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Analysis of Tensile and Bending Properties of Epoxy Resin Matrix Composites Using Variations of Pandanus Tectorius Leaf Fibers

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A B S T R A C T

With the rapid development of science and technology, people need to be innovative and contemporary. New structures have been widely developed using composite materials made from natural fibers. This research aims to determine the effect of the volume fraction of epoxy matrix pandan tectorius leaf fibers with an epoxy matrix on tensile and bending strength to determine the best results of speciments. Pandan tectorius leaf fiber composites with epoxy resin matrix adopts hand-laying technology, and pandan leaf fiber composites are used for two tires. In this research, the volume ratio of pandan leaf fiber and epoxy resin matrix was found to be 40:60, 45:55, 50:50, 55:45 and 60:40. In the tensile test, the highest value in the average tensile strength of the epoxy-based pandan fiber material was 15.8 N/mm^2, and the lowest value was observed when the fiber and matrix volume ratio (40:60) was changed. It occurs when the fiber and matrix volume ratio changes (50:50) is 12.2 N/mm^2. Meanwhile, in the bending test, the highest average value of bending strength was for the variation of fiber and matrix volume fraction (60: 40), and for the lowest value for the variation of fiber and matrix volume fraction (40: 60), it was equal to 17.36 N/mm^2.

Keywords: Composite, Epoxy, Hand laying, Pandan tectorius, Fraction.

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1. Introduction

Indonesia is a tropical country in Asia, Indonesia is rich in natural resources, including Pandanus tectorius. Pandan thistle is actually used by humans but only for the handicraft industry. Using pandan thorns is still considered best because the products produced are relatively simple and often unattractive, making the product difficult to market.

With the rapid development of science and technology, human beings need innovation and modernity. A widely developed innovation is the use of composites made from natural fibers. According to Salahudin [1], the use of natural fibers as composite materials has many advantages, including high mechanical properties and low production costs. The use of composite materials is already used in a variety of applications, from basic equipment to aerospace.

Leonard and Ratnawati [2] stated that composites are composites of two or more materials that, on a macroscopic scale, are better than the materials they form. Composite materials are non-metallic materials that are increasingly used today, considering that in addition to the importance of mechanical properties, materials also need better properties such as lightness, corrosion resistance and environmental friendliness [2].

Setyawan [3] examined the production of composites with 10%, 20%, 30% and 40% fiber fraction by hand lay-up method with randomly oriented short fibers along the same path in pineapple leaves. Test specimens were tested according to ASTM D3039 tensile strength standard. The results show that the tensile strength of the composite for unidirectional fiber orientation increases with increasing fiber fraction, which is inversely proportional to the random orientation of short fibers.

Sari et al. [4] researched the bending strength characteristics of polyester composite boards reinforced with pandan wangi fiber with sawdust filler. Where this research used fiber volume fractions of 20% and 30% and 5% sengon sawdust filler (volume fraction). The adhesive used is polyester resin with 1% methyl ethyl peroxide hardener. The results of the research show that at a volume fraction of 20% fiber, there is a tendency for an increase in bending strength at fiber length variations of 15, 20, 25, 50 and 100 (mm) with an average bending strength respectively of 56.7 MPa, 67 MPa, 90 MPa and 93.33 MPa. Furthermore, the lowest value is owned by a composite board with a fiber length of 100 mm, namely 78.3 MPa. Meanwhile, the fiber volume fraction of 30% with the same variation in fiber length tends to increase with variations in fiber length of 15 mm, 20 mm and 25 mm respectively, namely 77 MPa, 86.1 MPa and 93.6 MPa but for composite boards with lengths of 50 mm and 100 mm tends to decrease with sequential bending strength values, namely 76.11 MPa and 73.6 MPa.

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Plants from the Pandanus genus are often used as material for making woven items such as pandan mats, bags or wrapping materials which are mainly used from the leaves. This pandan has many branches, the leaves are green with a length of 90-150 cm and a width of up to 4 cm [5].

Figure 1. Pandanus Tectorius Leaves

In this research, there is a comparison of variations in volume fraction composition between pandan duri fiber and epoxy matrix. The reason behind making composites with variations in fiber volume fraction composition with an epoxy matrix aims to continue research and to obtain optimal tensile and bending strength values through comparing variations in volume fraction composition.

2. Material and Methods

The main focus of this research is to obtain optimal tensile and bending strength values through comparing variations in volume fraction composition.

2.1 Related Work

Mastur [6] conducted research entitled "The Effect of Pandan Samak Fiber Composite on the Tensile and Bending Strength of Vehicle Body Materials." This research uses variations in fiber volume fractions of 20%, 30%, and 40% which aims to determine the mechanical properties of the pandan samak fiber composite material. The research results showed that the highest tensile stress was obtained from a volume fraction of 40% with an average value of 9.49 MPa. Meanwhile, the highest bending stress was obtained from a volume fraction of 30% with an average value of 27.54 MPa.

R. Hidayat [7] conducted a study titled "Effect of volume fraction of sea pandan fiber on the bending and tensile strength of polyester composites". This research was carried out with an experimental approach. The experimental design used to prepare samples for bending and tensile testing is a design (four different fiber fractions, e.g. 10%, 15%, 20% and 25%, each repeated three times). At the same time, the data analysis used is One Way Anova. The research results showed that the maximum tensile strength value of the seagrass fiber material in the tensile test occurred when the fiber content was 25%, that is, 25.52 MPa; The lowest value occurs when the fiber content is 10%, i.e. 20.15 MPa. In the flexural test, the highest flexural strength value of Heliconia damaged fiber occurred when the fiber fraction was 25%, i.e. 53.16 MPa; The lowest value occurs when the fiber content is 10%, i.e. 28.86. MPa. One-way analysis of variance (ANOVA) based on statistical analysis showed that fiber fraction significantly affected the tensile strength and flexural strength of sea pandan fiber.

2.1 Methodology

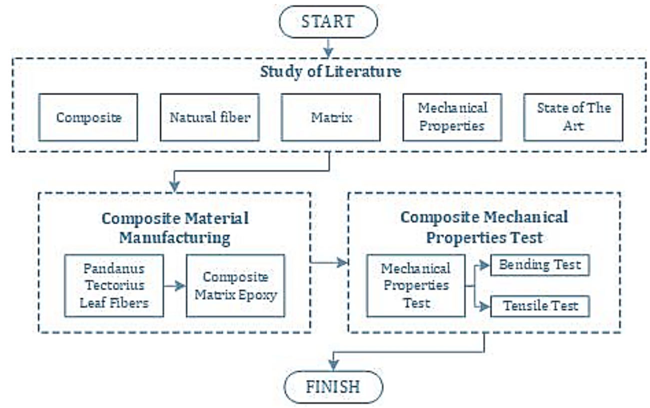


Figure 2. Flow Chart

In this research, it is divided into four steps as the foundation of the research, namely as follows.

- **Study of literature**

In this section, an in-depth study of composites, fibers, matrices, mechanical properties and several scientific studies on similar studies that have been conducted previously is carried out.

- **Composite Manufacturing**

Composite materials are products produced by combining two or more materials, each with different properties, through a combination process. Composite material is a composite material that combines matrix material (resin) as a binder with other materials as a filler phase. Composite materials often contain elements of traditional materials from the manufacturing process to the composition process, so by adjusting the product mix we can work regardless of the strength of the product mix we need [8].

This stage is the main part in the whole research process. The composite material was made using pandanus tectorius fibers and mixed with an epoxy matrix varying compositions to obtain several composite materials.

Table 1. shown the composition of tensile test materials dan table 2 shown the composition of bending test materials.

Table 1. Composite Composition for Tensile Test

No	Composite Composition				Volume (cm^3)
	Tectorius Pandan Fibers (%)	Epoxy (%)	Tectorius Pandan Fibers (cm^3)	Epoxy (cm^3)	
1	40	60	4,4	6,6	11
2	45	55	4,95	6,05	11
3	50	50	5,5	5,5	11
4	55	45	6,05	4,95	11
5	60	40	6,6	4,4	11

Table 2. Composite Composition for Bending Test

No	Composite Composition				Volume (cm^3)
	Tectorius Pandan Fibers (%)	Epoxy (%)	Tectorius Pandan Fibers (cm^3)	Epoxy (cm^3)	
1	40	60	3,2	4,8	8
2	45	55	3,6	4,4	8
3	50	50	4	4	8
4	55	45	4,4	3,6	8
5	60	40	4,8	3,2	8

The comparison of fiber density and fiber mass in tensile and bending test specimens can be shown in Table.3 and Table 4. below

Table 3. Comparison of Density of Fiber, Resin, and Hardener

Volume Fraction Comparison	Fiber Density (gram/cm^3)	Resin Density (gram/cm^3)	Hardener Density (gram/cm^3)
40 : 60			
45 : 55			
50 : 50	0,2	1,25	1,12
55 : 45			
60 : 40			

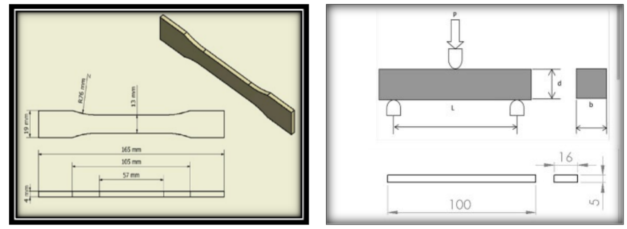
Table 4. Comparison of Mass of Fiber, Resin, and Hardener

Volume Fraction Comparison	Fiber Mass (gram)		Resin Mass (gram)		Hardener Mass (gram)	
	Tensile	Bending	Tensile	Bending	Tensile	Bending
40 : 60	0,88	0,64	5,5	4	2,46	1,79
45 : 55	0,99	0,72	5,04	3,66	2,26	1,64
50 : 50	1,1	0,8	4,58	3,3	2,05	1,49
55 : 45	1,21	0,88	4,13	3	1,85	1,34
60 : 40	1,32	0,96	3,66	2,66	1,64	1,19

After all the compositions are made and mixed according to the dose, the test specimens are printed using a mold according to ASTM D638 for the geometry of the tesile specimen and using molding method on the basis of ASTM D790 for the geometry of the bending specimen.

- **Composite Mechanical Properties Test**

Tensile test and bending test are tests of mechanical properties in this study. The composites were made using molding method on the basis of ASTM D638 for the geometry of the tesile specimen and using molding method on the basis of ASTM D790 for the geometry of the bending specimen.



(a) (b)

Figure 3. (a) ASTM D638; **(b)** ASTM D790

After the tensile and bending specimens were finished, the specimens were sent to laboratory for tensile and bending testing. The tool used for tensile and bending testing is the Universal Testing Machine.

(a) (b)

Figure 4. (a) UTM for Tensile Test; **(b)** UTM for Bending Test

3. Result and Discussions

The samples used were five samples with three replications for each sample. The specimen composition according to the Table 3. The purpose of repetition is to obtain realistic results.

Figure 5. Composite Specimen

Below is a diagram of the tensile and bending strength results for each change in fiber section. The graph was created from the data obtained for each test regarding the change in volume fraction of the tensile and bending samples. Below is a graph of variations in volume as a function of tensile and bending strength, as shown in Figure 6.

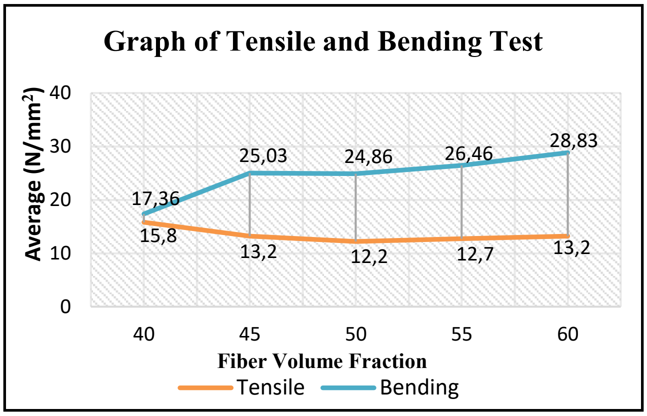


Figure 6. Graph of Tensile and Bending Test

Figure 6. describes the results of tensile and bending test with the following description.

- From the graph above, it can be seen that the highest average value of tensile strength for the 40% fiber volume fraction variation is 15,8 N/mm^2.
- The lowest average value of tensile strength for the 50% fiber volume fraction variation is 12,2 N/mm^2.
- The highest average value of bending strength was for the 60% fiber volume fraction variation is 28,83 N/mm^2.
- The lowest average value of bending test for the 40% fiber volume fraction variation was 17,36 N/mm^2.

4. Conclusion

This research shows that increasing the fiber volume does not mean that the tensile strength value decreases or the bending strength value increases, but rather that both strength values tend to increase and decrease.

In the tensile test, the highest value of the average tensile strength of the epoxy-based pandan fiber material appeared when the fiber and matrix volume ratio (40:60) changed, that is 15,8 N/mm2, and the lowest price occurred matrix (50:50) is 12.2 N/mm2. This shows that increasing the amount of fiber does not mean a decrease in the tensile strength value, but that the tensile strength value tends to increase and decrease.

In the bending test, the highest average bending strength of the epoxy-based pandan fiber composite material was 28,83 N/mm^2 when the fiber and matrix volume ratio (60:40). And the lowest value was found in the variation fiber volume fraction in matrix (40:60), its value is 17,36 N/mm^2. This shows that increasing the fiber volume does not mean an increase in the bending strength value, but that the bending strength value both increases and decreases.

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