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Analysis of the Tensile Strength of Composite Material from Fiber Bags

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ABSTRACT

The use of composite materials in Indonesia, as a nonmetal alternative material has begun to increase. Composite use has grown from water tanks from fiberglass materials, household appliances, children's toys, sports equipment, furniture/interior design to automotive components and aircraft. Many of the advantages of this composite material include hand, strong, anti-corrosion, finely tuned finish. Its mild nature has a direct impact on energy savings. The prospect of composite materials as a non-metal alternative material is rapidly growing and its use. Various types of reinforce used can be influenced by the prices available, so seek alternatives as a commonly used glass fiber substitute woven rowing. The substitute used is a sack of gourds of the same kind as woven rowing, from which the same type of fiber is tried to find its strength by undergoing a pull test. And as a result of the test the mateial can know its power.

INTRODUCTION

Due to the rapid development of technology, this industry demands the availability of good-performing materials, which criteria must be met: lightweight, high strength and low production cost. One of the materials that can meet these criteria is the composite besides having a high stain and stress ratio and relatively low composite manufacturing cost. In addition, the composite can be manufactured directly into a final shape or product with minimal machining treatment [1-4].

Glass fiber/polyester composite is one of the most widely used types of composite glass fiber reinforced composites. The strength of this composite is influenced by many factors, including the shape of the fiber, the direction of the fiber, the manufacturing process, and the amount of fiber that is often expressed in the volume fraction of the fiber. Based on theoretically are the greater the volume fraction of the fiber the higher the strength of the composite and also influenced the type of amplifier of the composite [5-8].

As a Reinforcement of the composite commonly used Woven Rowing glass fiber which has the most straightforward, sheet-shaped fiber direction, this type of composite is made with wet lamination method [9-10]. In this research or testing based on these reasons, try to observe the difference in tensile strength between Woven Rowing (wr) fibers and rubber sacs to obtain data on the influence of composite tensile strength by wet lamination method.

The composite is a blend of matrix from polyester resin using obsolete gasket sack fiber. In this study the glass fiber commonly used to make composite is replaced by a rubber sack with fiber shaped like glass fiber.

Composite materials

A combination of two or more materials forming one unit of material intended to obtain the desired characteristics, composites are formed on two components namely matrix reinforcement. The matrix reinforcement component works to increase the strength of the composite, while the matrix component acts as the body of the composite [11-12].

Generally composite material is made up of two groups, namely natural composite materials (such as wood, bamboo, muscle fibers and bones in the human body). And engineering composite materials (e.g. fiber reinforced plastic and metal composite matrix). Based on the composition of its composite materials the composite materials can be divided into: fiber composites (composites with fiber-reinforced matrix), specific composites (composites with particle-shaped amplifiers), synthetic composites (composites with flux-shaped reinforcements), and laminate composites (layers

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made from coated (material coating). Judging from the matrix used, the engineering composites are grouped into plastic and metal composites [13].

Plastic composites are made from polymer resin matrix, commonly used epoxy resin / epoxy resin glass fiber reinforcement, carbon/kevlar fiber. Whereas a metal composite is a metal matrix composite and is reinforced by metal and reinforced by metal, which has a higher strength than the matrix, examples of aluminum wire reinforced with steel [14].

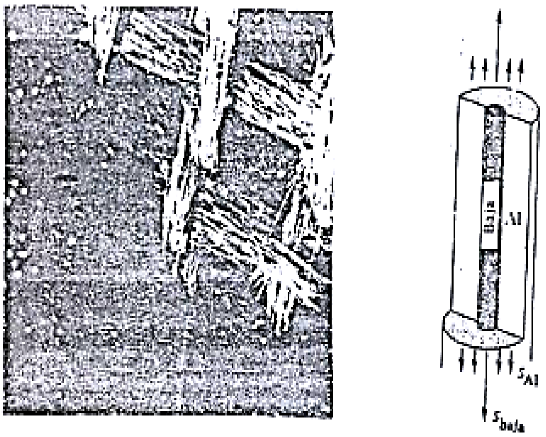


Fig. 1. Forms of plastic composites and metal composites [1]

One of the most widely used types of composite resin (plastic composite) composites. The reason for selecting this type of composite is because of its favorable properties, namely low weight, high strength, high strength risk against heavy loads and easy in formation. Plastic composites are widely used for aircraft composites, automobiles, oceans, oxygen tanks, sporting equipment and much more. Among the most widely used types of resin are polyester resin and epoxy resin while fibers used in carbon fiber. In the manufacturing process, the fibers and resins form into thin layers and then combine to the desired thickness. The manufacture of plastic composite products is largely done by wet lamination process. This process is done by placing the fibers in a mold, on the fibers of the liquid resin mixed with the promoter substance. Manually wet/squeezed/ pressed fibers to distribute resin evenly and to remove air bubbles and to assist in the absorption of resin into the fiber. This process is carried out to the desired thickness/number of layers, and then the structure is opened from the mold made according to the manufacturer's wishes [15-17].

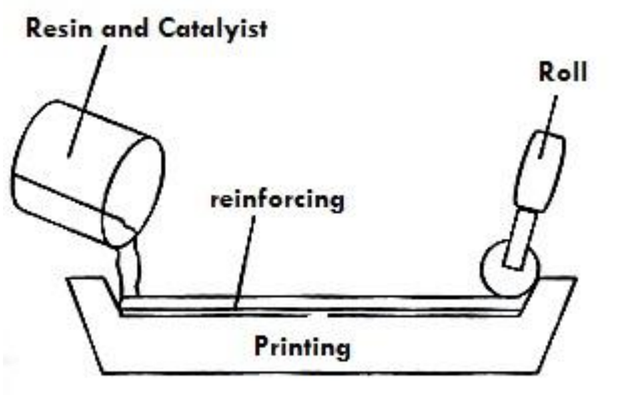


Fig. 2. Wet Lamination Process [3]

The properties of composite products are greatly influenced by their technique and materials. The superiority of fiber reinforced composites with thermoset matrix (epoxy and polyester) or thermoplastic as a metal replacement, due to its ability to enhance the mechanical properties of composites. The advantage of composite with polymer matrix compared to metal is its low type. Of the many types of composite materials, they can be grouped into 3 main parts:

1. Polymers
2. Reinforcement
3. Additive

Each molding material is made up of many types with specific properties, especially polymer / resin. As such, more knowledge of the forming material including the interaction between them, will be very helpful in creating the best possible composite product. On the other hand, when there is a lack of goodwill in the selection and handling of materials will be very detrimental [2].

Goat sack is used to store rice, sugar, or other of the same size, i.e. sack of 50kg and 100 kg. Goni is a woven sack cloth made from plant fibers (natural fibers), consisting of rosella fiber, kenaf fiber, yute fiber and other plant stem fibers. In Indonesia the sack of goni has a quality standard that is standard for the agreement between buyer and seller. These quality requirements are registered with the Department of Industry, below which indicates the quality requirements of the sack of rubber [2].

Table 1. Quality Requirements for Goni Bags Fiber [4]

Test Type	Required	Unit
Sack Dimension		
a. Outside length	108	cm
b. Outer width	73	
Construction		
a. Plait	Plain	
b. Weight per sheet	1070	gram
c. Total dozen / feed per 10 cm.	34x2	
d. Total feed / dozen per 10 cm.	34	
Tensile Strength per 5 cm	12,724	N/mm
a. Voltage when broken	981(100) 981 (100)	N (kg)
b. Dozen directions, drinks	539,5 (55)	N/kg
c. Feed direction, BeverageThe power of stitches	Not NG	N/kg
Power fell, dropped consecutively from	22	%
height of 180cm 3 times and 360 I times Regian Moisture, Maximum	8	%
Oil content, maximum		

Additives can be called key in composites. These materials play an important role in the development of composite properties. Although mixed in very small quantities, the additives strongly determine the properties and strengths of the composites. Additive uses include catalyst/promoter/inhibitor, mold lubricant, dyes, fireproof materials, surface finishers, UV rays, strength enhancers, power delivery, preventing shrinkage, lowering heat transfer costs, timer “Curing,” anti-static and so on.

Most types of additives come from organic peroxide groups. MEKP is often used for the process of forming at room temperature. TBC (Tertiary Butyl Catechol) to reduce reaction rate and is often called an "inhibitor", the opposite is DMA (Dimethyl Aniline), a part of the accelerator to accelerate curing [18].

Composite Coating Analysis

Most structural elements of a fibrous composite are made up of several layers or unidirectional lamina. Each lamina is made from the same constituent material, but can differ from each other in the relative volume of the arrangement material, the shape of the strengthening mechanism and the direction of the fiber axis. Unidirectional composites consist of fibers that are placed parallel to the matrix called layers, layers or lamina. This layer has three main axes, namely the x, y, and z axes called the material axis. Where lapse has the strongest is in the longitudinal direction, parallel to the fiber axis, and material properties in the other two directions, the y and z axes, are relatively nearly the same [2].

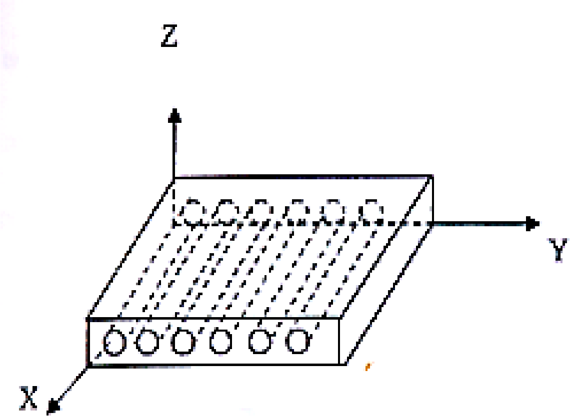


Fig. 3. Composite Axis

$$V_f = \frac{v_f}{v_c} \tag{1}$$

$$V_m = \frac{v_m}{v_c} \tag{2}$$

Where, $v_c = v_f + v_m$ and,

$$W_f = \frac{\varpi_f}{\varpi_c} \tag{3}$$

$$W_m = \frac{\varpi_m}{\varpi_c} \tag{4}$$

Where, $\varpi_c = \varpi_f + \varpi_m$

To obtain the relationship between the weight fraction and the volume fraction, the mass of the composite material mass, *p* must be known. The mass of the composite type in the volume fraction can be obtained by the following equation.

$$p_o = p_f \cdot V_f + p_m + V_m \tag{5}$$

$$W_f = \frac{P_f}{P_o} V_{fm} \tag{6}$$

$$W_m = \frac{P_m}{P_o} V_m \tag{7}$$

$$V = \frac{P_{ci} - P_{ce}}{P_{ci}} \tag{8}$$

Longitudinal Tension-Strain Analysis
The nature of the composite material depends on the nature of the material of the compiler and its distribution. This trait is determined either by experimental manipulation or by theoretical methods. Experimental measurements can only determine the composite properties created through the fabrication process with fixed variables. While semi empirical theoretical methods are used to estimate the effect of various system variables. And his mathematical model is to study some unidirectional composite properties [1].

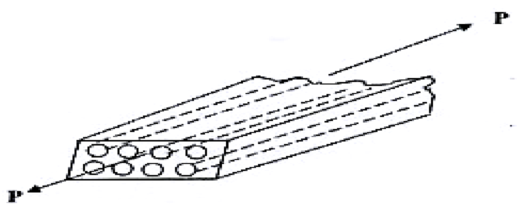


Fig. 4. Longitudinal composite model

$$\varepsilon_f = \varepsilon_m = \varepsilon_c \quad (9)$$

$$\sigma_f = E_f \cdot \varepsilon_f \quad (10)$$

$$\sigma_m = E_m \cdot \varepsilon_m \quad (11)$$

$$P_c = P_f + P_m \quad (12)$$

$$\sigma_c = \sigma_f \cdot V_f / \sigma_m \cdot V_m \quad (13)$$

$$E_c = E_f \cdot V_f / E_m \cdot V_m \quad (14)$$

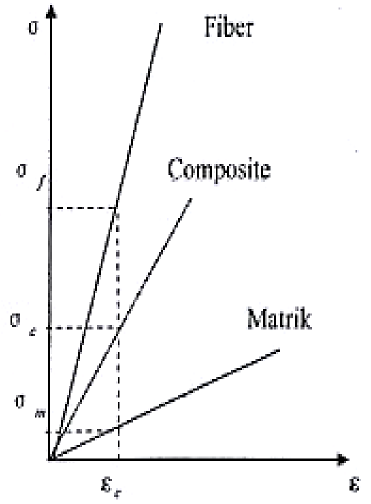


Fig. 5. Longitudinal Tension-Stretch Chart

EXPERIMENTAL METHOD

The research flowchart is done as in Figure 1 below:

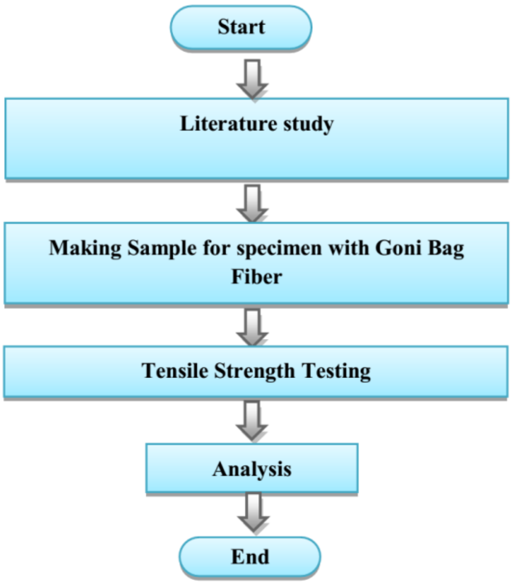


Fig. 6. Flowchart of this research

Based on the Figure 1 the research flow shows the path through which are:

a. Literature studies were conducted in relation to the research topic
b. Prepare and making samples for the specimen testing from Goni bag fiber.
c. Testing of tensile strength from sample with Goni bag fiber.
d. Taking analysis and conclusions from the research that has been done.

Composite Micromechanical Analysis
Tables 2 and 3 are micromechanical data from composites used in experiments.

Table 2. Characteristics of Goni Bags Fiber

Characteristics	Standard National Indonesia
Ultimate Tensile Strength	981 MPa
Diameter	0.5 mm
Moisture	22%
Density	550 kg/m^3
Elongation At Break	0.019375
Stress of Fiber At Failure	12.724 MPa

Table 3. Characteristics of Epoxy Resins

Characteristics	Standard International
Ultimate Tensile Strength	22.13 MPa
Density	1065.0 Kg/m^3
Tensile Modulus	656.7 MPa
Elongation At Break	0.0337

Composite Micromechanical Design

Table 4 is data about the micromechanical design of composites used in experiments.

Table 4. Characteristics of Multiple Layers of Analytical Results

Characteristics	Standard International
Fiber Volume Fraction	40%
Density	859.046 kg/m^3
Longitudinal Tensile Modulus	9367.6 MPa
Longitudinal Ultimate Tensile Strength	115.4 MPa
Longitudinal Elongation At Break	0.0123

Material

The materials for the production of Fiber Glass are made up of primary materials and auxiliary materials. The ingredients include:

1. Polyester Resin with its trade name is Ether 2,200 resin
   It is the main ingredient of the manufacture of composites as a matrix material.
2. A catalyst that acts as a dryer or dryer
   The accelerator material when combined with the catalyst will harden.
3. Fiber using a sack
   That is, the filler or reinforcement.
4. Mirror Glaze Wax (Anti-stick material)
   The material is anti-stick to the mold at the time of resin and the catalyst is poured into the mold.
5. Thiner as a detergent.

Fig. 7. The chemicals used to make the specimen

Process for Making or Printing Specimens

The process of printing specs is a few steps to take in order to obtain a good specimen material and in accordance with the test standard to be applied. The creation process can be seen from the flow chart as follows Fig.8.

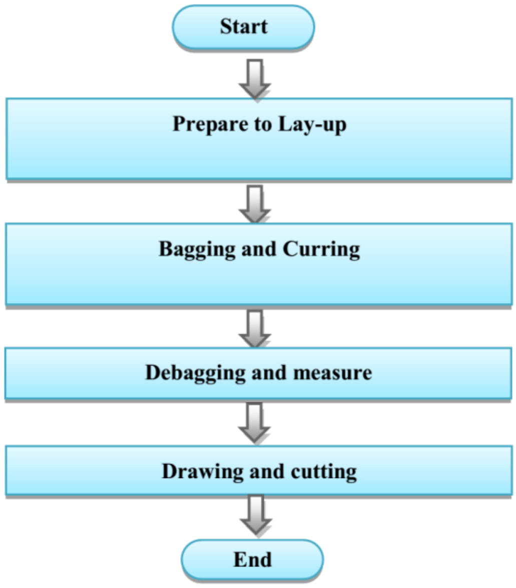


Fig. 8. Preparation of Specimen flow chart

Table 5 is the data obtained before tensile testing is performed.

Table 5. Data obtained before tensile test

Specimen	A Thickness (mm)	B Width (mm)	So (axb) Cross-sectional area (mm)	Lc Length of Test Area (mm)	Lo Initial length (mm)	Wo Grip width (mm)
1	3.75	15.5	58.12	43.07	110	20
2	3.61	13.2	47.65	39	113	20
3	3.43	14.3	49.04	39.56	112	19.5
4	3.4	14.5	49.3	39.6	115	20
5	3.55	14.3	50.76	40.2	115	20

RESULTS AND DISCUSSION

The Following is a picture of cutting standards in accordance with international standards (ASTM), as in Fig. 9.

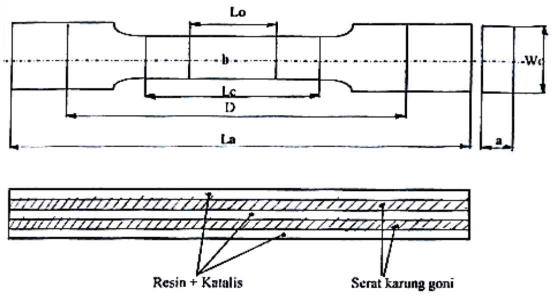


Fig. 9. Tensile test specimen

Tensile test results are shown in Table 6.

Table 6. Data after Tensile Testing

Specimen	P_f Break Up Burden (N)	δ_f Strength When Disconnect (N/mm)	L_i Different length (mm)	ε_f Break when stretched (%)	E Modulus Elasticity (Young) (MPa)
1	1098	18.9	1.4	1.27	14.8
2	1229.3	25.8	1.2	1.06	24.3
3	946	19.3	1.3	1.2	16.8
4	915.5	18.7	1.2	1.2	1.2
5	985	19.4	1.5	1.3	1.3

From tensile testing conducted on composite specimens with jute sack fibers obtained by tensile load data, the maximum that can be held by these specimens is ranging from 18.7 to 25.8 N/mm. The resulting strain from testing is ranging from 1.06 to 1.3%.

When the tensile test changes in the cross-sectional area (A_1), the change in cross-sectional area in the analysis is considered constant so that the stress (σ_1) after the test is calculated, based on the initial cross-sectional area.

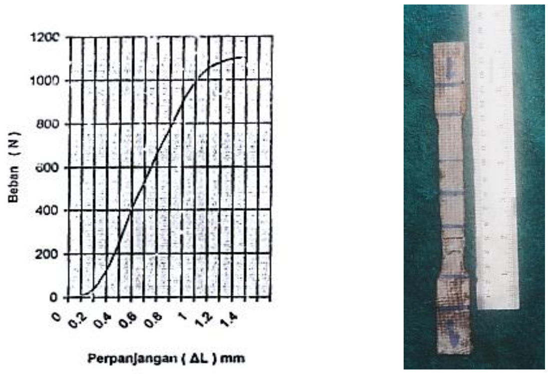
From the analysis of calculations from the test graphs obtained compared with the theory according to R.D and Mellick P.K shown the stress-strain graph that is with a voltage of + 60.5 N/mm and a strain of + 20% then the composite is considered brittle, listed in the book.

The results of the analysis of the defensive area after testing, fracture or broken specimens outside the test area are considered to be the same strength as the specimens whose defenses are in the work area. Table 7 is the Extension and load data of Specimen I.

Table 7. Extension and load of Specimen I

Load [N]	Extension Length (ΔL) [mm]
0	0
7.5	0.1
40	0.2
225	0.4
543	0.6
776	0.8
993	1.0
1080	1.2
1103	1.4

Figure 10 is Extension graph data with load for specimen I and picture of specimen I after tensile test.



(a) (b)

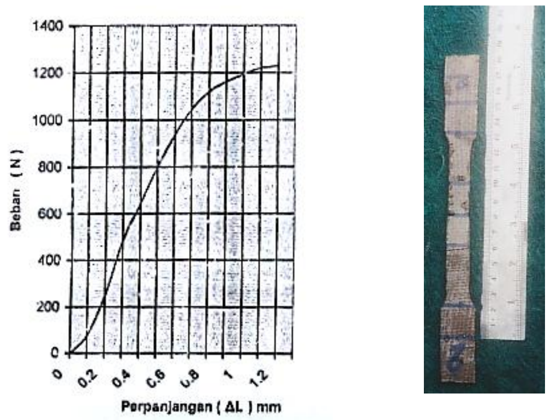
Fig. 10. Extension graph vs. load for specimen I (a) and picture of specimen I after tensile test (b)

Table 8 is the Extension and load data of Specimen II.

Table 8. Extension and load of Specimen II

Load [N]	Extension Length (ΔL) [mm]
0	0
7.5	0.1
75.5	0.2
643	0.4
937	0.6
1120	0.8
1195	1
1229	1.2

Figure 11 is Extension graph data with load for specimen II and picture of specimen II after tensile test.



(a) (b)

Fig. 11. Extension graph vs. load for specimen II (a) and picture of specimen II after tensile test (b)

Table 9 is the Extension and load data of Specimen III.

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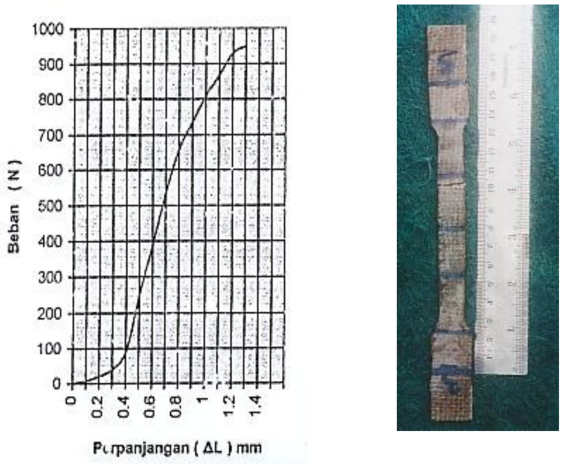
Table 9. Extension and load of Specimen III

Load [N]	Extension Length (ΔL)[mm]
0	0
7.5	0.1
20.5	0.2
90.5	0.4
390	0.6
660	0.8
807	1
930.5	1.2

Figure 12 is Extension graph data with load for specimen III and picture of specimen III after tensile test.



(a) (b)

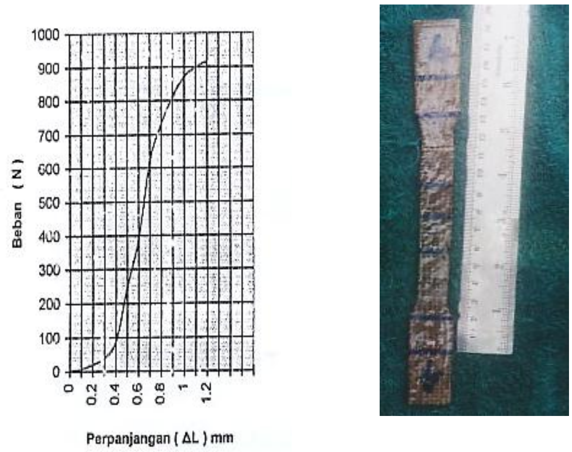
Fig. 12. Extension graph vs. load for specimen III (a) and picture of specimen I after tensile test (b)

Table 10 is the Extension and load data of Specimen IV.

Table 10. Extension and load of Specimen IV

Load [N]	Extension Length (ΔL)[mm]
0	0
7.5	0.1
20.5	0.2
90.5	0.4
390	0.6
730	0.8
870	1
915	1.2

Figure 13 is Extension graph data with load for specimen IV and picture of specimen IV after tensile test.



(a) (b)

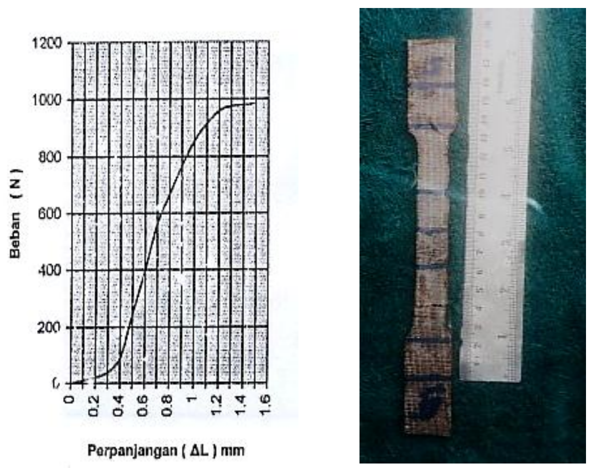
Fig. 13. Extension graph vs. load for specimen IV (a) and picture of specimen I after tensile test (b)

Table 11 is the Extension and load data of Specimen V.

Table 11. Extension and load of Specimen V

Load [N]	Extension Length (ΔL)[mm]
0	0
7.5	0.1
20.5	0.2
90.5	0.4
400	0.6
665	0.8
855	1
960	1.2
980	1.4
985.3	1.5

Figure 14 is Extension graph data with load for specimen V and picture of specimen V after tensile test.



(a) (b)

Fig. 14. Extension graph vs. load for specimen V (a) and picture of specimen I after tensile test (b)

From the tensile tests conducted on composite specimens with jute sack fibers, the maximum tensile load data that can be withstand from the specimens is around 18.7 to 25.8. The resulting strain from testing is ranging from 1.06% to 1.3%. When the tensile test changes in the cross-sectional area (A1), the changes in the cross-sectional area in the analysis are considered constant so that the stress after the test is calculated, based on the initial cross-sectional area.

Analysis of calculations from the test graph obtained compared with the theory according to [1] and [2] shown a strain stress graph that is with a voltage of 6.5 and a strain of 2%, then the composite is considered brittle. From the analysis of the fracture area after testing, there is a fracture or broken specimen outside the test area whose strength is the same as the specimen which has a fracture in the test area.

CONCLUSION

1. At the time of breaking up the tensile load applied to the composite with jute sack fibers, from specimens 1 to specimen 5 obtained varied results, with values between 946 N to 1229.3 N
2. The strain obtained from the calculation and analysis varies from 1.06% to 1.3%.
3. When the tensile test changes the cross-sectional area (A_1) changes in the cross-sectional area in the analysis are considered constant so that the stress (σ_1) after the test is calculated based on the initial cross-sectional area.
4. From the analysis and calculation of the results of tensile tests that have been carried out and then compared with the analysis and observations that have been put forward by Rawling RD and Mellick PK about composites obtained from the strain stress graph that is with a voltage of + 60.5 N / mm and a strain of + 2% then the composite is considered brittle.
5. Obtained from the results of the analysis of the fracture area after testing, the fracture or the breaking up of specimens outside the test area are considered to be the same strength as the specimens that have fractures within the test area.

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