Experimental Study Comparative Compressive Strength and Tensile Strength of Nail Fiber Concrete Against Fiber Concrete

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ABSTRACT

Concrete has high compressive strength but weak tensile strength. The innovations to increase tensile strength is addition fiber. Fiber concrete has been proven increase the tensile strength, but the basic material from flammable plastic and difficult to find in Indonesia, making polypropylene fibers less desirable, so an innovation was to add nails to concrete mix as substitute for polypropylene fibers. Nails made of steel, non-flammable, higher melting point than polypropylene, high tensile strength and easy to find in Indonesia. The purpose of this study was to determine the effect of adding nail and polypropylene fiber to the compressive and split tensile strength of concrete, and to determine the optimum proportion of nail fiber to polypropylene fiber concrete. Mix design using SNI 7656:2012. Based on the results, the compressive strength of normal concrete was 20,007 MPa and 1% polypropylene concrete was 20,097 MPa. The compressive strength of nail fiber concrete varies 0,5%, 1%, 1,5%, 2% and 2,5%, respectively, 16,334 MPa, 18,790 MPa, 21,290 MPa, 21,324 MPa, 19,242 MPa. The split tensile strength of normal concrete is 1,834 MPa and 1% polypropylene concrete is 2,361 MPa. The split tensile strength of nail fiber concrete varies 0,5%, 1%, 1,5%, 2% and 2,5%, respectively, 1,620 MPa, 1,990 MPa, 1,942 MPa, 1,800 MPa, and 1,730 MPa. The optimum proportion of nail fiber concrete as substitute for 1% polypropylene fiber concrete is variation of 1,5% with compressive strength of 21,290 MPa and split tensile strength of 1,942 MPa.

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1. INTRODUCTION

Concrete is a composite building material consisting of a mixture of coarse aggregate, fine aggregate, cement and water. Concrete is usually used to make road pavement, building structures, foundations, bridges, and so on. Concrete has high compressive strength, but weak tensile strength. The hardening properties of concrete increase with increasing temperature and the strength of concrete increases with age. The use of concrete as a construction material is currently still in demand because concrete has advantages such as high compressive strength, easy maintenance after the concrete hardens and is easy to shape according to needs. The disadvantage of concrete is that it is brittle and has a tensile strength value of only around ten percent of its compressive strength [1], therefore there are many new innovations to increase the tensile strength of concrete.

The innovations to increase the tensile strength of concrete likely use the reinforcement in the concrete and the addition of fiber to the concrete mix. The innovation that continues to develop is fiber concrete. Fiber concrete is concrete (a mixture of aggregate, cement and water) that which fiber is added during the mixing process. According to ACI (American Concrete Institute) Committee 544, fiber concrete is a mixture of cement, coarse and fine aggregate, water and also additional materials in the form of fibers which are distributed randomly to prevent cracks that occur due to loading, due to heat of hydration, or shrinkage [2]. The use of fiber has been proven to increase and improve the structural properties of concrete, including increasing the tensile strength of concrete thereby increasing the ductility of concrete against tensile forces from external loads, resistance to shock loads (impact resistance), tensile and flexural strength, fatigue, the effect of shrinkage and abrasion [3].

Research on fiber concrete using steel fiber additives which have rough surfaces, curved edges, corrugations and several other shapes has proven to be very effective in increasing the strength capacity of concrete significantly [1]. Fiber concrete has been proven to increase the tensile strength of concrete, however polypropylene fiber concrete is still difficult to obtain in Indonesia and is made from plastic so it is flammable, weak to sunlight and oxygen [4], making polypropylene fiber concrete less desirable. Based on several previous studies, it has been proven that adding nails to the concrete mixture causes the compressive strength of the concrete to decrease significantly. This can happen because the addition of nails makes the solidification process for making test specimens more difficult because nails are stiff unlike fiber which is more flexible. The use of nails will affect the density of the test object itself, causing cavities in the test object. Adding nails using the maximum ratio (1% – 2%) to the mixture can increase the split tensile strength of the concrete but slightly reduces the compressive strength of the concrete[5]. Based on Sumarno's research [6] on the effect of adding bagasse fiber and nails with various compositions on the compressive strength value of normal concrete, the results show that nails cannot increase the compressive strength of concrete but the decrease is very small compared to normal concrete. This background made the author innovate in the form of adding concrete nails to the concrete mixture as a substitute for polypropylene fiber because steel-based nails are non-flammable, have a higher melting point than polypropylene fiber, have quite high tensile strength and easy to obtain in Indonesia. This research was conducted to determine the compressive and split tensile strength values of nail fiber concrete and polypropylene fiber concrete, as well as to determine the optimum variation in adding nail concrete fiber as substitute for polypropylene fiber.

The polypropylene content was taken as 1% where an increase in compressive strength and split tensile strength can occur by adding a fiber content of 1% of the total volume of concrete based on several previous studies such as those carried out by Kartini[7] with research aimed at finding out the optimum size and dosage of polypropylene fibers in concrete mixtures using experimental methods with an ACI mix design with a FAS value of 0.55. Based on the research results, it was concluded that the optimum variation of fiber used was 0.9 kg/m3. Hasanr et al.,[8] with research on the effect of adding polypropylene fiber mesh on the mechanical properties of concrete by experimenting with concrete quality f'c 20 MPa and adding fiber 0 kg/m3, 0.4 kg/m3, 0.6 kg /m3, and 0.8 kg/m3 at a concrete age of 28 days. Based on the research results, it was found that the optimum value for compressive strength was at a dose of 0.60 kg/m^3, namely 29,170 MPa or an increase of 3.22% from normal concrete. For split tensile strength, the optimum value was obtained, namely at a dose of 0.65 kg/m^3, it was 3.842 MPa or an increase of 20.44% from normal concrete. The addition of fiber that exceeds the optimum level will increase the tensile strength of the concrete but will reduce the compressive strength value of the fiber concrete.

Sarya et al.,[1] in their research on the effect of nails as an additive material on the split tensile strength of concrete. The method used was experimentation with a concrete mix design fc' 25 MPa. Based on the results of his research, the compressive strength of concrete decreased with variations of 2% and 4% by 9.8% and 15.1% of normal concrete, while the split tensile strength of concrete with variations of 2% and 4% nails increased by 10% and 20% of normal concrete, so it can be concluded that the optimum proportion of adding nails to a normal concrete mixture is 2%. The research carried out by Istiani[9] regarding the effect of adding nails on compressive strength and tensile strength in split concrete aims to determine the effect of adding nail fiber which produces maximum tensile strength in splitting concrete at 28 days. Based on the research results, it was found that there was an increase in the splitting tensile strength value of nailed concrete compared to normal concrete with the optimum proportion of adding nails to the concrete mixture, namely 1%. Based on several studies above, the author uses variations in the nail mixture for normal concrete of 0.5%, 1%, 1.5%, 2%, and 2.5%.

2. METHODS

According to the Indonesian Reinforced Concrete Regulations (PBBI), concrete is a material obtained by mixing fine aggregate, coarse aggregate, Portland cement and water (additive) [10]. The mixture of concrete ingredients will harden like rock due to the chemical reaction that occurs between cement and water. The function of cement as a binder is very important even though the cement composition in the concrete mixture is only around 10% [11]. The aggregate content in the concrete or mortar mixture is around 70%, while the water required in the concrete mixture is only around 25% of the cement weight.

Fiber concrete is concrete made from a mixture of cement, aggregate, water and fibers that are randomly distributed in a fresh concrete mixture matrix [12]. The purpose of using fiber concrete for mass concrete because it has a large volume and large surface area so there is a temperature difference on the inside and outside due to the heat of hydration, fiber concrete is needed to prevent cracking and shrinkage [13]. According to Salain [5], planning a fiber concrete mixture must pay attention to several things, namely the fiber content that can be used is ≤ 2% of the concrete volume, the fiber aspect ratio (l/d) ≤ 100, and the diameter of the aggregate used ≤ 19 mm.

Concrete compressive strength is the ability of concrete to accept compressive force per unit area. The compressive strength of concrete is calculated using the formula:

$$f'c = \frac{P}{A} \tag{1}$$

Where :

f'c = Compressive strength (MPa)
P = Pressing force (N)
A = Cross-sectional area of the test object (mm^2)

Split tensile strength can be increased by adding fibers that can withstand tensile forces. Based on SNI 2491:2014, the formula for split tensile strength of concrete is:

$$fct = \frac{2 \times P}{\pi \times d \times L} \tag{2}$$

Where :

fct = split tensile strength (MPa)
P = load at splitting time (N)
d = diameter of the cylindrical test object (mm)
L = length of cylindrical test object (mm)

2.1 Literature Study

Based on the results of a literature study, data was obtained regarding nail materials and polypropylene fibers in Figure 4.1 and several sources which the author used as a reference in this research:

a. Examination of fine aggregate (sand), namely checking the gradation of aggregate grains referring to SNI ASTM C136-2012, testing the water content of fine aggregate referring to SNI 1971-2011, testing the specific gravity of fine aggregate referring to SNI 1970-2008, and testing the content of mud refers to SNI 4142-1996.
b. Coarse aggregate (split) inspection, namely checking aggregate grain gradation referring to SNI ASTM C136-2012, coarse aggregate moisture content testing referring to SNI 1971-2011, coarse aggregate specific gravity testing referring to SNI 1969-2008, and coarse aggregate wear testing referring to SNI 2417-2008.
c. SNI 7656-2012 concerning procedures for selecting a concrete mix (mix design), SNI 1971-2011 concerning methods for testing concrete slump, SNI 1974-2011 concerning methods for testing the compressive strength of concrete for cylindrical specimens, and SNI 2491-2014 concerning strength testing methods pull apart cylindrical concrete.

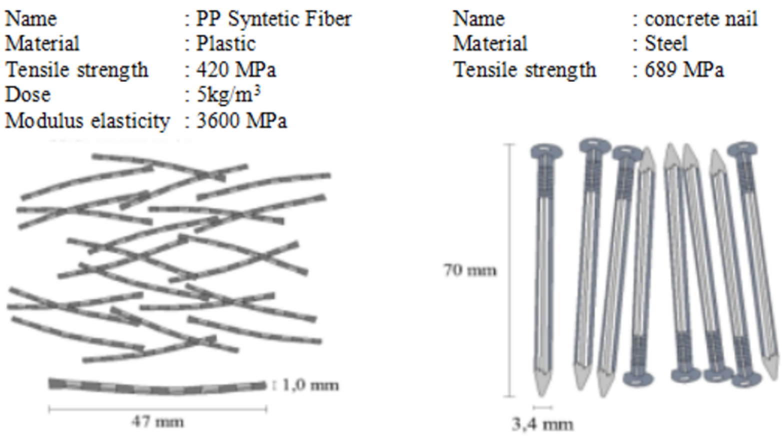

Figure 1. Material Data for PP Fiber and Iron Nails
Source: Author Documentation, 2022

2.2 Testing Materials and Equipment

The concrete ingredients that used in this research are Portland cement type I, coarse aggregate in the form of split aggregate, fine aggregate in the form of natural river sand, clean water with normal pH, 5 cm (2") iron nails, and polypropylene fiber made from plastic 5 cm long. Some of the equipment used is, ASTM standard sieve set, sieve shaker machine, oven, Los Angeles machine, concrete mixer, Abrams cone, cylindrical concrete mold with a diameter of 150 mm and height of 300 mm, and an Universal Testing Machine (UTM).

2.3 Mix Concrete Design

Based on references from Istiani [9], the optimum proportion of adding nails to the concrete mixture is 1%, the mix design was carried out based on SNI 7656: 2012 with 6 variations of fiber mixture, namely 0,5%, 1%, 1,5%, 2% and 2,5% nail fiber and 1% polypropylene fiber. This research uses 2 types of fiber mixture, namely polypropylene fiber and nail fiber. These two fibers are 50 mm long. The data needed to calculate the concrete mix design are concrete quality, design slump, maximum aggregate size, aggregate bulk density, cement specific gravity, aggregate specific gravity and water absorption, aggregate gradation analysis, and aggregate water content.

The steps for designing a concrete mix are determining the design concrete quality and design slump, determining the maximum aggregate grain size, determining the amount of mixing water, determining the water-cement ratio, calculating the cement content, determining the dry weight of the coarse aggregate, determining the estimated weight of the concrete and the weight of the fine aggregate, and calculate the weight correction for water content.

2.4 Slump Test

Concrete slump testing refers to SNI 1972-2008 (Concrete Slump Test Method) with the aim of ensuring that the quality of the concrete is maintained using an Abrahams cone (mould) which is placed flat, does not absorb water and is clean from dirt. The mold filling is divided into three parts, each approximately 1/3 of the mold volume, and each layer is compacted evenly with 25 punctures. The last layer is filled with more filling then leveled with an awl and immediately removed at a speed of 3-7 seconds.

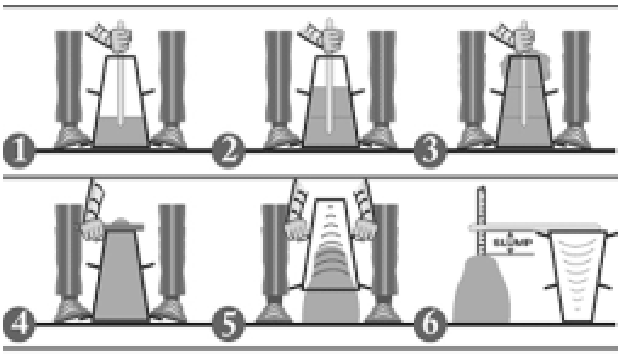

Figure 2. Concrete Slump Test
Source: BSN, 2008

2.5 Making and Treatment of Test Objects

Making and treating concrete test objects refers to SNI 2493: 2011 concerning Procedures for Making and Treating Concrete Test Objects in the Laboratory. The test object was made in the shape of a cylinder with a diameter of 150 mm and a length of 300 mm. The number of test specimens made for each mixture variation was 3 compression specimens and 3 split tensile specimens. The age of the concrete used is 28 days.

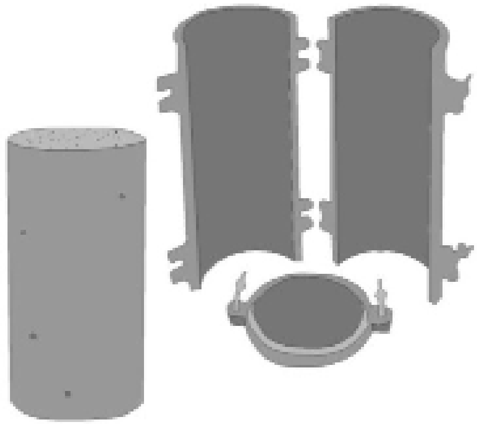

Figure 3. Formwork and Concrete Test Specimens
Source: BSN, 2008

To make it easier for the author to identify concrete variations in concrete that has been cast, the author uses a code for each concrete that is made, as follows:

Table 1. Concrete Code Naming

No.	Code	Explanation	Total Sample
1.	BN-KT	Normal concrete, compressive strength test	3
2.	BN-KTB	Normal concrete, split tensile strength test	3
3.	BS1-KT	1% Polypropylene fiber concrete, compressive strength test	3
4.	BS1-KTB	1% Polypropylene fiber concrete, split tensile strength test	3
5.	BP0,5-KT	0.5% Nail fiber concrete, compressive strength test	3
6.	BP0,5-KTB	0.5% Nail fiber concrete, split tensile strength test	3
7.	BP1-KT	1% Nail fiber concrete, compressive strength test	3
8.	BP1-KTB	1% Nail fiber concrete, split tensile strength test	3
9.	BP1,5-KT	1.5% Nail fiber concrete, compressive strength test	3
10.	BP1,5-KTB	1.5% Nail fiber concrete, split tensile strength test	3
11.	BP2-KT	2% Nail fiber concrete, compressive strength test	3
12.	BP2-KTB	2% Nail fiber concrete, split tensile strength test	3
13.	BP2,5-KT	2.5% Nail fiber concrete, compressive strength test	3
14.	BP2,5-KTB	2.5% Nail fiber concrete, split tensile strength test	3

2.6 Set-up of Concrete Compressive Strength Testing

Concrete compressive strength testing refers to SNI 1974 – 2011 concerning How to Test Concrete Compressive Strength with Cylindrical Test Objects. Set-up for concrete compressive strength testing using an Universal Testing Machine (UTM) by placing the test object on the pressing machine in a vertical and centric position. Then run the press machine with an additional load of between 2 to 4 kg/cm^2 per second until the test object experiences a significant decrease in strength. Then record the maximum load that occurs and draw the shape of the damage to the test object.

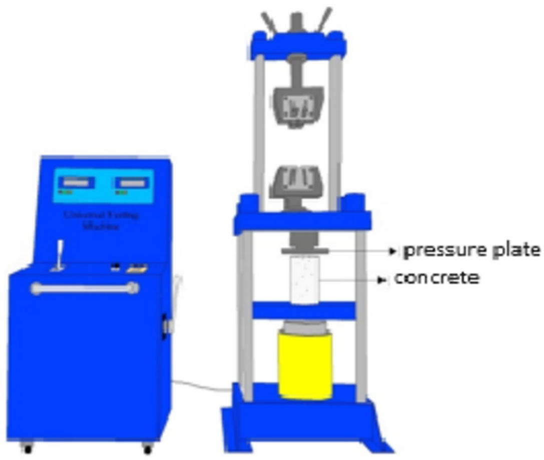

Figure 4. Set up for concrete compressive strength testing
Source: Author Documentation, 2022

2.7 Set-up of Concrete Split Tensile Strength Testing

Testing the splitting tensile strength of concrete refers to SNI 2491: 2014 concerning Test Methods for Splitting Tensile Strength of Cylindrical Concrete Specimens. Set-up for concrete split tensile strength testing using an Universal Testing Machine (UTM) by placing a load leveling board on the bottom and top of the test object so that the test object is squeezed by the board, applying a compressive force along the diameter of the cylindrical concrete specimen at a specified rate range to the point of collapse and experiencing a significant reduction in strength. Next, record the maximum load to draw the shape of the damage to the test object.

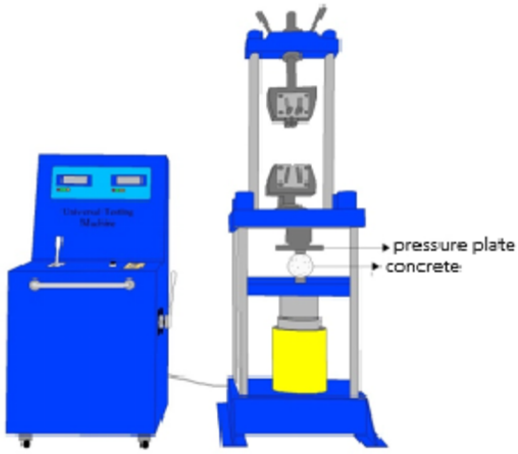

Figure 5. Split tensile strength test set up
Source: Author Documentation, 2022

3. RESULTS AND DISCUSSION

3.1 Material Testing Results

Based on the results of material testing, the characteristics of coarse aggregate and fine aggregate were obtained which include aggregate wear, aggregate grain gradation, aggregate specific gravity, water content and aggregate mud content. The results of this material testing are then used as a reference in mixing design calculations.

Table 2. Material Test Results

No.	Test	Standard	Range Limit	Result	Information
1	Coarse aggregate sieve analysis	SNI C136-2012	6,0 - 7,0	6,149	According to SNI
2	Fine aggregate sieve analysis	SNI C136-2012	1,5 - 3,8	2,654	According to SNI
3	Los Angeles Abration	SNI 2417-2008	< 50%	30,705%	According to SNI
4	Specific gravity of coarse aggregate	SNI 1969-2008	1,6 - 3,3	2,425	According to SNI
5	Specific gravity of fine aggregate	SNI 1970-2008	1,6 - 3,3	2,373	According to SNI
6	Coarse aggregate moisture content	SNI 1971-2011	0,5 - 2%	1,885%	According to SNI
7	Fine aggregate moisture content	SNI 1971-2011	2 - 5%	4,227%	According to SNI
8	Coarse aggregate sludge content	SNI 4142-1996	≤ 1%	0,405%	According to SNI
9	Fine aggregate sludge content	SNI 4142-1996	≤ 5%	9,861%	Does not comply with SNI
10	Weight of aggregate	SNI 1969-2008	≥ 1200 kg/m^3	1444,95 kg/m^3	According to SNI

3.2 Concrete Mix Design

Concrete mix design is carried out referring to SNI 7656:2012 concerning procedures for selecting mixes for normal concrete, heavy concrete and mass concrete. The calculations produce the need for mixed materials for 1 m^3 of concrete. However, in field manufacturing, you can only mix 3 cylinders in one batch. This is due to the limited capacity of the machine and human power.

Table 3. Composition of concrete mix f'c 20 MPa (cylinder 150 mm x 300 mm)

No.	Type of Concrete	Number of Samples	Fiber Content (%)	Compsition (kg)					
				Water	Cement	Sand	Gravel	Fiber	Nail
1	Normal concrete	3 compressive sample	0%	3,31	8,35	17,64	19,33	-	-
		3 tensile sample		3,31	8,35	17,64	19,33	-	-
2	Polypropylene concrete	3 compressive sample	1,0%	3,31	8,35	17,64	19,33	0.49	-
		3 tensile sample		3,31	8,35	17,64	19,33	0,49	-
3	Nail fiber concrete	3 compressive sample	0,5%	3,31	8,35	17,64	19,33	-	0,24
		3 tensile sample		3,31	8,35	17,64	19,33	-	0,24
		3 compressive sample	1,0%	3,31	8,35	17,64	19,33	-	0,49
		3 tensile sample		3,31	8,35	17,64	19,33	-	0,49
		3 compressive sample	1,5%	3,31	8,35	17,64	19,33	-	0,73
		3 tensile sample		3,31	8,35	17,64	19,33	-	0,73
		3 compressive sample	2,0%	3,31	8,35	17,64	19,33	-	0,97
		3 tensile sample		3,31	8,35	17,64	19,33	-	0,97
		3 compressive sample	2,5%	3,31	8,35	17,64	19,33	-	1,22
		3 tensile sample		3,31	8,35	17,64	19,33	-	1,22

3.3 Slump Test Results

Slump testing is carried out after every concrete mixing. This inspection is carried out to determine how much influence the added materials have on the workability or ease of working.

Table 4. Slump Test Results

No.	Test Object	Test Object Code	Slump (mm)
1	Normal concrete	BN-KT BN-KT BN-KT	85
2	Normal concrete	BN-KTB BN-KTB BN-KTB	85
3	1% Polypropylene fiber concrete	BS1-KT BS1-KT BS1-KT	78
4	1% Polypropylene fiber concrete	BS1-KTB	78

No.	Test Object	Test Object Code	Slump (mm)
		BS1-KTB BS1-KTB	
5	0,5% Nail fiber concrete	BP0,5-KT BP0,5-KT BP0,5-KT	88
6	0,5% Nail fiber concrete	BP0,5-KTB BP0,5-KTB BP0,5-KTB	88
7	1,0% Nail fiber concrete	BP1-KT BP1-KT BP1-KT	83
8	1,0% Nail fiber concrete	BP1-KTB BP1-KTB BP1-KTB	83
9	1,5% Nail fiber concrete	BP1,5-KT BP1,5-KT BP1,5-KT	80
10	1,5% Nail fiber concrete	BP1,5-KTB BP1,5-KTB BP1,5-KTB	80
11	2,0% Nail fiber concrete	BP2-KT BP2-KT BP2-KT	78
12	2,0% Nail fiber concrete	BP2-KTB BP2-KTB BP2-KTB	78
13	2,5% Nail fiber concrete	BP2,5-KT BP2,5-KT BP2,5-KT	75
14	2,5% Nail fiber concrete	BP2,5-KTB BP2,5-KTB BP2,5-KTB	75

Based on the table, the more added materials, the smaller the slump value, so that the level of ease with which the concrete mixture can be stirred, transported, poured and compacted decreases, but the slump value is still in the planned slump range, namely 75-100 mm. The same thing also happened in research by Widodo [14] because there were fewer air cavities in the concrete so that the concrete became denser due to the increase in surface area that had to be wetted, namely material in the form of nails.

3.4 Concrete Compressive Strength Test Results

Concrete compressive strength is the result of comparing the load with the surface area of the concrete and is expressed in units of MPa or kg/cm^2. Concrete compressive strength testing is carried out to determine the maximum load that the concrete can withstand. This test was carried out using an Universal Testing Machine (UTM) with cylindrical concrete test objects aged 28 days.

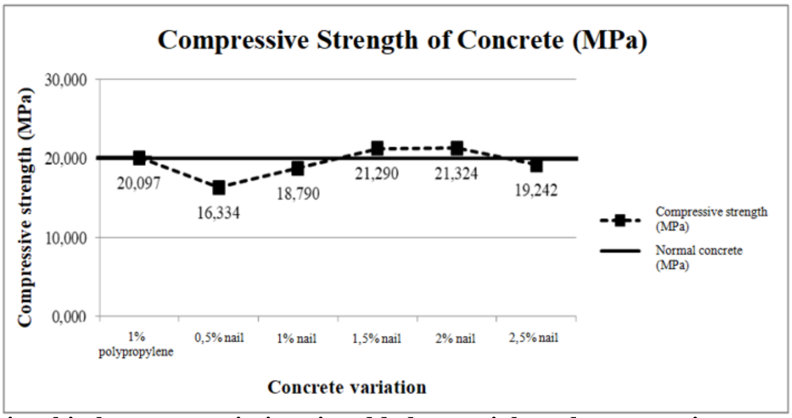

Figure 6. Relationship between variations in added materials and compressive strength of concrete

In **Figure 6** it can be seen that there is a decrease in the compressive strength of nail fiber concrete of 0,5% and 1% of the design compressive strength because the number of nails is very small so that there is no bond between the nails and other materials, so cracks easily occur on the inside of the concrete. The compressive strength value of nail concrete with a 1,5% variation is 21,290 MPa and a 2,0% variation is 21,324 MPa. In variations of 1,5% and 2%, the fiber functions optimally, namely increasing the bond between the aggregate and the cement paste. This also happened in research by Wariyatno [15] who said that the cracks that occur can be resisted by fibers that are evenly distributed randomly so that concrete is more ductile in certain fiber variations. In nail concrete of the 2,5% variation, there is a decrease in compressive strength because the number of fibers is too large so that other materials cannot spread evenly and makes the concrete too brittle (stiff) and cracks easily occur on the surface of the concrete due to the large number of nails touching each other. The same thing also happened in research by Wariyatno [15] who said that the decrease in compressive strength occurred because the number of fibers was too large so that other materials could not spread evenly and cracks easily occurred on the surface of the concrete due to the large number of nails clumping together (balling process).

3.5 Concrete Split Tensile Strength Test Results

The split tensile strength value of concrete is the result of lateral compression testing on cylindrical specimens to its maximum strength and is expressed in MPa units. This test was carried out using an Universal Testing Machine (UTM) with cylindrical concrete test objects aged 28 days.

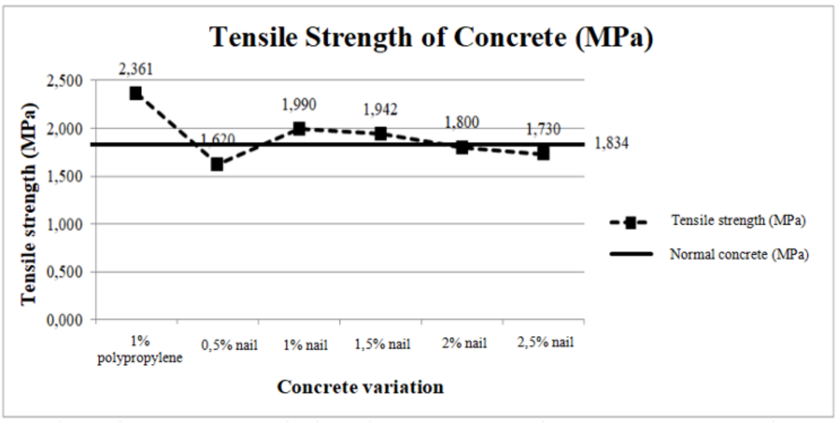

Figure 7. Relationship between variations in added materials and concrete split tensile strength

In **Figure 7**, it can be seen that none of the concrete with nail fiber has a split tensile strength that exceeds that of polypropylene fiber concrete. However, the 1% nail fiber concrete variation has a split tensile strength value that is higher than the other nail variations, namely 1,990 MPa. Furthermore, the split tensile strength decreased with increasing nail variations. The splitting tensile strength value of concrete with a nail variation of 1,5% has a value of 1,942 MPa, which means the decrease is not too far from the maximum splitting tensile strength value.

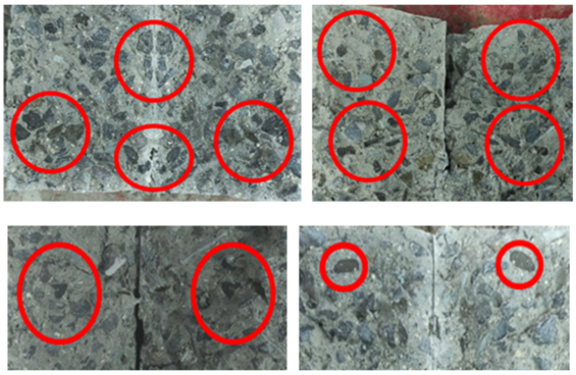

Figure 8. Crack Pattern of Concrete Split Tensile Strength

Based on the test results, it was found that the crack pattern in the concrete tested was split between the paste and aggregate. This can be seen in **Figure 8**. that there is a coarse aggregate that is also split, where all the pressure is spread evenly across all concrete elements and this means that the strength of the paste can be balanced with the aggregate so that both work optimally in supporting the load. The same thing also happened in research by Wariyatno [15] who said that concrete failure was partly caused by damage to the bond between the paste and the aggregate, so it can be said that all concrete elements are relatively strong in resisting compressive forces.

3.6 Optimum Proportion of Nail Fiber Concrete with Polypropylene Fiber Concrete

Based on the analysis results, it can be seen that the optimum proportion of nail fiber concrete that can be used as a substitute for 1% polypropylene fiber concrete is nail fiber concrete with a fiber variation of 1,5%. The compressive strength and splitting tensile strength of 1% polypropylene fiber concrete are 20,097 MPa and 2,361 MPa, while the compressive strength and splitting tensile strength of 1,5% nail fiber concrete are 21,290 MPa and 1,942 MPa. In the 1,5% nail variation, the compressive strength value has exceeded the compressive strength value of polypropylene fiber concrete, while the splitting tensile strength value has not exceeded but is close to the splitting tensile strength value of polypropylene fiber concrete.

4. CONCLUSION

Based on the background, problem formulation and research results, can be concluded that normal concrete produces a compressive strength value of 20,007 MPa. The compressive strength of concrete with 1% polypropylene fiber has a value of 20,097 MPa. Based on the compressive strength values, it can be concluded that nail variations of 0,5%, 1% and 2,5% do not exceed the design compressive strength. At nail variations of 1,5% and 2%, the compressive strength value exceeds the design compressive strength. The maximum compressive strength value is found in nail fiber concrete with a variation of 2%. The optimum compressive strength value of nail fiber concrete is found within a 1,5% variation of 21,290 MPa.

Normal concrete has a split tensile strength value of 1,834 MPa. The split tensile strength of concrete with 1% polypropylene fiber has a value of 2,361 MPa. Based on the splitting tensile strength value, it can be concluded that concrete with nail fiber does not have a splitting tensile strength value that is greater than polypropylene fiber concrete. The maximum split tensile strength value of nail fiber concrete varies within 1%. The optimum splitting tensile strength value of nail fiber concrete varies within 1,5%, amounting to 1,942 MPa.

The optimum proportion of nail fiber concrete that can be used as a substitute for 1% polypropylene fiber concrete is the 1,5% variation of nail fiber concrete. The compressive strength and splitting tensile strength of 1% polypropylene fiber concrete are 20,097 MPa and 2,361 MPa, while the compressive strength and splitting tensile strength of 1,5% nail fiber concrete are 21,290 MPa and 1,942 MPa. In the 1,5% nail variation, the compressive strength value has exceeded the compressive strength value of polypropylene fiber concrete, while the splitting tensile strength value has not exceeded but is close to the splitting tensile strength value of polypropylene fiber concrete.

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