Study of Utilizations Abaca Fibre with Kalimantan Local Material on The Concrete Compressive and Flexural Strength

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Abstract. East Kalimantan is an area which rich in natural resources, as a Mahakam sand and local stones. They also have abaca fibre waste to increase the flexural strength of concrete. This material is still underutilized by the people of East Kalimantan. But, they prefer to use materials imported from Palu, Sulawesi, so the unit price of concrete is very expensive. The purpose of this study was to investigate the effect of local Kalimantan material and abaca fibre on the strength of concrete. This research begins with a literature review, then material procurement, and material testing. After that, make a concrete mix design. Make of specimens with a variation of abaca fibre 0%, 0.4%, 0.5% and 0.6%. Then the compression test at the age of 7, 14, 21, and 28 days. The flexural strength testing at the ages of 28 days. From the test results can make analysis and conclusions. From the research results, it indicated that the maximum compressive strength in the addition of abaca fibre 0.0% with the compressive strength 27.31 MPa, and the maximum of flexural strength in the additional of abaca fibre 0.6 % wth flexural strength 3.56 MPa.

1. Introduction
Concrete is one of the construction materials used to make pavement, building structures, foundations, roads, bridges, parking structures, foundations for fences/gates, and cement in brick or block walls, drainage, and others. Based on its compressive strength, concrete is divide into three classifications, first normal concrete with a compressive strength of less than 50 MPa, second high-performance concrete with a compressive strength between 50 until 90 MPa, and third very high-performance concrete with a compressive strength of more than 90 MPa [1]. To get a better concrete quality, many things can be done. Start from improving the quality of the concrete materials to adding addictive substances. Addictive substances can be either liquid or fibre.

During its development, concrete has changed variations, one of which is fibre concrete. Fibre concrete is a structure composed of cement, fine aggregate, coarse aggregate, and a small amount of fibre as an added material [2]. The addition of fibre in a certain proportion is likely to affect the behaviour of the concrete structure as a whole [3]. Of the various fibres available, the authors chose abaca fibre and coconut coir. Both of these fibres are used as additives by utilizing the trunk of the Abaca banana tree and underutilized coconut fruit waste which is expected to improve the properties of the concrete.

Abaca banana has an advantage among banana fibres in general because it has mechanical characteristics over banana fibres in general. Unlike most other types of bananas, Abaca banana is used for its stems. Abaca is one of the non-wood fibre-producing plants that has long fibres. Abaca fibre has good tensile strength and flexural strength and is resistant to rot [4][5].
Coconut coir is the largest part of the coconut fruit, which is about 35% of its weight [6]. Fibre is made from waste which is only piled under coconut trees and then left to rot or dry. Its use is mostly for firewood. The thickness of coconut husk ranges from 5-6 cm which consists of the outermost layer (exocarpium) and inner layer (endocarpium). Endocarpium contains fine fibers that can be used as materials for making ropes, sacks, pulp, carpets, brushes, doormats, heat and sound insulators, filters, seat/car seat fillers and hardboard boards [7]. Coconut coir is a waste that is easily available in areas along the coast such as most parts of Indonesia. Indonesia is the main coconut producing country in the world with a coconut plantation area of 3.76 million hectares and a total production of 14 billion coconuts [6].

This study uses a fibre length of 2.2 cm with percentage of 0.4%, 0.5%, and 0.6%. This percentage refers to the results of previous research by [3] with the results of the addition of variations in the optimum length of abaca fibre from 2 cm to 2.3 cm with the results of her research. 10 mm, 20 mm, and 30 mm fibres [8]. Research use addition superplasticizer to increase compressive strength of concrete[9]. For 10 mm fibre length, the optimum fibre content addition is 0.49%, for 20 mm fibre length the optimum fibre content addition is 0.5%, while for 30 mm fibre length the optimum fibre content addition is 0.48% and the optimum fibre length is used to obtain the maximum compressive strength for variations in the addition of fibre content of 0.25%, 0.5%, 0.75%, and 1%. For 0.25% fibre variation, the optimum length is 20.72 mm, for 0.5% fibre variation the optimum length is 26.25 mm, for fibre variations 0.75% the optimum fibre length is 29.5 mm and for fibre variations, 1% of the optimum length is 22 mm. The compressive strength indicates that the addition of abaca fibre will increase the compressive strength.

2. Methodology
This research was conducted at the Materials Laboratory, Department of Civil Engineering, Samarinda State Polytechnic. This research begins with a literature review from several previous studies, then continues with the procurement of materials and testing of the materials to be used. The next step is to make a mixed design and make specimens. This research was design to study the effect of abaca fibers on compressive and flexural strength of concrete. The variation of abaca fibre 0%, 0.4%, 0.5% and 0.6% were used to evaluate influence of abaca fibers on compressive and flexural strength of concrete. For compressive strength test, a set of forty-eight cube specimens (150x150x150) mm were tested at 7, 14, 21 and, 28 days age. For the flexural strength test, a set of twelve beam specimens (150x150x60) mm were tested at 28 days age. After the age of the concrete meets the compressive strength and flexural strength tests. The last step is to analysis the data obtained from the test results.

2.1. Materials
2.1.1. Fine Aggregate
Mahakam sand is used as a fine aggregate in experimental work. It is obtained from East Kalimantan. By using the pycnometer instrument specific gravity of sand is calculated. The test results of fine aggregate are shown in table 3.

2.1.2. Coarse Aggregate
Local aggregates, comprising 20 mm and 12.5mm coarse aggregates, in a saturated surface dry state, were used. The type of coarse aggregates were used in this work is come from Samarinda, East Kalimantan. The test results of coarse aggregates are presented in table 3.

2.1.3. Water
Water that is clean and free from injurious amounts of oils, acids, alkalis, salt, sugar, organic materials or other substances that may be deleterious to concrete is used. The water is from Materials Laboratory, State Polytechnic of Samarinda.

2.1.4. Cement
The cement used in this study was ordinary Portland cement produced at Samarinda, East Kalimantan.

2.1.5. Abaca fibre
Abaca fibre materials is from Makroman, East Kalimantan.
2.2. Equipment
Some of the basic equipment used is a concrete mixer, slump cone, weighing scale, concrete cube mold (15×15) cm, block mold (15×15×60) cm, compression machine and flexural machine. All of the equipment are ready in the laboratory.

2.2.1. Mix Design
Mix design in this research refers to Indonesian national standard [10] for normal concrete. From the mixed design results, the required material composition will be obtained.

Table 1. Mix Design Abaca Fibre Concrete

| No | Abaca fibre variation | Materials          |
|----|-----------------------|--------------------|
|    |                       | Cement (kg) | Water (kg) | Sand (kg) | Coarse Aggregate (kg) | Abaca fibre (kg) |
| 1  | 0.4%                  | 16.79       | 9.56       | 36.02     | 53.22                | 0.067            |
| 2  | 0.5%                  | 16.79       | 9.56       | 36.02     | 53.22                | 0.084            |
| 3  | 0.6%                  | 16.79       | 9.56       | 36.02     | 53.22                | 0.100            |

2.2.2. Specimens
The percentage of abaka fiber is 0.0%, 0.4%, 0.5%, and 0.6% as an added material to the concrete mixture. In this study, the number of specimens in each variation of the addition of abaca fiber was 15 sample test. So, the total number of test objects is 60 sample test.

Table 2. The Specimens Abaca Fibre Test

| No | Abaca fibre variation | Specimens    |
|----|-----------------------|--------------|
|    |                       | Compression test | Flexural test |
|    |                       | 7 | 14 | 21 | 28 |             |
| 1  | 0.0%                  | 3 | 3  | 3  | 3  | 3            |
| 2  | 0.4%                  | 3 | 3  | 3  | 3  | 3            |
| 3  | 0.5%                  | 3 | 3  | 3  | 3  | 3            |
| 4  | 0.6%                  | 3 | 3  | 3  | 3  | 3            |

There are two types of concrete specimens, cube specimens, and beam specimens. Cube test object with a size of 15 x 15 x 15 cm, while the beam test object has a length of 60 cm, a width of 15 cm, and a height of 15 cm as shown in figure 1.

(a) (b)

**Figure 1.** a. Cube Specimens, b. Beam Specimens.
The compressive standard test for this research refer to Indonesian national standard [11] SNI 03-1974-1990 and also for flexural test refer to Indonesian national standard [12] SNI 4431:2011.

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fc' = \frac{P}{A} \quad (1)
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\[
\sigma_1 = \frac{P.L}{b.h^2} \quad (2)
\]

\[
\sigma_1 = \frac{P.a}{b.h^2} \quad (3)
\]

With \( fc' \) = concrete compression strength (kg/cm²), \( P \) = maximum load (kg), and \( A \) = section of area (cm²). \( \sigma_1 \) = flexural strength (MPa), \( P \) = maximum load (kg), \( L \) = distance between two placement (mm), \( b \) = width in horizontal direction, \( h \) = width in vertical direction, and \( a \) = the average distance between the cross-sectional fracture and outside the nearest outer support, measured at four places at four points angle of span.

3. Result and Discussions

3.1. Materials Properties

The result of material properties shown in table 3 and table 4. Based on the results of tests that have been carried out on fine aggregate and coarse aggregate, it shows that the materials meet the determined Indonesian National Standard (SNI). The material properties are used to create a concrete mix design. From results of the concrete mix design is used as a concrete mixture. The following are the results of the cement material test which are shown in table 3.

**Table 3. Characteristic of Cement**

| No. | Characteristics          | Result             |
|-----|--------------------------|--------------------|
| 1.  | Density                  | 3.012              |
| 2.  | Normal consistency       | 24.1%              |
|     | Setting Time             | 1 hour 23 minute   |
| 3.  | Initial binding          | 47.3 minute        |
|     | Final binding            | 135 minute         |

The material used for the concrete mixture is first tested to determine the level of feasibility. The results of testing for fine aggregates and coarse aggregates can be seen in table 4 below.

**Table 4. Physical Properties of Materials**

| No | Particulars              | Coarse Aggregate | Fine Aggregate |
|----|--------------------------|------------------|----------------|
| 1  | Bulk density (gr/cm³)    | 1.55             | 1.32           |
| 2  | Specific gravity         | 2.57             | 2.46           |
| 3  | Absorption (%)           | 0.88             | 0.56           |
| 4  | Water content (%)        | 0.64             | 1.83           |
| 5  | Abrasion (%)             | 25.74            | -              |
| 6  | Sludge content (%)       | 0.48             | 3.24           |

3.2. Compressive Strength

From figure 2, the result show that concrete with variations of abaca fibre 0.4% and 0.5% has an increase in the value of the compressive strength, but has a decrease in the value of compressive strength at a percentage of 0.6%. Based on figure 3 above, it can be seen that the optimum abaca fibre content is 0.5% with a characteristic compressive strength value of 26.29 MPa, an increase of 5.5% from the compressive strength value of 0.4% variation of abaca fibre, and a decrease occurs in concrete with fibre content of 0.6%.
3.3. **Flexural strength**

Based on figure 4, it is shown that the concrete with the abaca fibre variation has increased along with the addition of fibre content with the flexural strength values of 2.84 MPa, 3.38 MPa, and 3.56 MPa. The maximum flexural strength shown with addition of abaca fibre 0.6%.

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**Figure 2.** Compression Strength

**Figure 3.** Flexural Strength
4. Conclusions
Based on the experimental investigation with added of abaca fiber 0.4%, 0.5%, and 0.6%, the following conclusions that:

a. The addition of abaca Fiber to the concrete mixture can affect the value of the compressive strength. In general, the addition of abaca fiber can reduce the compressive strength of concrete. The greater the level of abaca fiber, the compressive strength of concrete will decrease.

b. The addition of abaca fiber can increase the flexural strength value. The flexural strength value of concrete will be directly proportional to the addition of fiber abaca content.

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