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Bending Properties of Elephant Grass Fiber Reinforced Epoxy Resin Composites

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Abstracts

Elephant grass fiber reinforced epoxy resin composites has been made and characterized on its mechanical properties that is bending properties. The specimen made by varying its filler's volume fraction. The elephant grass fiber treated by immersing in water for 3 days continued by beating the strips gently in order to loosen and separate the fiber and scrapped with sharp knife and combed until individual fibers were obtained and cut uniformly in 2 cm length and 1 mm diameter width average. Hand lay up process used to prepare the composite specimens with 1%, 3% and 5% volume fraction. This method is the simplest method and require a low cost. The dimensions of the specimens used to carry out the test adapted from ASTM D 3379-75 for Bend testing. The results showed that filler volume fraction has effect to its bending strength. Specimen with 1% filler volume fraction has the highest bending stress whereas 5% filler volume fraction specimen has the highest elasticity modulus value.

Key words: Grass fiber, Epoxy; Resin; Bending, Fraction.

1. Introduction

Environmental friendly materials, recyclable, biodegradable are technologically needed nowadays. One of expecting materials which has those criterias is natural fiber reinforced polymer composites. The interest in natural fiber reinforced polymer composite materials is rapidly growing both in terms of industrial applications and fundamental research. Natural fibers such as jute, flux, hemp, etc. can be alternately used to reduce the cost of the composites [1].

Composite materials are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components [2]. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons:

common examples include materials which are stronger, lighter or less expensive when compared to traditional materials. The making process through non homogenic mixing therefore it will be flexible to determine material's strength by managing the compositions [3].

Elephant grass is one of tall grass comes from Africa which was found in 1913. This kind of grass grows in clump and reach until 10 meters. Its physical features are green to yellowish or green purplish leaves with sharp edge, rough and hairy stem. Leaves height reach 2 to 3 meters with 1 inch width. Its density is 817.53 kg/m^3 [4, 5, 6].

Epoxy Resin has extensive uses in industry, chemical engineering, electrical, mechanical, and civil as a complement, the paint coating and molds casting. Epoxy Resin and hardener react with superior in mechanical strength and chemical resistance. Its nature varies depending on the type, condition and mixing and the hardener, very well bounding against to other components (synthesized from Bisphenol A). Highly resistant to substances and stable against acids. Epoxy Resin is a resin which is resistant to wear and shock resistant (abrupt load) very good used to make molds for manufacturing metal press. In addition it is used also in the aviation industry and construction [7].

This research tried to develop elephant grass reinforced epoxy resin composite materials which is expected to become alternative materials as well as enhance the economic value of elephant grass for structural applications in terms of the bending strength.

In this study conducted on the issue of restrictions that are examined, namely:

1. Composite prepared by using epoxy resin as a matrix and elephant grass fibers as filler.
2. The order of the elephant grass fiber as a filler is a random arrangement of fibers.
3. Material testing conducted with bending test.
4. Variations in volume or weight fraction used 1%, 3% and 5%.
5. The aspects analyzed is the bending stress and elasticity modulus of composite materials.

2. Experimental Methods

The main material that is used in this research is the elephant grass which growth in Maron Beach Semarang whose fiber as filler materials. The matrix material used in this study is epoxy resin Bakelite EPR 174. It also used wax for lubricant molder.

2.1 Extraction of Fiber

In this method, the culms of elephant grass were cut at their base and the leaves at the nodes and end of the culms were trimmed. After trimming, the culms were dried in shade for a period of one week. The node portions were removed by cutting, and the culms were separated into pieces. The short culms separated are composed of exodermis (bark), vascular bundle sheaths, soft tissue cells and endodermis (inner surface layers). The hollow cylindrical portion of culms was taken for extracting fiber and made into four strips peeling them in longitudinal direction. These strips of elephant grass were soaked in water for about 3 days. After this process the strips were subjected to a mechanical process, by beating them gently with a plastic mallet in order to loosen and separate the fiber. The resulting fiber bundle was scrapped with sharp knife and combed until individual fibers were obtained and cut uniformly in 2 cm length and 1 mm diameter width average.

2.2 Composites Fabrication

The specimens were preparated by mixing epoxy resin as matrix, elephant grass fibers as filler and hardener in proper proportions of fibers (0%, 3% and 5%) by volume then poured in to mold.

2.3 Bending Test Data Aquisition

Bending test done using bending machine in Materials Laboratory Machine Engineering and Industry Faculty Gadjah Mada University Yogyakarta. Specimens were prepared based on ASTM C393 standard by dimension 100 mm length and 30 mm width and 70 mm depth.

Bending strength is the biggest bending stresses can be received as a result of the imposition of outside without experiencing large deformation or failure. The great strength of bending depends on the type of material and loading. This research was conducted on the three point bending test [8]. The calculation in the bending test are:

$$\sigma_b = \frac{3PL}{2bd^2}$$

where:

σ_b = Bending stress (MPa)
P = Load (N)
L = Support span(mm)
b = Width(mm)
d = Depth(mm)

Bending elasticity modulus obatained by

$$E_b = \frac{L^3 m}{4bd^3}$$

where :

E_b = Bending Elasticity Modulus (MPa)
L = Support span(mm)
b = Width (mm)
d = Depth (mm)
m = Slope Tangent on deflection curve (N/mm)

Data analysis of this research done by interprenting to bending test graphs thereby mechanical properties of materials characterized.

3. Results and Discussion

The density of the elephant grass fiber is very less compared to established fibers like sisal, jute, coir and banana. So, elephant grass fiber can be used for designing light weight materials.

Table 1. Bending moment data of composite materials

Specimen	Bending moment in various volume fraction		
	1%	**3%**	**5%**
S-I	14.11	10.73	8.72
S- II	14.90	11.59	7.74
S- III	15.90	10.41	8.65
Average (Nmm)	14.9(5)	10.9(3)	8.4(3)

Based on Table 1, it showed specimens with 1 % volume fraction have bending moment range between 14.11 % to 15.90 %. Bending moment of these specimens tend to uniform. Specimens with 3 % volume fraction have bending moment range between 10.41 % to 11.59 %. Specimens in this volume fraction have lower value compared to the previous. Specimens with 5 % volume fraction have bending moment range between 7.74 % to 8.72 %. These have the lowest value (see Figure 1).

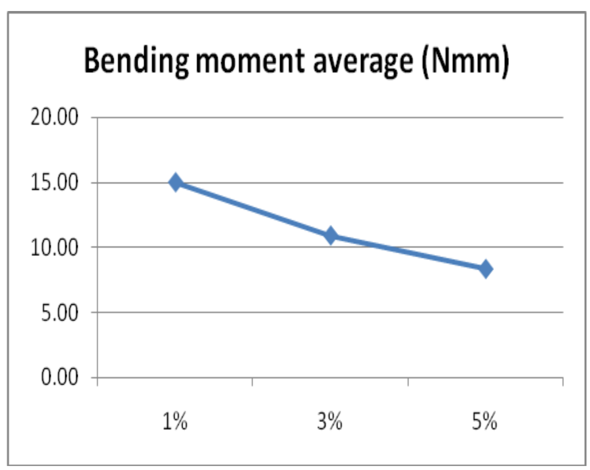

Figure 1. Bending moment average of composite materials

Figure 1 illustrated bending moment average of composites materials woth various volume fractions. It can be observed that the 1% fraction volume held the highest bending moment value that is 14.9(5) %.

Table 2. Bending stress of composite materials

Specimen	Bending Stress		
	1%	3%	5%
S- I	34.84	26.50	21.54
S- II	36.78	28.61	19.12
S- III	39.26	25.71	21.35
Average (MPa)	37(1)	26.9(9)	20.7(7)

On the specimen with a filler volume fraction of 1%, the bending stress value range between 34.84 to 39.26 MPa. The average value of the bending stress is 36.96 MPa. For specimens with filler volume fraction of 3% the bending stress value 25.71 up 28.61 MPa. The value of these specimens on bending stresses are lower compared to specimens with filler volume fraction of 1%. The specimen with the variation of filler volume fraction of 5% voltage has a value of bending stress at 19.12 to 21.54 MPa. These last have the lowest (see Figure 2).

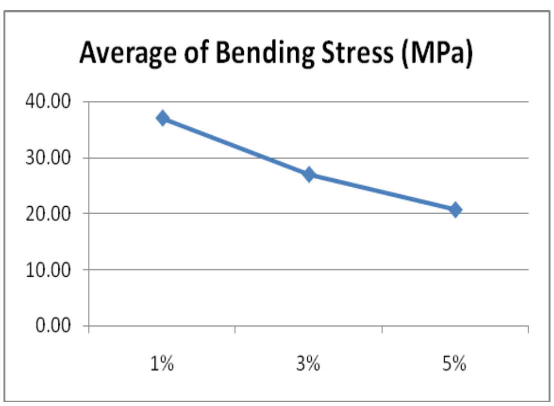

Figure 2. Graph of bending stress average of composite materials

Based on Figure 2, it can be seen that the highest bending stress is 37(1) MPa belongs to 1% volume fraction specimens in contrast the lowest belongs to 5% volume fraction specimens that is 20.7(7) MPa. Figure 3 showed that bending stress going decrease when the volume fraction increased.

Tabel 3. Elasticity modulus bending test data

Specimen	Elasticity Modulus		
	1%	3%	5%
S-I	992.72	981.34	2658.74
S-II	1047.87	963.42	3540.01
S-III	1038.64	952.22	2636.34
Average (MPa)	1026(17)	966(8)	2945(294)

Specimens with filler volume fraction of 1% has modulus elasticity value between 992.72 MPa to 1047.87 MPa with average of elasticity modulus 1026 (17) MPa. For specimens with volume fraction of 3%, the value of the modulus of elasticity between 952.22 MPa to 981.34 MPa. Its elasticity modulus values were lower when compared to the volume fraction of 1%. For specimens with a variation of 5% volume fraction, its elasticity modulus values between 2636.34 MPa to 3540.01 MPa. The value of the elasticity modulus of this specimen is the highest elasticity modulus values of specimens with a volume fraction of 1% and 3% (Figure 3).

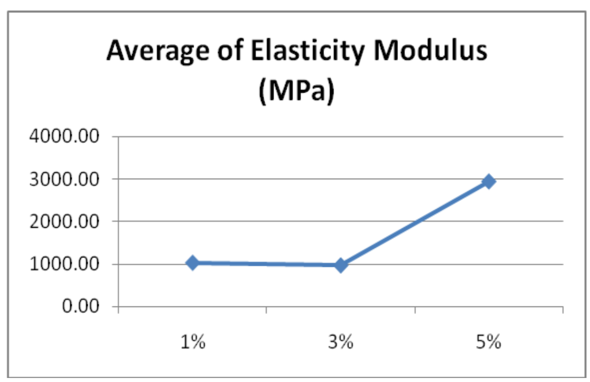

Figure 3. Graph of elasticity modulus average of composite materials

Based on Figure 3 it can be seen that increasing the value of the filler volume fraction, the elasticity modulus tends to increase. Based on the test results can be known [9, 10, 11]:

1) Elephant grass reinforced epoxy resins composites with 1% filler volume fraction have higher strength compared others variation.
2) Composite testing is not necessarily has good results but must consider the causes of strength decrease. Bending strength loss may caused by many factors:
   a) Non-homogenous filler and matrix mixtures when preparing composite materials.
   b) Voids occurred in the composite materials which might cause damage before mechanical testing applied.
   c) In addition there were no linkages between fibers which might cause fracture easily to the matrix component. Based on the teory, fibers' length have effect to the composites' strength.
   d) There were no strong enough bounding between filler and matrix due to fabricated manually.

4. Conclusion

Based on analysis results of composites materials testing data it can be concluded that filler volume fraction has effect to its bending strength. Specimen with 1% filler volume fraction has the highest bending stress whereas 5% filler volume fraction specimen has the hidghest elasticity modulus value.

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