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The amount of coir composition effect on the flexural and tensile strength of coir composites

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Abstract

This article is the result of research on the effect of soaking coir in sodium hydroxide solution. The objective of this study is to determine the effect of the composition of coir on the flexural and tensile strength of the coir composite as an effect of immersion in a sodium hydroxide (NaOH) solution. The stages of conducting the research are: (1) preparation of materials and tools; (2) treatment of coir and manufacture of composites; (3) tensile and flexural testing. Before being used as a composite reinforcement, coir was soaked in sodium hydroxide solution with a concentration (percent by weight) of 5% and 10% for 3 hours at room temperature 25°C. After that, the coir was washed with distilled water and then dried at room temperature for 18 hours. Next, we dried the coir in an oven at 90°C for 5 hours. After soaking, coir was used as a composite reinforcement with a composition of 10%, 15%, and 20% by weight of coir. The composite was made using the hand lay-up method, while the flexural test specimens were made based on ASTM-D790, and the tensile test was based on ASTM D 638-03. Then the flexural strength test of the coir composite was carried out using the Shimadzu Flexure Tester with a capacity of 5 kN and a compressive speed of 2 mm/minute. It was concluded that the highest flexural and tensile strengths were obtained by immersing coir in a 5% NaOH solution with 20% coir composition, respectively 41.114 MPa and 20.265 MPa.

Keywords:
Composition, flexural, composites, sodium hydroxide.

1 Introduction

Today, the use and utilization of composite materials is continuously being developed by the manufacturing industry. One of the composite materials developed is composite materials with reinforcement of natural fibers or artificial fibers. Currently, fiber-reinforced composite materials are engineering materials that are widely used because their specific strength and stiffness are better than engineering materials in general, so that their properties can be designed closer to requirements [1]. Composite is a material consisting of several materials whose properties are a synergistic combination of the properties of the constituent materials. Composite materials are a combination of more than one type of material, such as a combination of fiberglass, and polymer. In this composite, the material is designed to obtain high enough strength, which is the contribution of fiberglass materials, and has good flexibility, which is the contribution of polymer materials [2].

The existence of plans to ban the use of fiberglass is currently one of the considerations for switching to environmentally friendly fibers. The glass fiber used can cause itching when in contact with the skin. This material is made of chemicals, and glass fiber is very difficult to degrade naturally. Mechanical recycling of glass fiber will produce CO gas and dust, which are harmful to health, so alternative raw materials are needed that are safer and environmentally friendly [3]. Natural fiber-reinforced composites play an increasingly important role nowadays. Natural fiber composites are characterized by light weight, low cost, good strength, composite stiffness, low coefficient of friction, adequate resistance to erosive and abrasive wear, and most importantly, biodegradability [4]. Natural fibers have several advantages compared to glass fibers, such as being lighter, environmentally friendly, and cheaper. One of the composites that continues to be developed is the coir composite. Some of the advantages of coir fiber composites are that they are easy to obtain, cheap, can reduce environmental pollution so that this composite is able to overcome environmental problems that may arise from the large amount of coir that is not utilized, and does not endanger health [5]. The raw material for making fishing boats comes from wood or glass fiber reinforced composites. Continuous use of wood as a ship building component will reduce the amount of wood. Meanwhile, the use of in organic glass fibers can interfere with human health and damage the environment, especially the soil layer, as is the case with plastic [6]. Before the damage occurs, it is necessary to find a solution, for example, the use of natural fiber composites as a raw material for ship/boat components, especially for the needs of fishermen. A study reported that natural fiber-reinforced composites had a strength of 40% stronger and lighter than glass fiber-reinforced composites [7]. When used in transportation so that the weight becomes lighter, it means that it will lead to more efficient use of fuel. Natural fibers also have disadvantages, including: non-uniform quality, high water absorption, low strength, and being difficult to bond with resin because they are hydrophilic [8]. The disadvantages of natural fibers are one of the problems encountered in the development of natural fibers as composite reinforcement. Therefore, natural fibers that will be used as composite materials need to be treated to eliminate these deficiencies while improving the mechanical properties of the fibers. The alkalization process by soaking in sodium hydroxide solution is widely used because it can remove dirt that sticks to the fiber surface, which causes weak bonds between the resin and the fiber surface [9]. Factors that need to be considered in the manufacture of natural fiber-reinforced composites are: (1) the bond between the surface of the fiber and the resin; (2) how to arrange the fibers; and (3) the type of resin used [10].

Coir soaked in NaOH solution with a concentration of 5%, 10%, 15%, and 20% was used as a reinforcement for the coir composite with a composition of 5% coir and 95% polyester resin. It was concluded that: (1) tensile strength, the highest strain of 14.27 N/mm^2 was obtained on coir immersed in 10% NaOH solution; (2) the highest strain of 1.8% was obtained on coir immersed in 10% NaOH solution [11]. Coir soaked in NaOH solution with a concentration of 5% was used as a reinforcement for the coir composite with a composition of 20%, 25%, and 30% coir with variations in the length of coir 5, 10, and 15 mm. It was concluded that the tensile and flexural strength increased as the percentage increased composition; and length of coir [12]. In another study, it was reported that coir soaked for 5 hours in a 20% alkaline solution obtained the highest value of the interface shear stress, namely 7.86 N/mm^2 [13].

The research objective to be achieved is to determine the effect of coir composition on the flexural strength and tensile strength of coir composites due to immersion in sodium hydroxide (NaOH) solution.

2 Materials and Methods

The materials used in this study were: coir, NaOH solution, polyester resin, catalyst, and distilled water. While the equipment used is a set of immersion tools, scales, measuring cups, composite molding tools, and tensile/flexural test kits. The coir used was obtained from the Sidenreng Rappang Regency, South Sulawesi. NaOH solution, polyester resin, catalyst, vaseline, and distilled water were obtained from a chemical shop in the city of Makassar, South Sulawesi. Tensile and flexural tests were carried out in the Mechanical Engineering Materials Laboratory at Universitas Hasanuddin.

Composite production is carried out using the Wet Lamina method, which is commonly called Wet Lay Up or Hand Lay Up, as shown in Fig. 1. The prepared mold is greased with vaseline to obtain a smooth, even, and non-sticky surface to the mold, then the fibers are placed in the mold and then the resin is poured into the fiber arrangement with the help of a roller or brush. In order for the resin to fill the fiber gaps properly, pressure is applied with the help of a roller on the surface to help the fibers fully fill or be wetted by the resin. The composite was allowed to harden at atmospheric pressure and room temperature.

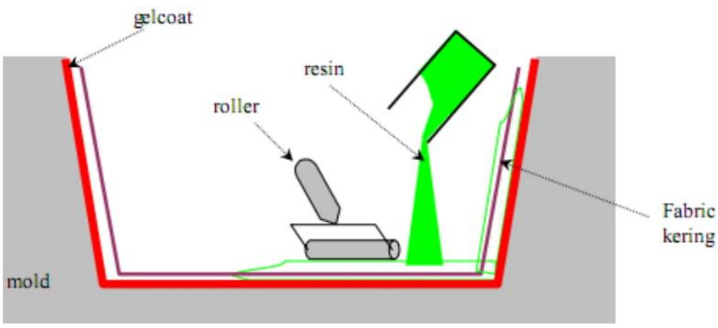


Fig. 1. Hand lay up method.

The stages of carrying out the research were: preparation of materials and tools, preparation of NaOH solution according to the desired concentration, immersion of coir in NaOH solution for 3 hours, drying of coir naturally at room temperature for 18 hours, then in an oven at 90°C for 5 hours. The NaOH solution was prepared in two concentrations, namely 5% NaOH and 10% NaOH. While the composite is made with a ratio of 10%, 15%, and 20% coir.

Flexure testing of the coir composite was carried out using Shimadzu Flexural Testing Equipment with a capacity of 5 kN. While the pressing speed used is 2 mm/minute.

The resulting composite shapes are then formed into flexural and tensile test materials with their respective specifications: ASTM D790 and ASTM D 638-03 [1]. The specimens for composite flexure tests comply with the provisions of ASTM D790 with length × width dimensions × thickness: 127 mm × 12.7 mm × 3 mm. While the flexure test uses the three-point bending method [3, 11, 13] as shown in Fig. 2. To determine the value of the flexural strength of a material can be found using Eq. 1.

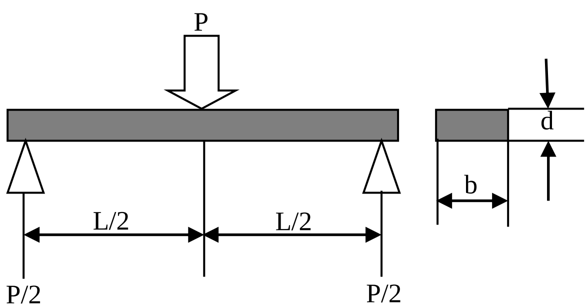


Fig. 2. Composite flexural test method.

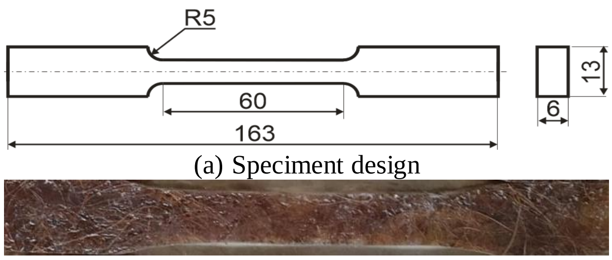
$$\sigma_L = \frac{3PL}{2bd^2} \tag{1}$$

σ_L = maximum flexural stress (N/m^2)
P = maximum load (N)
L = support distance (m)
b = specimens width (m)
d = specimens thickness (m)

The shape of the specimen for the composite tensile test in accordance with the provisions of ASTM D 638-03 is shown in Fig. 3 [11, 14]. The maximum stress retained by the specimen before breaking is called the maximum tensile stress, which is the ratio between the maximum load and the cross-sectional area of the material. At this point the stress that occurs is as Eq. 2.

$$\sigma_{maks} = \frac{F_{maks}}{A} \tag{2}$$

σ_{maks} = maximum tensile stress (N/m^2)
F_{maks} = maximum load (N)
A = cross-sectional area (m^2)



(a) Speciment design

(b) Speciment of tensile test

Fig. 3. ASTM D 638-03 composite tensile test specimens.

3 Results and Discussion

The results of the flexure tests are shown in Fig. 4. Meanwhile, the results of the tensile tests are shown in Fig. 5.

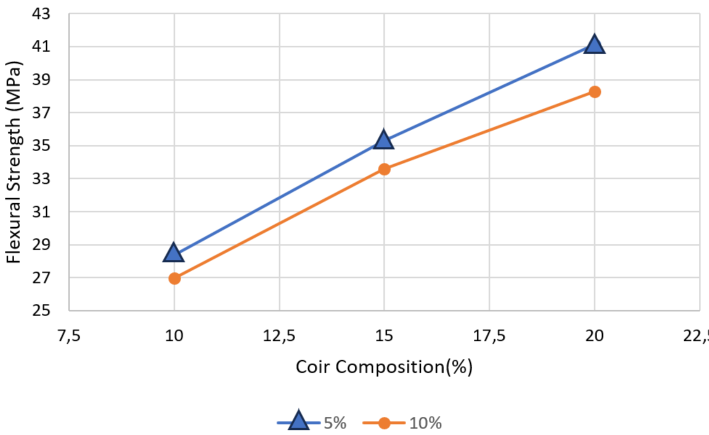


Fig. 4. Flexural strength coir composite.

Fig. 4 shows the flexural strength value of coir composite when immersing coir in 5% and 10% NaOH solutions in various compositions of the amount of coir. The flexural strength is directly proportional to the amount of the coir composition; the higher the coir composition, the value of the flexural strength also increases.

For immersing coconut coir fiber in a 5% NaOH solution, the flexural strength was obtained successively: in 10% coir composition, the flexural strength was 28.390 MPa, in 15% coir composition, the flexural strength was 35.314 MPa, and in 20% coir composition, the flexural strength was 41.114 MPa. And for immersing coconut coir fiber in a 5% NaOH solution, the flexural strength was obtained successively: in 10% coir composition the flexural strength was 26.953 MPa, in 15% coir composition the flexural strength was 33.578 MPa, and in 20% coir composition the flexural strength was 38.271 MPa. The effect of NaOH solution concentration gives results, where the flexural strength of coir composite soaked in 5% NaOH solution is higher compared to the flexural strength of coir composite soaked in 10% NaOH solution. This means that the flexural strength value of the coconut fiber composite is inversely proportional to the concentration of NaOH solution [12]. The flexural strength of epoxy composites reinforced with palm leaf midrib fibers also increased with increasing composition of palm leaf midrib fibers. In that study, palm fronds were soaked in a 5% NaOH solution [3].

The flexural strength of the coir composite in 5% NaOH immersion was 28.390×10^6 N/m^2 for the 10% coir composition, 35.314×10^6 N/m^2 for the 15% coir composition, and 41.114×10^6 N/m^2 for the 20% coir composition. Whereas in 10% NaOH immersion, respectively 26.953 x 10^6 N/m^2 for a composition of 10% coir, 33.578×10^6 N/m^2 for a composition of 15% coir, and 38.271×10^6 N/m^2 for a composition of 20% coir.

Fig. 5 shows the tensile strength value of coir composite when immersing coir in 5% and 10% NaOH solutions in various compositions of the amount of coir. The tensile strength is directly proportional to the amount of the coir composition, the higher the coir composition; the value of the flexural strength also increases.

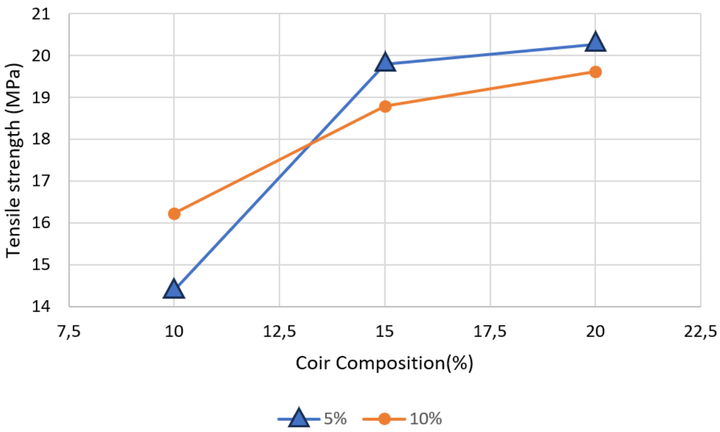


Fig. 5. Tensile strength coir composite.

For soaking coir in a 5% NaOH solution, at 10%, 15%, and 20% coir composition, the tensile strengths were 14.374 MPa, 19.785 MPa, and 20.265 MPa, respectively. And for soaking coir in 5% NaOH solution, the tensile strengths obtained at 10%, 15%, and 20% coir compositions were 16.225 MPa, 18.795 MPa, and 19.619 MPa, respectively. The effect of soaking coir in NaOH solution gives the same results, where the tensile strength of the coir composite soaked in a 5% NaOH solution is higher than the coir composition soaked in a 10% NaOH solution [12]. Alkali treatment can be used as the primary treatment for all types of natural fibers because the treatment with NaOH solution at concentrations of 5%, 6%, and 10% has shown an increase in flexural properties [15].

4 Conclusion

The determination of flexural and tensile strengths of coir composites with variations in coir composition has been carried out. The highest flexural and tensile strengths of coir composites were obtained respectively 41.114 MPa and 20.265 MPa, when coir was soaked in 5% NaOH solution with a composite composition of 20% coir.

Further research is needed on composites reinforced with coir combined with other natural fibers.

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