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EFFECT OF ADDING FLY ASH AND POLYCARBOXYLATE IN HIGH EARLY STRENGTH SELF COMPACTING CONCRETE (HESSCC) ON THE 1 (ONE) DAY OLD CONCRETE COMPRESSION STRENGTH

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ABSTRACT

The purpose of this study was to determine the effect of adding Fly Ash and Polycarboxylate to HESSCC on the compressive strength of the concrete. The percentage of Fly Ash and Polycarboxylate variant ranging of Fly Ash 5% and Polycarboxylate1%, 1.5%, 2%, 2.5%, 3%, 3.5% and 4%. Concrete testing will be done after the concrete has aged 1, 2, 3 and 28 days. This study used 96 cylindrical specimens with a size of 15 cmX15cmX15cm. From the laboratory research, it was found that the compressive strength of concrete at the age of 1 day with Normal Concrete + Fly Ash 5% was 189.36 Kg/Cm², the highest compressive strength was Normal Concrete + Fly Ash 5% + Polycarboxylate 3 % of 348.42 Kg/Cm² with 99.5% increase from the design compressive strength, for 28 days the initial compressive strength has reached 162.3% of the design strenght or equal to 568.1 Kg/Cm².

KEYWORDS: HESSCC, Fly Ash, Polycarboxylate.

INTRODUCTION

In the era of infrastructure development as well as rapid increase in the number of vehicles, it causing a lot of traffic jam mainly in big cities, especially if it is a crowded area or there is development in the area, those area are prone to traffic jams. therefore it is better to use concrete material that hardens quickly in a day with the strength has reached more than 80% of the planned strength.

Concrete is a mixture of fine aggregate (sand), coarse aggregate (coral and crushed stone), cement which is put together by adding a certain amount of water and additives as a unifier of these materials. To change the properties of the resulting concrete, so that it can produce a higher initial strength, Polycarboxylate can also be used, while to increase the strength of the concrete, Fly Ash which is a solid waste produced from burning coal in power plants can also be used.

Polycarboxylate contains polycarboxylate polymers and is specially formulated for ready mix concrete where slump retention, high strength and durability are required in hot climates. It is chloride free, meets SS EN 934, high degree of mixing retarding/water reduction/ superplasticization, and ASTM C 494 requirements.

Concrete is one of the commonly used construction materials which is made from cement, coarse aggregate, fine aggregate and water which are mixed in such a way based on estimates that have been calculated into solid materials such as rock. Some of the advantages of using concrete as a construction material include being easy to manufacture and execute, using raw materials that are very easy to obtain and resistant to fire and time. The application of making concrete in the field usually uses steel reinforcement which is then commonly called reinforced concrete.

The process of making conventional concrete takes quite a long time compared to other materials and requires formwork to put fresh concrete. Casting is carried out at least within one day, then you have to wait for the concrete to be 7 days old, then the formwork can be dismantled and working on the next casting. The length of time this process takes and waiting for the strength of the concrete to be at a safe limit to carry out the next work makes construction projects often take longer time to complete.

Through these problems, an analysis of the variation of the concrete mixture was carried out with the aim of producing a fairly high initial strength in the hope that it could help accelerate the work on construction projects made of concrete. Produce concrete with high initial strength can speed up the process of dismantling the formwork and can quickly move on to the next stage of work. The following table shows the comparison of the compressive strength of normal concrete with concrete with high initial compressive strength.

Table 1: Comparison of the compressive strength of concrete at different ages.

Concrete Age (days)	Common Portland Cement	Portland Cement With High Initial Compressive Strength
3	0.40	0.55
7	0.65	0.75
14	0.88	0.90
21	0.95	0.95
28	1.00	1.00
90	1.20	1.15
365	1.35	1.20

Normal concrete is concrete that only uses the basic ingredients of aggregate, cement and water. Meanwhile, concrete that uses admixture is given a more specific name according to its specifications, for example high-strength concrete, flowing concrete and so on.

Self Compacting Concrete (SCC) is fresh concrete which is very plastic and easy to flow to fill the space because SCC concrete is capable of self-compacting without the aid of a vibrator. Good SCC concrete must remain homogeneous, cohesive, not segregated, does not occur blocking, and does not bleed. The advantages that can be obtained from the use of SCC concrete are that it can reduce the length of the construction process and worker wages, optimum compaction and vibration of concrete, and can reduce noise that can interfere with the surrounding environment (Herbudiman & Siregar, 2013). The properties of self-compacting concrete (SCC) are as follows:

1. Filling ability, is the ability of SCC concrete to flow and fill the entire part of the mold under its own weight. To determine the "filling ability" of SCC concrete, the Slump-flow Test using the Abrams cone can be used to determine the workability of the concrete based on the spreadability of fresh concrete which is expressed by a diameter of between 60-75 cm. The slump flow test can be seen in Figure 1 below.

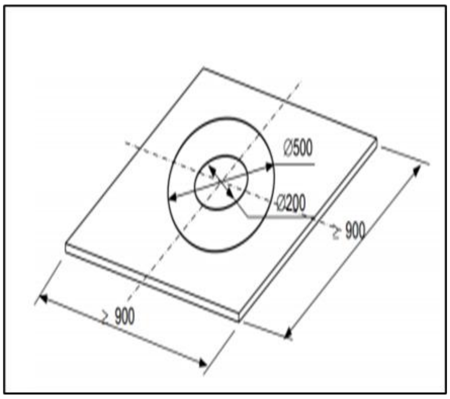

Figure 1: Slump Flow Test.

Source: EFNARC Standard, 2005.

2. Passing ability, is the ability of SCC concrete to flow through the gaps between the reinforcing bars or the narrow gaps of the mold without any segregation or blocking. To determine the "passing ability" of SCC concrete, a test tool is used, namely the L-Shape box. With the L-shape box test, the blocking ratio value will be obtained, which is the value obtained from the H2/H1 comparison. The higher the blocking ratio value, the better the fresh concrete flows with a certain viscosity. For SCC concrete criteria, the blocking ratio value ranges from 0.8 to 1.0. L-Shape Box testing is carried out as shown in Figure 2

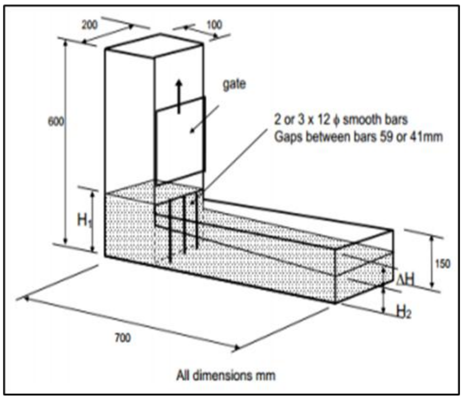

Figure 2: Shape Box Test.

Source: EFNARC Standard, 2005

3. Segregation resistance, is the ability of SCC concrete to maintain a homogeneous composition state during transportation to casting. The V-Funnel test is used to measure the viscosity of SCC concrete and at the same time determine the "segregation resistance". The ability of fresh concrete to immediately flow through the mouth at the bottom end of the V-funnel measuring instrument is measured with a time between 3-15 seconds. The V-funnel test can be seen in Figure 3.

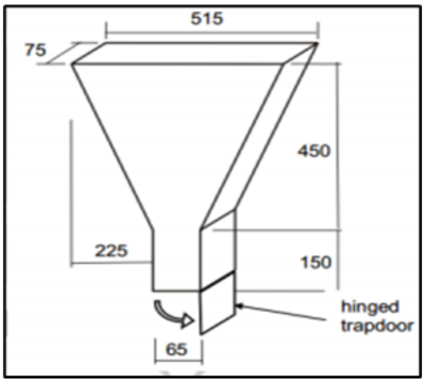

Figure 3: V-Funnel Test.

Source: EFNARC Standard, 2005

The advantages of Self Compacting Concrete (SCC) are:

1. Does not require compaction using a vibrator,
2. Less manpower needed,
3. Reducing noise that disturbs the surrounding environment, and
4. Easy casting, fast project time and improve structure durability.

The disadvantages of using self-compacting concrete are :

1. SCC is more expensive in terms of cost compared to conventional concrete,
2. The manufacture of concrete formwork must really be considered because it is easy to leak the SCC mixture,
3. Concrete should not experience segregation but must still meet the flowability requirements.

For self-compacting concrete, the composition of the material required for SCC and conventional concrete is different. The composition of Coarse Aggregate in SCC is less than the composition of Coarse Aggregate in conventional concrete, the limitation of Coarse Aggregate in SCC is intended so that the concrete mixture can flow and compact itself without a compactor.

The mixture in SCC that does not exist in conventional concrete mixtures is in the form of filler (binding material in a concrete mixture consisting of cement and filler). Comparison of conventional concrete and SCC concrete in terms of the proportion of mixing percentage from the total volume of concrete shown in Figure 4.

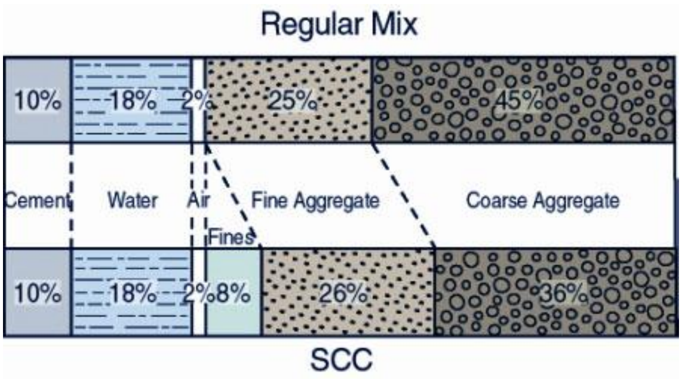

Figure 4: Comparation between Conventional Concrete with SCC (Okamura dan Ouchi 2003).

The purpose of this research was to determine the effect of the addition of Fly Ash and Polycarboxylate on the compressive strength of concrete so as to produce a higher initial strength than normal concrete.

The goal of this research was to determine concrete the optimum initial strength using Fly Ash and Polycarboxylate added materials compared to normal concrete.
In this study, to facilitate the discussion, the following limitations are given:

1. This study used the characteristic concrete quality of K-350 Kg/cm2 and the tests were carried out at the age of 1 day, 2 days, 3 days and 28 days.
2. This study using Fly Ash as much as 5% of the total weight of cement.

MATERIALS AND METHODS

The research was carried out at the Concrete Technology Laboratory, Faculty of Engineering, University of Muhammadiyah Palembang.

Material Preparation and Material Test

Before conducting research in the laboratory, it is necessary to know and prepare the materials and tools that will be used. The materials used are cement, fine aggregate, coarse aggregate, water, fly ash and polycarboxylate. The procedures and preparations carried out in this research are as follows

1. Material testing
2. Making JobMix Design
3. Making test objects
4. Slump flow test
5. Concrete compressive strength test

Making Test Object

In this study, 8 variations were used and each variation contained 12 samples, so that the total number of test objects carried out was 96 samples. The test object used is a cube-shaped test object. The variances of the test objects carried out were mixed variations, normal concrete added with 5% fly ash, normal concrete + 5% fly ash, + 1% polycarboxylate, normal concrete + 5% fly ash, + 1.5% polycarboxylate, normal concrete + fly ash 5%, + polycarboxylate 2%, normal concrete + fly ash 5%, + polycarboxylate 2.5%, normal concrete + fly ash 5%, + polycarboxylate 3%, normal concrete + fly ash 5%, + polycarboxylate 3.5%, and normal concrete + 5% fly ash, + 4% polycarboxylate. As well as for compressive strength testing carried out at the age of 1, 2, 3 and 28 days of concrete.

Table 2: Variation and amount of test objects.

No	Variation	Amount of Test Objects
1	Bn+FA5%	12
2	Bn+FA5%+Pc1%	12
3	Bn+FA5%+Pc1,5%	12
4	Bn+FA5%+Pc2%	12
5	Bn+FA5%+Pc2,5%	12
6	Bn+FA5%+Pc3%	12
7	Bn+FA5%+Pc3,5%	12
8	Bn+FA5%+Pc4%	12

Source : Researcher Test Result

RESULTS AND DISCUSSION

Concrete Compressive Strength Test Results

After making the concrete mixture, then a slump test is carried out. The slump test on this concrete mixture uses the slump flow test which aims to determine the flexibility of the mix and also to know the slump value because it greatly affects the level of workability. The results of the concrete slump test in this study are as follows:

Table 3: Slump Flow Test Results.

No	Variation	Slump (Cm)
1	Bn+Fa5%	35
2	Bn+Fa5%+Pc1%	40
3	Bn+Fa5%+Pc1,5%	47
4	Bn+Fa5%+Pc2%	50
5	Bn+Fa5%+Pc2,5%	55
6	Bn+Fa5%+Pc3%	60
7	Bn+Fa5%+Pc3,5%	65
8	Bn+Fa5%+Pc4%	70

Source: Researcher Test Result

After the slump test is carried out, then the compressive strength of the concrete is tested, starting from the age of the concrete 1 (one) day, 2 days, 3 days and 28 days, from these tests, the average concrete compressive strength is obtained from each variation carried out and the results can be seen in **Table 4** and **Figure 5** below:

Table 4: Concrete Compressive Strength Test Results.

No	Variation	Average Compressive Strength (Kg/Cm^2)			
		1 day	2 days	3 days	28 days
1	Bn+Fa5%	198,7	223,6	253,1	422,3
2	Bn+Fa5%+Pc1%	218,3	253,7	272,0	435,9
3	Bn+Fa5%+Pc1,5%	244,8	259,9	287,8	463,1
4	Bn+Fa5%+Pc2%	281,1	315,1	330,1	482,8
5	Bn+Fa5%+Pc2,5%	331,5	331,7	363,4	525,8
6	Bn+Fa5%+Pc3%	363,9	408,1	433,7	578,0
7	Bn+Fa5%+Pc3,5%	352,8	395,1	412,5	547,7
8	Bn+Fa5%+Pc4%	300,7	336,2	373,9	530,4

Source: Researcher Test Result

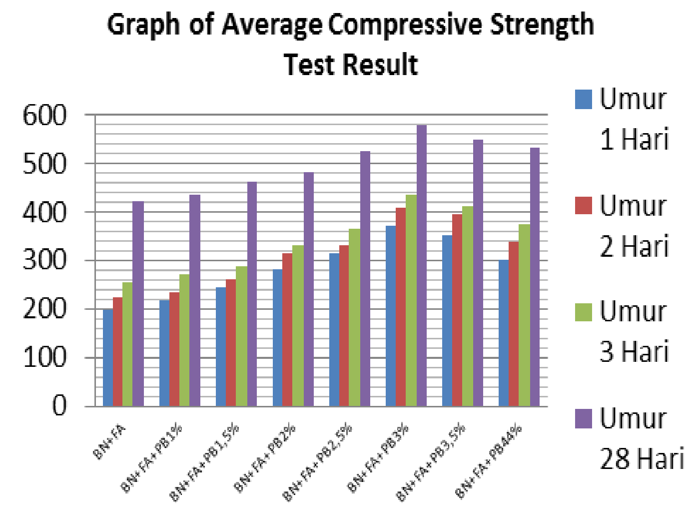

Figure 5: Graph of Concrete Compressive Strength Test Results.

Source: Researcher Test Result

After processing the data using the standard deviation of the average compressive strength results, the characteristic concrete compressive strength results are obtained from the test as shown in **Table 5** below.

Table 5: Characteristic Concrete Compressive Strength Test Result.

No	Variation	Average Compressive Strength (Kg/Cm^2)			
		1 day	2 days	3 days	28 days
1	1	189.3	212.28	241,1	401,4
2	2	209,1	219,5	264,5	422,9
3	3	237,3	255,6	278,0	442,0
4	4	273,6	306,6	317,1	459,6
5	5	304,1	323,9	355,6	512,4
6	6	348,4	390,8	422,3	568,1
7	7	341,5	380,1	402,6	545,6
8	8	281,9	330,5	364,1	515,5

Source: Researcher Test Result

DISCUSSION

From the test results on the test object, it is found that the compressive strength of the characteristic concrete (Table 5.) with high initial strength at the age of 1, 2, 3 days and exceeds the initial high strength of normal concrete.

Table 6: Compressive strength of concrete with high initial strength at the age of 1, 2 , 3 and 28 days.

No	Variation	Average Compressive Strength (Kg/Cm^2)							
		1 Day	% Increase In Compressive Strength Against The K-350 Design	2 Days	% Increase In Compressive Strength Against The K-350 Design	3 Days	% Increase In Compressive Strength Against The K-350 Design	28 Days	% Increase In Compressive Strength Against The K-350 Design
1	Bn+Fa5%	189,3	54,1%	212,28	59,1%	241,1	68,9%	401,4	114,7%
2	Bn+Fa5%+Pc1%	209,1	59,7%	219,5	61,1%	264,5	75,6%	422,9	120,8%
3	Bn+Fa5%+Pc1,5%	237,3	67,8%	255,6	71,2%	278	79,4%	442	126,3%
4	Bn+Fa5%+Pc2%	273,6	78,2%	306,6	85,4%	317,1	90,6%	459,6	131,3%
5	Bn+Fa5%+Pc2,5%	304,1	86,9%	323,9	90,2%	355,6	101,6%	512,4	146,4%
6	Bn+Fa5%+Pc3%	348,4	99,5%	390,8	108,9%	422,3	120,7%	568,1	162,3%
7	Bn+Fa5%+Pc3,5%	341,5	97,6%	380,1	105,9%	402,6	115,0%	545,6	155,9%
8	Bn+Fa5%+Pc4%	281,9	80,5%	330,5	92,1%	364,1	104,0%	515,5	147,3%

Source : Researcher Test Result

From **Table 6**, it can be seen that the most optimal high initial compressive strength at one day old occurs in variations of normal concrete mix with the addition of 5% Fly Ash and 3% Polycarboxylate and the initial compressive strength of one day old has reached 99.5% of the design concrete strength. Meanwhile, other inheritance conditions have also reached the high initial strength required for high initial strength. Even at the age of 2 days old of concrete, there are 2 variation conditions that have reached the initial high compressive strength to reach the design concrete compressive strength, namely the normal concrete variation condition with the addition of 5% Fly Ash and 3% Polycarboxylate, the other one was the normal concrete variation with the addition of 5% Fly Ash and Polycarboxylate 3.5%. Meanwhile for the age of 3 days old of concrete there are three variations which the initial strength has reached the compressive strength of the design concrete, namely the normal concrete variation with the addition of 5% Fly Ash and 3% Polycarboxylate, the normal concrete variation with the addition of 5% Fly Ash and Polycarboxylate 3,5% and normal concrete variations with the addition of 5% Fly Ash and 4% Polycarboxylate. However, the most optimal conditions occur in normal concrete variations with the addition of 5% Fly Ash and 3% Polycarboxylate. Starting from the age of 1 day old to the age of 28 days old of concrete.

For all conditions of test specimens aged 3 days old, it shows that the initial high strength of all specimens carried out has exceeded the provisions of 0.55% of the design compressive strength. Specificly for the concrete aged one day old, the compressive strength of concrete with high initial strength resulting from this test can be seen in **Figure 6** and **Figure 7** below.

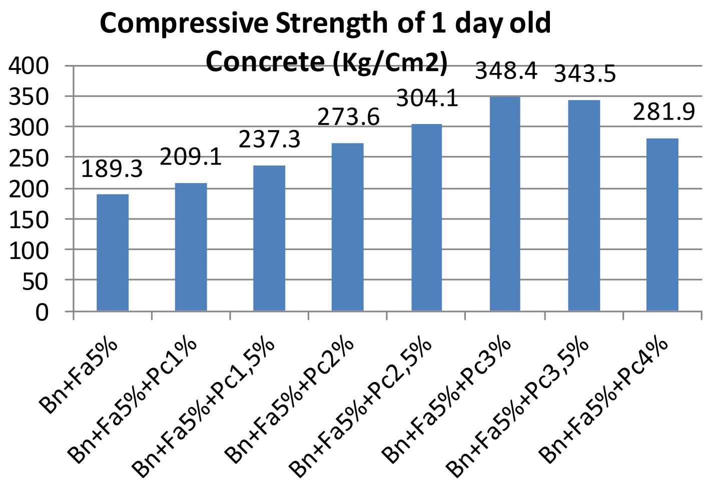

Figure 6: Graph of Compressive Strength of 1 day old concrete.

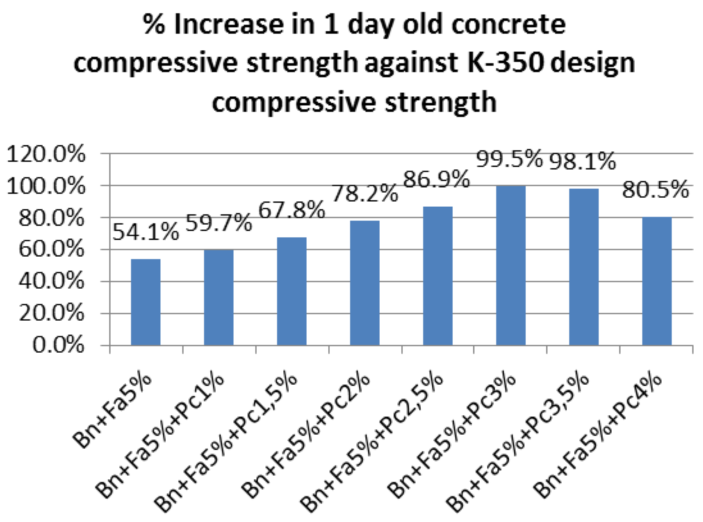

Figure 7: Graph of % Increase in 1 day old concrete compressive strength against K-350 design compressive strength.

When viewed from the compressive strength of the concrete produced for normal concrete mixtures with the addition of Fly Ash 5% and Polycarboxylate 1%, 1.5%, 2%, 2.5% and 3%, the concrete continued to experience a significant increase and again decreased at concrete with the addition of Fly Ash 5% and Polycarboxylate 3.5% and 4% at each age. Normal concrete mix with the addition of Fly Ash 5% and Polycarboxylate 3% has a compressive strength of concrete with high characteristics compared to concrete with other mixtures, with a compressive strength value of 348.42 Kg/Cm^2 at the age of 1 day of concrete and 568.17 Kg/ Cm^2 at the age of 28 days of concrete.

The increase in the compressive strength of concrete at the age of 28 days occurs very well. This can be seen from the normal variation of concrete with the addition of 5% Fly Ash and 3% Polycarboxylate which reached a concrete compressive strength of 568.17 Kg/Cm^2. This means that the compressive strength of the concrete produced at the age of 28 days is 165.3% of the design concrete compressive strength. For other variation conditions, it can be seen in following **Table 7**.

Table 7: 28 days old Concrete Compressive Strength.

No	Variation	Average Compressive Strength (Kg/Cm^2)	% Compressive Strength Increased against K-350 Design Compressive Strength
1	Bn+Fa5%	401,4	114,7%
2	Bn+Fa5%+Pc1%	422,9	120,8%
3	Bn+Fa5%+Pc1,5%	442	126,3%
4	Bn+Fa5%+Pc2%	459,6	131,3%
5	Bn+Fa5%+Pc2,5%	512,4	146,4%
6	Bn+Fa5%+Pc3%	568,1	162,3%
7	Bn+Fa5%+Pc3,5%	545,6	155,9%
8	Bn+Fa5%+Pc4%	515,5	147,3%

Source : Researcher Test Result

From **Table 7**, it can be seen that the addition of more than 3% polycarboxylate will decreased the compressive strength of the concrete, because the excessive polycarboxylate content will make the layer of the aggregate-cement paste meeting area thicker which will reduce the compressive strength of the concrete. The thinner aggregate-cement paste meeting area layer will increase the compressive strength of concrete (Zhang, 1996).

CONCLUSIONS

From the results of research conducted at the Concrete Technology laboratory, Faculty of Engineering, Muhammadiyah University of Palembang regarding the effect of adding Fly Ash and Polycarboxylate to Hight Early Strength Self-Compaccing Concrete (HESSCC) on the compressive strength of concrete at the age of 1 (one) day, it can be concluded as follows

1. The most optimal condition for high initial compressive strength for 1 day old concrete is achieved at the conditions of Normal Concrete + Fly Ash 5% + Polycarboxylate 3% of 348.42 kg/cm^2, with a percentage increase in compressive strength of 99.6% of the concrete strength plan.
2. Compressive strength ofNormal Concrete + Fly Ash 5% + Polycarboxylate 1%, 1.5%, 2%, 2.5%, 3%, 3.5% and 4% for concrete ages 1, 2 and 3 days old showed a high initial compressive strength increase, exceeds 0.55% of the design concrete compressive strength.
3. The mixture of Normal Concrete + Fly Ash 5% + Polycarboxylate 3% and 3.5% at the age of 2 days has exceeded the initial high strength to reach 108.9% and 105.9% of the design compressive strength.
4. The maximum compressive strength value at the age of 28 days was achieved in a mixture of normal concrete + Fly Ash 5% + Polycarboxylate 3% of 568.17 kg/cm^2, with a

percentage increase in concrete strength of 162.3% from the compressive strength of the design concrete.

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