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Elasticity modulus concrete of abaca fiber

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Abstract. This research study discusses the modulus of elasticity of concrete using abaca fibers. The addition of abaca fiber to concrete mix is done with the composition of abaca fiber 0% (normal concrete), 0.15%, 0.20%, 0.25% with a fiber length of 50 mm. Concrete cylindrical specimens (100 mm x 200 mm) with each variation of 3 cylinders with a total of 12 specimens tested after the specimens reached 28 days in a Universal Testing Machine (UTM) and evaluated through the ASTM standard in testing concrete compressive strength. Concrete compressive strength test results with variations in length of 50 mm with a fiber volume of 0.15% produces an elastic modulus of 23057.14 MPa. For a volume of 0.20% the modulus of elasticity is 19575.44 MPa. Then for the fiber volume of 0.25% the modulus of elasticity is 17104.90. Normal concrete modulus value 20058 Mpa. From these results it can be concluded that the more fiber volume, the smaller the modulus of elasticity. The modulus of elasticity of abaca fiber concrete with a fiber length of 50 mm and a fiber volume of 0.15% is the best and gives an increase of 14.96% to normal concrete.

1. Introduction

The development of science and technology in the field of material engineering as well as the development of environmental issues demands new breakthroughs in obtaining high quality and environmentally friendly materials. The final use of metal and ceramic materials will leave a residue in nature, because these materials are difficult to destroy by nature in a short time. Therefore, the use of plant fibers as an environmentally friendly material solution, being able to be recycled and being able to be destroyed by nature itself is a technological demand today. Research activities are continuing to produce alternative strengthening techniques that are better. The emergence of new materials in this case natural fibers, namely plant fibers in the group of leaf fibers, namely: abaca, banana, sisal, pineapple. Abaca fiber is one of the natural fibers with high tensile strength compared to other natural fibers, with folding strength, buoyancy, high porosity, resistance to saltwater damage, and fiber length of 2-4 meters [1]. Today there have been growing demands for the need for strengthening techniques both for the need for capacity building and for the need for structural improvement. This demand has encouraged researchers to develop technology and science related to strengthening techniques. Several



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reinforcement techniques have been developed, one of the strengthening technique methods is the addition of fiber to concrete. The presence of fiber in the concrete will increase the stiffness and reduce deflection (deflection) that occurs [2]. The addition of fiber can also increase the plasticity of the concrete, so that the structure will avoid sudden collapse due to excessive loading. The use of abaca fibers in concrete as reinforcement has been carried out the results show that the abaca fibers for concrete with an ideal fiber composition can make an optimal contribution to modulus of concrete breaking which is at 0.25% fiber weight of concrete, with a fiber length of 50 mm which gives a positive effect in the ability to rupture concrete modulus [3]. 15% it also provides an adequate increase (8%) in the compressive strength of fiber concrete against normal concrete. The addition of fiber significantly changes the composite energy absorption capacity and also contributes to a 39% increase in fracture energy compared to unconstrained concrete mixes. In addition the effect of fiber is evaluated in terms of load and deflection behavior in fiber concrete with an average increase of 21%.

1.1. Abaca fibre

Abaca (*musa textillis nee*), is a natural plant that is included in the banana plant (family musacease) originating from the Philippines which has been known and has been developed since 1519 [4]. Abaca banana plants are categorized as male bananas (do not produce fruit).



Figure 1. Abaca fiber from a banana plant (not bearing fruit)

Abaca fiber has on the physical properties of fiber is the strongest natural fiber of all other natural fibers with high tensile strength and folding strength, buoyancy, high porosity, resistance to saltwater damage, and fiber length of 2-4 meters. Table 1 shows the comparison of physical properties of abaca with other natural fibers [1].

Table 1. Physical properties of abaca fiber with other natural fibers

Physical properties	Abaca	Hemp	Sisal	Linen	Cotton
Density (g/cm ³)	1.510	1.46	1.33	1.4	1.54
Fibre length	2-4 m	3-3.5 m	1 m	Up to 90 cm	10-65 mm
Fibre diameter	150-260 microns	60-110 microns	100-300 microns	12-60 microns	11-22 microns
Tensile strength (N/mm ²)	857	400-800	600-700	800	400
Elongation (%)	1.10	1.80	4.30	2.7-3.5	3-10
Moisture regain (%)	5.81	13.75	11.00	10-12	8.50
Young's modulus (GPa)	41	20-25	17-22	50-70	-

1.2. Fibrous concrete

Fibrous reinforced concrete is defined as a concrete material made from a mixture of cement, fine aggregate, coarse aggregate, water and a number of fibers that are randomly distributed in a matrix of fresh concrete mix. Fibrous reinforced concrete is defined as a concrete material made from a mixture of cement, fine aggregate, coarse aggregate, water and a number of fibers that are randomly distributed in a matrix of fresh concrete mix. The behavior of fibrous concrete is determined by several factors, including the physical properties of the matrix and fiber and the attachment between the fiber and the matrix, namely: a) The physical properties of the fiber and matrix where the main factors that determine the ability of the fiber material are the physical properties of the fiber and the matrix and the attachment strength between the two. The average stress of the fiber is two to three times greater than the stress collapse matrix this will cause the concrete to crack before the maximum tensile strength of the fiber is reached. b) Effect of Fiber Length and Diameter is the ratio of fiber length and diameter (aspect ratio) will affect the attachment between the fiber and the matrix. Fiber with a ratio of $l/d > 100$ has a greater attachment to concrete than a short fiber with a ratio of $l/d < 50$.

The addition of steel fibers can increase the tensile strength of lightweight concrete slabs to 165% and can even exceed the tensile strength of normal concrete with the same steel fiber added material. The addition of steel fibers also increases the flexural strength of lightweight concrete up to 91%.

Adding fiber to the concrete mixture is also proven to be able to inhibit the rate of cracking due to concrete shrinkage effectively. A conducted an experimental test to determine the effect of the addition of steel fibers measuring 60 mm in length and 0.75 mm in diameter to the mechanical strength of concrete and the flexural behavior of reinforced concrete beams. The results showed that the addition of steel fibers of 60 kg/m³ could increase the tensile strength of concrete slabs by 54% and flexural strength by 46%. In the testing of reinforced concrete beams, also seen an increase in the flexural capacity and ductility of concrete.

According to Ozcan et al. The ability of fiber concrete to inhibit cracking can reduce the amount of tensile stress acting on reinforcing steel so that the ultimate capacity of concrete can be increased.

1.3. Test the compressive strength of concrete

Concrete compressive strength test, the test object in the form of a concrete cylinder (diameter 10 cm with a height of 20 cm or a diameter of 15 cm with a height of 30 cm) is pressed with a load P until it collapses. Because there is a compressive load P, there is a compressive stress on the concrete (f'_c) equal to the load (P) divided by the cross-sectional area of the concrete (A), so it is formulated:

$$f'_c = P / A \quad (1)$$

Where f'_c = concrete compressive stress (MPa), P = compressive load (N), A = concrete cross-sectional area, mm².

The modulus of elasticity of E_c concrete can theoretically be determined based on the following formula. For normal concrete, E_c values may be taken as follows:

$$E_c = 4700 \cdot \sqrt{f'_c} \quad (2)$$

Where E_c = Modulus of elasticity of concrete (MPa), f'_c = Concrete compressive strength value (MPa).

Experimentally according to ASTM C 469-02 the modulus of elasticity formula can be calculated with the formula:

$$E_c = \frac{S_2 - S_1}{\varepsilon_2 - 0.00005} \quad (3)$$

Where E_c = Modulus of elasticity of concrete (MPa), $S_2 = 40$ % maximum stress (Mpa), $S_1 =$ Strain on strain $S_1 = 0.000050$ (MPa), $\varepsilon_2 =$ Longitudinal strain at the time of stress S_2 .

1.4. Fiber reinforced concrete

Fibrous reinforced concrete is defined as concrete material made from a mixture of cement, fine aggregate, coarse aggregate, water and a number of fibers that are scattered randomly in a matrix of fresh concrete mix Types of Fiber [5]:

- Metal fibers, such as carbon steel or stainless steel fibers
- Synthetic fibers (acrylic, aramid, nylon, polyester, polypropylene, carbon)
- Glass Fiber
- Natural fibers (palm fiber, bamboo, hemp, wood pulp, straw, sisal, coconut fiber, abaca)

1.5. Behavior of fibrous concrete

The behavior of fibrous concrete is determined by several factors, including the physical properties of the matrix and the fiber and the attachment between the fiber and the matrix.

1.5.1. Physical properties of fiber and matrix. The main factors that determine the ability of the fiber material are the physical properties of the fiber and the matrix and the bond strength between the two. The average stress of the fiber is two to three times greater than the stress collapse matrix, this will cause the concrete to crack before the maximum tensile strength of the fiber is reached.

1.5.2. Effect of fiber length and diameter. Comparison of fiber length and diameter (aspect ratio) will affect the attachment between the fiber and the matrix. Fibers with a ratio of $l/d > 100$ have a greater attachment to concrete compared to short fibers with a ratio of $l/d < 50$. The test results for $l/d < 50$ cause fibers to be more easily pulled from concrete. Increasing the fiber aspect ratio will have a significant effect on the tensile strength and flexural strength of the concrete, as well as the addition of fiber volume to the concrete mixture.

1.5.3. Maximum size of the matrix. The maximum size of the matrix will affect the distribution and quantity of fibers that can enter the composite. Hannant D.J gives the average particle aggregate size of ± 10 -30 microns, while the maximum aggregate size of the aggregate is for a 5 mm stir. The aggregate in the composite must not be greater than 20 mm and is recommended to be smaller than 10 mm, with the aim that the fiber can be spread evenly. To avoid the occurrence of cavities, the specimens are recommended to use fillers (mixed aggregate) of at least 50% of the volume of concrete.

1.5.4. Behavioral mechanical properties of fibrous concrete. The parameters obtained from the compressive test on fibrous concrete include: modulus of elasticity, maximum crush load. From the results of recording deflection obtained the strain value that occurs when the maximum load and load curve behavior (P) with deflection (δ) or stress-strain curve behavior. Changes in modulus of elasticity due to addition of fiber are very small. Adding fiber to normal concrete can increase stress at peak loads. Fibrous concrete absorbs more energy than normal concrete before it breaks (failure). The increase in ductility by adding fibers to normal concrete depends on several factors such as: fiber geometry, fiber fraction volume and the composition of the matrix constituent itself. Increasing fiber volume can increase energy capacity. This increase in energy absorption occurs only in the range of 0 - 0.7% of the volume of the fraction, if the fiber content is increased again so that the fraction becomes greater than 0.7%, then the increase in energy that occurs is not too large. High-quality concrete is brittle compared to normal concrete, and with the addition of fiber a more ductile concrete is produced.

2. Research methodology

This type of research is a laboratory experimental study based on reinforcing concrete mix designs using abaca fiber with concrete compressive strength testing.

2.1. Design of test specimens

The method used in this research is the experimental method in the laboratory. The concrete mix method is carried out by the dry method with a fiber composition of 0%, 15%, 0.20%, and 0.25% with a fiber length of 38 mm and 50 mm. The size of cylindrical test piece with a diameter of 100 mm and a height of 200 mm for testing the compressive strength of concrete can be seen in table 2.

Table 2. Concrete cylindrical specimens with fiber composition

Fiber length	Fiber volume (%)	Compressive strength
Normal	-	3
38 mm	0.15	3
	0.20	3
	0.25	3
	0.15	3
50 mm	0.20	3
	0.25	3
Total		21

2.2. Preparation of fiber



Figure 2. Abaca fiber with a length of 50 mm

Abaca fiber preparation process is done manually, cut using scissors with a fiber length of 50 mm which will be mixed into fresh concrete with a fiber volume of 0.25% of the concrete weight.

2.3. Compressive strength testing

Concrete compressive strength testing is carried out using a Universal Testing Machine (UTM) machine with a capacity of 1000 kN, testing of compressive concrete cylinders is carried out based on Concrete compressive strength test in this study was to get the modulus of elasticity of abaca porous elasticity using an UTM (Universal Testing Machine) with a capacity of 1000 kN. Modulus of elasticity of concrete has a relationship with other concrete properties, especially the compressive strength of the concrete itself. This modulus is a comparison between stress and strain, and with this test can determine the amount of load that can be carried without damaging the concrete itself (still in a plastic state). The compressive strength testing procedure is as follows: Lift the concrete sample from the soaking tub that has reached the age of testing, then let the concrete sample stand for a few moments to dry the surface then weigh the sample. Install the compressometer on the sample and start the prepared concrete compressing machine, then raise the sample onto the concrete compressing machine table. After the position of the sample is installed properly, do the test. Stop

loading and record the maximum load achieved when a fault occurs in the test specimen. Record and save the test results and then do the experiments for each sample in the same way.

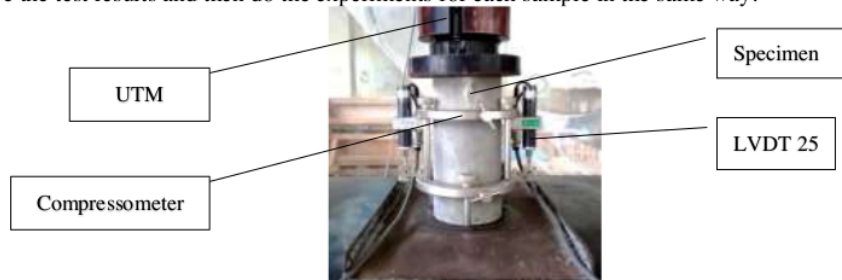


Figure 3. Testing the beam flexural strength

3. Experimental results and discussion

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3.1. Concrete compressive strength test results

Concrete compressive strength test results with variations in the composition of the addition of abaca fiber 0%, 0.15%, 0.20%, 0.25% with a fiber length of 25 mm, 38 mm, 50 mm shown in table 3.

Table 3. The results of compressive strength testing of cylindrical concrete

Specimen	Abaca fiber volume (%)	Fiber length (mm)	Slump test (mm)	Density (kg/m ³)	Compressive strength (MPa)
Normal	0	0	120	2.360,7	26,27
	0,15	38	75	2.264,8	21,06
		50	50	2.252,5	29,58
Abaca fiber	0,20	38	70	2.270,7	18,96
		50	50	2.243,2	23,89
	0,25	38	70	2.252,1	15,88
		50	55	2.222,4	20,83

The compressive strength test results show that the abaca fiber for concrete with an ideal fiber composition can provide an optimal contribution to the composition of the fiber 0.15% with a fiber length of 50 mm with a compressive strength value of 29.58 MPa or an increase of 26% to normal concrete.

3.2. Modulus of concrete elasticity

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The following results of concrete elastic modulus testing are shown in table 4 [6].

Table 4. Results of concrete elastic modulus testing

Fiber length	Volume	Modulus of elasticity (MPa)
0	-	20058
	0.15%	19739
	0.20%	18393
38 mm	0.25%	17263
	0.15 %	23057
	0.20%	19575
50 mm	0.25%	17105

The experimental results of the modulus of elasticity of concrete with abaca fiber can be seen experimentally in Table 12 with variations in length of 38 mm with a volume of 0.15% resulting in a modulus of elasticity of 19739 MPa. For the volume of 0.20% the modulus of elasticity is 18393 MPa and for the volume of 0.25% the modulus of elasticity is 17263.12 MPa. For a length variation of 50 mm with a fiber volume of 0.15%, the modulus of elasticity is 23057 MPa. For a volume of 0.20% the modulus of elasticity is 19575 MPa. Then for the volume of 0.15% the modulus of elasticity is 17104 MPa. The results of the modulus of elasticity of abaca fibrous concrete from several variations of fiber addition and variations in fiber length in concrete have an effect on the characteristics of abaca fibrous concrete, where the elasticity properties of abaca fiber concrete indicate the more volume of abaca fiber addition to the concrete, the smaller the value of the elastic modulus. The result of modulus of elasticity shows that the ideal fiber composition can contribute optimally to the fiber composition 0.15% with a fiber length of 50 mm is the best and gives an increase of 14.96% of normal concrete.

4. Conclusion

This study shows that the modulus of elasticity of abaca fiber concrete in the concrete mixture process which is used as a reinforcement in concrete and evaluated through concrete compressive strength test, can be concluded as follows:

- The composition of 0.15% abaca fiber with a fiber length of 50 mm is the best and gives a concrete compressive strength increase of 12.6% to normal concrete.
- Modulus of elasticity of abaca fiber concrete with a fiber length of 50 mm and a fiber volume of 0.15% is the best and gives an increase of 14.96% of normal concrete.

References

- [1] Vijayalakshmi K, Neeraja C Y K, Kavitha A and Hayavadana J 2014 Abaca fibre *Trans. Eng. Sci.* **2** 16–9
- [2] Rustendi I 2004 Pengaruh Pemanfaatan Tempurung Kelapa Sebagai Material Serat Terhadap Kuat Tekan dan Kuat Tarik Beton *Media Komun. Tek. Sipil* **12** 13–22
- [3] Beltran M G S 2011 Ductile cement-based composites with wood fibres
- [4] Suyadil A 2003 Penggandaan Tunas Abaca melalui Kultur Meristem *Ilmu Pertan.* **10**
- [5] Committee A C I 2008 State-of-the-Art Report on Fiber Reinforced Concrete-ACI 544.1 R-96 (Reapproved 2002) *ACI Man. Concr. Pract. Part 6*
- [6] Standard A 2010 Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression *ASTM Stand. C 469*

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