Effect of Fiber Immersion Time on Alkaline Treatment to the Mechanical Strength of the Composite Reinforced Oil Palm Empty Fruit Bunches (OPEFB) Fibers

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Abstract. The more outstanding palm oil production, the greater the waste production. One of them is the fiber of empty palm oil fruit bunches (EPOFB). The use of empty palm fiber bunches is still only in the agricultural sector. In other places, the development of natural fiber composite is currently being developed. This encourages the better utilization of empty palm oil fruit bunches (EPOFB) as a reinforcement for composites. One of the weaknesses of natural fibers as reinforcement in composites is the hydrophobicity of natural fibers, so the ability to bind the matrix to natural fibers is low. One way to overcome this is by immersion in an alkaline solution. The results of immersion in alkaline solutions also depend on the immersion time. Therefore, this research will see how the immersion time affects the composite's mechanical strength. This research is essential to find out the right time for immersion in an alkaline solution to optimize production time. Immersion was done for 2 h, 4 h, and 6 h. The test results have shown that the immersion times affect the material's mechanical strength. There was an increase in strength from immersion 2 h to 6 h.

Keywords: Empty Fruit Bunches · composite · immersion time · alkaline treatment

1 Introduction

The palm oil business is expanding at a rapid rate in the modern era, which has led to a corresponding increase in waste production. Waste products from the oil farming sector, including used palm oil bunches, palm fiber, and sludge. While some progress is made in the empty oil palm fruit bunches as road paving and fertilizer, the rest simply become waste that is very distressing to the neighborhood. In particular, the fiber from these empty palm oil bunches has potential as a composite reinforcement material.

T. P. Syawitri et al. (Eds.): MEST 2022, AER 222, pp. 133–140, 2023.
https://doi.org/10.2991/978-94-6463-134-0_14

Combining natural materials into composites improves the material in several ways, including its resistance to corrosion, its aesthetic appeal, and the smoothness of its surface. Recently, researchers have paid little attention to the potential of empty oil palm bunches as composite reinforcement. Therefore, it is essential to investigate empty palm fruit bunch fiber as a composite reinforcing material to find solutions to environmental issues and develop new materials. The mechanical strength of composites reinforced by empty palm fruit bunches is analyzed, with a focus on the impact of variations in immersion during fiber preparation.

Natural fiber necessitates a process of cleaning because it is frequently contaminated. Several researches have reported on the mechanism of fiber preparation treatment for natural fiber materials. Increasing the mechanical strength of the composite through alkali treatment of acacia arabica and kenaf fibers has been shown to be effective [1, 2]. The lignin in fiber from empty palm oil bunches can be removed by alkali treatment, resulting in a stronger bond with the matrix [3]. The next challenge is figuring out how to strengthen the connection between the fiber and the epoxy (matrix). The literature reveals that chemical treatment can enhance the composite by promoting greater fiber-to-matrix adhesion. The most common treatment for fibers is an alkaline by using sodium hydroxide (NaOH) [4]. The results of flexural strength tests on sugarcane fiber composites show that the strength of the material improves the longer the fibers are submerged in alkaline solutions [5, 6]. Thistle fiber and napier fiber investigations revealed findings similar with those from sugar cane fiber study [7, 8]. Extensive contact with an alkaline solution causes the surface fiber to roughen, resulting in a stronger connection with the matrix [9]. The fiber of empty palm oil bunches is likewise a natural fiber, thus if it is utilized as reinforcement in composites without treatment, the bond between the reinforcement and the matrix is weak. Consequently, studies on the alkaline treatment of empty oil palm fruit bunches are required. The purpose of this study was to compare the flexural strength of the composite fiber of empty palm oil fruit bunches to the mechanical test results after soaking the fibers in an alkaline solution (NaOH) for various lengths of time.

2 Method and Materials

Research to obtain data on the effect of using variations in the soaking time of empty palm oil fruit bunches was carried out using palm fiber which had undergone a process of separating the seeds and bunches. The fiber of empty palm fruit bunches has a density of 0.47 g with a tensile strength of 10008 kg [10]. Before being used as a composite reinforcement, the fiber is soaked in an alkaline solution. The alkaline solution used is NaOH. The fiber is soaked in the liquid with different duration 2, 4, and 6 h. After being soaked, the fibers are cleaned in running water and then dried in the sun to dry. Figure 1 shows the soaking and drying process. Figure 1(a) shows a row of jerry cans used for the process of soaking bunch fiber using NaOH solution. The fiber drying process is done using natural drying under the sun as shown in Fig. 1(b). In this research, resin polyester was used as matrix.

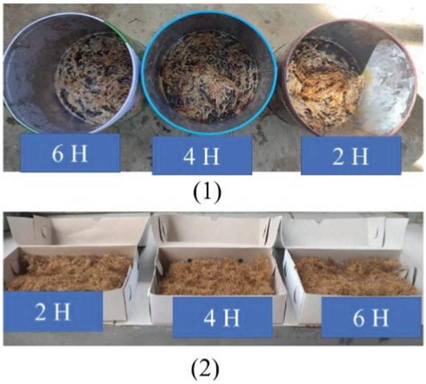

Fig. 1. Natural fiber pre-processing (1) fiber immersed in an alkaline (2) The fibers are dried in the sun to dry

Fig. 2. Hand layup process

The manufacturing procedure for producing natural fiber composites is carried out using the hand lay up method. The ratio of the volume of the matrix to the volume of its reinforcement or OPEFB fiber is 80%:20%. Each material is calculated as its mass with the standard density of the material. Natural fibers are prepared by applying pressure to facilitate fabrication as shown in Fig. 2. After printing, the composite is left for five hours and then unloaded from the mold.

In this study, mechanical studies were carried out to determine the performance of the composite by bending and tensile testing. Flexure strength is the greatest strength that can be received due to external loading. As a result of the flexure test, the upper part is stressed, while the lower part will experience tensile stress; in composite materials, the compressive strength will be higher than the tensile strength because it cannot withstand the tensile stress received, and the specimen will break. In this study, using the ASTM D7264 standard flexure test. The tensile test is to determine the tensile strength and strain values of the matrix or fiber composites. The method used is that the object being tested is clamped in the testing machine, with the load slowly increasing until a certain load, and in the end, the object being tested breaks. The tensile load acting on the object under test will increase in length and, at the same time, decrease the diameter of the object being tested. This test used the ASTM D3039 standard.

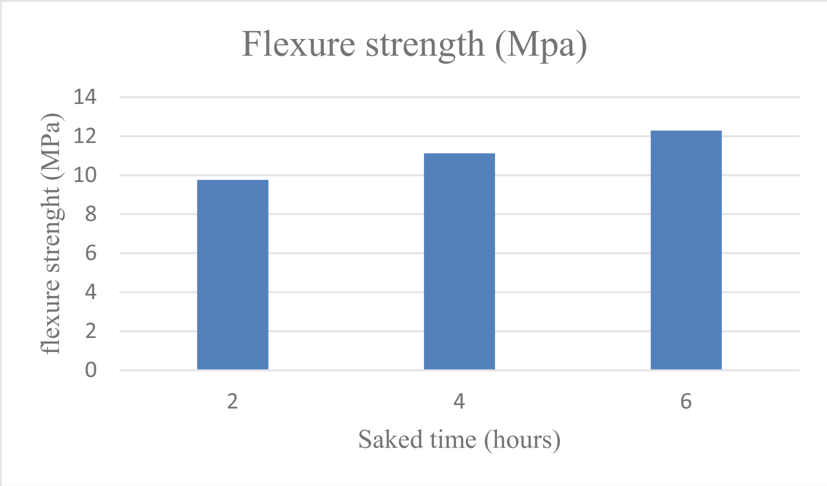

Fig. 3. Flexure strength of composite reinforcement OPEFB fiber

3 Result and Discussion

3.1 Flexure Strength

The bending test is carried out after waiting for the composite to dry completely. Test samples are produced from the fabrication process using larger molds so that at a single process can produce several samples. Tests were carried out using the UTM test machine with settings in accordance with ASTM standards. The results of the flexure test from this study are Fig. 3.

Figure 3 shows the bending strength of the immersion composite. Based on the data, we know that the longer the immersion process, the higher the bending resistance. The maximum value in this test is obtained during the longest immersion, which is 6 h. There is a difference in the increase in bending strength when the immersion time is prolonged. The increase in immersion from two hours to four hours increased by 10%, while increasing the soaking time from 4 h to 6 h increased by 25%. The cause of difference in bending resistance results can occur because the longer the immersion process causes the fibers to become cleaner and free from impurities. These impurities cause a low bond between the fiber and the matrix. Figure 3 shows that the most prolonged soaked, 6 h, had the highest flexural strength value. As well as creating rough surface structure. The composite's flexure strength is improved because, at these particular compositions, the EPOFB fiber can effectively transfer the load from the matrix as reported from another discussion [11]. The results of this flexure strength are confirmed by the appearance of the specimen fracture as shown in Fig. 4.

Figure 4 shows the fracture cross-section after the bending data collection process. It can be seen that there are more fibers detached from the composite in Fig. 4a than in the other names. The detachment of natural fibers from the matrix shows that the bond between the fibers and the matrix is weaker so that the fibers do not break but only detach from the matrix. The small amount of loose fiber in Fig. 4c explains the high bending

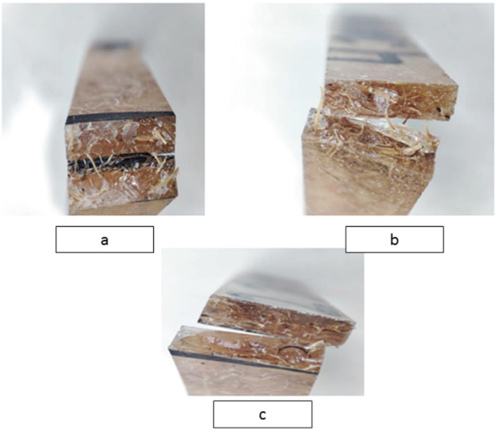

Fig. 4. Fracture of the specimens during testing. a) 2 h immersion time. b) 4 h immersion time, c) 6 h immersion time

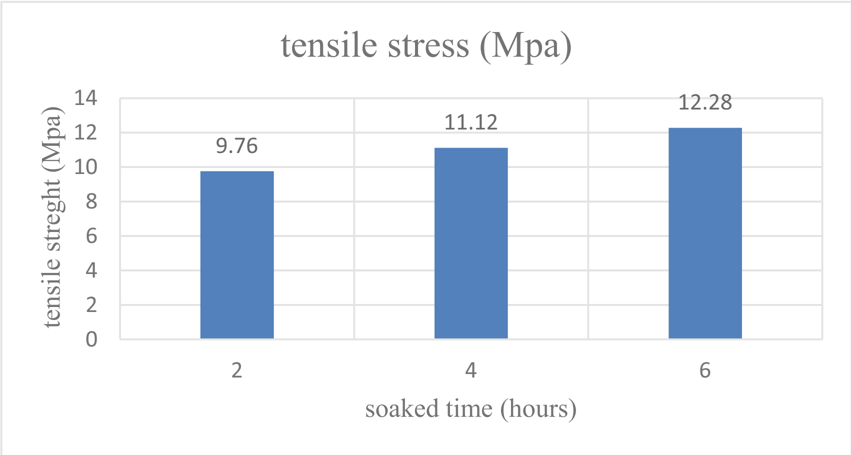

Fig. 5. Tensile strenght of composite reinforement OPEFB fiber

value, where the fiber's applied mechanical force is received by the fiber and causes the fiber to break. Cross sections provide information, with fewer visible fibers indicating a stronger bond between the fibers and the matrix.

3.2 Tensile Strength

The result of the tensile strength of the composite reinforcement by OPEFB fiber shown at Fig. 5. From the tensile test data, we can see an increase in the tensile strength value of the composites along with the addition of immersion time.

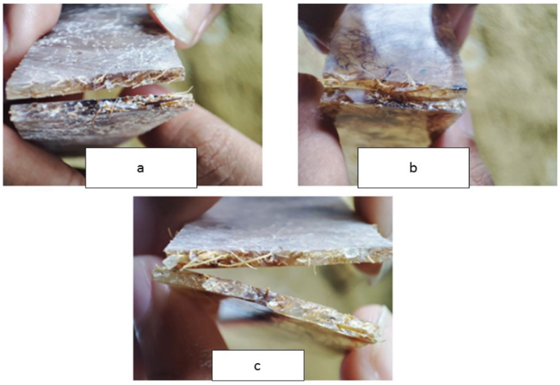

Fig. 6. Fracture of specimen during tensile testing a) 2 h immersion time. b) 4 h immersion time, c) 6 h immersion time

This figure shows that there is an increase in tensile strength when the immersion time is extended. The increase in tensile stress from 2 h to 4 h of immersion was 12.2%, while the gain between 4 and 6 h was 9.4%. This increase in tensile strength is due to the rough surface structure due to the effect of the more extended alkali treatment. Alkali increases the pores of fiber, it makes bonding between fiber as reinforcement and resin as matrixs increasing [12]. This is confirmed by the appearance of a broken shown at Fig. 4.

Figure 6 shows the fracture of the specimen tested for bending. Figure 6a shows a worse bond compared to Figs. 6b and 6c, and this is because the bond between the fibers and the matrix in Fig. 6c is better than the others. Good bonding is affected by the surface roughness of the fibers immersed longer.

4 Conclusion

Alkali treatment of OPEFB fiber varied in time 2, 4, and 6 h with the aim to determine the effect of soaking time on the mechanical strength of the composite. Composites are made using the hand layup method. The results show that the longer the soaking time in the pretreatment process will increase the tensile and bending strength of the composite. This is because the bond between the resin as a matrix and OPEFB fibers as a composite reinforcement is getting better. The rougher surface of the OPEFB fiber after soaking makes the bond between the resin and OPEFB fiber better. For further research, it is necessary to carry out a long time variation to determine the maximum time limit for immersion before the fiber is damaged by soaking with alkali.

Acknowledgement. This research was supported by funding from RisetMu at the PP Muhammadiyah Diktilitbang. Therefore we would like to thank the PP Muhammadiyah Diktilitbang Council for their support.

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