Journal of Engineering Science and Technology
Vol. 17, No. 3 (2022) 1755 - 1763

THE EFFECT OF THE ADDITION OF COCONUT FIBERS AND COCONUT SHELLS ON THE MECHANICAL CHARACTERISTICS OF POROUS CONCRETE

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Abstract

The purpose of this study was to analyze the effect of the additional mass composition of fiber and coconut shells on the mechanical properties of porous concrete. Porous concrete was made from organic waste fiber and coconut shells for flood prevention. Experiments were done by weighing, material mixing, molding, and drying process. Porous concrete was made into 5 variations by combining variable comparisons of coconut shell and coconut fiber with variations of 10.00/; 7.50/0.50; 5.00/1.00; 2.50/1.50; and 0.00/2.00. The porous concrete is tested through compression tests and water absorption tests. The results showed that the composition of the added concrete affected the strength of its water absorption ability. The porous concrete with the best level of strength and water absorption is obtained in porous concrete with the addition of 2 g of coconut fiber and 0 g of coconut shells with values of 156.1 N/s and 0.196%. The addition of coconut fibers at a certain concentration showed a direct proportion to the compressive strength and air absorption. This research is required to analyze and show evidence of the use of porous concrete with coconut fiber and coconut shell addition in overcoming floods and reducing the amount of coconut waste.

Keywords: Agro-waste, Coconut fiber, Coconut shell, Coconut waste, Porous concrete.

1. Introduction

Concrete is a crucial component in engineering [1-5]. One of the attractive concrete is porous concrete. Porous concrete is a distinctive variation of concrete. As the name suggests, porous concrete has a porous or hollow structure so it can be passed by water. Porous concrete consists only of coarse aggregate, cement, and water. Currently, a lot of research is directed at the manufacture of high-quality concrete, the quality of the concrete depends on the press. To produce high-quality concrete, fairly strict quality control is required. The use of admixture in the manufacture of porous concrete is expected to increase the binding capacity with other concrete-forming materials so that the expected concrete quality can be achieved.

Porous concrete is made to prevent flooding that often happens in less water catchment areas, especially in several cities in Indonesia. Porous concrete has a fairly large cavity because of the use of coarse aggregate and cement admixture as a binder. Porous concrete can be a preventive way of overcoming flood problems. When it rains, the water flows through the porous concrete and then penetrates the ground so the water may be directly absorbed by the soil and there will be no stagnant water left.

Several studies have analyzed strength in concrete, including Gunasekaran et al. [6] which reported the compressive strength test of coconut shells as aggregates in concrete. Concrete with coconut shell aggregates has a resistance comparable to conventional concrete. In addition, Kumar et al. [7] reported on coconut fibers as additional concrete. The addition of coconut fibers can increase the flexibility level of concrete as well as a good bond to the concrete. Nawati et al. [8] researched variations of coconut shells used in normal concrete with a concentration of 0.00; 2.50; 5.00; 7.50; and 10.00% where they concluded that the addition of coconut shells to concrete can affect the strength value of the concrete so that the more coconut shell composition in the concrete decreases the strength of the concrete. Other research conducted by Prahara et al. [9] on the effect of coconut coir on the quality value of concrete with the proportion of the addition of 1.50; 2.00; 2.50; and 3.00% conclusion that the addition of coir fiber to the concrete mixture can increase the compressive strength of concrete. The drawback of some existing research is unrevealed results of mechanical research, especially in the existence of porous concrete with the addition of added materials (admixture).

In this study, coconut shells and coconut fibers were used as additives to the porous concrete mixture. Based on data released by the Ministry of Agriculture of the Republic of Indonesia [10], Indonesia produced 2,798,980 coconuts in 2020. Judging from coconut information sources in Indonesia, coconut waste, one of which is a coconut shell, is used as an additive for coarse aggregate in concrete because it has different properties. hard. Coconut shells contain 33.61% of cellulose, 36.51% of lignin, 29.27% of pentosan, and 0.61% of ash [11]. In addition, coconut fibers contain 26.60% of alpha-cellulose, 27.70% of hemicellulose, 29.40% of lignin, 8.00% of water, 4.20% of extractive components, 3.50% of anhydrous uronate, 0.10% of nitrogen, and 0.50% of ash [12]. The cellulose and lignin content contained in coconut fibers and shells play an important role in the strength of concrete. Cellulose can reduce cracks in concrete [13]. Besides, lignin can be an air-reducing mixture in concrete so that the concrete will be stronger [14].

The difference between this research and previous research is that we examined the value of compression tests on porous concrete with additional ingredients of coconut shell and coconut fiber, which tests have not been carried out in previous studies, especially in porous concrete. In addition, the high rate of coconut production in Indonesia has encouraged us to make porous concrete with a mixture of coconut fiber and coconut shells.

2. Method

2.1. Tools and materials

The main ingredients used in this study are coarse aggregate and fine aggregate. Coarse aggregate consists of gravel, coconut fiber, and coconut shell, while fine aggregate is in the form of cement. Another material is distilled water. The tools used in this study were a scale, molds with dimensions of 6 × 4 × 2 cm, a stirrer, a mixing bowl, a scissor, a hammer, and labels.

2.2. Porous concrete production

Figure 1 shows an illustration of the process of making porous concrete with the addition of fiber and coconut shell composition. Gravel is collected and then weighed as much as 30 g for a prototype porous concrete measuring 6 × 4 × 2 cm. Cement was weighed as much as 10 g and distilled water as much as 15 ml. The coconut fibers are cut into small pieces and the coconut shell is broken using a hammer to make it the size of gravel. Table 1 shows the variations in the composition of additives (admixture) for the manufacture of porous concrete.

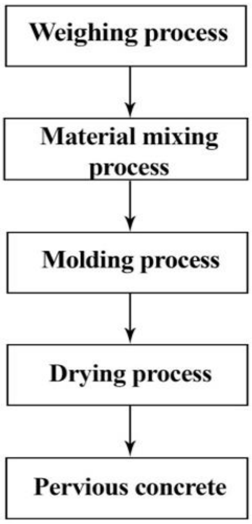

Fig. 1. Flow diagram of the making of porous concrete.

Table 1. Variations in the composition of porous concrete addition.

Admixture	Varians 1	Varians 2	Varians 3	Varians 4	Varians 5
Coconut fiber	0.00 g	0.50 g	1.00 g	1.50 g	2.00 g
Coconut shell	10.00 g	7.50 g	5.00 g	2.50 g	0.00 g

The fibers and coconut shells are stirred together with the gravel, cement, and air until the cement is evenly mixed. Next, the porous concrete dough is then put into a 6 × 4 × 2 cm mold. Porous concrete is dried for 1 day until it is completely dry and hard.

2.3. Mechanical characteristics test of porous concrete

Physical characteristics of concrete were analyzed. To determine the mechanical characteristics of the porous concrete, the hardness test was carried out using a hardness test using the Screw Stand Test Instrument (Mode I ALX-J, China) equipped with a measuring instrument (a Digital Force Gauge (Model HP-500, Serial). No. H5001909262)). In the hardness test, the measurement was carried out by applying a compressive force to the porous concrete to produce a curve showing the texture profile of the porous concrete. Hardness is expressed as the maximum force (peak value) in newton (N) units.

2.4. Water absorption test of porous concrete

The test was carried out by weighing the paving block sample first to determine the dry weight, then soaking it for 2 minutes and weighing it again to find out the wet weight. The absorption test can be calculated using Eq. (1) [15]:

$$W_A = \frac{(W_2 - W_1)}{W_1} \times 100\% \quad (1)$$

3. Results and Discussion

3.1. Physical appearance of porous concrete

Figure 2 shows the porous concrete that has been created. The size of the porous concrete specimen is 6 × 4 × 2 cm. Porous concrete with an added ratio of coconut fiber and coconut shell: 0 g coconut fiber and 10 g coconut shell (a), 0.50 g coconut fiber and 7.50 g coconut shell (b), 1 g coconut fiber, and 5 g shell coconut (c), 1.50 g coconut fiber and 2.50 g coconut shell (d), 2 g coconut fiber and 0 g coconut shell (e).

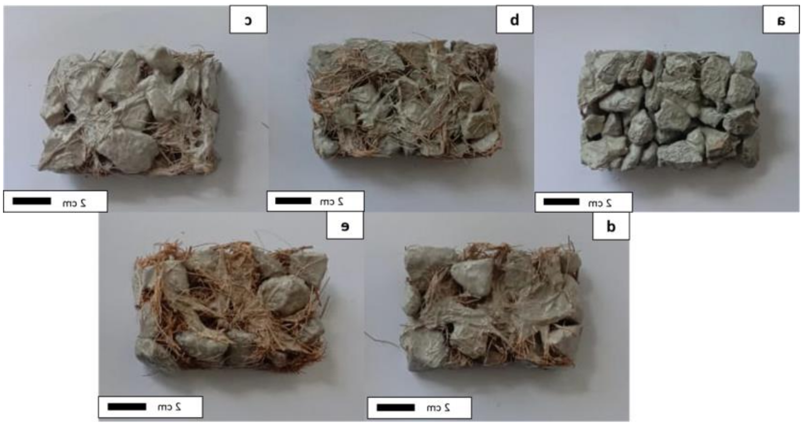

Fig. 2. The physical appearance of porous concrete with various admixtures containing coconut shells and coconut fiber.

Concrete with more coconut shell added material has larger and larger pores, as well as a coarse and strong structure, while concrete with more coconut fiber added material has smaller pore space. This is caused by the size of the coconut fibers which are smaller than the coconut shell. The addition of coconut fibers fills the empty space in the porous concrete. The distribution of coconut shell, coconut fiber, and gravel are uneven due to the coconut fibers clumping together when mixed with cement and water. However, when the gravel, coconut fiber, and coconut shell are placed in the mold, they are made to be spread out and not just agglomerate on one side.

3.2. Physical and mechanical characteristics of porous concrete

Figure 3 shows the hardness test results of the porous concrete. Based on Fig. 3, Porous concrete without coconut shell and with 2 g of coconut fiber has the highest curve with values of 156.10 N/s, which indicates that the porous concrete has hard properties. The lowest curve is owned by the variety of porous concrete with 10 g of coconut shell and without coconut fiber with values of 103.1 N/s. This indicates the more coconut fiber is added, the harder the properties of the porous concrete. Conversely, the less coconut fiber is added, the weaker the properties of porous concrete can be obtained.

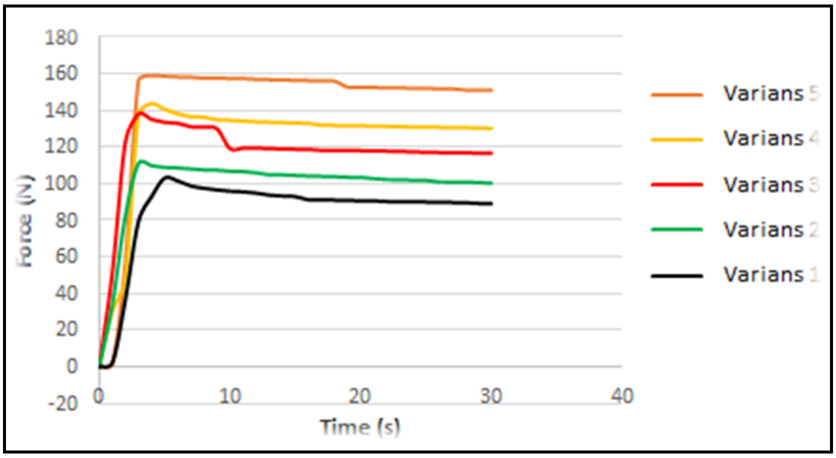

Fig. 3. The hardness test of porous concrete.

The fibers have a physical shape that is smaller than coconut shells. This causes the strength of porous concrete to increase because the pores produced from porous concrete with a fiber mixture have fewer and smaller pores [16]. Coconut fibers have a small diameter, allowing coconut fibers to fill the pores between aggregates and contribute to resisting the tension between aggregates so that there is no destruction of porous concrete [17]. Porous concrete with variations in the concentration of 2 g of fiber and without coconut shells still has pores, but not as many and as large as the pores of porous concrete with variations in the concentration of 10 g of shells and without coconut fibers. The more pores the concrete has, the easier it will be to break down [18]. The use of water and cement also affects the compressive strength of the porous concrete. The compressive strength results of the porous concrete decrease when a large amount of water is used while a small amount of cement is used [19].

In addition, as already presented in the introduction, coconut fibers contain the most alpha-cellulose, hemicellulose, and lignin [12]. The cellulose and lignin contained in coconut fibers play an important role in the strength of porous concrete. Cellulose reduces concrete cracking [13] while lignin can be a mixture of reducing air in concrete [14]. Thus, porous concrete can be stronger.

3.2. Physical and mechanical characteristics of porous concrete

Figure 4 shows the results of the percentage of the water absorption test. Paving block samples that have high absorption power are found in the composition concentration of 2-g coconut fiber and 0-g coconut shell with values of 0.196%. Meanwhile, samples of paving blocks that have low absorption power are found in the material composition of 10-g coconut shell and 0-g coconut fiber with values of 0.0675%.

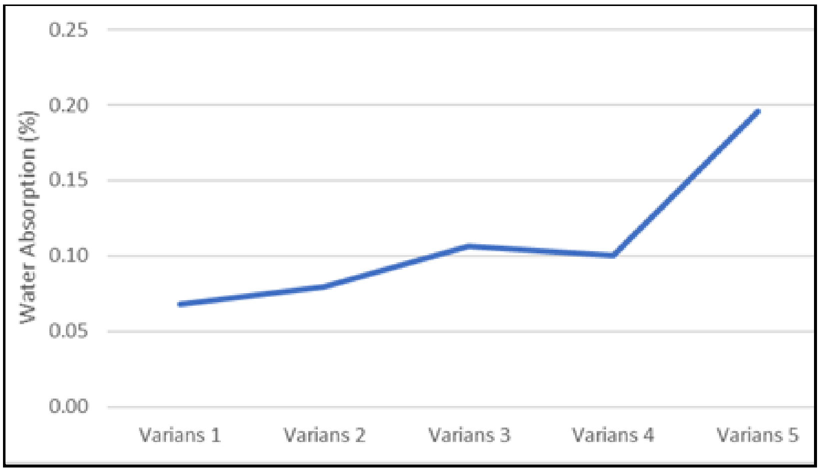

Fig. 4. The water absorption test results in porous concrete.

Based on the research of Bui et al. [20], coconut fibers are hygroscopic, which means that coconut fibers can absorb water. The use of coconut fiber as a material for making porous concrete is as a water absorber and as a support for coconut shells and gravel so that they are not easily broken [21]. The more coconut fiber added, the higher the percentage value of the concrete that absorbs water. In addition, the shrinkage rate and water absorption test results increase when a large amount of water and cement is used [22]. This study is in line with previous studies [23-32].

4. Conclusion

The effect of coconut shell and coconut fiber on the properties of the porous concrete mixture has been investigated. Based on the research, the results of the mechanical characteristics test of porous concrete and water absorption test showed that the porous with the addition of 2 g of coconut fiber and without the addition of coconut shell had the best strength and water absorption with values of 156,1 N / s and 0.196%. It shows that the addition of coconut fiber is directly proportional to the value of the compressive test and water absorption test.

Acknowledgements

We ackowledged RISTEK BRIN (Grant Penelitian Terapan Unggulan Perguruan Tinggi) and Bangdos Universitas Pendidikan Indonesia.

Nomenclatures

W_A	water absorption, %
W_1	dry sample weight, g
W_2	wet sample weight, g

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