The Influence of Rattan Fibre Addition to The Compressive Strength of Normal Concrete

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Abstract. Concrete is high in compressive strength but low in tensile strength and very brittle material. In this study, rattan fibre used as an added material to help eliminate the brittle properties of normal concrete. Variations of fibre used consisted of 0%, 0.5%, 1%, 1.5%, and 2% by weight of cement with mixed planning using the American Concrete Institute method. The compressive strength and stress-strain tests were carried out when the concrete was 28 days old, with a design compressive strength of 25 MPa as many as 15 pieces. The value resulting from testing on normal concrete without the addition of fibres is 24.94 MPa, 0.5% variation of rattan fibres is 23.23 MPa, 1% variation of rattan fibre is 25.3 MPa, 1.5% variation of rattan fibre is 25.85 MPa, 2% variation of rattan fibre is 25.85 MPa. Normal concrete compressive strength test showed an increase in strength at 1.5% rattan fibre and decreased at an additional 2%. The result of stress-strain test in normal concrete without rattan fibre is 0.00125, 0.5% of 0.00254, 1% of 0.00067, 1.5% of 0.00053, 2% of 0.00333. The stress-strain test shows that the addition of rattan fibre can help eliminate the brittle properties that are lacking in normal concrete in general.

1. Introduction

Concrete is well known and widely used as the primary basic material in construction planning and design. It is because concrete has advantages, including known as a material with a high enough compressive strength, easy production, and maintenance, its constituent materials are widely available in nature and also economical but also brittle. Sometimes, to get good quality in the process, added materials (admixture), fibres, or non-chemical building materials with a particular ratio value and stirring and processing method. The opposite of brittleness is ductile. Ductility is the ability of a structure or its components to carry out repeated inelastic deformations beyond the first melting point limits while maintaining a large amount of load-bearing capacity [1].

To increase ductility, the concrete mixture in this study given an added material in rattan fibre, a waste produced by many industries. The attractiveness of rattan utilization is none other than because of its advantages; namely, it is lighter in weight, gives a unique impression, and has high tensile strength. As based on the research results conducted by [2], the rattan's tensile strength parallel to the fibres shows a high enough value, namely 481.99 kg/cm². The strength is potential if combined into part of normal concrete mix. Normal concrete has a weight of content (2200-2500) kg/cm³ using natural gravel [3].

From testing the compressive strength of concrete, the tensile strength of concrete, and the flexural strength of concrete blocks, it found that the highest increase in concrete strength was the addition of rattan fibre by 1% of the weight of cement. The compressive strength of concrete has increased by 12.84% from normal concrete. The tensile strength of the concrete has increased by 22.17% from normal concrete. The flexural strength of concrete blocks has increased by 9.69% from normal concrete [4].

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The results of this study obtained the average compressive strength of the concrete with a mixed type without fiber of 391.378 kg/cm², while the 0.1% mixed type was 371.734 kg/cm², 0.3% mixed type was 308.267 kg/cm² and type 0.5% mixture of 297.689 kg/cm². Each of the mixed types decreased by 5.02%, 21.24% and 23.94%. The more fibers you add, the lower the compressive strength you get, but the more fibers you use, the greater the strength of the concrete in resisting cracks [5].

The results of testing and research [6], showed that the water absorption capacity of coco fiber and also fibers used to make fiber cement with a fiber composition of 2.5% - 15% by weight of cement, there is a tendency that the more fiber the higher the water absorbed, each addition of 1% palm fiber and coconut fiber in the cement mixture will cause an increase in absorption of 0.22%. Furthermore, with the increasing fiber, the lighter the weight of the concrete, there is a reduction in weight of -0.013 gram/cm³ for every 1% increase in fiber.

2. Materials and Methods
In this study, using FAS 0.52 with a concrete compressive strength plan (f'c) of 25 MPa and a total of 15 specimens in the form of a cylinder 15/30 cm. Variations in the addition of rattan fibre are 0%, 0.5%, 1%, 1.5% and 2%. The coarse aggregate used is natural stone obtained from Krueng Meureubo with a maximum aggregate diameter of 19 mm. The compressive strength test and the concrete's stress-strain test carried out at 28 days of concrete.

2.1. Material
The materials used in this study were Portland cement types I, Aggregates from the Krueng Meureubo river in West Aceh, and rattan from community plantations in Rantau Gedang Village, Aceh Singkil Regency. The clean water used comes from the Laboratory of the Faculty of Engineering, Teuku Umar University. The rattan material is shaved in such a way that it measures 1 mm x 1 mm x 20 mm, can be seen in figure 1.

![Figure 1. Rattan Fibres](image)

2.2. Mix Design, Specimens and Test
This normal concrete mixture's design uses the American Concrete Institute (ACI) [7] method with a design compressive strength of 25 MPa for a cylindrical specimen measuring 15/30 cm. the water-cement ratio is 0.52. The coarse aggregate used is a natural stone with a maximum aggregate diameter of 19 mm. The percentage of rattan fibre are 0.5%, 1%, 1.5%, and 2% as an added material to the concrete mixture and as a comparison also made normal concrete specimens without the use of fibre. In this study, the number of cylindrical specimens with a 15 cm diameter and a height of 30 cm were 15, which shown in Figure 2.
Figure 2. Specimens

The compressive strength test and behavior of stress-strain carried out after the concrete reaches 28 days, using a compressive strength of testing machine and a strain gauge tool. Mix planning for all specimens using [3][7] calculated, as shown in the table 1.

Table 1. Mix Design

| Material          | Amount for 30 Concrete Cylinder | Unit |
|-------------------|---------------------------------|------|
|                   | 0%                              | 0.5% | 1%  | 1.5% | 2%  |
| 1 Cement          | 6.757                           | 6.757| 6.757| 6.757| 6.757| Kg  |
| 2 Rattan Fibre (RF)| 0.000                           | 0.034| 0.068| 0.101| 0.135| Kg  |
| 3 Water           | 2.703                           | 2.703| 2.703| 2.703| 2.703| Kg  |
| 4 Fine Aggregates | 11.884                          | 11.884| 11.884| 11.884| 11.884| Kg  |
| 5 Coarse Aggregates| 18.756                          | 18.756| 18.756| 18.756| 18.756| Kg  |
| Total             | 40.101                          | 40.134| 40.168| 40.202| 40.236| Kg  |

The making process of normal concrete specimens without fibres carried out by first mixing all the materials (coarse aggregate, fine aggregate, cement, and water). The material then put into a concrete mixer machine and poured into a mould of concrete for 24 hours. The manufacture of rattan fibre concrete is as follows: cement mixed with coarse and fine aggregates, water and rattan fibres added to become part of the concrete mixture. Testing the compressive strength and behavior of stress-strain of the concrete carried out after the concrete reaches the planned age, which is 28 days. Testing the compressive strength of the test object carried out by placing it centrically or vertically. The engine run slowly until the test object crushed [7]. In testing the behavior of stress-strain of concrete, it carried out by installing a strain gauge on the test object before placed centrically on the press machine gradually until the test object reaches 80% of the compressive test. The details of the whole test specimen, as many as 15 cylinders (Ø15 cm, T = 30 cm) with various variations in the percentage of fibres, can be seen in table 2.

Table 2. Percentage Variation of Rattan Fibre

| Concrete Age | Percentage of Rattan Fibre | Information |
|--------------|----------------------------|-------------|
| 28 days-old | 0.0% | 0.5% | 1.0% | 1.5% | 2.0% | 3 specimen of each variation |
3. Result and Discussion

The concrete compressive strength testing aims to obtain load data used by cylindrical concrete specimens until damage occurs. The compressive strength obtained from the maximum load ratio to the cross-sectional area of the cylindrical specimen. The concrete compressive test carried out when the specimen reaches the design age of 28 days, the concrete use 0% of fiber obtained strength is 24.943 MPa, 0.5% of fiber obtained is 23.230 MPa, 1.0% of fiber obtained 25.300 MPa, 1.5% of fiber obtained and 2% of fiber obtained strength is 23.593 MPa. This condition indicates the addition of 0.5% rattan fiber; 1.0% and 2.0% resulted in a decrease in compressive strength when compared to concrete that did not use rattan fiber, except for the addition of 1.5% rattan sera, there was an increase in compressive strength by 1.036%. Results in Table 3 shows that the highest strength value is 25.850 MPa with 1.5% rattan fibre, which is the largest strength and exceeds the design strength compared to 24.943 MPa for 0% rattan fibre. The optimum percentage use rattan fibre at 1.5% compare [4] obtained optimum usage of fiber at 1% weight of cement.

| Fibre Percentage | Code of Specimen | Cylinder Volume | Weight of Specimens | Load (P) | Compressive Strength (MPa) |
|------------------|------------------|----------------|--------------------|---------|--------------------------|
|                  |                  | Cm             | Kg                 | KN      | f’c                       | f’c (average) |
| 0%               | RF. 1            | 0.0053         | 12.550             | 440.000 | 24.910                   |               |
|                  | RF. 2            | 0.0053         | 12.770             | 450.000 | 25.480                   | 24.943        |
|                  | RF. 3            | 0.0053         | 12.760             | 431.640 | 24.440                   |               |
|                  | RF. 1            | 0.0053         | 12.760             | 350.000 | 19.820                   |               |
| 0.5%             | RF. 2            | 0.0053         | 12.470             | 400.000 | 22.650                   | 23.230        |
|                  | RF. 3            | 0.0053         | 12.600             | 480.690 | 27.220                   |               |
|                  | RF. 1            | 0.0053         | 12.550             | 480.000 | 27.180                   |               |
| 1.0%             | RF. 2            | 0.0053         | 12.525             | 370.000 | 20.950                   | 25.300        |
|                  | RF. 3            | 0.0053         | 12.690             | 490.500 | 27.770                   |               |
|                  | RF. 1            | 0.0053         | 12.480             | 400.000 | 22.650                   |               |
| 1.5%             | RF. 2            | 0.0053         | 12.575             | 430.000 | 24.350                   | 25.850        |
|                  | RF. 3            | 0.0053         | 12.480             | 539.550 | 30.550                   |               |
|                  | RF. 1            | 0.0053         | 12.630             | 300.000 | 16.990                   |               |
| 2.0%             | RF. 2            | 0.0053         | 12.455             | 430.000 | 24.350                   | 23.593        |
|                  | RF. 3            | 0.0053         | 12.520             | 519.930 | 29.440                   |               |

Normal concrete stress-strain data with the addition of rattan fibres obtained from the test results and presented in graphical form. Based on the data obtained, a graph of the stress-strain relationship of the test object made by calculating the stress-strain of each interval at an increase in load of 1000 kg and adjusted for the results of loading until the test object experiences 80% of the compressive test. The results obtained, seen in table 4. Then it can be seen in the strain value in table 4, there is an increase in the value of strain as the percentage of rattan fiber increases.

| Specimens | Load (P) (Kg) | Stress (Kg/cm²) | Maximum Strain |
|-----------|---------------|----------------|---------------|
| RF-0%     | 44000         | 249            | 0.00125       |
| RF-0.5%   | 49000         | 277            | 0.00254       |
| RF-1%     | 50000         | 283            | 0.00067       |
| RF-1.5%   | 55000         | 311            | 0.00053       |
| RF-2%     | 53000         | 300            | 0.00333       |
The maximum strain value with a cylindrical specimen with a 15 cm diameter and a height of 30 cm, seen in the figure 3, which shows a 2% variation in rattan fibre, which is equal to 0.00333.

Figure 3. The Maximum Strain Value

The figure 3 shows that the addition of rattan fibre affects the behavior of stress-strain that occurs in concrete. With the addition of rattan fibre, it can increase the value of strain at 2.0% added fiber compared to the other variation additional fiber. In Figure 3, it can be seen that the strain increases quite significantly at maximum load until the concrete experiences destruction, this condition shows a fairly good ductility value, the percentage of using concrete fiber is 2%. This, if applied to reinforced concrete beams, will result in an increase in the performance of reinforced concrete beams.

4. Conclusion
Based on the results of the research and data obtained, there are several conclusions as follows:

a. The use of rattan fibre to normal concrete mixtures can increase the structure's strength to an additional 1.5%, which is 25.85 MPa. However, the strength begins to decrease if the rattan fibre added greater than 1.5%.

b. Rattan fibre added to the concrete mixture can increase the concrete's ductility, causing an increase in the stress that occurs so that the concrete's brittle properties can improved.

c. Concrete with variations in the addition of rattan fibre classified as normal concrete because the resulting compressive strength is much greater than 21 MPa.

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Acknowledgments
My great appreciation I would to give to my family and my colleagues for their support and encouragement. also my gratitude to the very assistive member in this writing paper. Thank you very much for University of Teuku Umar as the funders.