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Submission date: 21-May-2022 02:30PM (UTC+0800)

Submission ID: 1841137556

File name: Tampi_2020_IOP_Conf._Ser._Earth_Environ._Sci._419_012060.pdf (411.69K)

Word count: 3497

Character count: 17435

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To cite this article: R Tampi *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **419** 012060

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Reinforced concrete mixture using abaca fiber

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Abstract. This research study discusses the reinforcement of concrete mix design using abaca fiber. The process of mixing the abaca fibrous concrete used in this mixing is the dry mixing method. The addition of abaca fiber to concrete mixture was done with abaca fiber composition with fiber variation: 0%; 0.15%; 0.20%; 0,25% and variation of fiber length: 25 mm; 37.5 mm; 50 mm. The specimens of cylindrical material (100mmx200mm) and beam (100mmx100mmx400mm), are tested after the test object reaches the age of 28 days in the Universal Testing Machine (UTM) and are evaluated through the ASTM standard in compressive strength test, splitting tensile strength and flexural strength. The addition of fibers significantly affects the physical properties of the concrete, when the fiber increases the slump value will be smaller so the mixture becomes more difficult to mix. The results obtained by the abaca fiber concrete mixture for the composition (0.15%) and the ideal fiber length (50 mm) by providing an optimum value increase in the compression test of 12.61%, 72.64% tensile test, 98.98% flexural test of the normal concrete mixture.

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1. Introduction

Concrete is the material of a mixture of cement, fine aggregate (sand), coarse aggregate (gravel), water with the addition of air cavities. The mixture of concrete-forming materials should be set in such a way by mix design, resulting in easy-to-do wet concrete, meeting the strength of the plan after hardening and economical enough [1].

One of the concretes added materials is fiber. Concrete added with fiber-added material is called fiber reinforced concrete. Because of added fiber, it becomes a composite material that is concrete and fiber. Concrete fiber is a mixture of concrete plus fiber. The fiber material can be asbestos fiber, plastic fiber (polypropylene), glass fiber, steel wire fiber, plant fiber such as abaca, hemp, jute, sisal, linen, cotton, etc. The use of fiber in the concrete mixture, in essence, gives a good effect that can improve the nature of concrete such as increasing the ductility and flexural strength of concrete. Cracks that carry collapse in concrete structures usually start from cracked hair (microcrack).

The research obtained that the addition of fiber into the mortar will reduce workability quickly in line with the increase of fiber concentration and fiber aspect ratio [2]. So, to get the optimal result there are two things that must be considered, namely: Fiber aspect ratio, that is the ratio between fiber length (l) and fiber diameter (d). Fiber volume fraction (V_f), which is the percentage of fiber volume added to the unit of concrete volume.

The research concluded that the presence of fiber in the concrete will increase the stiffness and reduce deflection that occurs [3]. The addition of fibers can also increase the viscosity of the concrete so that the structure will avoid sudden collapse due to overloading.

The results show that Abaca fiber for concrete with ideal fiber composition can contribute optimally to modulus rupture concrete which is in 0.25% fiber of concrete weight, with a 50 mm-fiber length



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which gives a positive effect on the modulus rupture capability of 15% [4]. It also provides an adequate increase (8%) in the compressive strength of fibers concrete against normal concrete. The addition of fiber significantly alters the energy absorption capacity of the composites and also contributes to a 39% increase in the fracture energy compared to the unconfined concrete mix. In addition, the fiber effect was evaluated in terms of load and deflection giving behavior on fiber concrete with an average increase of 21%.

2. Theoretical bases

2.1. Abaca fiber

Abaca (*Musa textiles knee*) is a natural plant that belongs to a family Musaceae (banana plant) originating from the Philippines that has been known and has been developed since 1519. Abaca banana plants are categorized as male bananas (fruitless). The main production of this banana cultivation is in the form of fiber which is famous in international trade as a high-quality fiber because abaca banana fiber is resistant to saltwater and is so much used as wrapping underwater cable or rope on the ship. But lately, abaca fiber is also widely used for raw materials of high-quality paper pulp such as paper money, checks, filter paper and wrapping paper [5].

The development of science and technology in the field of materials engineering and the development of environmental issues demands a new breakthrough in creating materials of high quality and environmentally friendly. The final use of metal and ceramic materials will leave residues in nature since they are difficult to destroy by nature in a short time. Therefore, the use of environmentally friendly materials, capable of being recycled and able to be destroyed by nature itself is the current technological demands. One of the concretes added materials is fiber. Concrete added with fiber-added material is called fiber reinforced concrete. Because of added fiber, it becomes a composite material that is concrete and fiber. Concrete fiber is a mixture of concrete plus fiber. Fiber materials can be asbestos fiber, plastic fiber (polypropylene), glass fiber, steel wire fiber, plant fibers such as hemp, coco fiber, bamboo, fibers [6].

Abaca fiber is the strongest fiber of all other natural fibers with high tensile strength, folding, buoyancy, high porosity and resistance to saltwater damage, and fiber length of 2000 - 4000 mm. In (Table 1), we can see the comparison of the physical properties of abaca with other natural fibers [7]. The use of fiber in the concrete mixture, in essence, gives a good effect that can improve the nature of concrete such as increasing the ductility and strength of concrete bending. Cracks that carry collapse in concrete structures usually start from cracked hair (microcrack).

Table 1. Comparison of physical properties of abaca fibers with other natural fibers.

Physical properties	Abaka	Hemp	Jute	Sisal	Linen	Cotton
Density (g/cm ³)	1.5	1.48	1.46	1.33	1.4	1.54
Fibre length (mm)	2000-4000	1000-2000	3000-3500	1000	Upto 900	10-65
Fibre diameter	150-260 microns	16-50 microns	60-110 microns	100-300 microns	12-60 microns	11-22 microns
Tensile strength (N/m ²)	980	550-900	400-800	600-700	800	400
Elongation (%)	1.1	1.6	1.8	4.3	2.7-3.5	3-10
Moisture regain (%)	5.81	12	13.75	11	10-12	8.5
Young's modulus (GPa)	41	30-60	20-25	17-22	50-70	6-10

2.2 Test of compressive strength

The compressive strength of concrete is the magnitude of the load per unit area, which causes the concrete test object to be destroyed when loaded with a certain compressive force produced by the press machine in accordance with the ASTM C39-1996 standard [8]. Concrete compressive strength is the most important quality in concrete compared to other properties.

The compressive strength of concrete on concrete cylindrical test objects can be calculated with the following formula:

$$\sigma = P/A \quad (1)$$

Where (σ) is the modulus of rupture in the mega Pascal (MPa), (P) is the maximum load at the time of the specimen failure indicated by the test machine on Newton (N), (A) is the cross-sectional area of the specimen specified in (mm).

2.3 Test of splitting tensile strength

The test of the tensile strength of concrete can be done with a concrete cylinder test in accordance with ASTM C standard 496 - 1996. In conducting a tensile test, cylindrical specimens are tested using the same machine for tensile testing but from different positions. Tensile strength is calculated using the formula,

$$T = 2P/\pi ld \quad (2)$$

Where (T) is the tensile strength measured in units of mega Pascal (MPa), (P) is the maximum load at the time of the failure of the specimen indicated by the testing machine in Newton (N), whereas (l) and (d) are the length and diameter of the specimen in millimeters (mm).

2.4 Flexural strength test

The test object of the concrete beam is tested by using a compression machine related to deflection according to the ASTM C293-1996 standard. The deflection of the specimen is recorded by two LVDT (Linear Voltage Displacement Transducers). Both LVDT is mounted next to mid-span to record the vertical displacement of the beam test specimen. After reaching the maximum load, the specimen shows a failure by cracking into two segments. The value of the modulus rupture is calculated using the following formula:

$$R = 3PL / (2bd^2) \quad (3)$$

Where (R) is the rupture modulus measured in units of mega Pascal (MPa), (P) is the maximum load at the time of the failure of the specimen indicated by the test machine in units of Newton (N), (L) is the length of the specimen between the two pedestals in millimeters (mm) where (b), and (d) are the width and depth of each specimen are expressed in mm.

3. Research methodology

The type of research conducted is a laboratory experimental study based on reinforcing concrete mix design using abaca fiber.

3.1 Design of normal concrete mixture for 25 MPa concrete quality

Table 2. Concrete mix concrete design 25 MPa.

Concrete Material	Weight / M3 Concrete	Remarks
Cement	425.00	Tonasa Cement
Sand	638.68	River sand
Gravel	1057.40	Stone breaks
Water	188.00	Clear water

3.2 Design and proportion of mixtures

The design mixture is based on the physical properties specified from the material according to standard and the specifications of ACI 211 using the heavy-weight method design [9].

Table 3. Mixed proportion.

Code	Water/Cement (%)	Gravel (kg)	Sand (kg)	Cement (kg)	Water (kg)	Fiber (kg)
NC-00-000	0.6	26.7	16.1	10.2	6.3	-
FC-25-0,15	0.6	26.7	16.1	10.2	6.3	0.09
FC-25-0,20	0.6	26.7	16.1	10.2	6.3	0.12
FC-25-0,25	0.6	26.7	16.1	10.2	6.3	0.14
FC-37,5-0,15	0.6	26.7	16.1	10.2	6.3	0.09
FC-37,5-0,20	0.6	26.7	16.1	10.2	6.3	0.12
FC-37,5-0,25	0.6	26.7	16.1	10.2	6.3	0.14
FC-50-0,15	0.6	26.7	16.1	10.2	6.3	0.09
FC-50-0,20	0.6	26.7	16.1	10.2	6.3	0.12
FC-50-0,25	0.6	26.7	16.1	10.2	6.3	0.14

The description in Table 3 summarizes the proportions of different mixtures for all the materials used in various concrete mixtures by reinforcing the abaca fibers. The code number "FC-50-0.15" indicates the type of matrix, fiber length and abaca fiber content used. "FC" means that the concrete matrix is fibrous. The next term "50" signifies the fiber length of 50 mm. Finally, the last digit "0.15" shows the amount of fiber content of 0.15% of the weight of the concrete.

3.3 Composition of a mixture of abaca fibrous concrete

The variation of the compositions of the abaca fibrous concrete mixture consisted of 10 different mixed variations performed with different fiber amounts ranging from 0, 0.10%, 0.15%, 0.02% and 0.25% of the total weight of the concrete and variable fiber lengths ranging from 25, 37.5, and 50 mm. Mixing is done through a concrete mixer. Fresh concrete is then subjected to slump testing immediately after mixing (ASTM C 143) [10].

3.4 Preparation of specimens

The making of the specimen consists of two kinds of a test specimen, namely:

- Cylindrical test specimens with a diameter size of 100 mm and a height of 200 mm, each variation made three pieces of the cylindrical test specimen for the compressive strength test. For splitting tensile test, the test object of each variation was made three pieces of a cylindrical test object.
- Beam test object with a size of 100 mm x 100 mm x 400 mm, each variation is made three pieces of beam test object for the flexural strength test.

3.5 Curing specimens

The treatment of the specimen is carried out after removal from the mold, then the specimen is immersed in the immersion bathwater until it reaches the age of 28 days before all tests are performed.

3.6 Testing

Testing the specimens after reaching the age of 28 days, the cylindrical test object was tested for compressive strength and tensile strength and flexural strength test on the Universal Testing Machine (UTM) in accordance with ASTM C 39 and ASTM C 496 standard. The test specimens tested flexural

strength using standard ASTM C 293.

4. Empirical result

4.1 Test results

After reaching the desired curing age (28 days) of different concrete specimens with varying lengths and proportions of fibers, the specimens were removed from the immersion pool and underwent a series of standardized tests (ASTM C 39, ASTM C 496 and ASTM C 293). Table 4 shows the test results in terms of slump, compressive strength, tensile strength, flexural strength. The explanation in table 4 summarizes the proportions of different mixtures for all the materials used in various concrete mixtures by reinforcing the abaca fibers. The code number "FC-50-0.15" indicates the type of matrix, fiber length and abaca fiber content used. "FC" means that the concrete matrix contains cement, fine and coarse aggregates with the addition of fibers. The next term "50" signifies the fiber length of 50 mm. Finally, the last digit "0.15" shows the amount of fiber content of 0.15% of the weight of the concrete.

Table 4. Test results.

Code	Slump (mm)	Density (kg/m ³)	Compressive Strength (MPa)	Tensile Strength (MPa)	Flexural Strength (MPa)
NC-00-000	155	2360.7	26.268	2.109	3.555
FC-25-0,15	95	2290.3	24.490	2.596	4.243
FC-25-0,20	75	2264.8	20.408	2.735	4.688
FC-25-0,25	50	2252.5	19.437	2.831	4.946
FC-37,5-0,15	80	2288.1	21.063	2.767	4.597
FC-37,5-0,20	70	2270.7	18.957	2.608	4.959
FC-37,5-0,25	50	2243.2	15.875	2.842	5.174
FC-50-0,15	85	2292.8	29.580	3.641	7.074
FC-50-0,20	70	2252.1	23.887	2.984	5.855
FC-50-0,25	55	2222.4	20.831	2.872	5.285

4.2 Effect of fiber content on a slump

The addition of abaca fiber to fresh concrete significantly alters stability, workability, and compatibility. Abaca fiber concrete produces a more cohesive mixture, which is a good indicator of stability and stiffness. The addition of fibers causes the concrete to close in the matrix, which makes the character extra cohesive. In terms of workability, where the addition of fiber quantities may increase the water-cement ratio resulting in a mixture showing better slumps. During the casting process, it was indicated that the compatibility of the concrete was affected by the amount of fiber in the mixture.

4.3 Effect of fiber content on concrete density

Abaca fiber concrete density is inversely proportional to the amount of fiber added in the concrete. This indicates that the greater the number of abaca fibers given in the mixture, the lighter the concrete will be. This is because abaca fibers are less dense than normal components such as gravel, sand, and cement.

4.4 Influence of fiber on compressive strength

The results of the compressive strength test show that the proportion of the fibers (0.15%) in the concrete mixture and the fiber length (50-mm), contributes optimally to the compressive strength of 12.61% against the normal mixture.

4.5 The effect of fiber on tensile strength

The results of the tensile strength test on the length and composition of the abaca fiber (50-mm and 0.15%) showed a significant increase in the concrete tensile properties of 72.64% of the normal concrete. Although the length and composition of abaca fibers (25-mm and 0.15%) provide the lowest tensile strength but still larger than normal concrete.

4.6 The effect of fiber on modulus rupture

The effect of fiber on modulus rupture from testing of bending strength on abaca fiber length (50 mm) and abaca fiber composition (0.15%), showed optimal results of 98.98% of normal concrete. From the data obtained, it is clear that the addition of abaca fiber contributes positively to the increase of the flexural resilience of the concrete. The ideal amount of fiber that will contribute optimally to the breaking modulus is at 0.15% fiber of the weight of the concrete. The significant contribution of abaca fiber to concrete is recommended for 50 mm fiber length.

5. Conclusions

This study shows that the use of abaca fibers in concrete mixtures used as reinforcement in concrete and evaluated through a series of tests, sufficient interpretation, and data analysis, and thus the following conclusions are drawn:

- The concrete mix used in this research is designed using a heavy basic method, the method of mix of abaca fibrous concrete using a dry mix method.
- The addition of fibers significantly affects the physical properties of fibrous concrete that behave as follows:
 - As the fiber increases, the slump value becomes smaller, and the mixture becomes more difficult to mix the abaca fibrous concrete of all specified lengths. The amount of fiber added to the mixture contributes to the decrease in the compatibility of the concrete.
 - The density of abaca fibrous concrete is inversely proportional to the amount of fiber added to the concrete. As the fiber content increases, the weight of the abaca fiber concrete becomes lighter than the normal concrete mixture.
- Abaca fiber composition (0.15%) and ideal fiber length (50 mm) in a fibrous concrete mixture are obtained by providing optimum results on compressive strength, tensile strength, and flexural strength.
- Abaca fiber strength of reinforced concrete gives an optimal contribution in compressive strength of 12.61% to the normal mixture.
- Tensile strength shows optimal improvement in concrete tensile properties of 72.64% of normal concrete.
- Modulus of rupture is evident to be one of the properties that give significant results of abaca fiber concrete fibers compared to other mechanical properties. The rupture modulus of the flexural strength test provides an optimal yield of 98.98% of the normal concrete.

References

- [1] Tjokrodimulyo K 1996 *Teknologi Beton* (Jakarta: Penerbit Nafiri)
- [2] Suhendro B 1992 *Ketahanan Kejut (Impact Resistance) Beton Fiber Lokal dan Kemungkinan Aplikasinya pada Struktur – Struktur Sabo untuk Penanggulangan Bahaya Gunung Berapi* (Yogyakarta: PAU ilmu teknik Universitas Gadjah Mada)
- [3] Sudarmoko 1991 *Kuat tarik beton–serat Seminar Mekanika Bahan dalam Berbagai Aspek* (Yogyakarta: PAU ilmu teknik Universitas Gadjah Mada)
- [4] Beltran S 2011 *Mercedes Guadalupe Ductile Cement-Based Composites with Wood Fibres* (TU-Delft)
- [5] ASTM C469-94 1996 *Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression, Section 4* (US and Canada: Annual Book of ASTM Standards) 237-240

- [6] ASTM C39-94 1996 *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens, Section 4* (US and Canada: Annual Book of ASTM Standards) 17-21
- [7] Vijayalakshmi 2014 Abaca fiber *Transactions on engineering and sciences* **2**(9)
- [8] Wibowo A 1998 Abaca (musa textillis nee) penghasil serat *Duta Rimba* **XXIV**(222) 31-37
- [9] Sayed M 2014 *Investigation on the Possible Application of Natural Fibres (Abaca Fibres) as Reinforcement in Concrete to Create Ductility* (Delft University of Technology: Department of Materials and Environment)
- [10] ASTM 2002 *Concrete and Aggregate, Annual Book of ASTM Standards* (Philadelphia: American Society for Testing and Materials)

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