American Journal of Engineering Research (AJER)
E-ISSN: 2320-0847 p-ISSN: 2320-0936
Volume-8, Issue-2, pp-01-06
www.ajer.org
Research Paper Open Access

Comparative Study on Mechanical Properties of Banana and Rattan Fiber Reinforced Epoxy Composites

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ABSTRACT: *In this paper, the mechanical properties of banana and rattan fiber reinforced epoxy composite are investigated. Towards that, banana and rattan fiber are extracted and with this extracted fiber, unidirectional banana and rattan fiber composite are manufactured by using hand lay-up process. Tensile and flexural strengths are considered to compare their mechanical properties. It is found that, the tensile strength of banana fiber composite is 2.57 times higher than the rattan fiber composite. But, the flexural strength of banana and rattan fiber composite is comparable.*
KEYWORDS: *Banana fiber, Rattan fiber, Natural fiber composite, Tensile strength, Flexural strength.*

Date of Submission: 24-01-2019 Date of acceptance: 08-02-2019

I. INTRODUCTION

The field of composite materials has great importance within the study in the recent years [1]. Fiber reinforced polymer matrix composites have wide applications including aerospace, nuclear and automobile industries [2]. There are different types of composite materials such as: metal matrix composite, ceramic matrix composite and polymer matrix composite. Polymer matrix composites are very popular compared to other types because of their strength to weight ratio [2, 3]. Different fibers can be used in polymer matrix to enhance the mechanical properties which includes synthetic fiber and natural fiber. Synthetic fibers like, carbon, glass or kevlar fiber are used in high strength application. But the cost involved in these composites are very high. On the other hand, natural fibers are very cost effective [4, 5] and can be extracted from renewable sources [5, 6].

In recent years, significant number of research are carried out on natural fiber composites including bamboo [6-10], jute [11-13], kenaf [14-17], pineapple [18-20], sisal [7, 21, 22], hemp [23-25], coir [26-28], henequen [29, 30] fiber as reinforcement in composites. However, study on rattan fiber based epoxy composites are limited. Therefore, the specialty of this study is to explore the new sources of natural fiber. Rattan, a plant abundantly available in Bangladesh or other Indian subcontinental country is investigated in this paper for making natural fiber composite. The mechanical properties of rattan fiber composites are compared with banana fiber composites for the possible structural application such as ceiling sheets, partitioning board and wall or floor tiles.

The paper is organized in the following sections: Section 2 presents the details of the experimental procedure containing the fiber extraction process, composite manufacturing and mechanical testing. Section 3 discusses the results followed by conclusions.

II. EXPERIMENTAL PROCEDURE

II.1 Banana Fiber Extraction Process

The banana fiber extraction from the banana plant required certain care to avoid damage. In the present experimental examination, initially the banana plant sections (Fig. 1(a)) are cut from the main stem of the plant (Fig. 1(b)) and then rolled lightly to remove the excess moisture. The process of obtaining natural fiber from rolled plant stem is known as Retting. Retting is the most widely practiced method which is performed by submerging bundles of stalks in water. The banana plant sections are submerged into water for 15 days to get fibers from it. The cleaned fibers are then treated with 15% NaOH solution in room temperature. A study by Venkateshwaran and Elayaperumal found that 15% NaOH solution gives better fiber compared to other percentage of NaOH [31].

(a) (b)

Fig. 1. (a) Banana plant sections and (b) Banana plant.

II.2 Rattan Fiber Extraction Process

The rattan fiber is collected from rattan plant (Fig. 2(a)). Rattan cane are then separated from the plant as shown in Fig. 2(b). The rattan cane between inter-nodes are sliced by using a slicer. The sliced rattan are then immersed in water for 25 days. The fibers are extracted from the rattan cane and cleaned with water and dried in sunlight for one day. The cleaned fibers are then treated with 15% NaOH solution in room temperature.

(a) (b)

Fig. 2. (a) Rattan plant and (b) Rattan cane.

II.3 Material System

Dry banana and rattan fiber fabric are used as reinforcement with Epoxy Resin as matrix material. The extracted fiber is stitched with a swing machine to make the fabric as shown in Fig. 3. Special care is taken during stitching so that it does not damage the fiber. The hardener is mixed with the resin at a ratio (weight) of 1:10 as recommended by the manufacturer.

Fig. 3. Stitched banana fabric.

II.4 Manufacturing Process

The banana and rattan fiber based epoxy composite are fabricated using hand lay- up process. Hand lay-up method is the simplest method of composite manufacturing. A schematic diagram of hand lay-up process is shown in Fig. 4. First of all, a mold release is applied on the mold surface to avoid the sticking of polymer to the surface. Thin plastic paper is used at the top and bottom of the mold plate to get good surface finish of the product. Banana and rattan fiber fabrics are cut as per the mold plate size and placed at the surface of the mold plate. Then the epoxy resin mixed with prescribed hardener poured onto the surface of dry fabric already placed in the mold. The polymer is uniformly spread by the help of a brush. A roller is moved with a mild pressure on the fabric-polymer layer to remove any air trapped [32]. The similar process is repeated for each layer of polymer and fabric, till the required layers are stacked. After placing the plastic sheet, mold release is applied on the inner surface of the top mold plate which is then kept on the stacked layers and the pressure is applied. After curing at room temperature for 24 hours, mold is opened and the manufactured composite laminate is taken out and further cut into strips for mechanical testing. Fig. 5 shows a manufactured rattan fiber laminate by hand lay-up process.

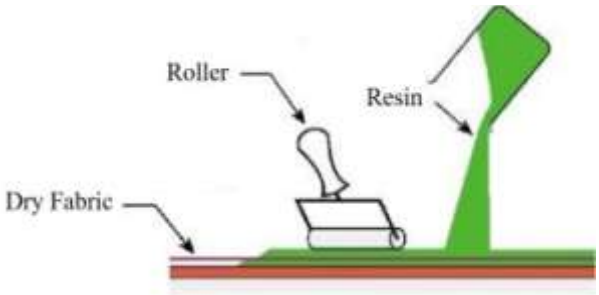

Fig. 4. Schematic diagram of hand lay-up process.

Fig. 5. Manufactured rattan fiber laminate.

II.5 Tensile Tests

Tensile tests are performed on both banana and rattan fiber reinforced epoxy composites. Total 10 samples are prepared (5 for banana fiber and 5 for rattan fiber composite) for tensile test following ASTM D3039 standard [33]. The specimen dimensions are: length 250 mm, width 26:8 mm and thickness 3:3 mm (refer to Fig. 6). Tensile specimens were loaded to Universal Testing Machine (UTM) machine with a loading rate of 2 mm/min and performed the tests until failure. For each test, ultimate tensile stress is recorded.

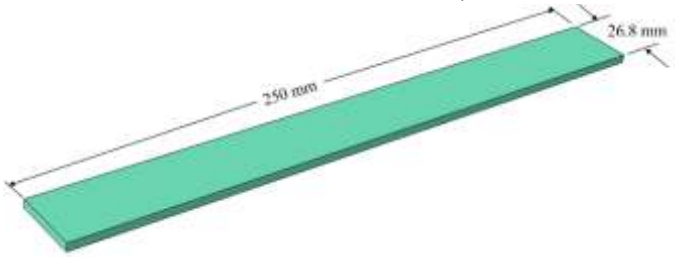

Fig. 6. Schematic tensile test specimen.

II.6 Flexural Tests

Three-point bending tests are carried out on fabricated composite specimen to determine the flexural properties of the composites. A total of 10 specimens (5 for banana fiber and 5 for rattan fiber) are prepared for the flexural tests according to ASTM D7264 standard [34]. Specimens are cut parallel to fiber direction and dimensions are: length 150 mm, width 11.88 mm and thickness 3.3 mm. Three point bending tests are carried out on UTM. A constant span length to width ratio of 32:1 maintained for fabricated composites that resulted in a span length of 105 mm and the diameter of the roller is 18.7 mm.

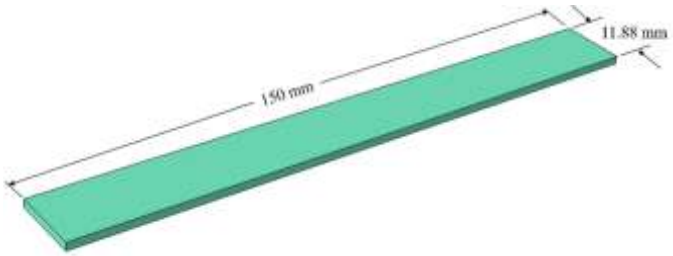

Fig. 7. Schematic flexural test specimen.

III. RESULTS AND DISCUSSION

Unidirectional banana and rattan fiber epoxy composites are investigated in this paper in order to understand their respective mechanical behaviors. Here 5 tensile specimens are tested according to ASTM D3039 standard by using UTM and 5 flexural specimens are tested according to ASTM D7264 standard. Results from the different experimental investigations mentioned above are discussed in this section.

III.1 Tensile Test Results

Tensile tests are performed for both banana and rattan fiber reinforced epoxy composites as mentioned in section 2.5. Fig. 8 shows the tensile strength of both types of composites. It is found that the tensile strength of banana fiber composite is much higher compared to rattan fiber composite which is summarized in Table I. The average tensile strength of banana fiber composite is found 33.46 MPa, whereas the average tensile strength of rattan fiber is 13.01 MPa which indicates that, the tensile strength of banana fiber is 2.57 times higher than that of rattan fiber composite.

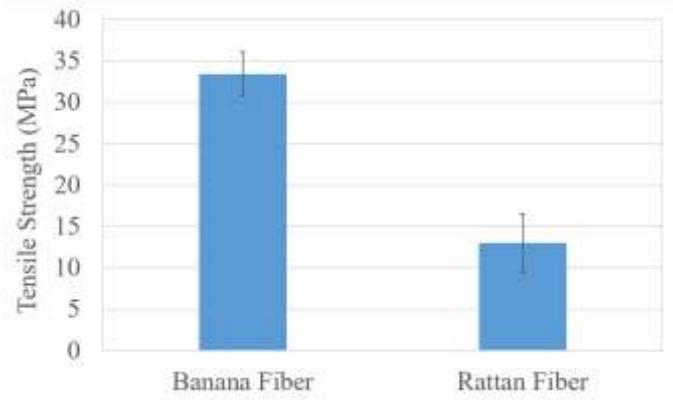

Fig. 8. Bar chart showing tensile strength of composites with standard deviation.

TABLE I: Tension test results with standard deviation.

Material	Tensile Strength (MPa)
Banana	33.46±2.64
Rattan	13.01±3.49

III.2 Flexural Test Results

Flexural strength of both type of composite is compared. Fig. 9 shows the flexural strength of banana and rattan fiber composites found from the 3-point bending test. It is observed that the flexural strength of both composite is comparable which is summarized in Table II. For banana fiber composite, the average flexural strength is 128.47 MPa with a standard deviation of 15.68 MPa and for rattan fiber composite, the average

flexural strength is 131.56 MPa with a standard deviation of 12.84 MPa.

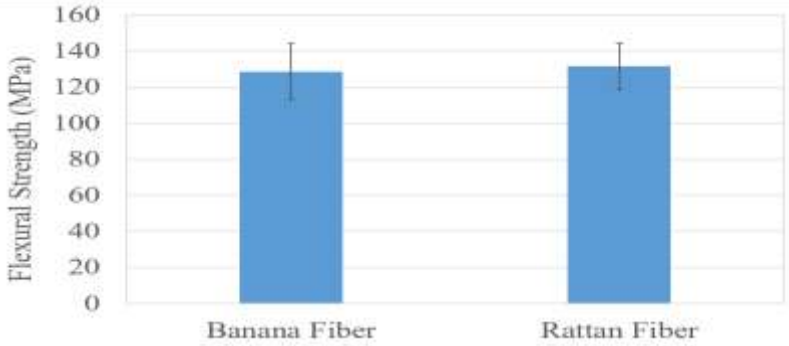

Fig. 9. Bar chart showing flexural strength of composites with standard deviation.

TABLE II: Flexural test results with standard deviation.

Material	Flexural Strength (MPa)
Banana	128.47±15.68
Rattan	131.56±12.84

IV. CONCLUSION

Unidirectional banana and rattan fiber reinforced epoxy composites are manufactured by using hand lay-up process in this paper with the objective of comparing their mechanical properties. Tensile and flexural strength are considered to compare their properties. The average tensile strength of banana fiber composite is found 33.46 MPa while the average tensile strength of rattan fiber composite is 13.01 MPa. The flexural strength of banana fiber is 128.47 MPa and for rattan fiber it is found to be 131.56 MPa.

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Md. Shariful Islam" Comparative Study on Mechanical Properties of Banana and Rattan Fiber Reinforced Epoxy Composites" American Journal of Engineering Research (AJER), vol.8, no.02, 2019, pp.01-06