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EFFECT OF ADDING SUPERPLASTICIZER ON HIGH INITIAL COMPRESSIVE STRENGTH OF HIGH-PERFORMANCE CONCRETE (HPC) FC'= 36.62 MPA

Ahmad Junaidi [1], R Dewo Hiraliya Maesa Hariyanto [1]

[1] University of Muhammadiyah Palembang, Faculty of Civil Engineering, Palembang, Indonesia

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Corresponding Author
Ahmad Junaidi,
junaidi.3537@gmail.com

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ABSTRACT

This research aims to determine the effect of the most optimal variation of the addition of Sikament- NN in producing high initial strength in High Performance Concrete (HPC) using Superplasticizer (Sikament-NN) added material on the compressive strength of concrete Fc' = 36.62 Mpa or K-450, by using 4%,5%,6%,7% and 8% variation of the Superplasticizer Sikament NN with the effect of accelerating hardening and strengthening the concrete to determine the most optimal variation. Researchers will test 150 cylindrical-shaped concrete samples with a size of 15 x 30 cm at the age of 3, 7, 14, 21 and 28 days. The result shows that the most optimum high initial compressive strength was achieved by concrete with 5% Sikamen NN added, at the age of 3 days with the initial compressive strength of the test object has surpassed the design compressive strength by 100.4% or equal to 34.65 Mpa, while at the age of 28 days produces an average concrete compressive strength of Fc' = 57.77 Mpa.

Keywords: High Performance Concrete, High Initial Strength, Fc' = 36.62 Mpa

1. INTRODUCTION

Along with the current development of concrete technology, especially in the field of concrete construction, it is never separated from efforts to create alternative technologies that are quite innovative to improve the quality of concrete, which is a widely used structural material. Concrete has advantages, includes high compressive strength, resistance to heat, chemical, etc.

To get the desired quality of concrete, it is not only necessary to mix Portland cement or other types of cement with fine aggregate, coarse aggregate, and water, but it is also necessary to add additional materials (admixture). As for the admixtures in the concrete construction used in this paper is a superplasticizer (sikament-NN).

Concrete is a mixture of Portland cement or other hydraulic cement, fine aggregate, coarse aggregate, water Badan Standarisasi Nasional (1990) with or without additional admixtures to form a solid mass Febriansyah (2020). Concrete is a composite material from its constituent materials. Broadly speaking, it is divided into two types, namely basic materials, and additives Febriansyah (2020). The basic material for forming concrete is cement which is needed as a binding material, fine aggregate can be in the form of natural sand or it can also be in the form of brick ash and coarse aggregate can be in the form of stone whose size is in accordance with the standard or in the form of broken stone (split) and water which when mixed with cement will bond and harden, followed by the release of heat (hydration). Admixtures also used during the manufacture of concrete to achieve certain goals. Concrete is a mixture of materials in the form of coarse aggregate, fine aggregate, cement, and water. In this mixture, cement and water form a cement paste that binds materials to each other. Concrete is a high-strength material and has properties that are resistant to rusting or decay by environmental conditions, if it is made in a good way its compressive strength is the same as natural rock Badan Standarisasi Nasional (2011).

In general, concrete consists of approximately 15% cement, 8% water, 3% air, the rest is sand and gravel Badan Standarisasi Nasional (BSN). The mixture after hardening has different properties, depending on the method of manufacture, mixture ratio, mixing method, transport method, casting method, compaction method, treatment method and so on to affect the concrete properties. The general properties of the concrete mix are as follows Badan Standarisasi Nasional (2013) Pratama (2019):

1) Workability

   The concrete ingerdients after being mixed together, produce a mixture of such a nature that the mortar is easily transported, poured/molded, and compacted according to the purpose of the work without any changes that cause damage or decrease in the quality of the concrete.

2) Durability

   durability of concrete is a property where concrete is durable against the effects of weather during use. The durable properties of concrete can be distinguished in several ways, including the following:

   - Resistant to weather influences, the weather effects in question are changing effects such as rain and freezing in winter, as well as expansion and shrinkage caused by wet and dry over time.
   - Resistant to the influence of chemical substances with chemical destructive power by materials such as sea water, swamps and waste water, industrial chemicals and waste water, dispose of dirty water in a clean box.
   - Resistant to erosion, concrete can experience erosion caused by pressure.

3) Watertight properties

   Concrete has a tendency to contain cavities caused by the presence of air bubbles that form during work or after the casting is completed or the room that when working (finished in work) contains water.

With the increasing use of concrete in the construction industry, there are more and more efforts to make it more sophisticated and more economical. Sophistication is expressed in the manufacture of concrete with high quality, while trying to keep costs as low as possible. In addition, there are efforts to take advantage of the properties of concrete that have not been revealed before.

From an economic point of view, we see that the most expensive part of concrete is cement and reinforcement. With all kinds of efforts, the two types of materials were attempted to be replaced or reduced in use. With the existence of industry, the remaining industrial waste is trying to be utilized, rather than being a destroyer of the environment Simatupang et al. (2017) Risdiyanto (2013).

The definition of High-Performance Concrete / HPC is often confused with high strength concrete. High strength concrete is a type of high-performance concrete. The definition of the American Civil Engineering Research Foundation (CERF) defines high-performance concrete as concrete that meets specific performance requirements that cannot always be achieved routinely using only conventional materials and normal mixing, laying and maintenance practices.

Some of the requirements currently in use with regard to high performance concrete are Badan Standarisasi Nasional (BSN):

- Ease of laying
- Compaction without segregation
- Initial compressive strength
- Long term mechanical properties
- Permeability
- Density
- Volume stability
- Can survive in various environments

The development of high-performance concrete is still being carried out. The following is an example of the development of high-performance concrete, namely Ultra High-Performance Concrete (UHPC). UHPC is a new type of concrete that is being developed by the relevant agencies. UHPC is characterized by being a cement composite material reinforced with steel fibers. The compressive strength of this concrete is more than 150 MPa, up to and may exceed 250 MPa. UHPC is also characterized by its constituent materials in the form of fine sand, silica fume, small steel fibers and a special mixture of high strength Portland cement. In this type of concrete there is no large aggregate.

High Performance Concrete (HPC) is a concrete mixture that has high durability and high compressive strength when compared to conventional concrete. High Performance Concrete is a variant of concrete that has a high level of workability so that it does not require further compaction and has a high performance. To get a concrete mix with a high level of workability and high performance, the following things need to be considered:

1) Coarse aggregate is limited in amount to approximately 50% of its solid volume.
2) Limiting the amount of fine aggregate is approximately 40% of the volume of the mortar.
3) Water-binder ratio maintained at a level of approximately 0.3
4) The use of Superplasticizer in the concrete mix to get a high level of workability while suppressing the value of the water-binder ratio.

5) Added a filler in the form of silica fume to increase the durability and compressive strength of the concrete. Handoko (2006).

Sikament-NN is a highly effective dual action superplasticizer for the production of flowable concrete and as a material to reduce the use of water in concrete to produce high compressive strength Mecha et al. (2018), in accordance with American Society for Testing and Material (ASTM) Type F (water reducing, high range admixtures) standards. Sikament NN has the advantage of increasing ductility which facilitates casting for lean structures with tight reinforcement. Sikament NN has a chemical content of 35-50% folmaldehyde condensate and less than 10% sodium salt of gluconic acid as a water reducing agent which can reduce up to 20% and will provide a 40% increase in compressive strength in 28 days (Sika).

The purpose of this research was to plan High Performance Concrete (HPC) using the addition of Superplasticizer (Sikament-NN) to the compressive strength of high-performance concrete.

The goal of this research was to determine the effect of the most optimal variation of the addition of Sikement NN on the high initial compressive strength of High-Performance Concrete (HPC) using added material Superplasticizer (Sikament-NN) on the compressive strength of concrete.

In this study, to facilitate the discussion, the following limitations are given:

1) This study used the characteristic concrete quality of Fc' = 36.62 Mpa. and the tests were carried out at the age of 3 day, 7 days, 14 days, 21 days, and 28 days.
2) This study using only Sikament-NN as an additive.

2. MATERIALS AND METHODS

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

2.1. MATERIALS 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, water, coarse aggregate, fine aggregate, and sikament-NN. The procedures and preparations carried out in this research are as follows:

1) Testing material
2) Making JobMix Design
3) Making test objects
4) Slump flow test
5) Concrete compressive strength test

2.2. TEST OBJECT

In this study, 6 variations were made, and each variation consisted of 25 samples, so that the total number of test objects carried out were 150 samples. Cube-shaped test object were used in this research. The test of concrete compressive strength carried out at the age of 3, 7, 14, 21 and 28 days old.

Table 1

Table 1 Variation and Amount of Test Objects

No	Variation	Amount of Test Objects
1	Normal Concrete	25
2	Normal Concrete + Sikament-NN 4%	25
3	Normal Concrete + Sikament-NN 5%	25
4	Normal Concrete + Sikament-NN 6%	25
5	Normal Concrete + Sikament-NN 7%	25
6	Normal Concrete + Sikament-NN 8%	25

3. RESULTS AND DISCUSSIONS

3.1. CONCRETE COMPRESSIVE STRENGTH TEST RESULTS

Before being casted, concrete mixture needs to be tested, then a slump test is carried out. This test is to determine the workability of the concrete mix and to determine the slump value of the concrete. The results of the concrete slump test in this study are as follows:

Table 2

Table 2 Slump Flow Test Results

No	Variation	Slump Value
1	Normal Concrete	8
2	Normal Concrete + Sikament-NN 4%	6
3	Normal Concrete + Sikament-NN 5%	5
4	Normal Concrete + Sikament-NN 6%	4.9
5	Normal Concrete + Sikament-NN 7%	4.5
6	Normal Concrete + Sikament-NN 8%	5.2

Table 2 shows that the slump value of concrete with the addition of Sikament NN Superplasticizer is lower than normal concrete. This happens because Superplazticizer only uses enough water because according to its function it can reduce the use of water. After the slump test done, then the compressive strength of the concrete is tested, starting from the age of the concrete 3 days, 7 days, 14 days, 21 days, and 28 days old, from these tests, the average concrete compressive strength is obtained from each variation carried out and the results can be seen in Table 3 below:

Table 3

Table 3 Concrete Average Compressive Strength Test Results

No	Variation	Average Compressive Strength (Mpa)				
		3 days	7 days	14 days	21 days	28 days
1	Normal Concrete	17,29	24,41	32,80	35,00	36,85
2	Normal Concrete + Sikament NN 4%	30,80	34,30	43,12	49,27	55,78

3	Normal Concrete + Sikament NN 5%	39,53	42,71	47,32	51,07	57,77
4	Normal Concrete + Sikament NN 6%	33,98	35,43	38,00	42,47	51,46
5	Normal Concrete + Sikament NN 7%	30,74	35,06	37,15	42,45	45,2
6	Normal Concrete + Sikament NN 8%	25,90	30,15	33,04	35,39	38,42

The most optimum high initial compressive strength is achieved at the condition of adding 5% NN sikament which has a high compressive strength quality so as to produce High Performance Concrete (HPC) compared to other mixed concrete, at the age of 3 days to get the desired concrete quality with an average compressive strength of concrete of fc' = 39.53 Mpa and at the age of 28 days produces an average concrete compressive strength of Fc' = 57.77 Mpa, Meanwhile, the increase in compressive strength that occurs against the normal compressive strength of concrete can be seen in Table 4.

Table 4

Table 4 Increased Compressive Strength of 28 Days Old Concrete

No	Mixing Variations	Average Compressive Strength (Mpa)	% Increasing Compressive Strength
1	Normal Concrete	36,85	0
2	Normal Concrete + Sikament NN 4%	55,78	51,36
3	Normal Concrete + Sikament NN 5%	57,77	56,77
4	Normal Concrete + Sikament NN 6%	51,46	39,66
5	Normal Concrete + Sikament NN 7%	45,20	22,67
6	Normal Concrete + Sikament NN 8%	38,43	4,28

From Table 4, it can be seen that the most optimum increase in the compressive strength of 28-day old concrete occurs under normal conditions of concrete + 5% Sikament NN with an increase of 56.36% from normal concrete compressive strength. This can be seen in the following Figure 1.

Figure 1

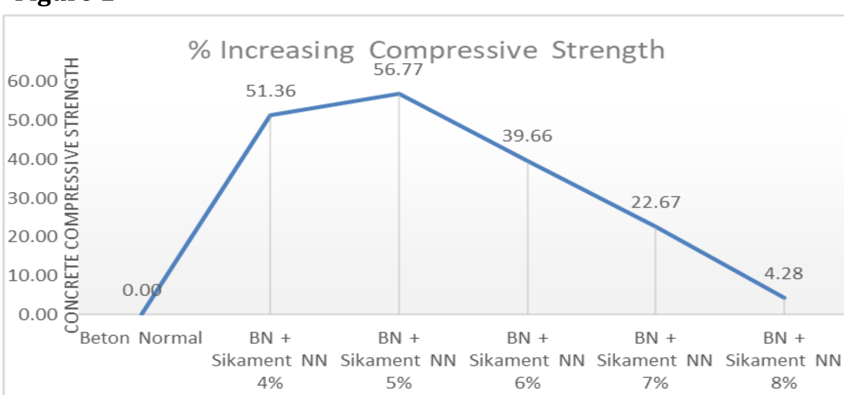

Figure 1 Percentage Increase in the Compressive Strength of Characteristic Concrete at the Age of 28 Days

4. DISCUSSION

After the compressive strength test was carried out, the data obtained for the compressive strength of the characteristic concrete as follows:

Table 5

Table 5 Compressive Strength of Concrete with High Initial Strength at the Age of 3, 7, 14, 21, and 28 days Old

Variation	% Increase of the Concrete Compressive Strength									
	Age									
	3 Days Old		7 Days Old		14 Days Old		21 Days Old		28 Days Old	
Normal Concrete	17,29	0%	24,41	0%	32,80	0%	35,01	0%	36,85	0%
Normal Concrete	17,29		24,41		32,80		35,01		36,85	
Normal Concrete	17,29	69,78%	24,41	62,00%	32,80	46,73%	35,01	54,00%	36,85	51,36%
+ Sikament NN 4%	29,36		39,54		48,13		53,92		55,78	
Normal Concrete	17,29	100,40%	24,41	75%	32,80	44,24%	35,01	44,70%	36,85	56,76%
+ Sikament NN 5%	34,65		42,72		47,31		50,67		57,77	
Normal Concrete	17,29	96,52%	24,41	45,13%	32,80	15,84%	35,01	21,30%	36,85	39,51%
+ Sikament NN 6%	33,98		35,43		38,00		42,47		51,46	
Normal Concrete	17,29	77,76%	24,41	43,60%	32,80	13,25%	35,01	21,70%	36,85	22,63%
+ Sikament NN 7%	30,74		35,06		37,15		42,45		45,20	
Normal Concrete	17,29	49,78%	24,41	23%	32,80	0,74%	35,01	1,09%	36,85	4,26%
+ Sikament NN 8%	25,90		30,15		33,04		35,39		38,43	

From the data processing that has been described above, it can be drawn several summary results regarding the characteristics of concrete in the study, including the following:

1) From all existing test objects, it shows that the high initial strength at the age of 3 days for the addition of Sikament NN 4% to 7% has exceeded 55% of the compressive strength of the design concrete and this is the minimum limit of the high initial strength concrete requirements. For the most optimum test specimens, the initial high compressive strength was achieved by concrete with the addition of 5% Sikament NN with an initial compressive strength of 100.40% of the design concrete compressive strength.
2) In the variation of the concrete mixture with the addition of Sikament NN Superplasticizer 4%, 5%, 6%,7% and 8%, the optimum conditions were found in the 5% Sikament NN variation at 3, 7, 14, 21 and 28 days old to produce High Performance Concrete with the most optimum one is Fc' = 57.77 MPa at the age of 28 days.
3) There was a decrease in the characteristic compressive strength of the variation of the concrete mixture with the addition of 6%, 7% and 8% Sikament NN Superplasticizer due to the excessive use of Sikament NN Superplasticizer so that it was no longer effective in increasing the concrete compressive strength, because the optimum conditions had been achieved with the addition of 5% Superplasticizer Sikament NN.

For the percentage increase in concrete at the age of 3 days, we can see in table 5, the compressive strength of concrete with the addition of 5% Superplasticizer Sikament NN increased by 100.4% with a characteristic compressive strength value of Fc' = 34.65 Mpa so as to produce High Performance Concrete. While the researchers themselves obtained the compressive strength of characteristic concrete at the age of 28 days of Fc' = 57.77 Mpa with an increase of 56.76%, so it can be concluded that the concrete mixture with the addition of 5% Superplasticizer Sikament NN is the optimum condition to produce HPC.

5. CONCLUSIONS AND RECOMMENDATIONS

Based on the results of research and calculations carried out, the following conclusions are obtained:

1) The highest initial strength was achieved at the condition of the addition of Sikament NN 5%, which was 100.4% of the compressive strength of the design concrete at the age of 3 days.
2) The optimum characteristic compressive strength of concrete is found in the addition of Superplasticizer Sikament NN 5% with a characteristic compressive strength value at the age of 3 days with a characteristic compressive strength of Fc'=34.65 Mpa and at the age of 28 days a characteristic compressive strength of Fe'= 57.77 Mpa is obtained.
3) The percentage increase in optimum compressive strength occurs in the conditions of Normal Concrete + Sikament NN 5% with an increase of 56.77% from normal concrete at the age of 28 days
4) With the addition of the Sikament NN Superplasticizer to the concrete mixture, it can produce the concrete into concrete with a high initial strength exceeding 55% of the design concrete.

CONFLICT OF INTERESTS

None.

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