The Effect of Rebar Tie Fiber as a Concrete Mixture Material on Compressive and Tensile Strength

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Abstract: Concrete is one of the construction materials made of a homogeneous mixture between cement, coarse aggregate, fine aggregate, and water. Concrete is widely used in construction, both on bridges, roads, buildings, and other constructions. The purpose of this study is to determine the differences of compressive and tensile strength between normal concrete and concrete with rebar tie fiber. The addition of tie wire fibers with a length 8 cm. Variations in the addition of rebar tie fiber 0%, 0.2%, 0.4%, 0.6%, 0.8%, and 1% form material total weight. Concrete was tested at the age of 28 days. From the test results, it was found that the highest compressive strength is 29.48 MPa with the addition of 0.8% rebar tie fiber. The compressive strength increase 13.5% from normal concrete. The highest tensile strength is 7.39 MPa with the addition 0.8% rebar tie fiber. The tensile strength increase 17.3% from normal concrete.

1 INTRODUCTION

Concrete is one of the construction materials made of a homogeneous mixture between cement, coarse aggregate, fine aggregate, and water. Concrete is widely used in construction, both on bridges, roads, buildings, and other constructions.

Concrete also has the advantage of high compressive strength, resistance to fire and weather, concrete mortar is easy to transport and shape according to needs, and maintenance costs are quite low. In addition to having the advantages of concrete also has weaknesses such as tensile strength that is much smaller than the compressive strength so this makes concrete requires special treatment to overcome the weaknesses in concrete.

This can be improved by the addition of steel reinforcement or fibers consisting of certain materials. Fiber materials that can be used to correct concrete weakness according to the American Concrete Institute (ACI) Committee 544 (2002) one of which is steel fiber (rebar tie fiber).

The purpose of the study was to find out and analyze the additional influence of Rebar tie fiber on compressive and tensile strength.

Studies about rebar tie fiber concrete has been conducted by An M Shende et al., 2012; Juliansyah et al., 2019; Kolawole et al., 2013; Komal Chawla and Bharti Tekwani, 2013; Ngudiyono., 2012; Rajarajeshwari et al., 2013; Wahyono and Agustinus., 2013, Widodo and Aris., 2012. The result of these studies obtained that fibers can improve the mechanical properties of concrete such as compressive strength, tensile strength, shear strength, bending strength, ductility, and shock resistance.

2 CHARACTERISTICS OF CONCRETE

2.1 Concrete Volume Weight

The weight of concrete volume is a comparison between the concrete Weight divided by concrete volume. The weight of concrete volume is influenced by the aggregate shape, aggregate gradation because the weight of the concrete volume depends on the weight of the aggregate volume. The weight of the concrete volume is in an air dry state. The weight of the volume is calculated using the following formula:

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$$\gamma c = W/V$$

Where:
γc = Concrete volume weight (kg/m^3)
W = Weight of test object (kg)
V = Concrete volume (m^3)

2.2 Concrete Compression Strength

Concrete Press is the magnitude of the load per unit area, which causes the concrete test object to be destroyed when weighed with a certain compressive force, which is produced by the press machine. In the testing of the strong concrete press, the test object can be a cube and cylinder. The strength of the concrete press is determined by material i.e. cement, coarse aggregate, fine aggregate, and water. Strength concrete press is the most important property of concrete. Strength concrete press is usually related to other properties, meaning when the concrete press is high, the other properties are also good. According to SNI 1974:2011 strong concrete press can be searched with the following formula:

$$f'_C = P/A$$

Information:
f'_C = Strength concrete press (MPa)
P = Maximum compressive load (N)
A = Depressed cross-sectional area (mm2)

2.3 Concrete Tensile Strength

Tensile Strength tensile is one of the important parameters in concrete strength. Tensile strength values are obtained through laboratory press testing by overloading each cylinder test object laterally to

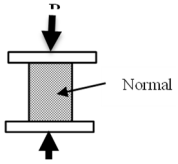

Figure 1: Compression test.

its maximum strength. The test object used is a cylindrical test object that is placed evenly in the direction of diameter along with the test object. When the tensile strength is reached then the test object will be split in half (SNI 03-2491-2002). The tensile strength can be calculated by the following formula:

$$f'_{Ct} = 2P/LD$$

With:
f'_{ct} = Concrete tensile strength (MPa)
P = Maximum load when the test object is split (N)
L = Test object length (mm)
D = Diameter of the test object (mm)

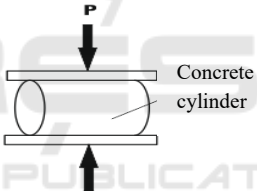

Figure 2: Split Tensile Tes.

2.4 Use of Rebar Tie Fibers

Table 1: Requirement of Cube rebar Tie fibers test objects.

No	Rebar tie fibers (%)	Requirement (gr)	
		One specimen	Five specimen
1	0.2	19	95
2	0.4	38	190
3	0.6	57	285
4	0.8	76	380
5	1.0	95	475

Table 2: Requirement of Cylinder rebar tie fibers test objects.

No	Rebar tie fibers (%)	Requirement (gr)	
		One specimen	Five specimen
1	0.2	10	50
2	0.4	20	100
3	0.6	30	150
4	0.8	40	200
5	1.0	50	250

Table 3: Number of test object.

Rebar tie fibers (%)	0	0.2	0.4	0.6	0.8	1	Total
Compressive Strength	5	5	5	5	5	5	60
Tensile Strength	5	5	5	5	5	5	
Number of test object	10	10	10	10	10	10	

2.5 Statistical Analysis

In this study, statistical analysis was conducted to determine the accuracy of data obtained from the research that has been done. There are two methods used in this study are ANOVA and regression analysis. The ANOVA method is an analysis that tests the average difference between groups. The hypothesis used in this study is H_0 = the absence of a significant influence between the addition of connective wire fibers with the value of compressive strength and tensile strength of concrete and H_1 = the presence of a significant influence between the addition of rebar tie fibers and the value of compressive strength with the tensile strength of concrete. H_0 applies if F count < F table while H_1 applies if F count > F table.

Regression analysis is one method in statistics to measure the influence of free variables (x) on bound variables (y). In this study, the free variable (x) was the percentage of the addition of connective wire fibers (%) whereas variable bound (y) is the value of compressive strength and tensile strength of concrete. The regression analysis in this study was used to determine the contribution of variable x (percentage of addition of rebar tie fibers) to variable y (value of compressive strength and tensile strength of concrete).

3 METHODOLOGY

3.1 Research Location

The research site was conducted in the Laboratory of Civil Engineering Department, Samarinda State Polytechnic.

3.2 General

The research was conducted using experimental methods in the laboratory with several stages. Starting from the preparation of equipment and materials, material inspection, mixed planning is continued with the manufacture of test objects. The shape and size of the fibers of the rebar tie fibers with a straight variation with a length 8 cm can be seen in figure 3.

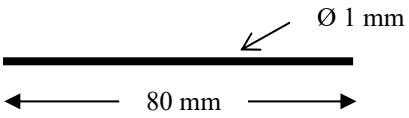

Figure 3: Cross-section of rebar tie fibers.

3.3 Dimensions of the Test Object

Pressure force test objects in the form of cubes size 15 cm x 15 cm x 15 cm and cylindrical tensile strength test objects with a diameter of 10 cm and height of 20 cm. In this study, the total number of test objects made as many as 60 pieces consists of 30 pieces of press force test objects and 30 pieces such as Table 1. Testing of compressive strength and tensile strength of concrete is performed after the test object is 28 days old.

3.4 Mixed Design

The mix design between cement, water, and aggregates -essential to obtain the desired concrete strength. In this study the composition of concrete mixture design using SNI 03-2834-2000 with the planned strength of K-250 and 20 MPa Of Normal Concrete. The fiber of the connecting wire is straight with a length of 8 cm and a diameter of 1 mm (Figure 3).

3.5 Addition of Rebar Tie Fibers

Sowing the fibers evenly into a mixing tub containing ordinary concrete mortar. Sowing fiber is done carefully and cultivated fibers are spread evenly in the concrete mortar so that there is no clumping of fibers that can affect the strength of concrete fibers. The amount of fiber added corresponds to the percentage of predetermined variations (Table 1 and Table 2).

3.6 Test Object

At this stage is carried out concrete compression testing and concrete tensile strength at the age of 28

days because concrete at the age of 28 days has maximum compressive strength. The procedure of testing strong press refers to (SNI 1974-2011) and strong pull refers to (SNI 03-2491-2002).

Figure 4: Concrete Press Test Equipment.

Figure 5: Concrete Cube Test Objects.

Figure 6: Split Test Equipment.

Figure 7: Split Dance Test Objects.

Based on the values obtained from the inspection of materials to achieve a concrete quality of 20 MPa with FAS 0.60 it takes a mixture composition as in Table 4 and Table 5.

4 RESULT AND DISCUSSION

4.1 Composition Concrete Mixture

Table 4: Composition of Cylindrical Concrete Mixture.

Composition of Cylindrical Concrete Mixture						
5 cylinders concrete mixture volume ϕ 10 x 20 = 0,0102 m^3	0 %	0.2 %	0.4 %	0.6 %	0.8 %	1.0 %
Cement (kg)	3.32	3.25	3.19	3.12	3.05	2.98
Water (kg/ltr)	1.80	1.76	1.72	1.69	1.65	1.62
Rough Aggregate ½ (kg)	6.53	6.39	6.27	6.14	6.00	5.87
Rough Aggregate 2/3 (kg)	6.38	6.25	6.12	5.99	5.87	5.74
Fine Aggregate (kg)	6.91	6.77	6.63	6.49	6.36	6.22
Rebar tie fibers (kg)	0	0.05	0.10	0.15	0.20	0.25

Source: Research Results

Table 5: Composition of Concrete Cube Mixture.

Composition of Concrete Cube Mixture						
5 Cubes concrete mix volume 15x15x15 = 0,0194 m^3	0 %	0.2 %	0.4 %	0.6 %	0.8 %	1.0 %
Cement (kg)	6.3	6.17	6.05	5.92	5.79	5.67
Water (kg/ltr)	3.5	3.43	3.36	3.29	3.22	3.15
Coarse Aggregate ½ (kg)	12.4	12.15	11.90	11.65	11.41	11.16
Coarse Aggregate 2/3 (kg)	12.1	11.85	11.62	11.37	11.13	10.89
Fine Aggregate (kg)	13.1	12.84	12.58	12.31	12.05	11.79
Rebar tie fibers (kg)	0	0.095	0.190	0.285	0.380	0.475

Source: Research Results

4.2 Slump Test

The result of making concrete samples conducted using cement water factor (fas) = 0.6 produces a diverse slump value with intervals between 30-60 mm. Slump test results can be seen in the following table 6:

Table 6: Slump Value For Cube Test Objects.

No.	Slump Value (mm)		
	%	Cylinder Test Objects	Cube Test Objects
1	0	45	45
2	0,2	40	40
3	0,4	40	40
4	0,6	40	40
5	0,8	35	35
6	1	35	30

Figure 8: Concrete Slump Test.

Based on Figure 9 of the test results obtained the value of the compression strength at the percentage of

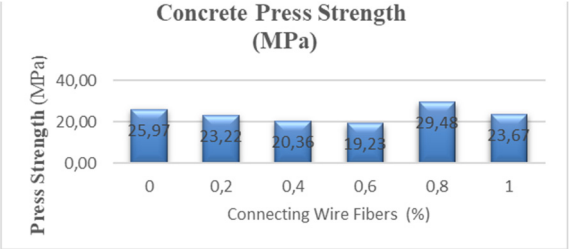

Figure 9: Concrete Press Strength Test.

the addition of rebar tie fibers 0% which is 25.97 MPa, then there was a decrease in the percentage of the addition of rebar tie fibers 0.2% is 23.22. The percentage of the addition of rebar tie fibers 0.4% is 20.36 MPa, the percentage of the addition of the weight of rebar tie fibers 0.6% is 19.23 MPa. Then the strong press increased at the percentage of the addition of rebar tie fibers can be 0.8% is 29.48 MPa and decreased again at the percentage of the addition of rebar tie fibers 1% which is 23.67 MPa.

Based on Figure 10 R Square (R^2) value of 0.008 means the amount of influence of the addition of rebar tie fibers to the concrete press strength by 0.8%. While the rest (100% - 0.8% = 99.2%) other variables outside of research. Other variables in this study are the lack of test objects, timeliness in the manufacturing process, and temperature changes.

Based on Table 9 known value F count = 1,300 while F table = 7,709 which means F calculate < F table then H0 received at signification level 0.05 means the addition of rebar tie fibers does not cause a real change in the value of tensile strength.

Table 7: Average compressive strength analysis results.

No	R	R Square	R Square Customized	Std. Estimation error
1	0.88[a]	0.008	-0.240	4.16463

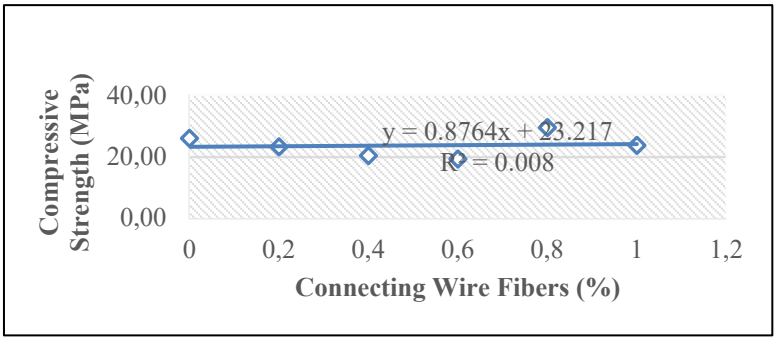

Figure 10: Curve R Square Strength Press.

Table 8: Compressive Strength Testing Analysis Results.

ANOVA						
Variasi		df	Kuadrat Mean	F count	F Table	H0
Regression	0.540	1	0.540	0.031	7.709	receive
Residual	69.377	4	17.344			
Total	69.917	5				

4.4 Tensile Strength Test

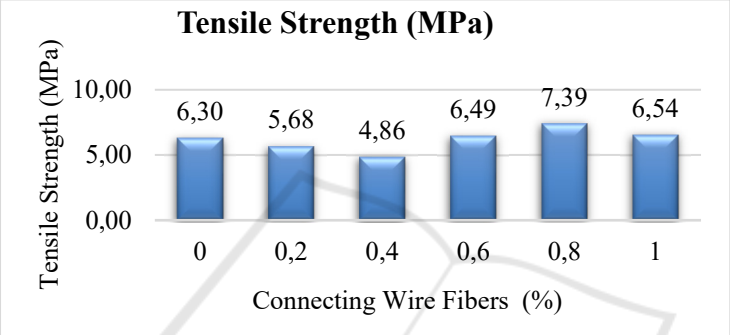

Figure 11: Concrete Tensile Strength Test.

Table 9: Tensile Strength Testing Analysis Results.

ANOVA						
Variasi		df	Kuadrat Mean	F count	F Table	H0
Regression	0.905	1	0.905	1.300	7.709	receive
Residual	2.786	4	0.697			
Total	3.691	5				

(source: SPSS)

Based on Figure 11 obtained the value of R Square (R2) of 0.246 which means the magnitude of the influence of the addition of connecting wire fibers to the concrete press strength by 24.6%. While the rest (100% - 24.6% = 74.4%) other variables outside of research. Other variables in this study are the lack of test objects, timeliness in the manufacturing process, and temperature changes. Based on Table 10 known value F count = 1.300 while F table = 7.709 which means F calculate < F table then H0 received at signification level 0.05 means the addition of rebar tie fibers does not cause a change in the value of the pull force in real.

5 CONCLUSIONS

From the results of research conducted on the variation of connective wire fiber mixture 0%. 0.2%. 0.4%. 0.6%. 0.8% and 1% can be concluded as follows:

- From the test result of concrete press strength decrease occurred at 0.2% = 23.22 MPa. the addition of rebar tie fibers 0.4% = 20.36 MPa. the addition of rebar tie fibers 0.6% = 19.23 MPa then increased at the addition of rebar tie fibers 0.8% = 29.48 MPa and decreased again at the addition of

rebar tie fibers 1% = 23.67 MPa to normal concrete of 25.97 MPa.

- From the test result of concrete tensile strength the decrease occurred in the addition of rebar tie fibers 0.2% = 5.68 MPa. the addition of rebar tie fibers 0.4% = 4.86 MPa. then increased at 0.6% = 6.49 MPa. increased the addition of rebar tie fibers 0.8% = 7.39 MPa and again decreased at the addition of rebar tie fibers 1% = 6.54 MPa to normal concrete with a tensile strength of 6.30 MPa.
- From the results of statistical analysis on compressive strength obtained the value of R Square (R2) = 0.008 and Anova obtained H0 received then there is no significant influence between the addition of rebar tie fibers with the value of compressive strength.
- From the results of statistical analysis on the tensile strength of concrete tensile obtained the value of R Square (R2) = 0.246 and Anova obtained H0 received then there is no significant influence between the addition of rebar tie fibers with the value of I pull concrete..

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