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RELATIONSHIP BETWEEN 35 MEGAPASCAL COMPRESSIVE STRENGTH AND FLEXURAL STRENGTH

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ABSTRACT

In the modern era like now in the construction sector, there are so many innovations in infrastructure along with the times. Concrete is an important factor in the construction sector with a function as one of the formers of the upper and lower structures. Concrete material is the result of a mixture of cement, coarse aggregate, fine aggregate, water and sometimes added materials with various kinds of innovations. The method used in this study is experimental, by making the test specimen laboratory samples by using two different specimens but with the same quality of concrete is fc'35 MPa. Based on the results of the values on the flexural and compressive test specimens in the laboratory, an unsuitable relationship between flexural strength (has been obtained fs) and compressive strength (fc ') according to SNI 2847: 2013. On formulas (fr = 0.62 $\sqrt{fc'}$) applis to the concrete test 28 day.

Keywords: *Innovations in infrastructure, concrete, SNI 2847:2013*

1. PRELIMINARY

Background of Study

Modern era like this in the field of construction so many innovations in infrastructure along with the Times. In the field of construction in Indonesia, the use of concrete for building materials is widely known. Concrete is the most important factor in the field of construction as one of the formers of the structure, both the upper structure and the lower structure.

Therefore, the purpose of this study was to determine the compressive strength with a quality of 35 Mpa and determine the value of the bending strength of concrete with the formula (fr = $0.62\sqrt{f\ c'}$), with reference to concrete references and previous research. So in this study is expected to achieve the target compressive strength that has been hinted and compare with the flexural strength of the same quality is fc’35 MPa.

Limitation Of The Problem

To limit the scope of this study, the limited problems as follows:

1. The cement used in this study is OPC cement type I. Fine aggregate used in the form of bangka sand and the coarse aggregate used in the form of crushed stone rumpin.
2. This experiment reviewed the value of compressive strength and flexural strength that has been hinted at 35 MPa, as well as the comparison of the two samples.

3. In the test of compressive strength and flexural strength performed at the age of concrete 7, 14, and 28 days.

4. The sample used 16 pieces consisting of 9 pieces of cylinder 15 x 30 cm and 7 pieces of beam (beam) 15 x 15 x 60 cm

Formulation Of The Problem

From the background mentioned above, the problem can be formulated as follows :

1. How to make mix design on concrete design?

2. How to get the average value of concrete compressive strength and flexural strength of concrete?

3. How to get the difference of concrete flexural strength value with concrete compressive strength value through formula 0.62 $\sqrt{}$ f c ' on 35 MPa quality concrete?

Research Objectives

The purpose of this study is to determine the correlation between two concrete tested with different sample shapes but have the same quality. With the following aspects :

1. To determine the value of compressive strength in concrete.

2. To determine the value of bending strength in concrete.

3. To determine the relationship between the value of flexural strength and compressive strength compared using the formula fs = 0.62$\sqrt{}$fc'.

Research Benefits

The benefits of this study are as follows:

1. It is expected that from this study can determine whether the value of compressive strength of concrete is achieved.

2. Is the formula 0.62$\sqrt{}$fc ' applicable to flexural strength with a quality of 35 MPa.

2. LITERATURE REVIEW

Definition Of Concrete

Concrete is a composition of materials consisting of many types, namely cement, gravel, sand, and water, using additives (mixtures) or without additives. (SNI - 2847:2013). Concrete is most often used or used for many types of structures, such as building structures, bridges and roads, because concrete has good compressive strength. At the time of the concrete design process will be influenced by each composition on forming elements, workmanship, compaction to treatment during the drying process, in order to produce the strength that has been planned in concrete.

In the construction of construction on the pavement (rigid pavement) requires strong bending (F's) but to create concrete with quality quality, must be considered on the compressive strength, compressive strength (fc') is the strength on the surface and has been indicated (MPa).

Concrete Building Materials

1. Air

The most basic concrete material is water and must always be in concrete, cement without water will not be able to become a paste other than for water cement hydration also makes it easier when working so that the concrete is lecak (workability). Water acts as a reaction (±25%) on the weight of the cement. In addition to the water mixture is also needed in the treatment of concrete. To make concrete almost the average used is, natural water that can be drunk, does not smell, and has no taste can meet the criteria as a water mixture in concrete. Water is needed to smooth between the grains of aggregate and the reaction with cement to make it easy on during the processing and when compacted.

2. Fine Aggregate

Is a natural sand as an enhancer between gravel and sand has a dose that varies in the American standard filter arrangement

ranging from Number 4 - 100. (sihombing, 2018). Fine aggregate is sand from the results that have been crushed or produced by a stone crusher and has a grain size of 4.75 mm.

3. Coarse Aggregate

Gravel is the result of artificial stone fragments or obtained from stone – breaking companies, with a dose of 4.76-150 mm. On coarse aggregate must meet the requirements of strength, texture, shape and size. Therefore, the limitation on the size of the aggregate is mandatory because if there is a provision on the maximum size of the aggregate it is clear that the size of the aggregate can affect the process when the main work during the casting process. For coarse aggregates, at least must meet the requirements: have minimal porosity, have a maximum shape and scale according to the existing reference, clean, hard, have a good arrangement and uniform (obtained from the same material location).

4. Semen

Its function is to attach the granules to the aggregate in order to unite into a solid and strong moment. The amount of cement that exceeds the maximum dose in concrete can affect the compressive strength, if the amount of cement is small and the amount of water is small, it can cause a difficult and difficult stirring process to be compacted and the compressive strength is low. If the amount of cement exceeds, meaning a lot of water then the concrete will be a lot of pores and will result in strong pressure to be low. Cement has a function to add empty cavities between aggregate grains.

Concrete Properties

Consists of a combination of cement, aggregate (fine and coarse), and water that stick to each other in a plastic State before the Solid is still mushy and can be formed easily. The formation process is through the process of combining fine aggregate with coarse aggregate, then if added to the cement into a paste and added with water little by little will become concrete. Fresh concrete must have high performance, among others: agility or easy during the manufacturing process.

1. Ease of workmanship (workability) in the process of making concrete can be judged from the slump equivalent to the level of homogeneous plasticity.

2. Segmentation

Segmentation is a condition when the granules are separated from the concrete mixture, and can cause porous concrete.

3. Bleeding

The state in which water rises to the surface that has just been done is called bleeding.

Concrete Grade and Quality

Concrete with normal quality is a mixture using standard materials in general, according to (Paul Nugraha,Antoni, 2007). Cement is an important element in concrete, although the levels are only 7-15% in its components, with a lot of cement content of about 15% called fat concrete while with a little cement content to 7% called skinny concrete (Hartono, 2013).

Quality concrete each aggregate is fused, so the gap between the aggregates must be filled with mortar. Therefore the quality of the concrete depends on the pasta and mortar. In a structural and non-structural work usually requires various needs for the class and quality of concrete according to the needs of the work itself.

Compressive Strength and Flexural Strength

Concrete has a compressive strength that is more dominant in testing compressive strength using a machine (compression testing machine) is a concrete compressive strength test equipment with a destructive system with a test on this tool almost close to the actual concrete Press results, this test was carried out in the laboratory of PT Adhimix Lenteng Agung. In the compressive test on the test object as a reference to establish concrete quality standards, and as

a condition of acceptance of concrete quality.

Strong bending occurs due to stretching due to external loads. If the load on the beam increases, it results in cracks in the beam span. Therefore, the concrete bending test has become a condition for acceptance of the results of the work. However, the challenge for implementers in the work of making concrete that has been based on compressive strength is required to recreate the planning in the mix design and trial mix, so it is necessary evaluation to find the correlation value (Suryani, 2018). Compressive strength research was conducted in order to know for sure the concrete with the age of 28 days whether it is in accordance with the provisions. Here is the formula for calculating the compressive strength of concrete :

$$\mathbf{P} = \frac{\boldsymbol{F}}{\boldsymbol{A}}$$

Where:

P = maximum power of the press machine, kg

F = pressurized cross-sectional area, cm2

A = compressive strength, kg/cm2

3. RESEARCH METHODOLOGY

The method used in this study is experimental by stating the relationship between two variables and using existing formulas so as to make an innovation.

Techniques in collecting data is done by observation and measurement.

In this study used two different forms of concrete test objects but with the quality of concrete that has been indicated that is 35 MPa. In the research conducted when making samples only do one mix in the manufacturing process for cylindrical and beam test objects of the same quality. Test object the first is to find the compressive strength (fc) using a cylinder with a height of 30 cm and has 15 cm with a total of 9 pieces, the second is a flexible strength test object (fs) concrete beam (beam) with a size of 60 x 15 x 15 cm with a total of 7 pieces. Both will be tested when the concrete is 7, 14, and 28 days old.

Raw Materials and Equipment

Raw material is a collection of materials that will be used for 35 MPa quality concrete mixture in the form of, cement, gravel, sand and water. With the equipment can make it easier to at the time of the work to be done. The following materials are used, among others :

1. Semen
2. Coarse Aggregate
3. Fine Aggregate
4. Air

Equipment used to support or support in the manufacture of concrete in this study is :

1. Maximum Weighing Capacity 50 Kg
2. Measuring Instrument Meter
3. One Set of ASTM sieve
4. Molen Mix Machine
5. Mold test object cylinder and Beam
6. Small Carts
7. Small Size Shovel
8. Bolt Lock Size 14
9. Sack
10. Rubber Hammer
11. Brushes For Lubricants
12. Large Bucket
13. Iron For Cornering
14. Concrete Surface Leveling Plate
15. AbRam's Cone

Research Locations

The location of the study will be conducted in the laboratory of PT. ADHIMIX PRECAST is located at Jl. Lenteng Agung, South Jakarta.

Research Flow

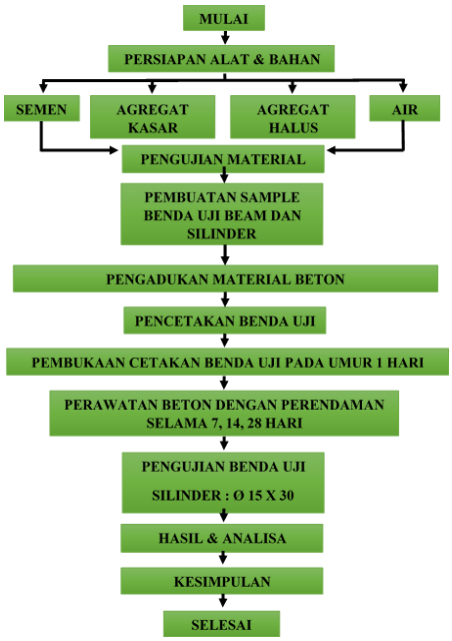

Figure 1. Flow Chart of Research

4. RESEARCH AND DISCUSSION

Material Test Result

In this chapter before making the test object the author will discuss the results of research conducted at PT. ADHIMIX PRECAST INDONESIA by conducting a data search that refers to the formulation of the problem. In this analysis using cement OPC Type I, Bangka sand and gravel rumpin contained in Plant Adhimix Lenteng Agung.

Fine Aggregate Inspection Results

In the fine aggregate test, it includes organic content, specific gravity, and material that passes sieve no. 200 (%), the following material testing results contained in Table 1.

Table 1. Fine Aggregate Test Results

No	Testing Type	Results	Tolerance	Conclusion
1	Material Passing Sieve No. 200 (%)	2.83	Max 3%	Qualified
2	Specific gravity SSD	2.61	Min 2.55	Qualified
3	Absorption (%)	2.01	Max 4%	Qualified
4	Weight Content	1.55		Qualified
	a. Solid Condition	1.65	Min 1.2	Qualified
	b. Loose Condition	1.44		Qualified
5	Fine Modulus	2.61	2.3 – 3.1	Qualified
6	Organic Content	3	Max 3	Qualified

Source: Adhimix Laboratory

Results of Coarse Aggregate Examination

The coarse aggregate test used in this study includes the gradation of coarse aggregate and inspection of the test materials that have been received according to existing criteria and references, the following tests are contained in table 2.

Table 2. Results of Coarse Aggregate Testing

No	Testing Type	Results	Tolerance	Conclusion
1	Material Passing Sieve No. 200 (%)	2.02	Max 3%	Qualified
2	Specific gravity SSD	2.59	Min 2.55	Qualified
3	Absorption (%)	2.3	Max 4%	Qualified
4	Weight Content	1.44		Qualified
	a. Solid Condition	1.5	Min 1.2	Qualified
	b. Loose Condition	1.37		Qualified
5	Fine Modulus	7.85	5.5 – 8.5	Qualified
6	Organic Content	4.68	Max 5%	Qualified

Source: Adhimix Laboratory

Slump Test Results

In this slump test, the slump obtained with the value of the mixture is 12 ± 2 cm, therefore the slump is read with a height of 12 cm with a collapse tolerance of 2 cm.

Compressive Strength Test Results

Before conducting the compressive strength testing process, the sample was removed from the bath and then left for 1 day. Testing is done when the concrete has been left for 1 day and tested at the specified age. The testing process before starting, the weight is weighed first, which affects the strength of the concrete, among others, by, surface shape, maximum size of the aggregate.

In the study using the calculation of standard deviation (S) which will be explained in table 3.

Standard deviation formula:

$$\sqrt{\frac{\sum(Xi-Xrt)}{(n-1)}}$$

Where:

Σ = Summation

Xi = Data on the compressive strength of each test specimen

Xrt = Average compressive strength data of test specimens

n = Number of test specimens

Table 3. Compressive Strength Standard Deviation

No	Sample Code	Age (Day)	Compressive Strength Average (MPa)	Compressive Strength Standard Deviation (MPa)
1	I	7	27.73	20.06
2	II	14	31.88	30.15
3	III	28	34.8	33.75

Source: Research

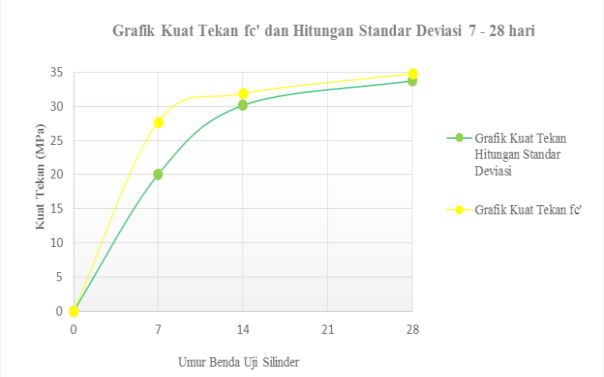

Figure 2. Graph of Compressive Strength

The graph of the average fc' obtained at the age of 7 days with a compressive strength of 27.73 MPa, at the age of 14 days a compressive strength of 31.88 MPa, and at the age of 28 days obtained compressive strength of 34.80 MPa with a deviation value of 0.2% at the required target of 35MPa.

Flexural Strength Test Results

In the flexural strength test, beam samples with dimensions of 15 x 15 x 60 cm. For the age of 7 days the sample amounted to 2 pieces, at the age of 14 days the sample amounted to 2 pieces, and at the age of 28 days the sample amounted to 3 pieces. The results of the flexural strength of the concrete that has been tested will be entered with the calculation of the standard deviation (S) which will be explained in table 4.

Table 4. Flexural Strength Standard Deviation

No	Sample Code	Age (Day)	Compressve Strength Average (MPa)	Compressive Strength Standard Deviation (MPa)
1	IV	7	2.95	2.38
2	V	14	3.55	1.93
3	VI	28	4.18	3.34

Source: Research

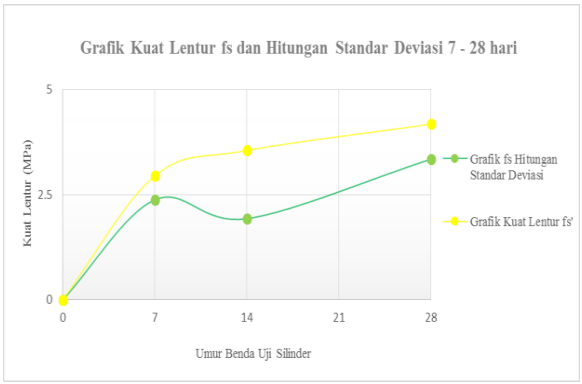

Figure 3. Flexural strength graph

Graph of the average flexural strength obtained at the age of 7 days with the result of compressive strength 2.95 MPa, at the age of 14 days obtained 3.55 MPa, and at the age of 28 days obtained a compressive strength of 4.18 MPa.

Analysis of Compressive Strength and Flexural Strength

SNI 2487:2013 has stated the relationship with a formula, namely fr = $0.62\sqrt{f}c'$ which has a minimum compressive strength and flexural strength that has not been fulfilled in the concrete.

The minimum compressive strength and flexural strength have not been met in accordance with the formula in SNI 2487:2013. The objective of the study was to review the relationship between compressive strength and flexural strength using concrete grade fc'35 MPa, to ascertain whether the formula used to convert compressive strength to flexural strength is still valid or not.

For compressive strength in accordance with SNI 1974: 2011 for flexural strength in accordance with SNI 4431: 2011. The test equipment used is available at PT Adhimix Precast Lenteng Agung.

Relationship Between Fc' and Fs

In this study, the correlation or relationship between fc' and fs with a quality of fc'35 MPa using the existing formula 0.62 $\sqrt{fc'}$ is explained in Table 5.

Table 5. Compressive and Flexural Strength Results Based on Formula 0.62 $\sqrt{fc'}$

No	Sample Code	Age (Day)	Compressve Strength Average (MPa)	Compressive Strength Standard Deviation (MPa)
1	I	7	20.06	2.38
2	II	14	30.15	1.93
3	III	28	33.75	3.34

Source: Research

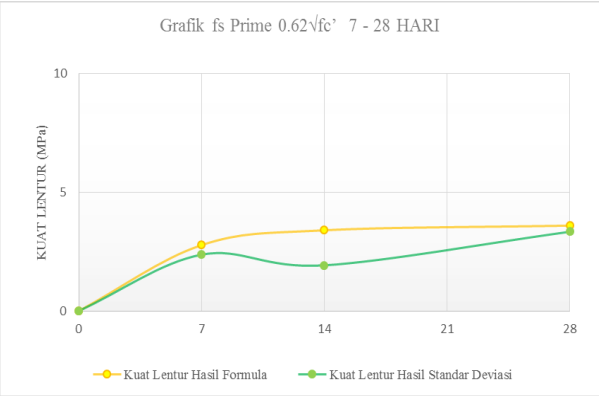

Figure 4. Grafik *fs* Prime 0.62 $\sqrt{fc'}$

From the graph of flexural strength obtained based on the formula fs = 0.62$\sqrt{}$ fc' at the age of 7 days, 3.44 was obtained, at the age of 14 days, 3.63 was obtained, and at the age of 28 days, 3.60 was obtained.

The relationship between flexural strength and compressive strength is completely accurate at 28 days of concrete testing, if the testing age is less, the flexural strength value using the formula basically results in relatively lower compressive strength.

In the compressive and flexural strength tests, it can be seen that the relationship between flexural strength and compressive strength is not in accordance with the formula in SNI 2847-2013, namely fs = 0.62 $\sqrt{fc'}$. Therefore, the use of high strength concrete in accordance with the description of binamarga revision 3 division 7 section 7.1 in 2010 in concrete pavements cannot obtain the minimum strength at the flexural strength of 28 days old concrete (fs = fr = 4.4 MPa) because the concrete has a high compressive strength.

4.4 MPa) because fc'45 MPa concrete will only obtain a flexural strength of fs = 0.62 $\sqrt{}$ 45 = 4.15 MPa. (Suhendra, 2017).

5. CONCLUSION

1. Based on research in the laboratory, the average compressive strength with a quality of 35 MPa has not been achieved at 28 days with a value of 34.80 MPa from the target of 35 MPa with a deviation of 0.2%.

2. Based on the results of research in the laboratory, the average flexural strength was obtained with a result of 4.18 MPa at the age of 28 days. If using the formula in SNI 2847: 2013 the bending strength of the beam is relatively smaller than the beam test results themselves.

3. Based on the results of the values of fs and fc' in the laboratory, an inappropriate relationship between the flexural strength (fs) and compressive strength (fc') has been found in SNI 2847:2013 (fs). SNI 2847:2013 (fs = 0.62 $\sqrt{fc'}$) applicable in 28 days old concrete test. The recommended flexural strength in binamarga 2010 is fs = 45 kg/cm2 (fs = 4.4 MPa), therefore the

concrete quality (fc'35 MPa) has not been achieved.

Suggestions

1. For further research, it is hoped that the accuracy of the calculation accuracy in the calculation of the concrete mix plan and the innovation with the addition of additional materials, because in this study the normal concrete plan 35 MPa when tested compressive tests, concrete only up to an average number of 34.80 at the age of 28 days.
2. In the process of testing the beam test specimens, try to keep the beam position straight and the surface flat in order to achieve maximum flexural strength.
3. In the compressive strength test, the test sample must be dry and must not be in a damp state and at the time of pengkapingan on the surface of the concrete must be completely flat because it will greatly affect the compressive strength.

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The bibliography just insert references that are used or quoted directly in the article. Format of references in the article is written with the number in brackets, starting from number [1], etc. The format using references to the IEEE bibliography with minimum 5 titles. Bibliography should use the Mendeley format.

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