 Cement Type V Non Fly Ash (Holcim)
Cement (Kg/m ³)	<i>Gresik</i>	460	254	497
Fly Ash (Kg/m ³)	<i>Suralaya</i>	-	169	-
Water (Kg/m ³)	<i>Bid</i>	181	166	196
Sand (Kg/m ³)	<i>Palangkaraya</i>	696	695	667
Split 4.75/25 mm (Kg/m ³)	<i>Rumpin</i>	1022	1021	982
Admixture Type D (litter/m ³)	<i>BASF</i>	1.84	1.02	1.99

Source: own studied (2022).

Knowing the value of concrete crack and slump loss is necessary for completing the mix correction result, as shown in Figure 3.

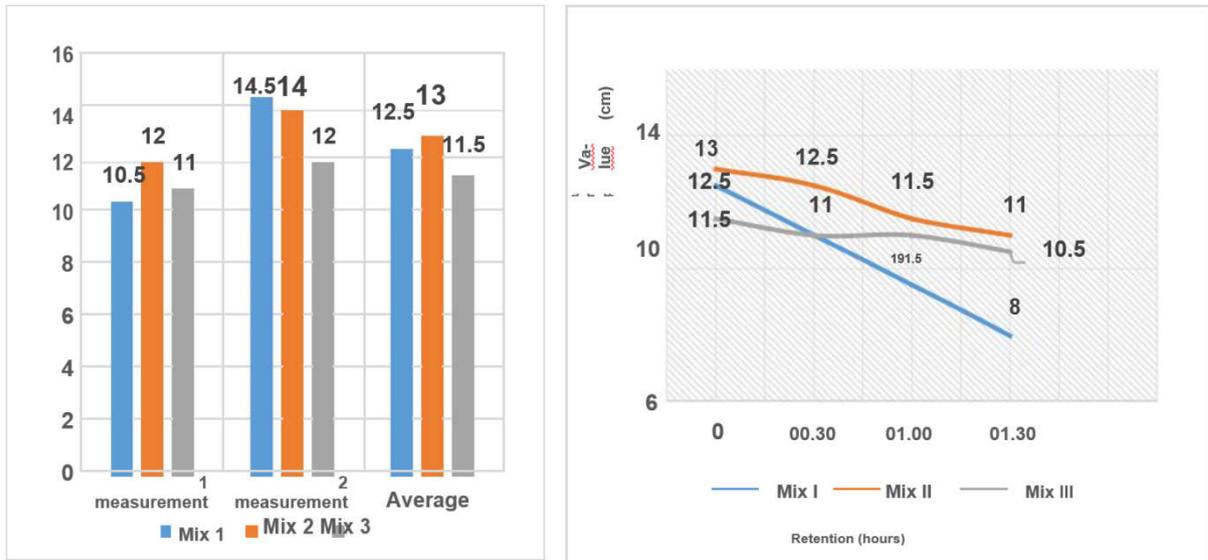


Figure 3. Result of concrete crack value (left) and slump loss (right).

Based on Figure 3, the higher concrete crack value is 2nd measurement, followed by 1st measurement. For the retention by hours, mix I am decreased significantly than others.

3.5. Object Test

The following is the classification of the number of test objects for each variable; it can be seen in Table 6.

Table 6. Result of object test.

No.	Test Type	Test Age	Amount Test	Amount Whole
1	Compressive Strength of Concrete	3	2	12
		7	2	12
		14	2	12
		21	2	12
		28	2	12
2	Chloride Ion Penetration	28	4	12
3	Porosity	28	2	6
Amount			16 Pieces	48 Pieces

Source: own studied (2022).

Based on Table 6, the manufacture of test objects refers to the ASTM regulations set on the process of making test objects.

3.6. Analysis of the Compressive Strength of Concrete

The concrete compressive strength test was carried out after the concrete underwent treatment until it was 28 days old. The compressive strength test of concrete is carried out after first measuring the dimensions of each side of the concrete cube. The compressive strength of concrete at the age of 3,7,14 and 21 days is projected to obtain the characteristic compressive strength at 28 days. The compressive strength test results at the period of 28 days and the projection of the characteristic compressive strength (k') at the age of 3,7,14, and 21 days, for the details in Figure 4.

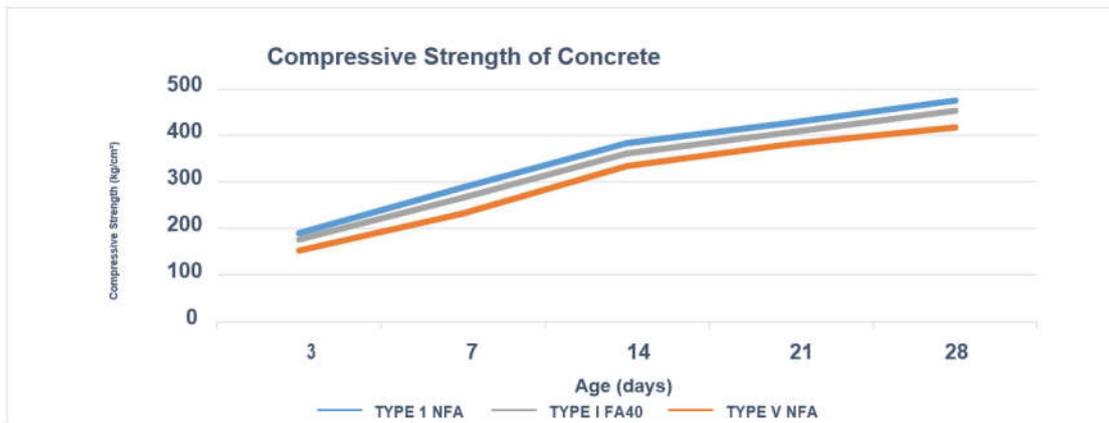


Figure 4. Result of compressive strength of concrete.

Based on Figure 4, the target characteristic of 350 kg/cm² at the age of 28 days which has calculated the deviation value per individual from the three mixes, has met the requirements for concrete acceptance according to the concrete mix planning, namely Mix I = 431.71 Kg/cm², Mix II = 402.03 Kg/cm², Mix III = 356.00 Kg/cm². For the deviation value, Mix I = 16.99 Kg/cm², Mix II = 19.14 Kg/cm², Mix III = 23.0 Kg/cm², the experiment of the three mixtures has reached the target.

3.7. Analysis of Chloride Ion Penetration

From the experimental results of the three mixtures with chloride ion testing for 6 hours, significant results were obtained for each variable where the concrete was resistant to high chloride penetration in Mix III, namely type V cement, which had different characters from Type I, for Mix II, namely cement. Type I FA 40% medium yield and can be applied as chloride ion resistant concrete, and for Mix I, namely cement type I NFA, the results was low because it was not resistant to chloride attack. Therefore, it can be concluded from the compressive strength test. The definitive chloride ion penetration test is Mix II; this refers to the economic value, which is more efficient than Mix I and Mix III, as shown in Table 7.

Table 7. Analysis of chloride ion penetration.

No	Mixed Code	Test Results (Coulomb)	Chloride Ion Category
1.	MIX I K350 NFA TYPE I	4612	Tall
2.	MIX II K350 FA40 TYPE I	2081	Intermediate
3.	MIX III K350 NFA TYPE V	727	Very low

Source: own studied (2022).

3.8. Porosity Analysis in Concrete

The relationship between porosity and compressive strength in this study, namely, the greater the porosity of the test object, the lower its strength; this is proven in the porosity test on the compressive strength of concrete; in Mix I, the porosity is 6%, and the average compressive strength is 28 days 475.06 kg/cm², Mix II porosity is 9.10%. The average compressive strength is 28 days 453.06 kg/cm², Mix III porosity 11.02%, and moderate compressive strength 28 days 417.91 kg/cm². Therefore, the mixture of the three experiments that have been carried out is seen from the side of compressive strength, chloride ion penetration, and porosity ideal is Mix II after the review of 3 tests. It can be seen in Table 8.

Table 8. Porosity analysis in concrete.

No.	Test Object Code	Age (Day)	Porosity (%)
1	MIX I K350 NFA Type I	28	6.00
2	MIX II K350 FA40 Type I	28	9.10
3	MIX III K350 NFA Type V	28	11.02

Source: own studied (2022).

3.9. Cost Analysis in Indonesian Rupiah

After conducting research and evaluating strength, chloride penetration, and porosity, a cost analysis of each variable will be carried out, which aims to compare the economical price of concrete per meter and the quality that meets the requirements. It can be seen in Table 9.

Table 9. List of material prices.

No.	Material	Unit	Unit price (IDR)
1	Cement Type I	Kg	920.00
2	Type V Cement	Kg	950.00
2	Fly Ash	Kg	280.00
3	Water	Kg	25.00
4	Sand	m	237,500.00
5	Split	m	225,000.00
6	Admixture	Litter	3,5000.00

Source: own studied (2022).

The price of sand and split materials in the market uses units of m³. In contrast, in planning for a concrete mix, the composition of sand and split uses kg/m³, the portion of the sand and split composition is divided by the volume weight discussed before. The following Table 10 explains concrete price calculation.

Table 10. Concrete price calculation.

Mixture Type	Cement (Kg)	Fly Ash (Kg)	Water (Kg)	Sand (Kg)	4.75/25 (Kg)	Admixture (L)	Material Price per meter (IDR)	Selling price of 25% Operational + 20% Margin
MIX I	460	-	184	685	1030	1.84	694,542.2	1,007,086.13
MIX II	254	169	169	684	1029	1.02	549,029.1	796,092.15
MIX III	497	-	199	657	989	1.99	733,567.3	1,063,672.61

Source: own studied (2022).

4. CONCLUSION

The addition of high-volume fly ash (40% fly ash) with Type I cement has a lower compressive strength than normal Type I cement and higher than normal Type V cement, testing chloride ion penetration, porosity, and cost analysis. The information in this study still needs to be studied further by using the salt content in the immersion of the concrete to find out how much influence the saltwater has on the resistance of the concrete. Likewise, it is necessary to increase the age of immersion in sulfate water to determine its effect on concrete in the longer term.

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