Effect of substitution of coconut coir waste on the compressive strength of non-structural concrete

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ABSTRACT

Using coconut fiber waste (LSK) in concrete mixes has good prospects because Indonesia has abundant natural resources. The addition of this fiber aims to improve the properties of concrete. This study aims to determine the effect of adding coconut fiber waste (LSK) as a substitute for coarse aggregate on the compressive strength of non-structural concrete and utilizing coconut fiber waste to reduce the accumulation of coconut waste and increase the selling value of coconut fibers. Making concrete mixtures with standard SNI 03-2834-2000, concrete compressive strength f'c 16.9 MPa concrete age 28 days, with 4 variations of the mixture, namely LSK 0%, LSK 0.5%, LSK 1%, LSK 1.5%, and LSK 2%. The test object is cylindrical with a diameter of 15 cm and a height of 30 cm, with 30 specimens. According to the findings of this study, the addition of coco fiber reduced the compressive strength of the concrete. In the compressive strength test of concrete, aged seven days and 28 days, the highest average compressive strength values of LSK 0 were 14.72 MPa and 21.62 MPa. Of the three variations of LSK, LSK 0.5 and LSK 1 are closest to normal concrete. The relationship between the uses of LSK on the compressive strength of concrete at the age of 28 days. Its effect on the decrease in compressive strength occurs in LSK 0.5, LSK 1, LSK 1.5, and LSK 2. The equation obtained from the linear regression equation y=4.764+19.88 with a value of R2 = 0.827. The results show that the coconut fiber mixture (LSK) cannot provide a compressive strength of concrete that exceeds the compressive strength of normal concrete.

Keywords: Coconut fiber, coarse aggregate, compressive strength test, non-structural concrete.

Kata kunci: Sabut kelapa, agregat kasar, uji kuat tekan, beton non-struktural.
Introduction

More than 10 billion tons of concrete are produced every year. Annual production represents about 1.5 tonnes for every person on the planet. Aggregate is the largest constituent in concrete. Around 70–80% of the volume of structural concrete is made up of aggregate, of which 25–30% is fine aggregate and 40–50% is coarse aggregate [1]. Concrete with a mixture of fibrous materials or what is often referred to as fibre-reinforced concrete can be in the form of synthetic fibres or fibres to improve the mechanical properties of the concrete [2]. Fibrous concrete has several advantages, including increased concrete resistance to abrasion and impact, also compressive, tensile and flexural resistance can also be increased [3]. Meanwhile, non-structural concrete is concrete mixed with Portland cement, coarse, fine-textured aggregate and mixed with water, or without a mixture of additives to form a solid mass according to Sksni T-15-1990-03 [4].

Coconut husk, a horticultural waste, is obtained from the cocoa husk (mesocarp) of coconut (Cocos nucifera) from coconut tree belonging to the palm family group. If not managed properly, this waste can develop social and ecological problems. There must be more productive management and business by utilizing it as a concrete innovation. This utilization also helps in reducing the cost of using concrete materials [2, 5-6]. Coir that can absorb water is coconut core. One way to make cement is by mixing coconut core. Strong durability in the manufacture of coconut core cement has good resistance. Therefore, a mixture of coconut fibre can give hope to producing good quality fibre. There are properties possessed by coconut core, which are persistent, water can be absorbed, and have long durability and are good if there is no direct relationship with the weather.

Previous studies have tried to mix coconut core into a concrete mixture. Research [8] with coconut core has 4%, 3%, 2%, and 1% coconut volume mixed. The findings show that when 1% coconut fibre is added, the maximum flexural strength gain is 15% compared to the flexural strength without fibre. Through thealkalization process, the chemical NaOH is used to increase the strength of the coconut core fibre. Some of the ingredients needed are 10, 9, 8, 7, 6, 5, 4, 3, 2, and 1 gram. With just 4 grams of NaOH composition per 100 ml of water, the outcome is a 35% improvement in the fibre's tensile strength [9]. The use of fibre with percentages of 1%, 0.5%, and 0.75%, fibre without alkali treatment for each volume of concrete, alkali treatment for fibre 1.25 M and 1 M. Based on the results of tests that have been carried out, there is an increase coconut fibre waste (LKS) with a percentage of 0.5% produces an optimum composition with alkaline treatment. It is proven that with 1.25 M alkali treatment, the increase in the compressive strength value of conventional concrete has a percentage of 17.8%. For 1 M alkali at treatment, the compressive strength value of conventional concrete has a percentage of 13.5%, the presence of alkali treatment which has the highest strength value among concretes that combine other fibre variations provides an additional fibre percentage of 0.75% [10].

Research with concrete quality planning in K-225 with 28 days can be tested for pressure. This study increased the amount of coconut core waste (LSK), resulting in a pressure strength of 244.84 kg/cm² with a percentage of 0.125% and a pressure strength of 272.14 kg/cm² with a percentage of 0.5%. There was an increase in the pressure strength test with a percentage of 29.55% and 16.56% of normal concrete [11]. Research [5] used concrete quality f'c 25 MPa with variations of coconut fibre 0.75%, 1%, 1.25%, and 1.50%, as an alternative material to the strength of the split tensile and compressive strength test concrete for 28 days. The test results show that the results of the split tensile strength and compressive strength of cylindrical concrete can be drawn into the conclusion that the largest compressive strength can be obtained from coconut husk 0.75% with a characteristic value of f'c 23.44 Mpa for 28 days and the largest split tensile strength can be obtained, obtained 0.75% coconut husk with a characteristic f'c value of 2.11 MPA for 28 days. The addition of coconut core fibre with a percentage of 2% increased the flexural strength and split tensile strength but experienced a decrease in the compressive strength. Therefore, 2% is the optimum level of addition of coconut core fibre in terms of split tensile strength and flexural strength with an average flexural strength of 5.705 MPa and split tensile strength of 2.38 MPa [12].

The purpose of this study was to understand the relationship between the addition of coco fibre waste (LSK) as a substitute for coarse aggregate on the compressive strength of concrete with a mixed variation of 0.5%, 1%, 1.5%, and 2% of the reduction in the percentage of coarse aggregate in non-solid concrete. -structural. This study aims to understand the composition and effect of adding coconut core waste (LSK), which increases the compressive strength of non-structural concrete and is useful for overcoming premature damage to concrete and digging deeper to find the effect of this addition on the compressive strength of concrete. The coconut core waste used is from the many coconut sellers in Pojsk Hamlet, Wonorejo Village, Sambeng District. The coconut shadrs pile will get bigger if we cannot use it yet [13]. This research is expected to reduce the accumulation of coconut waste and increase the selling value of coconut core waste. The best mixing of coconut core waste (LSK) in a concrete mixture with a 2% variant is the best [12]. From this study, the authors took different variants under 2%, namely 0%, 0.5%, 1%, 1.5% and 2% and on non-structural concrete f'c, which is useful for finding the effect of adding LSK on the compressive strength of concrete.

Research Methodology

In this study, the method used is the experimental method. Using SNI standards, the research was conducted at the Civil Engineering Laboratory, Universitas Islam Lamongan. Several processes that need to be carried out in this research activity are divided into three stages, including the initial stage in preparing materials, the second stage in the form of tools used to test research and the third stage in testing.

2.1. Material Preparation Stage

Characteristic testing in the form of coarse and fine aggregates must be prioritized. The coarse aggregate and fine aggregate results can be seen in Table 1. From table 1, the characteristics for coarse and fine aggregate have met the requirements so that fine and coarse aggregate materials can be used. Before conducting research, the preparation that needs to be done is to prepare the tools used. Several materials are the research object, namely Lumajang sand, 1-2 inch gravel, water, cement, and coconut fibre. The source of the data in this study was obtained from the results of laboratory tests of the Department of Civil Engineering, Universitas Islam Lamongan, adjusting data from several works of literature that already have Indonesian national standards (SNI) or foreign standards, namely ASTM [14].

2.2. Coconut Fiber Waste

Taking coconuts, which are taken from the coir and cut with a diameter of 3-5 cm, can be seen in Figure 1. The test results on coconut coir fibre (SSK) with a test of water that has been absorbed from coconut husk can be seen in Figure 2. The results of laboratory tests showed that the average water value absorbed
from coconut fibre was 2.67%. Standard quality is required in testing for gravel infiltration water (ASTM C 127-8893) permitted with a value of 4-1%. The coconut coir fibre is included in the requirements category, picture. Figure 1 shows the coconut coir used, and Figure 2 shows the moisture test results of the coconut coir.

| Aggregate type | Test             | Result              | Condition      |
|----------------|------------------|---------------------|----------------|
| Coarse aggregate | Density          | 2.51 gr/cm³        | 2.2 – 2.7 gr/cm³ |
|                 | Water absorption | 2.92 %             |                |
|                 | Weight           | 1.43 gr/cm         | >1.2 gr/cm     |
|                 | Filter analysis  | 5.4                | 3.0 – 8.0      |
| Fine aggregate  | Density          | 2.48 gr/cm³        | 2.2 – 2.7 gr/cm³ |
|                 | Water absorption | 3.34 %             |                |
|                 | Weight           | 1.69 gr/cm         | >1.2 gr/cm     |
|                 | Filter analysis  | 3.07               | 1.5 – 3.8      |

(Source: Preliminary analysis, 2021)

2.3. Calculation Stage of Mix Design and Making Test Items

The calculation of the composition of the concrete material in this research carried out a comparison between the compressive strength and weight of the concrete and the design of low-strength (non-structural) concrete. The concrete mix design refers to SNI 03-2834-2000, regarding several ways of making normal concrete mixes. The purpose of strengthening the concrete compression requirement (fc) at the age of 28 days of concrete is fc 16.9 MPa. Four types of mixture variations will be made in this study, namely LSK 0 for concrete mixtures without coconut fibre mixture, LSK 0.5 for concrete with coconut husks of 0.5%, LSK 1 for concrete with coconut husks of 1%, LSK 1.5 with coconut fibre is 1.5%, and LSK 2 with coconut fibre is 2%. The concrete mix design in this study can be seen in Table 2.

| No  | Mixed code | Variance | Cement | Sand  | Gravel | Water | Added material |
|-----|------------|----------|--------|-------|--------|-------|----------------|
|     |            |          | Kg     | Kg    | Kg     | Liter | Kg             |
| 1   | LSK 0      | 0%       | 394    | 761   | 1050.00| 205   | 0.00           |
| 2   | LSK 0.5    | 0.5%     | 394    | 761   | 1044.75| 205   | 5.25           |
| 3   | LSK 1      | 1%       | 394    | 761   | 1039.50| 205   | 10.5           |
| 4   | LSK 1.5    | 1.5%     | 394    | 761   | 1034.25| 205   | 15.75          |
| 5   | LSK 2      | 2%       | 394    | 761   | 1029.00| 205   | 21             |

(Source: Preliminary analysis, 2021)

2.4. Testing Stage

Two test equipment are carried out, namely fresh concrete and hardened concrete testing. Fresh concrete testing uses the slump test, where this test is carried out before the fresh concrete is poured into the formwork. In comparison, testing the concrete using a compressive test (compressive test) [15]. The main performance of concrete is part of its compressive strength [16]. The ability of concrete to accept compressive forces per unit area is part of compressive strength performance. According to the Indonesian National Standard, the meaning of pressure strength is that the concrete test object will crumble if it is burdened with a certain pressure force caused by a unit area load [17]. For testing hard concrete, the test object is made of concrete with a cylindrical shape with a diameter of 15 cm and a height of 30 cm. Inspection and testing of specimens on the compressive strength of concrete at the age of 7 and 28 days. The number of test objects used was 3 for each variant, so the total of all test objects was 30.
3. Results and Discussion

3.1. Slump Test

The test is carried out to know the viscosity of fresh concrete (fresh concrete) with the slump test. The slump test value shows the workability value of the concrete made. The higher the slump test value, the better the workability. Figure 5 is the average slump test value of adding coconut fibre waste (LSK) at a certain level to reduce the workability of concrete. Figure 5 is the average slump test value of adding coconut fibre waste (LSK) at a certain level to reduce the workability of concrete. The outcome is a reduction in slack with an increase in the amount of LSK, which is impacted by the coir geometry, which binds together, causing the new concrete to be unable to flow during the slump test. As a result, this fresh fibre reinforced concrete has weaker mechanical properties than conventional fresh concrete.

Table 3. Slump test results.

| Mixed variety       | Slump height (cm) | Mean (cm) |
|---------------------|-------------------|-----------|
|                     | I                 | II        |          |
| Normal + 0 % LSK    | 13                | 12        | 12.5     |
| Normal + 0.5 % LSK  | 9                 | 11        | 10       |
| Normal + 1 % LSK    | 10                | 10        | 10       |
| Normal + 1.5 % LSK  | 9                 | 9.5       | 9.3      |
| Normal + 2 % LSK    | 11                | 9         | 10       |

Figure 5. Average slump test value
(Source: Preliminary analysis, 2021)

3.2. Effect of Addition of LSK on Concrete Density

The addition of coconut coir waste also affects the density of normal concrete. The specific gravity values of conventional concrete (without LSK) and LSK concrete can be seen in Table 4.

Figure 6. Graph of specific gravity of concrete.
(Source: Preliminary analysis, 2021)
The higher the proportion of fibre used, the lower the density. [18].

Slump test indicate that the addition of the proportion of fibre will affect the decrease in slump and density. The results of the concrete density test, where the calculation is obtained by dividing the weight of the concrete by its volume, show that the normal specific gravity of concrete with coconut coir waste (LSK) was lower in value than normal concrete. For concrete, aged seven days, the lowest specific gravity value was with LSK 2 and for concrete, aged 28 days. For 7-day-old concrete, the specific gravity of the concrete has not met the normal specific gravity, while for the 28-day concrete, only LSK 0.5 and LSK 1 have met the normal density of concrete. The results of this slump test indicate that the addition of the proportion of fibre will affect the decrease in slump and density. The higher the proportion of fibre used, the lower the density. [18].

### 3.3. Compressive Strength of Concrete

Figures 7 and 8 show a comparison of the compressive strength of concrete vs quantity fluctuations at 7 and 28 days of age. Figure 7 is a comparison diagram of the compressive strength of 7 days old concrete. In sample 3 of non-fibre concrete (0%), the highest compressive strength occurred with a strength value of 16.45 MPa. Meanwhile, sample 1 of 2% LSK concrete is the lowest strength with a compressive strength of 7.05 MPa. Figure 8 is a comparison diagram of the compressive strength of 28 days of age, where the highest concrete compressive strength was obtained in 3 samples of non-fibre concrete (0%) with a strength value of 24.91 MPa. In comparison, the lowest strength occurred in sample 2 of 2% LSK concrete, namely the compressive strength of 8.69 MPa. The average compressive strength of each sample can be seen in Table 5.

| Mixed variety (%) | Weight (kg) | Concrete density (kg/m³) | Average concrete density | Weight (kg) | Concrete density (kg/m³) | Average concrete density |
|-------------------|-------------|--------------------------|--------------------------|-------------|--------------------------|--------------------------|
| 0                 | 12.6        | 2,377.92                 |                          | 13.2        | 2,491.15                 |                          |
| 0                 | 12.6        | 2,377.92                 | 2.391                    | 13.2        | 2,491.15                 | 2.441                    |
| 0                 | 12.8        | 2,415.66                 |                          | 12.4        | 2,340.17                 |                          |
| 0.5               | 12.6        | 2,377.92                 |                          | 13.0        | 2,453.41                 |                          |
| 0.5               | 12.6        | 2,377.92                 | 2.365                    | 12.8        | 2,415.66                 | 2.441                    |
| 0.5               | 12.4        | 2,340.17                 |                          | 13.0        | 2,453.41                 |                          |
| 1                 | 12.2        | 2,302.43                 |                          | 12.6        | 2,377.92                 |                          |
| 1                 | 12.4        | 2,340.17                 | 2.315                    | 13.0        | 2,453.41                 | 2.416                    |
| 1                 | 12.2        | 2,302.43                 |                          | 12.8        | 2,415.66                 |                          |
| 1.5               | 12          | 2,264.69                 |                          | 12.6        | 2,377.92                 |                          |
| 1.5               | 12          | 2,302.43                 | 2.290                    | 12.4        | 2,340.17                 | 2.365                    |
| 1.5               | 12          | 2,302.43                 |                          | 12.6        | 2,377.92                 |                          |
| 2                 | 12          | 2,264.69                 |                          | 12.4        | 2,340.17                 |                          |
| 2                 | 12          | 2,264.69                 | 2.240                    | 12.2        | 2,302.43                 | 2.315                    |
| 2                 | 11.6        | 2,189.20                 |                          | 12.2        | 2,302.43                 |                          |

(Source: Preliminary analysis, 2021)

Figure 6 is a graph of the specific gravity of concrete, where the calculation is obtained by dividing the weight of the concrete specimen by the volume of the concrete specimen. The value of specific gravity of concrete with coconut coir waste (LSK) was lower in value than normal concrete. For concrete, aged seven days, the lowest specific gravity value was with LSK 2 and for concrete, aged 28 days. For 7-day-old concrete, the specific gravity of the concrete has not met the normal specific gravity, while for the 28-day concrete, only LSK 0.5 and LSK 1 have met the normal density of concrete. The results of this slump test indicate that the addition of the proportion of fibre will affect the decrease in slump and density. The higher the proportion of fibre used, the lower the density. [18].

3.3. Compressive Strength of Concrete

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![Figure 7. Comparison diagram of the compressive strength of 7 days old.](Source: Preliminary analysis, 2021)
There was a change in the development of each compressive strength of each test age and LSK variations. Figure 9 shows the average compressive strength achieved by concrete aged 7 and 28 days. At the age of 7 days, the average compressive strength of concrete has not reached the design compressive strength, which is still less than 16.9 MPa, in contrast to the average compressive strength of 28 days of concrete which has exceeded the compressive strength of the design concrete. The maximum compressive strength of concrete, aged 7 and 28 days, is at LSK 0 without substitution of coconut coir waste. The average compressive strength value in 7-day-old concrete with LSK 0 variation is 14.72 MPa, then at LSK 0.5 and LSK 1, the compressive strength value is 13.47 MPa, experiencing a decrease of 8.5% from normal concrete. Meanwhile, LSK 1.5 and LSK have the same compressive strength value of 8.77 MPa, decreasing 40% from normal concrete. While at the age of 28 days, the average compressive strength of LSK 0 is 21.62 MPa, already exceeding the compressive strength of the design concrete, while at LSK 0.5 and LSK 1, the compressive strength value is 14.88 MPa, a decrease of 31% from normal concrete. Of the three variations of LSK, LSK 0.5 and LSK 1 are closest to normal concrete. Further analysis of the effect of adding coconut fibre waste (LSK) to the compressive strength of concrete, using linear regression analysis, using Microsoft Excel on concrete aged 7 and 28 days.
Figure 10. Linear regression analysis of the effect of the addition of LSK on the compressive strength of 7 day old concrete.
(Source: Preliminary analysis, 2021)

Figure 10 shows the relationship between the use of LSK and the compressive strength of concrete at the age of 7 days. It can be seen that the addition of LSK in the concrete mixture affects the compressive strength of the concrete. The effect with the addition of LSK can be seen from the decrease in compressive strength that occurs in LSK 0.5%, LSK 1%, LSK 1.5% and LSK 2%. The regression results of the relationship between the increase in the average compressive strength of concrete and the percentage of LSK stated that there was a similar relationship between the addition of variations in LSK and the compressive strength of concrete. The value of the relationship obtained from the regression equation $y = -3.32x + 15.16$ with a value of $R^2 = 0.849$. Figure 11 depicts the link between the usage of LSK and the compressive strength of concrete after 28 days, which is almost identical to the age of 7 days. The addition of LSK to the concrete mix affects the compressive strength of the concrete. The effect on the decrease in compressive strength occurs in LSK 0.5, LSK 1, LSK 1.5 and LSK 2. The equation obtained from the linear regression equation $y = -4.764x + 19.88$ with $R^2 = 0.827$.

Figure 11. Linear regression analysis of the effect of the addition of LSK on the compressive strength of 28 day old concrete.
(Source: Preliminary analysis, 2021)

4. Conclusion

The addition of coco fibre resulted in a decrease in the compressive strength of the concrete. In the compressive strength test of 7 days old concrete, the average compressive strength value of LSK 0 is 14.72 MPa, then at LSK 0.5 and LSK 1, the compressive strength value is 13.47 MPa, which has a decrease of 8.5% from normal concrete. Meanwhile, LSK 1.5 and LSK have the same compressive strength value of 8.77 MPa, decreasing 40% from normal concrete. In contrast to the average compressive strength of concrete, aged 28 days, the average compressive strength value of LSK 0 is 21.62 MPa which has exceeded the compressive strength of the design concrete, while at LSK 0.5 and LSK 1, the compressive strength value is 14.88 MPa. 31% reduction from normal concrete. Of the three variations of LSK, LSK 0.5 and LSK 1 are closest to normal concrete. The effect of LSK on concrete compressive strength after 28 days is almost identical to that at seven days. The addition of LSK to the concrete mixture affects the compressive strength of the concrete. The effect on the decrease in compressive strength occurs in LSK 0.5, LSK 1, LSK 1.5 and LSK 2. The equation obtained from the linear regression equation for 28 days is $y = -4.764x + 19.88$ with a value of $R^2 = 0.827$. The results show that the coconut coir mixture (LSK) cannot provide a compressive strength of concrete that exceeds the compressive strength of normal concrete.

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