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Effect of Addition of Iron Lathe Waste as an Additive to Normal Concrete Compressive Strength and Tensile Strength of Concrete

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***Abstract*— *Concrete is obtained from mixing fine and coarse aggregate materials, namely sand, crushed stone and other materials by adding sufficient cement adhesive and water. Concrete itself is a material that is often used because it is durable, inexpensive, and can be moulded into complex shapes. Concrete has a fairly large compressive strength but has a small tensile strength. To overcome these problems, concrete with special characteristics was found, namely steel fiber concrete (BSB). However, steel fiber is quite expensive if used for small scale construction. In this research, lathe iron waste was used as an added ingredient in the concrete mixture with varying levels of 0.75%, 1.5%, 2.25%, 3%, 3.75%. From this composition, concrete compressive strength and concrete split tensile strength tests were then carried out. The results showed that the addition of iron lathe in concrete to the compressive strength of concrete characteristics did not really show a significant difference in results, namely a decrease in compressive strength of 0.0496% in the 1.5% variation of 22.24 MPa when compared to the value in the 0% variation (normal) of 22.25 MPa. The addition of iron lathe in concrete to the tensile strength of concrete characteristics shows more results, namely an increase of 10.739% in the 2.25% variation of 10.04 MPa when compared to the value in the 0% (normal) variation of 9.07 MPa.*

***Keywords*— *Compressive strength, Split Tensile Strength, Iron Lathe.*

I. INTRODUCTION

Concrete is made up of fine and coarse aggregate materials such as sand, crushed stone and other materials by adding sufficient cement adhesive and water. Concrete itself is a structural material that is most often used for the construction of buildings, roads, bridges and others. Concrete is often used because it is durable, inexpensive, can be easily molded into complex shapes and has considerable compressive strength.

However, concrete itself has weaknesses, namely being brittle, low specific gravity and tensile strength and uneven load distribution due to the relatively small load absorption in the concrete. In overcoming these things, concrete with special characteristics was found, namely steel fiber concrete (BSB). The purpose of adding fiber to concrete is to increase the tensile strength of the concrete, considering that the tensile strength of concrete is low.

At the beginning of research on steel fiber concrete (BSB), the use of steel fiber concrete (BSB) was not too much due to the high cost of steel fiber fabrication. However, the use of steel fiber concrete (BSB) has recently become more attractive and the use of steel fiber concrete (BSB) is increasing throughout the world. However, steel fiber itself is still considered quite expensive if used for small scale construction.

Based on this, through this research, material in the form of lathe iron waste is used as an additive to normal concrete which is intended to determine the increase that occurs in compressive strength and in tensile strength of concrete by adding lathe iron waste fiber as an additive to normal concrete.

II. LITERATURE REVIEW

According to SNI 03-2834-2000 concrete is a mixture of Portland cement or other hydraulic cement, fine aggregate, coarse aggregate and water with or without added ingredients to form a solid mass. In its development concrete undergoes changes in variations, one of which is fiber concrete.

Fiber concrete is a mixture of concrete plus fiber, generally in the form of rods with a size of 5-500μm with a length of about 25 mm (Mulyono, 2004). Fiber concrete is used in constructions that must have large surfaces where temperature, oxidation and evaporation have a major influence on the amount of expansion shrinkage, such as airport runways, roof plates, roads, and others.

Types of fiber:
1. Metal fiber
2. Polymeric or synthetic fiber
3. Fiberglass
4. Natural fiber

Fiber concrete composing material:
1. Composite Portland cement
2. Coarse aggregate (gravel)
3. Fine aggregate (sand)
4. Water
5. Iron lathe waste

Fig 1. Iron lathe waste that will be used

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The concrete mix planning used in this research is the SNI 03-2834-2000 method. For each trial mixture at least two cylinders 150 x 300 mm or three cylinders 100 x 200 mm were made (SNI 1874:2013).

a. Concrete compressive strength testing

According to SNI 03-1974-2011, the compressive strength of concrete load is the amount of load per unit area, which causes the concrete test object to be destroyed when loaded with a certain compressive force, produced by a press machine.

$$fc' = \frac{P}{A} \left(\text{kg/cm}^2\right)$$

Keterangan :
fc' = concrete compressive strength
P = maximum load (kg)
A = cross-sectional area of the test object (cm^2)

b. Concrete split tensile strength testing

The commonly used concrete split tensile strength test is SNI 03-2491-2002.

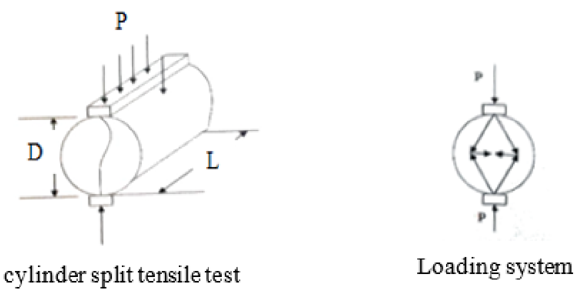

Fig 2. Split Tensile Strength Test Image

The formula used according to SNI 03-2491-2002 is as follows:

$$f_{ct} = 2P/LD$$

Description :
f_{ct} = tensile strength (MPa)
P = maximum test load (split/crushed object) in Newtons (N) indicated by the compression testing machine
L = length of test specimen in mm according to sub-article 5.3
D = diameter of the test object in mm according to sub-article 5.3

III. REASEARCH METHODOLOGY

In this research, the method used is an experimental method in the laboratory, namely by conducting an experiment directly to obtain the results in this research. In this research process, prioritization was carried out by reviewing the literature on the use of turning waste as an additive to concrete.

The materials to be used in this research are type I PCC cement with Tiga Roda brand, coarse aggregate crushed stone from Palu, fine aggregate natural sand from Palu, and iron lathe waste from Jaya Teknik Samarinda lathe workshop.

$$c + d = \alpha$$

Making Job Mix with lathe waste fiber additives with variations of 0%, 0.75%, 1.5%, 2.25%, 3%, 3.75%. There are 6 variations made by the researchers, where each variation made 4 test objects for each compressive strength and split tensile strength test. The cylindrical test object had a height of 20 cm and a diameter of 10 cm. Compressive strength tests and split tensile strength tests were carried out at the age of 28 days of concrete test objects.

Table 1 Material Testing

No	Material Testing		
	Coarse Aggregate	**Fine Aggregate**	**Cement**
1	Sieve Analysis	Sieve Analysis	Specific gravity
2	Water Content	Water Content	Normal Consistency
3	Specific gravity and Absorption	Specific gravity and Absorption	Setting Time
4	Content Weight	Content Weight	
5	Abrasion		

IV. RESEARCH RESULTS AND EXPLANATION

- The research data was then analyzed to determine the effect of adding iron lathe waste to concrete. The tests carried out are divided into 2 parts, namely material testing and concrete compressive and tensile strength testing.
- In this study, the cement used is PCC (Portland Composite Cement) type cement with the Tiga Roda brand, testing the cement includes Normal Consistency, Setting Time and Specific Weight of Cement.
- In this material testing, there are 2 kinds of tests with the aim of obtaining data about the aggregate material to be used. These data include Sieve Analysis, Water Content, Specific Gravity and Absorption, Bulk Weight and Aggregate Wear.
- Compressive Strength Testing

Testing the compressive strength of concrete is carried out at the age of 28 days. The test steps are as follows:

a. The concrete cylinder is removed from immersion, then wiped and aired until the surface is dry.
b. Weigh and record the weight of concrete samples.
c. Place the sample on the compressive strength testing tool, then turn on the machine so that the machine slowly presses the concrete sample.
d. Load the maximum compressive strength.
e. Record the results of the maximum concrete load for each sample.
f. Determines the form factor value.
g. Compressive strength x form factor.

The following is an example of cylinder calculations for specimen 1 of normal concrete with 0% lathe waste content aged 28 days:

Diameter (D) = 10 cm
Height (t) = 20 cm
Weight (W) = 3.905 kg = 3905 grams
28-day age conversion = 1
Solution :
- Cross-sectional area (A) = $¼.\pi.d^2$
= ¼ x 3,14 x 10^2
= 78.4 cm^2
= 7854 mm^2
- Volume (V) = $¼.\pi.d^2.t$
= ¼ x 3,14 x 10^2 x 20

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= 1570.80 cm^3

- Content weight (γ) =W/V $= \frac{W}{¼ \times \pi \times d^2 \times t}$

-
= 3905 / 1570,80
= 2.486 gr/cm^3
= 2486 kg/m^3

- Compressive strength (Mpa)

1 KN = 1000 N
200 KN = 200000 N

$fc' = P/A = \frac{\text{Maximum load}}{\text{Cross sectional area}} = \frac{P}{¼ \times \pi \times d^2}$

$= \frac{200 \times 1000}{7854} = 25{,}46$ Mpa

- Estimated compressive strength of 28 days

$= \left(\frac{\text{Estimated compressive strength}}{\text{age conversion}}\right)$ x shape conversion

= (25.46 / 1) x 1.04 = 26.48 Mpa

Calculations for other test objects can be seen in table 2 to table 7.

Table 2 Compressive strength of concrete with 0% variation

Sample name	Diameter (cm)	Height (cm)	Cross section area (mm^2)	Age (Days)	Compressive strength(KN)	Conversion		Comp. Strength (Mpa)
						Day	Shape	
N1	10	20	7854	28	200	1	1,04	26,48
N2	10	20	7854	28	180	1	1,04	23,84
N3	10	20	7854	28	175	1	1,04	23,17
N4	10	20	7854	28	190	1	1,04	25,16
mean	10	20	7854		186			24,66

Table 3 Compressive strength of concrete with 0,75% variation

Sample name	Diameter (cm)	Height (cm)	Cross section area (mm^2)	Age (Days)	Compressive strength(KN)	Conversion		Comp. Strength (Mpa)
						Day	Shape	
V1.1	10	20	7854	28	230	1	1,04	30,46
V1.2	10	20	7854	28	190	1	1,04	25,16
V1.3	10	20	7854	28	180	1	1,04	23,84
V1.4	10	20	7854	28	190	1	1,04	25,16
mean	10	20	7854		198			26,15

Table 4 Compressive strength of concrete with 1,5% variation

Sample name	Diameter (cm)	Height (cm)	Cross section area (mm^2)	Age (Days)	Compressive strength(KN)	Conversion		Comp. Strength (Mpa)
						Day	Shape	
V2.1	10	20	7854	28	210	1	1,04	27,81
V2.2	10	20	7854	28	225	1	1,04	29,79
V2.3	10	20	7854	28	175	1	1,04	23,17
V2.4	10	20	7854	28	200	1	1,04	26,48
mean	10	20	7854		203			26,81

Table 5. Compressive strength of concrete with 2,25% variation

Sample name	Diameter (cm)	Height (cm)	Cross section area (mm^2)	Age (Days)	Compressive strength(KN)	Conversion		Comp. Strength (Mpa)
						Day	Shape	
V3.1	10	20	7854	28	190	1	1,04	25,16
V3.2	10	20	7854	28	200	1	1,04	26,48
V3.3	10	20	7854	28	175	1	1,04	23,17
V3.4	10	20	7854	28	140	1	1,04	18,54
mean	10	20	7854		176			23,34

Table 6 Compressive strength of concrete with 3% variation

Sample name	Diameter (cm)	Height (cm)	Cross section area (mm^2)	Age (Days)	Compressive strength(KN)	Conversion		Comp. Strength (Mpa)
						Day	Shape	
V4.1	10	20	7854	28	160	1	1,04	21,19
V4.2	10	20	7854	28	185	1	1,04	24,50
V4.3	10	20	7854	28	155	1	1,04	20,52
V4.4	10	20	7854	28	170	1	1,04	22,51
mean	10	20	7854		168			22,18

Table 7 Compressive strength of concrete with 3,75% variation

Sample name	Diameter (cm)	Height (cm)	Cross section area (mm^2)	Age (Days)	Compressive strength (KN)	Conversion		Comp. Strength (Mpa)
						Day	Shape	
V5.1	10	20	7854	28	155	1	1,04	20,52
V5.2	10	20	7854	28	175	1	1,04	23,17
V5.3	10	20	7854	28	180	1	1,04	23,84
V5.4	10	20	7854	28	155	1	1,04	20,52
mean	10	20	7854		166			22,01

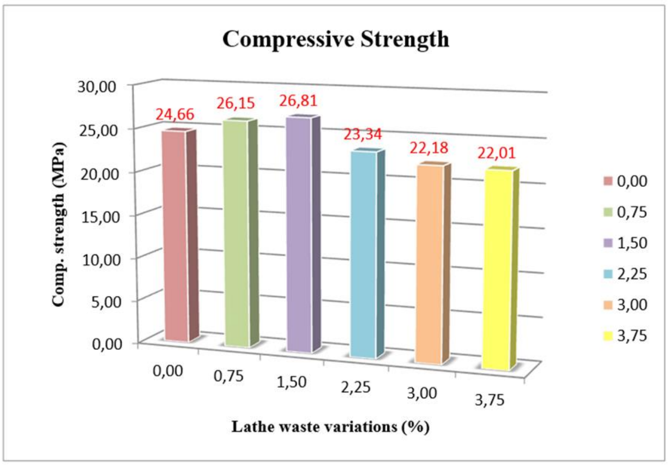

Fig 3. Comparison Chart of compressive strength of lathe waste concrete and normal concrete

In Figure 3, it can be seen that the compressive strength test results of lathe waste fiber concrete increased by 2.532% from 23.73 MPa in the 0% concrete variation (normal) to 25.80 MPa in the 1.5% concrete variation.

Split Tensile Strength Testing

In this split tensile strength test, the test method is the same as the concrete compressive strength test, namely testing the sample at the age of 28 days.

The following is an example of cylinder calculations for specimen 1 of normal concrete with a turning waste content of 0% aged 28 days:

Known :
Diameter (D) = 10 cm = 100 mm
Length (L) = 20 cm = 200 mm
Load (P) = 110 KN x 1000 = 110.000 N
28-day age conversion = 1
Solution :

$$f_{ct} = \frac{2P}{LD}$$

$$= \frac{2 \times 110.000}{200 \times 100} = \frac{220.000}{20.000}$$

= 11 MPa

Estimated compressive strength of 28 days

$= \left(\frac{\text{Estimated compressive strength}}{\text{age conversion}}\right)$ x shape conversion

= (11 / 1) x 1,04
= 11.44 MPa

Calculations for other test objects can be seen in table 8 to table 13.

Table 8 Split tensile strength of concrete with 0% variation

Sample name	Diameter (cm)	Width (cm)	Cross section area (mm^2)	Age (Days)	Split Tensile Strength (KN)	Conversion		Split Tensile Strength (Mpa)
						Day	Shape	
N1	10	20	20000	28	110	1	1,04	11,44
N2	10	20	20000	28	105	1	1,04	10,92
N3	10	20	20000	28	90	1	1,04	9,36
N4	10	20	20000	28	100	1	1,04	10,40
mean	10	20	20000		101			10,53

Table 9 Split tensile strength of concrete with 0,75% variation

Sample name	Diameter (cm)	Width (cm)	Cross section area (mm^2)	Age (Days)	Split Tensile Strength (KN)	Conversion		Split Tensile Strength (Mpa)
						Day	Shape	
V1.1	10	20	20000	28	100	1	1,04	10,40
V1.2	10	20	20000	28	110	1	1,04	11,44
V1.3	10	20	20000	28	100	1	1,04	10,40
V1.4	10	20	20000	28	110	1	1,04	11,44
mean	10	20	20000		105			10,92

Table 10 Split tensile strength of concrete with 1,5% variation

Sample name	Diameter (cm)	Width (cm)	Cross section area (mm^2)	Age (Days)	Split Tensile Strength (KN)	Conversion		Split Tensile Strength (Mpa)
						Day	Shape	
V2.1	10	20	20000	28	120	1	1,04	12,48
V2.2	10	20	20000	28	100	1	1,04	10,40
V2.3	10	20	20000	28	100	1	1,04	10,40
V2.4	10	20	20000	28	110	1	1,04	11,44
mean	10	20	20000		108			11,18

Table 11 Split tensile strength of concrete with 2,25% variation

Sample name	Diameter (cm)	Width (cm)	Cross section area (mm^2)	Age (Days)	Split Tensile Strength (KN)	Conversion		Split Tensile Strength (Mpa)
						Day	Shape	
V3.1	10	20	20000	28	100	1	1,04	10,40
V3.2	10	20	20000	28	120	1	1,04	12,48
V3.3	10	20	20000	28	110	1	1,04	11,44
V3.4	10	20	20000	28	110	1	1,04	11,44
mean	10	20	20000		110			11,44

Table 12 Split tensile strength of concrete with 3% variation

Sample name	Diameter (cm)	Width (cm)	Cross section area (mm^2)	Age (Days)	Split Tensile Strength (KN)	Conversion		Split Tensile Strength (Mpa)
						Day	Shape	
V4.1	10	20	20000	28	100	1	1,04	10,40
V4.2	10	20	20000	28	60	1	1,04	6,24
V4.3	10	20	20000	28	80	1	1,04	8,32
V4.4	10	20	20000	28	80	1	1,04	8,32
mean	10	20	20000		80			8,32

Table 13 Split tensile strength of concrete with 3,75% variation

Sample name	Diameter (cm)	Width (cm)	Cross section area (mm^2)	Age (Days)	Split Tensile Strength (KN)	Conversion		Split Tensile Strength (Mpa)
						Day	Shape	
V5.1	10	20	20000	28	70	1	1,04	7,28
V5.2	10	20	20000	28	70	1	1,04	7,28
V5.3	10	20	20000	28	90	1	1,04	9,36
V5.4	10	20	20000	28	60	1	1,04	6,24
mean	10	20	20000		73			7,54

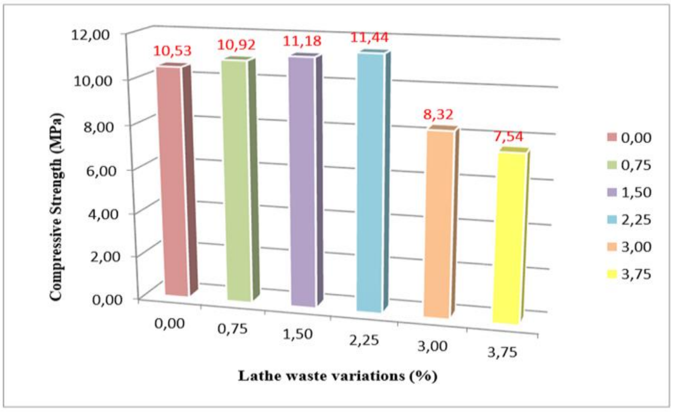

Fig. 4 Comparison Chart of split tensile strength of lathe waste concrete and normal concrete

From figure 4 above, it can be seen that in the 0.75% variation to the 2.25% variation, the split tensile strength has increased when viewed from the 0% variation, the maximum increase is in the 2.25% variation, which is 10.04 MPa.

V. Conclusion And Recommendations

A. Conclusion

From the research that has been carried out, the effect of the addition of iron lathe as an additive to fiber concrete on the compressive strength and split tensile strength of concrete can be concluded that:

1. The addition of lathe iron waste in concrete to the compressive strength of concrete increased by 8.725% in the addition of lathe iron waste with a variation rate of 1.5% at 26.81 MPa when compared to the 0% variation (normal concrete) of 24.66%.
2. The addition of lathe iron waste in concrete to the split tensile strength of concrete increased by 8.64% in the addition of lathe iron waste with a variation rate of 2.5% at 11.44 MPa when compared to the 0% variation (normal concrete) of 10.92%.

B. Recommendations

Suggestions that can be conveyed from writing the results of this research are:

1. More test objects are needed so that the research results show more valid data.
2. It is best to use the same type of iron fiber/lathe so that the influence of the iron fiber on the test data is more uniform.
3. Concrete tensile tests should be carried out on fiber concrete with lathe waste materials considering that iron is a material that has high tensile strength.

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