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The performance optimization of concrete bricks using a sagu fiber

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Abstract
Sagu (sinonggi/kapurung) is a typical food of the Tolaki ethnic group. Sagu (Metroxylon sagu rottb) is an endemic plant in Southeast Sulawesi Province. So far, sagu waste in the form of fibers (sagu fiber) has not been optimally utilized. Sagu fiber waste is only left to mount; some are dumped into the river, so it is feared that it could pollute the environment. Through innovation in reducing waste in the principles of sustainable construction, sagu fiber will be used as an added material to manufacture concrete brick wall pairs. This study aimed to test the compressive strength and water absorption capacity of sagu fiber concrete bricks with variations of 0%, 50%, 60%, and 70% sagu fiber under the sand. This study uses an experimental method with stages such as preparing work tools and work materials, making test objects, and testing. Data were analyzed using mathematical formulas for the compressive strength of concrete bricks and water absorption capacity, compared with SNI 3-0349-1989 for solid concrete bricks, and analyzed comparatively. Based on the test results in this research laboratory, it is concluded that a balanced composition to get good quality is found in 70% sagu fiber and 30% sand.

Keywords:
Performance;
Sagu fiber brick;

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INTRODUCTION

The current earth situation is quite alarming regarding climate, natural resources, and human resources [1]. The concern in terms of natural resources is that exploitation does not pay attention to the capacity and carrying capacity of the environment, so the environmental quality tends to decline [2]. Furthermore, the increase in the earth's temperature has resulted in the issue of global warming due to human activities, which tend to be less environmentally friendly.

One of the solutions made by humans to reduce the impact of global warming is to apply the concept of sustainable development [3]. The concept of sustainable development agreed upon by the United Nations Organization (UNO) is Environmentally Sustainable Development (ESD). ESD is developed to meet the needs of the present without forgetting the needs of future generations [4]. One of the derivatives of the ESD is the Indonesian construction document 2030.

The Indonesian Construction 2030 document states that Indonesian construction must be oriented to be a pioneer in improving and improving environmental quality. One of the agendas for promoting sustainable construction is to save materials and reduce waste (waste materials) [5]. The philosophy of reducing waste is how to give a second life breath to waste for the long term, so it has useful value. This means that sustainable construction revives the remains of products that are no longer used (waste) into something that can still be used again. Thus, the product will not die or lose its quality but is given the opportunity through the second innovation in life design philosophy for future product generations.

On the other hand, concrete has high compressive strength, can be formed as needed, is easy to maintain, and is useful for light and heavy construction. However, concrete has weaknesses such as small concrete tensile strength, so the concrete is brittle and can cause sudden failure. Therefore, concrete requires special treatment with added materials. Applying added material to the concrete mix is intended to slow down the binding time, accelerate hardening, increase the dilution of the mixture, increase ductility, reduce hardening cracks, reduce hydration heat, increase tightness, and increase durability [6]. One of the added materials used in concrete is fiber. Fiber concrete consists of hydraulic cement, water, fine aggregate, coarse aggregate, and fiber (fiber, steel, plastic, glass, and natural fibers). The addition of fibers to concrete is intended as follows: (1) To improve the low tensile strength properties of concrete [7]; (2) To increase the ductility of concrete [8]; (3) Can improve the properties of concrete [9]; (4) So that the modulus of elasticity of concrete is higher [10].

The theories that support the addition of fibers to concrete can improve the properties of concrete as follows. First is the spacing concept theory states that the distance of the fibers that are close together will make the concrete not crack. The second is theory of the composite material concept assumption which states that the constituent materials of the concrete are perfectly attached to the tensile and flexural strength of the concrete. Fiber concrete mixers need to pay attention to the traceability of the concrete mix and fiber mixing techniques [11]. The addition of fibers to concrete that researchers with good test results often examine is natural fibers and synthetic fibers. Natural fibers have advantages such as being economical, readily available, renewable, and harmless. Synthesis fiber is relatively inferior because of its high cost, non-renewable, and possibly dangerous [12]. Concrete fibers that are focused on in this study are natural fibers that come from growing vegetation.

Like bamboo fiber was added to concrete. The addition of bamboo fiber to the concrete only slightly increased the compressive strength by 9.9%, the tensile strength significantly by 30.5%, and the best bamboo fibre size was 20 mm. The use of coconut fibers in concrete also produces good mechanical properties of concrete. Adding coconut fibre increases concrete mechanical properties such as the compressive test, tensile strength test, modulus of elasticity, and permeability testing of concrete standards. The use of pineapple fiber in concrete is also very good. Adding pineapple fibers to concrete can increase strength and tensile strength in concrete so that it can be applied to thin structural elements so that they are not easily cracked due to impact [13]. Ori bamboo has also been added to concrete. Adding bamboo ori fibers to the concrete mixture by 2% by weight of cement can increase the compressive strength and tensile strength of concrete [14]. Apart from bamboo fiber, resin fiber has also been added to concrete. The addition of resam fiber to concrete as much as 0.5%, 1%, 1.5%, and 2% can increase the compressive strength and tensile strength of concrete [15].

Likewise, with the pandanus shoulder blades fiber, the addition of pandanus shoulder blades to the concrete provides a lower tensile strength value than normal concrete. The percentage of the decrease in the value of the lowest and highest split tensile strength was 9.687% (variation 0.25%) and 25.718% (variation 1%) [16]. Apart from the above fibers, bagasse fiber can be used as a substitute for coarse aggregate in concrete. The effect of substitution of coarse aggregate with bagasse fiber on the compressive strength and flexural strength of concrete K 350, the following conclusions are obtained: the compressive strength value obtained is by the planning concrete of K 350 of 31.1 MPa. The maximum flexural strength results were obtained in concrete with a variation of 1% bagasse fiber of 4.88 MPa. The maximum porosity results obtained in normal concrete were 6.7% and the maximum density results were obtained in normal concrete and concrete with a variation of 0.5% bagasse fiber of 2.26 g/cm^3 [17].

In areas where oil palms are available, palm fiber can also be used as an added material for concrete. The effect of adding palm fiber in the mixture on each fiber percentage verification (5%, 10%, 15%) cannot increase the compressive strength of concrete. The addition of palm fiber in the mixture can slow the collapse time of the concrete and the largest increase occurred in the addition of 15% of the fiber by weight of cement volume, which is 123.25% of the normal time [18]. In palm-producing areas, palm waste can also be used as an added material for concrete. Alkali treatment on palm dregs can increase the compressive strength of fiber concrete by up to 50% compared to fiber concrete without alkaline treatment. In other research, palm fiber can be optimized as a natural fiber that can be used in addition to making concrete bricks because it will affect the flexibility properties of the clever concrete bricks [19]. In adding fibers to concrete, the average addition of fibers with a length of 3 cm can affect the tensile strength value. The addition of fibers can cause the tensile strength to increase if it is in a small percentage. The addition of palm fibers did not find optimum tensile strength data from variations in the addition of 3% -10% of the fibers [20].

In other studies on fibers with different variations, it was found that the greatest compressive strength was 0.75% alkaline treatment fiber palm fiber concrete, while the largest split tensile strength was fiber fibers concrete with 1.25% alkaline treatment [21]. Of the various natural fibers above, banana fiber can also be used in concrete mixes. The addition of banana fiber can reduce the compressive strength of concrete but increase the ability of concrete to withstand cracks [22]. Besides banana fiber, water hyacinth can also be used as an added material for concrete. Adding water hyacinth fiber to the concrete mixture can reduce the compressive strength. The concrete compressive strength test results with the addition of water hyacinth fibers were 0% (normal), 4%, 6%, and 8% [23].

In the addition of rattan fibers to concrete, it was found that the more rattan fibers the split tensile strength and flexural strength of the concrete decreased compared to normal concrete [24]. Nowadays, sagu waste fiber has never been studied as an additive to concrete mixtures. In addition, the average addition of natural fibers from the grown vegetation results in a good physical test except for banana fiber, rattan fiber, water hyacinth fiber, palm fiber for certain treatment, and thorn shoulder pandanus fiber. Based on the 1982 PUBI, the brick absorption test can be calculated using the formula [25].

$$Water\ Absorption = \frac{A - B}{F} x100\% \quad (1)$$

Information

A : The weight of the brick after soaking (kg)

B : Heavy brick before soaking (kg)

F : The area of the submerged brick (cm)

Pressure is the compressive force that acts on one unit of surface area that experiences the compressive force. The symbol for pressure is P. So if a force of P acts on a plane L (area), the amount of pressure is [26].

$$f' = \frac{P_{max}}{L} \quad (2)$$

Information

f^1c : Compressive strength of materials, units N/m^2 or kg/cm^2

P : Maximum compressive load (compressive force), units (kg or N)

L : Material area (m^2)

One of the innovations in building material design by utilizing waste is the brick wall material from the added material of sagu fiber waste. So far, the mindset of local people in Indonesia is that the name for installing walls is only wooden planks, red bricks, concrete bricks, and light bricks. Besides that, there are no more walls. The four wall mounting materials have each of the following weaknesses: (1) The wooden planks are easily rotten, so they are not efficient; (2) Red brick requires burning in the manufacturing process, so it is not effective; (3) Concrete bricks explore sand material excessively so that it is unsustainable and; (4) Hebel has a high price. Thus, an innovative and effective wall mount is needed.

Sagu (sinonggi/limestone) is a typical food of the Tolaki ethnic group and sagu (metroxylon sagu rottb.) is an endemic plant in Southeast Sulawesi Province. Sagu is obtained from the stems of sagu plants which are skinned and forged with a wooden axe so that they are crushed and formed fibers.

The fibers are mixed with water and squeezed like sagu milk. This sagu milk is allowed to stand for a few days and will become sagu. Sagu waste in the form of fiber is disposed of as waste. So far, sagu waste in the form of fiber has not been optimally utilized. Sagu fiber waste is only left to mount and some are dumped into the river, so it is feared that it can pollute the environment. The mountain of sago waste can be seen in Figure 1.

Figure 1. Sagu fiber waste is allowed to mount.

Through innovation in reducing waste in the principles of sustainable construction, sagu fiber will be used as an added material to manufacture concrete brick wall pairs. Therefore, this study aimed to test the compressive strength and water absorption capacity of sagu fiber concrete bricks with variations of 0%, 50%, 60%, and 70% sagu fiber under the sand.

METHOD

Work Tools

The working tools for making concrete bricks are quite simple, efficient, and economical, except for a compression testing machine [27]. The concrete brick moulding tools made of sagu fiber added are a trowel, a broomstick, a mould, a fresh mixing compactor, a cement spoon, a bucket, an old newspaper base, and a compression testing machine.

Working Materials

Portland cement

Type I is portland cement for general use, which does not require special requirements as required in other types [28]. The weight of cement is 50 kg/sack.

Sand

This research uses local sand types in Kendari City. This sand is often called Nambo sand. This sand was chosen because the type of sand is rather coarse (contains lots of gravel) and the economical price [29], so economical and appropriate concrete bricks can be achieved.

Sagu Fiber Waste

Sagu fiber waste is immersed in seawater for three days. This is intended to minimize the number of bacteria in sago fiber [30]. The composition of sago fiber used is 0%, 50%, 60%, and 70% by weight of Nambo sand.

Water

Concrete mixing water is as follows: (1) mixing water such as water for mixing and free water in the aggregates; (2) drinking water; (3) mixing water is like undrinkable water [31]. In this study, the water for mixing concrete came from drilled wells around the laboratory.

Test Object

In this study, four treatments were made. For each treatment, 10 test objects were made. The specimens were made with a size of 20 x 10 x 5 cm. An example of a sago fiber brick image can be seen in Figure 2. The composition of the working materials on the test object. The sample composition can be seen in Table 1.

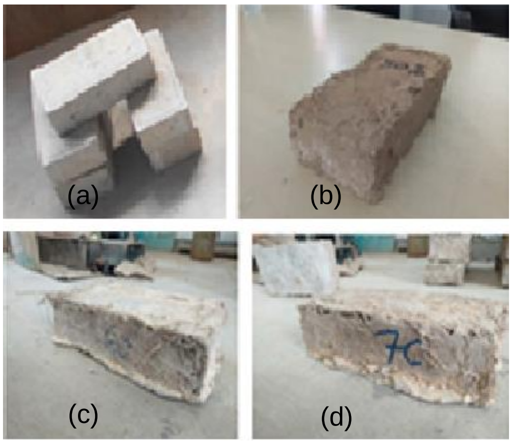

Figure 2. Sagu fiber concrete brick sample (a) 0%, (b) 50%, (c) 60%, and (d) 70%

Table 1. The composition of the working materials on the test object

Code (%)	Waste sagu fiber (kg)	Sand (kg)	Cement (kg)	Cement Water Factor	Number of samples	
0	0	28	12	0.4	5	5
50	2	28	12	0.4	5	5
60	2.2	25.2	12	0.4	5	5
70	2.4	22.4	12	0.4	5	5

Research Implementation

This research was conducted on Thursday, September 12, 2021, at the Material Testing and Construction Laboratory, Civil Engineering Department, Engineering Faculty, Halu Oleo University. In Figure 3, the implementation of the research was carried out in the following stages: The first stage is the preparation of work materials; The second stage includes the code for the composition of the object of test object; The third stage is mixing; The fourth stage is the object maintenance test; The fifth stage is testing of test objects; The sixth stage is data analysis; The seventh stage includes conclusions and recommendations.

Data analysis

The data collection technique was performed in the laboratory. The test includes compressive strength and water absorption. In Table 2, the gross compressive strength is the overall compressive load when the specimen breaks, divided by the actual size of the brick including the area of the hole, and the hollow edge. While the maximum average water absorption is the difference between weighing in a wet state and a dry state. The amount of water absorption must be calculated based on the percent by weight of dry specimens [32].

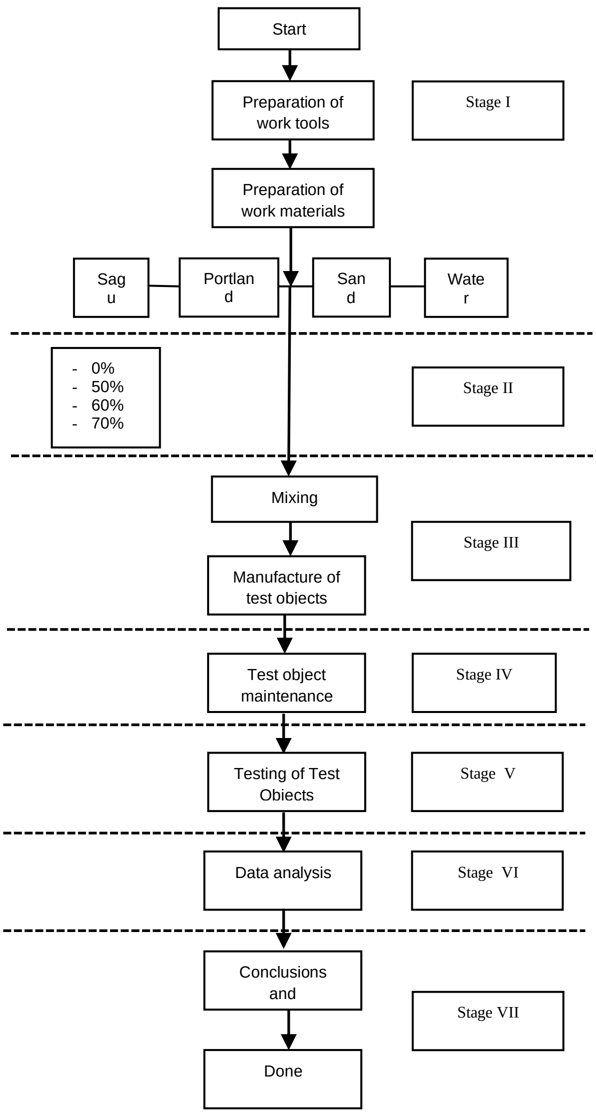

Figure 3. Research flowchart.

Table 2. Physical Requirements for Compressed Concrete Brick According to SNI 3-0349-1989

Nu.	Condition physics	Unit	Solid Concrete Brick Quality Level			
			I	II	III	IV
1.	Minimum average gross compressive strength	(Kg/cm^2)	100	70	40	25
2.	The gross compressive strength of each test object	(Kg/cm^2)	90	65	35	21
3.	Maximum average water absorption	(%)	25	35	-	-

The results of laboratory tests on compressive strength and water absorption of sago fiber bricks were compared with SNI 3-0349-1989, normal concrete (non-sago fiber), Ranomeeto local red brick, and Kendari local solid concrete brick. This is intended to obtain good quality sago fiber bricks.

RESULTS AND DISCUSSION

Compressive Strength of Sagu Fiber Concrete Brick

The analysis of the average compressive strength of sagu fiber bricks from 50% sagu fiber: 50% sand: and 12 kg cement obtained an average compressive strength value of 68 kg/cm2. This value is included in the compressive strength of Quality III SNI 3-0349-1989 solid concrete brick (40 kg/cm^2). This 50% sagu fiber concrete brick is higher than the average compressive strength of Kendari local perforated concrete brick of 19 kg/cm^2 and normal concrete of 44 kg/cm^2 but lower than the average compressive strength of Ranomeeto local red brick of 77 kg/cm^2.

The results of the analysis of the compressive strength of sagu fiber concrete bricks from 60% sagu fiber: 40% sand: and 12 kg cement obtained an average compressive strength value of 88 kg/cm^2. This value is included in the compressive strength of Quality II SNI 3-0349-1989 solid concrete brick (70 kg/cm^2). This 60% sagu fiber concrete brick is higher than the average compressive strength of normal concrete of 44 kg/cm^2, the average compressive strength of Kendari local perforated concrete bricks is 19 kg/cm^2, and the average compressive strength of Ranomeeto's local red brick is 77 kg/cm^2.

The results of the analysis of the compressive strength of sagu fiber concrete bricks from 70% sagu fiber: 30% sand: and 12 kg cement obtained an average compressive strength value of 94.5 kg/cm^2. This value is included in the compressive strength of Quality II SNI 3-0349-1989 solid concrete brick (70 kg/cm2). This 70% sagu fiber concrete brick is higher than the average compressive strength of normal concrete of 44 kg/cm^2, the average compressive strength of Kendari local perforated concrete bricks is 19 kg/cm^2, and the average compressive strength of Ranomeeto's local red brick is 77 kg/cm^2.

Comparative Analysis of Compressive Strength Test Results of Sagu Fiber Concrete Brick

The results of the compressive strength test showed a tendency to increase the addition of sagu fiber to concrete bricks from 50% (68 kg/cm^2), 60% (88 kg/cm^2), and 70% (94.5 kg/cm^2) compared to normal concrete (44 kg/cm[2]). This increase occurs because the sagu fiber functions as a binder fiber that helps maintain the material so that it is not easily crushed when it receives a load (compression). In addition, when there is pressure, the fibers help the sand and cement (paste) to bind these materials and maintain the paste bond so that it is not easily separated so that the sagu fiber concrete brick has good compressive strength. The results of the comparison can be seen in Figure 4.

Water Absorption Capacity of Sagu Fiber Concrete Brick

The results of the water absorption test of sagu fiber concrete brick material from 50% sagu fiber: 50% sand: and 12 kg cement obtained an average value of 11.9%. This 50% sagu fiber brick is included in the water absorption quality I SNI 3-0349-1989 solid concrete brick category because it is below 25%. 50% sagu fiber concrete brick has a lower water absorption capacity than SNI 3-0349-1989 hollow concrete brick (Quality I) by 25% and the water absorption capacity of local red brick Ranomeeto by 21.4%.

However, Kendari local perforated concrete blocks have a lower water absorption capacity of 8.1% and normal concrete water absorption of 9% compared to sagu fiber concrete bricks with a 50% composition of 11.9%.

The results of the water absorption test of sagu fiber concrete brick material from 60% sagu fiber: 40% sand: and 12 kg cement obtained an average value of 7.4%. Therefore, this 60% sagu fiber brick is included in the water absorption quality I SNI 3-0349-1989 solid concrete brick category because it is below 25%.

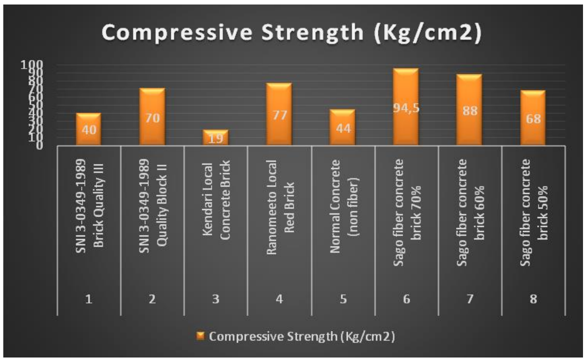

Figure 4. Comparative analysis of the results of the compressive strength of sagu fiber concrete bricks.

60% sagu fiber concrete brick has a lower water absorption capacity than the water absorption capacity of SNI 3-0349-1989 hollow concrete brick (Quality I) of 25%, the water absorption capacity of local red brick Ranomeeto is 21.4%, water absorption normal concrete is 9%, and Kendari local perforated concrete block water absorption is 8.1%.

The results of the water absorption test of sagu fiber concrete brick material from 70% sagu fiber: 30% sand: and 12 kg cement obtained an average value of 5.67%. This 70% sagu fiber brick is included in the water absorption quality I SNI 3-0349-1989 solid concrete brick category because it is below 25%. Sagu fiber concrete brick 70% has lower water absorption than SNI 3-0349-1989 perforated concrete brick (Quality I) 25%, normal concrete water absorption 9%, local red brick water absorption Ranomeeto by 21.4%, and the water absorption capacity of Kendari local perforated concrete blocks by 8.1%.

Comparative Analysis of the Absorbability Test Results of Sagu Fiber Concrete Brick

The results of the water absorption test showed a tendency to decrease the addition of sagu fiber to concrete bricks from 50% (11.9%), 60% (7.4%), and 70% (5.7%). Sagu fiber concrete brick material with a composition of 50% sagu fiber: 50% sand is categorized as unbalanced (larger absorption) and sagu fiber concrete brick material with a composition of 70% sagu fiber: 30% sand is categorized as balanced (less absorption). The absorption is smaller because sagu fiber has the characteristics of palm fiber, smooth surface, has no pores, and is covered with cement. Possibility equivalent to 0% is in the composition of the addition of sagu fiber at intervals of 55% and the possibility at 90% the absorption is lower because of the large number of fibers. The results of the comparison can be seen in Figure 5.

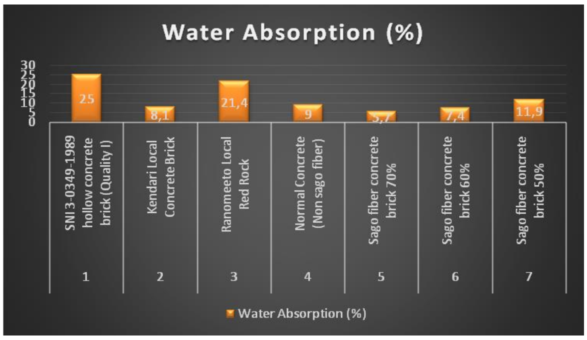

Figure 5. Comparative analysis of water absorption test results for sagu fiber bricks.

CONCLUSION

Based on the test results in the research laboratory, it was concluded that a balanced composition to obtain good quality was found in 70% sago fiber and 30% sand. Balanced quality is obtained after the sago fiber concrete brick is juxtaposed with the SNI for Physical Requirements for the Brick by SNI 3-0349-1989. The composition of 70% sago fiber and 30% sand can maintain the material is not easily crushed when receiving a load. But on the other hand, the composition of 70% sago fiber is concerned with the water-cement factor. The water-cement factor is feared to be able to corrode the concrete bricks because the sago fiber comes from the vegetation that is grown. This research can be continued by examining the water-cement factor on sago fiber concrete bricks.

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