Effect of the Addition of Natural Fibers on the Mechanical Properties of Concrete

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Abstract. The use of rattan and bamboo fibers increases the compressive strength, tensile strength and improves the ductility of concrete. Shell ash also contains pozzolanic compounds that can improve the properties of concrete. In this study, rattan and bamboo were used as concrete fibers and seashell ash was used as filler. The purpose of this study is to measure the compressive and tensile strength of concrete. In this study, rattan and bamboo fibers were added to the concrete mix with a mix design 25MPa. The additive variation is 0%, 0.5%, 1%, 1.5%, 2%. The results showed that the average compressive strength at 28 days was 0.26.29 MPa, 0.5, 19.71 MPa, 1.21.69 MPa, 1.5, 24.72 MPa and 2.18 MPa. Accordingly, the average tensile strength after 28 days was 0.736 MPa, 2,359 MPa, 2,312 MPa, 2.453 MPa and 2,595 MPa. These results show that the addition of rattan and bamboo fibers to concrete can increase the crack resistance of concrete, while the optimal increase in compressive strength with the addition of rattan fiber is achieved only with the change of 1.5%. This indicates that the addition of 1.5% natural fibers improves the tensile strength of concrete.

1 Introduction

Concrete is known as the main raw material for construction works and is widely used. This is because concrete has high compressive strength, is easy to form on demand, has low maintenance costs, and can be made from local materials [1-4].To achieve good quality in the process, additives (mixtures), fibers or non-chemical building materials can be added according to specific ratio values, and mixing handling methods. Various studies have been conducted to eliminate certain weaknesses [5-6]. Of course, from time to time, there will also be innovations to improve the quality of concrete. Innovation can be achieved by changing the basic composition of concrete or by adding composite components to the concrete mix [7-9].

The forest resource potential of the Indonesian territory is very large, with an area of 99.6 million hectares, accounting for 52.3% of the total area of Indonesia. Rattan is a forest product of Indonesia with many uses [4]. The appeal of rattan is its light weight, unique feel, high tensile strength which improves the ductility of concrete, enhances compressive and

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tensile strength, and the fact that it is very difficult to crack. Indonesia is also the third largest bamboo producer in the world [10-12]. Bamboo has several advantages such as non-rotting, relatively cheap price, and low shrinkage properties. Bamboo fiber is a natural fiber that can be used in concrete mixes and has been studied for many years to produce structural concrete. According to the studies of [8, 13-16], the bamboo fiber mixture from 1% to 2% of cement tested significantly improved the compressive strength of concrete. This is the basis for the author's interest in further research to find the optimal mixing ratio to achieve the optimal compressive strength. Rattan and bamboo fibers are natural fibers used as auxiliary materials in this study [17-19]. In this study, seashell ash was also used in the production of concrete. Since the coating contains pozzolanic compounds including lime (CaO), aluminum oxide and silica, it can improve the properties of concrete [20-21].

2 Research methods

2.1 Materials

The aggregate used comes from the KRUENG Aceh region and has a maximum diameter of 19 mm. The cement used is type 2 cement produced in the Aceh region. The cement used is grade 2 standard cements produced in Aceh region. The design concrete quality is performed on the 28th day after birth. In this study, rattan from SINABANG area, SIEMEULUE island and bamboo from LAPAN village, West Aceh province was used. Processing rattan and bamboo into fibers is done at MEULABOH. The rattan fibers used have a knot length of 2 cm, and the bamboo fibers have a length of 2 cm. The shell ash was collected from the UJONG BAROH area, West Aceh. The rattan and bamboo fiber percentages used were 0%, 0.5%, 1% and 1.5% of the cement weight, and the shell ash used was 4% of the cement weight.

Experimental methods were used in this study. That is, test specimens were made and tested in the laboratory to determine the effect of fiber as an additive on compressive and split tensile strength [5, 22-24].

Fig. 1. (a) Rattan Fiber, (b) Bamboo Fiber, (c) Clamp Shell Ash

Table 1. Mix design for concrete volume 1 m^3

Materials	Weight	Specimen Volume	For 30 Objects Test	Unit
	(Kg)	(m^3)		
Cement	395.245	0.0063	74.01	Kg
Water	158.121	0.0063	29.885	Kg
Coarse Aggregate	1097.076	0.0063	207.347	Kg
Fine Aggregate	695.141	0.0063	131.382	Kg

Table 2. Mix design for 6 specimens of concrete cylinder

Materials	Fiber Addition Percentage					Total	Unit
	0%	0,5%	1%	1,50%	2%		
Cement	15.000	15.000	15.000	15.000	15.000	75.000	Kg
Water	5.977	5.977	5.977	5.977	5.977	29.885	Kg
Coarse Aggregate	41.469	41.469	41.469	41.469	41.469	207.347	Kg
Fine Aggregate	26.276	26.276	26.276	26.276	26.276	131.382	Kg
CSP (4%)	0.598	0.598	0.598	0.598	0.598	2.988	Kg
Rattan, and Bamboo Fiber	0.000	0.075	0.149	0.224	0.299	0.747	Kg

Planning a concrete mix with a design rating of 25 MPa begins with determining the slump value, reviewing the plan, then determining the amount of water for the concrete mix, the amount of water needed to be drawn from determining. The determination of the settlement plan and the maximum sum is expected. The next step is to determine the water-cement coefficient (FAS) obtained on the basis of determining the quality of the expected concrete, after obtaining the value of the water-cement coefficient (FAS), then determine When determining the weight of the cement itself, the weight of the cement is determined based on the difference between the amount of water obtained and the water index of the cement (FAS) obtained previously. The next step is to determine the amount of coarse aggregate for the intended concrete mix, the coarse aggregate obtained from the largest aggregate diameter and the fine aggregate fineness modulus multiplied by the weight of the aggregate quantity to obtain required amount of coarse aggregate. aggregates in the concrete mix. The next step is to determine the amount of fine aggregate for the intended concrete mix. Fine aggregate is obtained from the weight of the concrete minus the amount of water, cement, and coarse aggregate, thus reducing the amount of sand used for the mix. concrete compound. concrete mix (25) is obtained.

Figure 2 is the test diagram of compressive strength of concrete. That is, the cylindrical specimen is placed vertically in the middle of the press and the concrete compressive strength is tested, that is, the cylindrical specimen is placed horizontally in the center of the press.

Fig. 2. Testing of compressive strength and tensile strength of concrete

3 Results and discussion

3.1 Aggregates

The physical properties were tested on coarse aggregates and fine sand used as building blocks for concrete [4]. This test is carried out to determine the quality of concrete members [26-28]. Composite tests include bulk density, specific gravity, absorption test, and sieve analysis. Table 3 shows the results of the synthetic physical property tests.

Table 3. Aggregated test results.

Examination of Aggregate Physical Properties	**Examination Results**	
	Coarse Aggregate	Fine Aggregate
Bulk Density	1.784	1.855
Specific Gravity SSD	2.660	2.430
Specific Gravity OD	2.600	2.350
Absorption	2.35%	3.19%
Fineness Modulus	5.98%	3.10%

3.2 Slump test

The slump test is performed on conventional concrete for the purpose of determining the thickness of the concrete mix. This factor is due to the addition of fibers to the concrete mix. The data obtained from the deflection test on the casting of each range from 7.5 cm to 10 cm, which is the predicted sag height. Figure 4 shows that there is a difference in the shape of the slump. In this study, the resulting slump height investigation showed that the slump value was influenced by the proportion of fibers mixed into the concrete mixture. The graph below shows that the minimum slump is 7.5 cm with 2% rattan and bamboo fibers, while the normal concrete without rattan and bamboo fibers has a maximum slump of 9.5 cm. is shown. This indicates that the higher the fiber content, the higher the water absorption of the concrete.

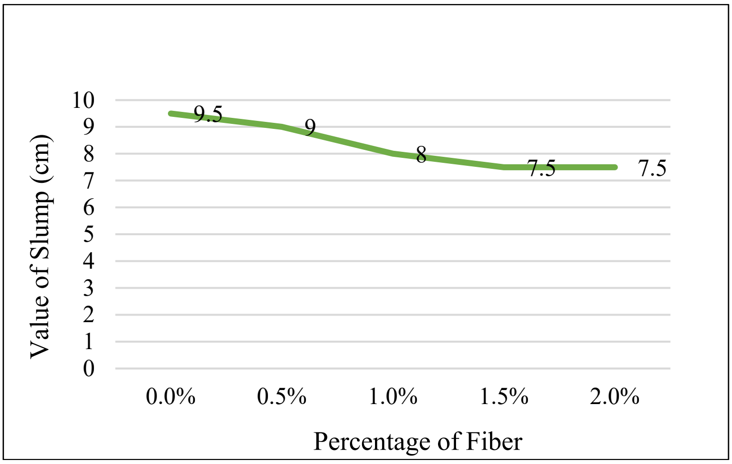

Fig. 3. Concrete slump value relationship with fiber variation

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3.3 Strength of concrete

Concrete compressive strength tests were performed when the samples were 28 days old. After the treatment process is finished, the test object can be removed from the tank and tested. The test object is then left for 24 hours until the surface is dry. After this process, the test objects are weighed to determine the weight of each test object. In addition, a compressive strength test is performed on the specimen using a compression tester. Compressive strength testing of concrete is carried out according to the design age, i.e., 28 days of concrete age. Data on the compressive strength test results of the concrete after 28 days are shown in Table 4 and the compressive strength graph is shown in Figure 4.

From Table 4 and Figure 4, we can see that the compressive strength of normal concrete without fiber (0% fiber) is 26.29 MPa after 28 days. Compressive strength values for samples with fiber at levels of 0.5%, 1.0%, 1.5%, and 2.0% and with 4% shell added were 19.71 MPa, 21.69 MPa, 24, 72 MPa, and 23.18 MPa. The compressive strength of the resulting concrete is relatively low compared to ordinary concrete without the addition of rattan or bamboo fibers. The compressive strength graph of fiber concrete aged for 28 days shows that when the planned fiber content exceeds 1.5%, the determined compressive strength values are also lower. The optimal compressive strength for specimens with fibers is a percentage of 1.5% (24.72 MPa). Compressive strength test results for fiber concrete aged for 28 days are consistent with the design compressive strength, 25 MPa, which corresponds to a fraction of 1.5% (24.72 = 25 MPa). Concrete tests with different fiber ratios and a design age of 28 days resulted in similar specimen weights. That is, the weight of the concrete specimen (0% fiber) was 12.618 kg, and the weight of the contents was 2380.76 kg/. m3. For test objects with fiber percentages of 0.5%, 1.0%, 1.5% and 2.0%, the weights of the test objects are 12.951

kg, 12.615 kg, 12.618 kg, and 12.515 kg respectively, giving a unit weight of 2443.71 kg/m³, 2380.19 kg/m³, 2380.76 kg/m³, 2361.44 kg/m³.

Table 4. Calculation of concrete compressive strength after 28 days

Fiber Percentage	**Specimens Code**	**Sample Weight**	**Cylinder Volume**	**Volume Weight**	**Press Force**	**Compressive Strength (MPa)**	
		(kg)	(m^3)	(kg/m^3)	(KN)	f'_c (MPa)	f'_c (MPa) (average)
0%	FB 1	12.645	0,0053	238585	400	22.647	26.289
	FB 2	12.564	0,0053	2370.57	400	22.647	
	FB 3	12.645	0,0053	2385.85	593	33.574	
0,5%	FB 1	12.945	0,0053	2442.45	260	14.720	19.710
	FB 2	12.965	0,0053	2446.23	260	14.720	
	FB 3	12.945	0,0053	2442.45	524	29.689	
1%	FB 1	12,585	0,0053	2374.53	290	16.419	21.690
	FB 2	12.675	0,0053	2391.51	330	18.684	
	FB 3	12.585	0,0053	2374.53	529	29.967	
1,5%	FB 1	12.655	0,0053	2387.74	410	23.213	24.724
	FB 2	12.544	0,0053	2366.79	410	23.213	
	FB 3	12.655	0,0053	2387.74	490	27.747	
2%	FB 1	12.490	0,0053	2356,60	310	17.551	23.184
	FB 2	12.567	0,0053	2371.13	350	19.816	
	FB 3	12.490	0,0053	2356.60	568	32.186	

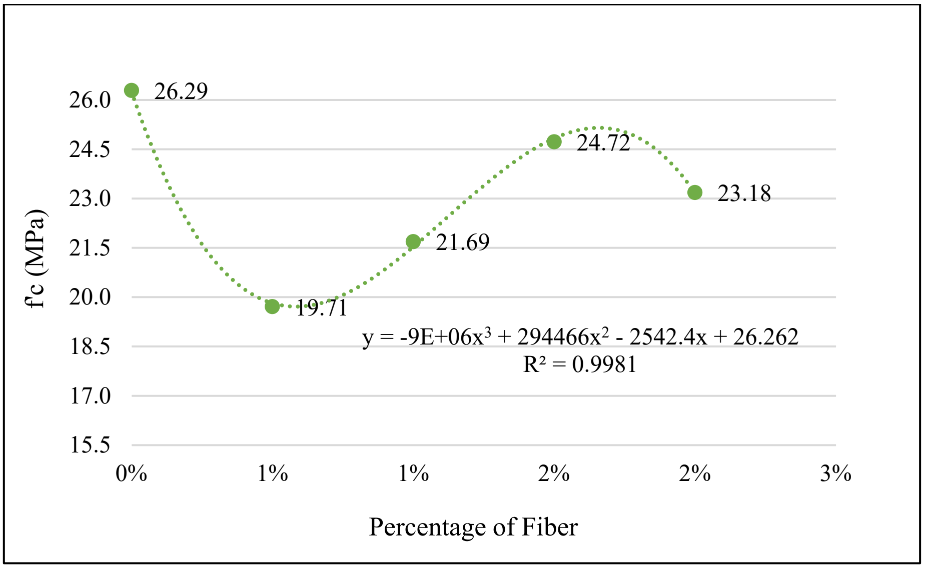

Fig. 4 Compressive strength curve of concrete after 28 days curing

3.4 Split tensile strength of concrete.

Concrete split tensile strength tests were performed when the samples were 28 days old. Table 5 shows the data of the concrete splitting tensile strength test results after 28 days, and Fig. 5 shows the tensile strength graph. Table 5 and Figure 5 show the split strength values for the normal case. The average split strength of the concrete without fiber (0% fiber) after 28 days is 2.736 MPa. The average breaking strengths of concrete were 2.359 MPa, 2.312 MPa, 2.453 MPa and 2.595 MPa, respectively, and the splitting strength decreased with the addition of rattan and bamboo fibers with variations of 0.5%, 1.0%, 1.5% and 2.0%. Strength values compared to tear strength values without the addition of rattan and bamboo fibers. The optimum cleavage strength of the specimen when using fiber is 2.0% of 2.595 MPa. Concrete tests with different fiber ratios and a design age of 28 days resulted in similar specimen weights. That is, the weight of the concrete specimen (0% fiber) was 12.622 kg, and the weight of the contents was 2381.51 kg/. m3. Subjects with 0.5%, 1.0%, 1.5%, and 2.0% fiber weighed 12.865 kg, 12.604 kg, 12.714 kg, and 12.640 kg, each with a unit weight of 2427.29 kg. /m^3, 2378.11kg/m^3, 2398.80kg/m^3, 2384.91kg/m^3.

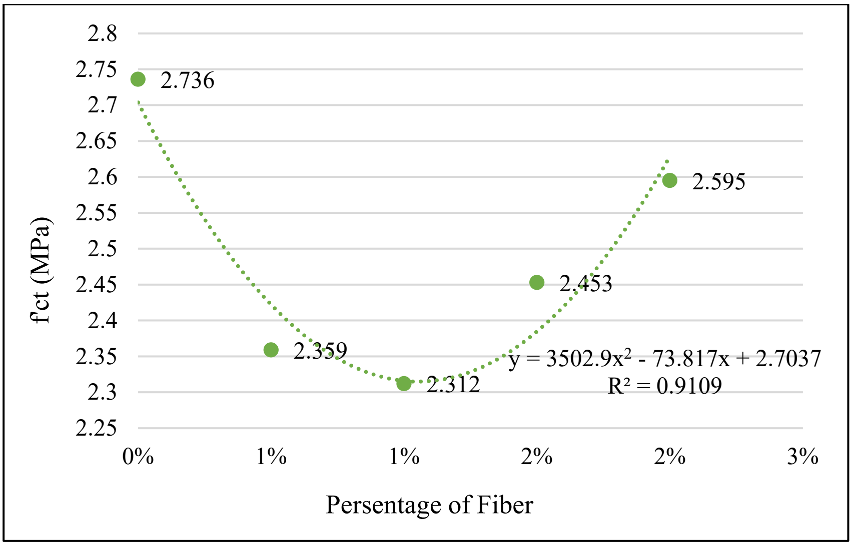

Fig. 5. Graph of concrete split tensile strength results after 28 days of curing

Table 5. Calculation of Split tensile strength of 28-day concrete

Fiber Percentage	Specimens code	Weight of Sampel	Cylinder Volume	Volume Weight	Tensile Force	Strength Split Tensile Concrete (MPa)	
		(kg)	(m^3)	(kg/m^3)	(KN)	(N/mm^2)	$f'_{ct}\ (MPa)$
0%	SRB 1	12.654	0.0053	2387.55	190	2.689	2.736
	SRB 2	12.578	0.0053	2373.21	180	2.548	
	SRB 3	12.634	0.0053	2383.77	210	2.972	
0,5%	SRB 1	12.932	0.0053	2440.00	180	2.548	2.359
	SRB 2	12.876	0.0053	2429.43	150	2.123	

	SRB 3	12.786	0.0053	2412.45	170	2.406	
1%	SRB 1	12.590	0.0053	2375.47	170	2.406	2.312
	SRB 2	12.568	0.0053	2371.32	170	2.406	
	SRB 3	12.654	0.0053	2387.55	150	2.123	
1,5%	SRB 1	12.688	0.0053	2393.96	170	2.406	2.453
	SRB 2	12.766	0.0053	2408.68	170	2.406	
	SRB 3	12.687	0.0053	2393.77	180	2.548	
2%	SRB 1	12.567	0.0053	2371.13	150	2.123	2.595
	SRB 2	12.698	0.0053	2395.85	200	2.831	
	SRB 3	12.655	0.0053	2387.74	200	2.831	

4 Conclusions

Some conclusions that can be drawn from the findings of this study are:

1. Slump test results show that the addition of rattan and bamboo fibers reduces the slump value. This means that the more variation in the fibers used, the more absorbent the concrete.
2. Based on compressive strength tests, rattan and bamboo fibers have been used as cement substitutes in concrete. The average compressive strength after his 28-day variation for fiber-free concrete samples is 26.29 MPa. The highest average compressive strength with fiber is his 1.5 fiber variant with average compressive strength value of 24.72 MPa. The lowest compressive strength occurs at a fiber variation of 0.5 inch with a compressive strength value of 19.71 MPa.
3. Using rattan and bamboo fibers as cement substitutes in concrete based on split tensile strength tests. The average split strength of the fiber-free concrete sample was 0.736 MPa after 28 days of variation. The highest average split tensile strength with fiber is the 2.0 fiber variant with an average split tensile strength value of 2.595 MPa. The fiber variant has the lowest split strength at 1.0 inch with a split strength value of 2.312 MPa.
4. Significant increases in compressive strength of concrete mixes with rattan and bamboo fibers only occur up to 1.5%. This is because the results show that the compressive strength decreases as soon as 2% fiber is added. 5. The split tensile strength value results show that the split tensile strength value increases as more fiber is used.
5. The production of rattan fiber concrete, bamboo and shell ash is of economic value as the fibrous material added to the concrete mix is recovered from industrial waste.

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