The effect of addition of banana tree bark for compressive strength and crack tensile strength of rice husk ash concrete

Muhammad Rizqi^{1,*}, Hernu Suyoso¹, and Gati Annisa Hayu¹

¹University of Jember, Department of Civil Engineering, 68121 Jember – East Java, Indonesia

Abstract. The use of concrete as the main material in the construction does not mean it has no weaknesses. The brittle, low-density concrete properties make it collapse unexpectedly. In this work, a concrete innovation was performed to increase the compressive strength by the addition of rice husk ash as cement substitution that contains 92.31% of SiO₂ and by the addition of banana tree bark. The proportion of rice husk ash used was obtained from preliminary tests to determine the proportion of rice husk ash by 5%, 7%, 10%, 12% and 15% of the cement's weight. The result of the proportion which yielded the optimum concrete compressive strength by 24.4 MPa in the proportion of rice husk ash by 7%, then was made with the same ash content with banana tree bark fiber variation 0%; 1.5%; 2% and 3%. The Result of the test concluded that the addition of banana tree bark fiber can decrease the compressive strength and tensile strength of concrete because it is caused by the fibers that make hard concrete become solid. However, for all proportions of fiber, it still qualifies as the minimum tensile strength to be achieved i.e. 8% of the compressive strength of the plan.

1 Introduction

Concrete has a resistance to temperature effect (hydration heat), high acidity (Sulfate Resistance) and is resistant to corrosion. In addition, the weakness of concrete is that it is easily cracked or is brittle because it has a low ductility level, this is seen in the stress-strain curve of concrete where there is a rapid decline in the area after the peak load, causing a sudden collapse. [1] in his research to make concrete with the addition of fibers, concluded that the concrete has a very large push force, but the tensile strength of concrete is very low [2]. The use of Natural Fiber (natural fiber) is an option because of its availability in nature that can be renewed and is relatively cheap.

In Indonesia, one of the natural fibers that can be utilized as a concrete mixture is banana tree bark fiber, with a total production of banana trees in 2016 reaching 7.3 million tons [3]. According to previous research, banana tree bark has 5% Lignin content, 63-64% Cellulose content, 20% Hemicellulose, while the mechanical properties of banana tree bark fiber have an average tensile strength of 600 MPa and an average tensile modulus of 17.85

---

* Corresponding author: muhammadrizqi97@gmail.com

GPa. Banana bark fiber diameter is 5.8 μm , while the fiber length is about 30.92-40.92 cm [4].

Another mixed material that can be used to improve the performance of concrete is rice husk ash, with a total rice production of 75.36 million tons of dry milled grain [5]. Rice yield will produce waste husk ash rice containing pozzolan material, that is silica (SiO_2) equal to 92,31%.

In this research, it will be made of structural fiber concrete with a mixture of rice husk as substitution material of cement and the addition of banana tree bark fiber so as to produce strong structural concrete to compressive strength and tensile strength, and to obtain fiber composition that yields optimal compressive strength.

2 Material and methods

The research was made by proportioning some concrete mixtures using banana tree bark fiber and rice husk ash. The research design will be implemented as in the table.

Table 1. Research design.

Specimen code	Proportion		Testing	
	Rice Husk Ash	Bark Fiber	Compressive Strength	Crack Tensile Strength
NF	x%	0%	7	7
FC1,5	x%	1,5%	7	7
FC2	x%	2%	7	7
FC3	x%	3%	7	7
Σ Number of Specimens			28	28
Σ total			56 Specimen	

Ash husk ash content is the result of preliminary test of cylindrical concrete measurement $\varnothing$ 10 cm x 20 cm with rice husk ash mixture which has the highest compressive strength value of some percentage which is made, then the result was used as substitution of cement in all proportion of fiber concrete.

In this study, mixing of concrete took place with rice husk ash as a substitute for cement and also banana tree bark fiber was added as an added material. In this research, the ash husk used it has been through a combustion process at a temperature of 550 - 800 $^{\circ}\text{C}$. The selected banana tree is banana tree type kepok originating from Lumajang, Eastern Java.

Prior to the planning, a preliminary test of the maximum proportion of rice husk ash used is used to produce a good compressive strength of concrete. Preliminary tests were also conducted on the feasibility of banana tree bark fiber including testing of tensile strength and weight-volume testing.

2.1 Trial tensile test of banana tree bark fiber

This feasibility test is conducted to determine the ability of fiber to be used as a mixture of fiber in concrete. This feasibility test is done by testing the tensile strength of banana tree fiber.

The stages performed are: the banana tree bark was cut so that it has a length of 500 mm, then twisted to have a diameter of 18.9 mm. Both ends are given a wire to clamp and then the test will be done with Universal Testing Machine.

2.2 Treatment of banana tree bark fiber

Treatment performed on the banana stem is the separation of fiber and cutting of the banana tree bark. The stages are: separating the stem so that it becomes the sheets and then is separated from the fibers by removing the stem flesh. After the process, the drying is done to remove the water content in the fiber and then the fiber is cut with a length of 5 cm to be mixed in the concrete.

2.3 Preliminary test of rice husk ash

This preliminary test is conducted to determine the maximum proportion of rice husk ash as a cement substitution material for maximum compressive strength, which is then used as the proportion of the mixture of fiber concrete. Then the percentage of rice husk ash is determined to be 5%, 7%, 10% and 12% of the weight of cement. The test object used is a cylinder size Ø 10 cm x 20 cm as much as 3 Samples of test specimen per proportion.

2.4 Treatment of rice husk ash

The treatment is done by observing the temperature of the furnace at the time of combustion in the tile-making industry using a Thermometer Furnace with Temperature being hinted to be at 550 - 800 °C. Ash husk obtained was then pounded and sieving was performed to produce RHA that has a physical shape resembling cement, by passing it through 200 sieves.

3 Results and discussion

3.1 Testing of banana tree fiber

Testing of the banana tree bark fiber was performed to include weight volume and fiber tensile strength. It aims to be easy in analyzing the effect of added fiber as mixture concrete.

3.1.1 Weight volume percentage

To know the characteristics of banana tree bark fiber, then one of them is done by weight volume test

Table 2. Banana tree bark weight volume percentage.

Testing Number	1	2	3	Unit
Fiber Weight	36,2	36,6	37,2	gram
Volume of Mold Cube	125	125	125	cm ³
Weight Volume	0,2896	0,2928	0,2976	g/cm ³
Mean	0,293			g/cm ³

Based on table 4:20 from laboratory testing, can be obtained data weight volume of banana tree bark fiber is equal to 0.293 g/cm³.

3.1.2 Tensile strength of banana tree bark fiber

From laboratory tests, the data of banana tree bark fiber with the diameter of 18,9 mm can be obtained, it has a tensile strength equal to 8,211 MPa with a maximum force that can bear the load up to 2,304 KN or 230,4 Kg and increased fiber length by 9.33%.

Table 3. Tensile strength of fiber.

Result	Value	Unit
Initial Diameter	18,9	mm
Initial Length	300	mm
Tensile Strength	8,211	MPa
Maximum Force	2,304	KN
Final Diameter	9,4	mm
Final Length	328	mm
Elongation Percentage	9,33	%

The fiber tested has a shape like a rope that has a diameter of 18.9 mm. The fiber behavior shown on the graph shows that the fiber has two melting points. At the first peak, the fiber decreases but can still carry the load until it reaches the second peak and the second peak is higher than the other one. The second peak is the final tensile strength of the banana tree bark that is equal to 8,211 MPa.

Fig. 1. Banana tree bark fiber tensile strength.

3.2 Rice husk ash concrete preliminary test

This concrete compressive strength test uses a cylindrical sized Ø 10 h 20. The test specimen of each proportion has a total of 3 pieces then the compressive strength value taken as the average value of the 3 specimens. Age of concrete to be tested is 7 days.

Fig. 2. Preliminary test of rice husk ash concrete.

From the results of the rice husk ash concrete assay, a mixture of rice husk ash is proportionally assumed to be 7% in subsequent fiber concrete making. This is because the proportion of 7% is the maximum proportion of the use of added materials such as husk ash which can produce an optimal compressive strength of 24.44 MPa.

3.3 Specimen test

3.3.1 Slump test

The level of workability or slump value is closely related to the fas and the amount of water used. The more water used then the slump value generated will also be higher. The addition of water to the fiber concrete test specimen, given the same treatment as concrete without fiber. Provision of fiber in the concrete will certainly give effect to the value of slump generated.

Table 4. Slump test.

Proportion	Water needed from mix design	Slump (mm)
7% RHA, 0%Fiber	0,371	62
7% RHA, 1,5%Fiber	0,371	25
7% RHA, 2%Fiber	0,371	10
7% RHA, 3%Fiber	0,371	5

The effect of adding fiber to slump value obtains linear graph with the equation $y = -19.893x + 57.827$ with correlation coefficient (r) = 0.9648. With a value of r close to 1, it indicates that between the addition of fiber and the slump value there is a very strong relationship. The addition of fibers in the concrete causes the concrete mixture to get thicker and more difficult to work on. It can be concluded that the addition of fiber greatly affects the value of slump because the fiber is binding.

Fig. 3. Slump and fiber correlation.

3.3.2 Weight of concrete fiber

Based on the test results data that the addition of fiber can make the weight of the concrete content decrease because the weight of the contents closely relates to the level of concrete density. While the concrete density is determined by how easily the concrete is a solid and relates to the workability of the concrete. The more fiber is added, the lower the concrete density.

With each addition of fiber, the concrete continues to decrease the volume weight. Non-fiber concrete has a volume weight of 2576,75 kg/m³, while concrete with 1.5% fiber content has a decreased volume weight of 2549,55 kg/m³. For concrete with a fiber of 2% it

has a volume weight of 2540,45 kg/m³ and concrete with a proportion of 3% fiber has a volume weight of 2516,15 kg/m³.

Table 5. Weight of concrete fiber.

Proportion	Weigth (Kg)	Weight (Kg/m³)
7% RHA, 0%Fiber	4,0492	2576,75
7% RHA, 1,5%Fiber	4,0042	2549,55
7% RHA, 2%Fiber	4,0064	2540,45
7% RHA, 3%Fiber	3,9540	2516,15

The effect of adding fiber to the weight of concrete obtains a linear graph with the equation $y = -19.951x + 2578.1$ with the value of correlation coefficient (r) = 0.996. With a value of r close to 1, it indicates that between the addition of fiber and the slump value there is a very strong relationship.

Fig. 4. Weight content and fiber correlation.

3.3.3 Compressive strength

From the compressive strength test, the value of concrete compressive strength decreased at each fiber variation. The proportion of husk ash without adding fiber produces a compressive strength of 25.175 MPa. Then for husk ash concrete with the addition of fiber equal to 1,5 it decreased by 15,4% from non fiber concrete and a has compressive strength equal to 21,302 MPa. In the 2% mixture of fibers, the concrete decreased by 19.3% and the concrete compressive strength to 20,327 MPa while for the concrete the proportion of fiber 3% experienced a very drastic reduction of 46% and had a compressive strength of 13,605 MPa.

Fig. 5. Compressive strength.

The cause of the decrease in compressive strength is the difficult level of workability so that the concrete is difficult to compact. The better the level of workability, the better the

compressive strength. Another thing that causes a decrease in compressive strength is from the weight of the concrete content. The weight of concrete fibers tends to be lighter than normal concrete because there is a cavity which is caused by the small level of workability. The higher the weight of the concrete content the higher the strength of the compressive strength.

Previous research, using rice husk ash as a cement substitution material, yielded an optimum compressive strength of 23.26 MPa. From this research, the optimum compression strength of 29.1 MPa is obtained for the mixture of 7% rice husk ash and 0% fiber and the average is 25.17 MPa and the addition of fiber in each variation can decrease the compressive strength.

Fig. 6. Fiber and compressive strength correlation.

3.3.4 Crack tensile strength

From the Crack Tensile strength test, it was found that the value of tensile strength of concrete has decreased in the provision of fiber variations. The proportion of husk ash without adding fiber resulted in a tensile strength of 8,519 MPa. Then for the husk ash concrete with the addition of fiber by 1.5% decreased by 2.6% of non-fiber concrete and has a tensile strength of 8.301 MPa. In the 2% mixture of fibers, the concrete also decreased the tensile strength of the previous proportion of 8.06 MPa and decreased by 5.3% of its normal concrete. For concrete, the proportion of fiber 3% decreased by 9.9% and has a tensile strength of 7,674 Mpa. From the tensile strength data, it can be concluded that the tensile strength of concrete has decreased but the optimum tensile strength for Concrete with the fiber mixture is found in the proportion of 1.5% fiber.

Fig. 7. Crack tensile strength.

The tensile strength of concrete usually ranges from 8-15% of compressive strength, then the minimum tensile strength to be met is 8% of compressive strength [6]. The compressive strength of concrete planned in mixed design is 25 MPa. So the tensile strength that must be met (8% of 25 Mpa) is 2 MPa. The overall yielding tensile strength of all proportions can meet the specified limits even though the tensile strength of the concrete decreases. The tensile strength also decreases as well as the decrease that occurs in compressive strength, but for the decrease in tensile strength, it is not as much as the

decrease in compressive strength. With value $r = 0,96203$, the value of r is based on the interval table can be concluded that between the addition of fiber to the drop of tensile strength there is a strong relationship.

Fig. 8. Fiber and tensile strength correlation.

4 Conclusions

This experimental study was to present the ratio of adding fiber as a concrete mixture of rice husk ash. Rice husk ash which we know contains silica (SiO_2) of 92.31% and can improve the compressive strength of concrete. It is proven from the preliminary test results of rice husk ash making which has a compressive strength of 24.4 MPa in the proportion of rice husk ash by 7%. Banana tree fibers can also be used as a concrete mixture having a tensile stress of 8.2 MPa.

The effect of the percentage of banana stem fiber on concrete strength and tensile strength of concrete was 7% rice husk ash and 0% fiber yielding compressive strength of 25,175 MPa and tensile strength of 8,519 MPa, 7% rice husk ash and 1.5% fiber yielding compressive strength of 21,302 MPa and tensile strength of 8,301 MPa, 7% rice husk ash and 2% fiber yielding compressive strength of 20,327 MPa and tensile strength of 8,065 MPa and 7% ash husk rice and 3% fiber yielding compressive strength of 13,605 MPa and tensile strength of 7,674 MPa .

It can be concluded that the addition of banana tree bark fiber can decrease the compressive strength and tensile strength of concrete because it is caused by the fibers that make hard concrete become solid and the decrease of compressive strength and tensile strength is directly proportional to the weight of the contents. The lower the weight of its contents, the more it goes down the compressive strength. However, for all proportions of fiber, it still qualifies as minimum tensile strength to be achieved i.e. 8% of the compressive strength of the plan.

References

1. Wilhelmus. *The Effect of Gwang Leaf Fiber Addition (Corypha Utan lam) for Flexural Strength and Crack Tensile Strength of Concrete*. Kupang. Civil Engineering Department Nusa Cendana University. (2015)
2. V. G. Ndoen, D. A. T. Sina, W. Bunganaen. *Effects of additional fiber leaf (corypha Utan lam) on strong and powerful strength Concrete*. Civil Eng. **4**, 14 (2015)
3. Suwandi, N. Leli, W. Budi. *Agricultural commodities in the field of horticulture*. Ministry of Agriculture. **ISSN 1907-1507**. 68 (2016)
4. Nopriantina, et al. *Effect of Kepok Banana Leaf Thickness (Musa paradisiaca) To the Mechanical Properties of Natural Fiber-Polyester Composite Materials*. Padang. Physics Department of FMIPA Andalas University. (2013)

5. S. C. P. District. *Pasirian District in numbers*. Statistic Agency. **35080.1605**, 118 (2016)
6. Rahmatullah D. *Making of structural concrete by using skoria stone and plastic seed*. Departement of Civil Engineering, University of Jember (2017).