Analysis of Impact Strength and Fracture Pattern of Hybrid Composite Materials Reinforced with Lontar and Gebang Midrib Fibers

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Abstract: The use of natural fibers as a filler in composite materials is starting to be widely used. One of the most promising ones is hybrid composites. Hybrid composites are composites consisting of a combination of two or more types of fiber as reinforcement in a single matrix. This study used Lontar Midrib Fiber (LMF) and Gebang Midrib Fiber (GMF) as reinforcement and Polyester as binder. The method used is an experimental method with hand lay up material printing. The results obtained that the highest impact energy value is owned by hybrid composites with a volume fraction ratio of 70% Polyester, 20% LMF, 10% GMF (7,2,1) which is 20.8 Joule, with the highest impact value 0.1576 J/mm^2 and the lowest impact energy value was owned by a composite with a volume fraction of 80% Polyester, 10% LMF, 10% GMF (8.1.1) which was 7.4667 Joule, with a strength value of the lowest impact is 0.0566 J/mm^2. The fracture pattern that occurs in the hybrid composite material shows brittle fracture with fiber pull out.

1 INTRODUCTION

Lontar Tree (Borassus Flabellifer) and Gebang Tree (Corypha Utan Lamarck) are tree species known as the tree of life for people in East Nusa Tenggara Province. In this plant, almost all parts are useful for mankind, including as food, building, household furniture, art and cultural goods. Various benefits can be obtained from various parts of the lontar and gebang tree or plant, among others, the stems are used to support houses, the leaves are used to make mats, sasando musical instruments, traditional hats, the sap to make brown sugar, the fruit to make makeup and the midrib is used as a fuel substitute for kerosene.

Based on the data reported that the area of natural grazing areas on Timor Island is 24,382.04 ha and it is estimated that around 5-10% of the area is covered with gebang trees, while palm trees are commonly found on the islands of Rote Ndoa, Sabu, Flores and East Sumba with the area of palm trees in NTT. 20,555 Ha. So it can be said that the population of palm trees and gebang trees is quite developed in NTT. However, until now it can be said that the lontar and gebang plants are still one of the flora of Indonesia, especially in the East Nusa Tenggara region that has not been used optimally. The processing of parts of the lontar and gebang trees, such as the base of the palm frond and the gebang frond, has so far only been used as organic waste and as a substitute for kerosene fuel for cooking. On the other hand, the base of the lontar midrib and the gebang frond are also used as a seat mat and a tool for carrying water. This is because the gebang midrib and lontar midrib have flexible properties and are not easily broken.

Judging from the utilization of palm and gebang trees and their mechanical properties, it is very good if the fibers at the base of the palm and gebang midribs are used as reinforcement for hybrid composite materials. The reasons for choosing the base fibers of the palm and gebang midribs as raw materials for hybrid composites are that they have flexible properties, are easy to obtain in large quantities and provide opportunities for wood substitute raw materials, which are decreasing in availability due to utilization in all fields.

Hybrid composites are composites consisting of a combination of two or more types of fiber as reinforcement in a single matrix, either continuous or discontinuous (Budinski,1995). Composite materials are materials formed from a combination of two or more constituent materials through an

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inhomogeneous mixture, where the mechanical properties of each constituent material are different (Matthews and Bawlings,1993).

The advantages of hybrid composite materials when compared to metals are that they have good mechanical properties, are not easy to corrode, are easily obtained raw materials at lower prices, and have a lower density than mineral fibers. Natural fiber composites have other advantages when compared to synthetic fibers, natural fiber composites are more environmentally friendly because they can be degraded naturally and the price is cheaper than synthetic fibers.

In Hybrid composite materials, there are several factors that greatly affect its mechanical strength, such as fiber volume fraction, fiber length, fiber type variations. The larger the fiber volume fraction in the matrix, the strength is increased. also increasing. This is because the greater the length of the fiber in the metric, the surface of the fiber that bears the load given by the matrix becomes large, conversely the shorter the fiber in the matrix, the surface of the fiber that bears the load given by the matrix becomes smaller, so that its strength is also getting stronger low (Moto et al., 2018). Composites with natural fibers have also been researched and developed previously. Shomad et al., 2020, Researching the Hybrid Composite Characterization Analysis on the Matic Motorcycle Front Fender. The highest tensile test results for the two types of fiber arrays with the SR-SR-SK fiber arrangement of 47.67 MPa, while the lowest tensile strength value for the SR-SF-SK variation of the fiber array is 35.59 MPa. The highest impact test result was 0.0141 J/mm^2 for the SR-SF-SK variation, and the lowest impact strength for the SF-SR-SK variation was 0.01226 J/mm^2. Banowati et al, 2020, Researching comparative analysis of hibrid composite tensile strength pineapple leaf fiber hybrid-E-glass/ epoxy bakalite EPR 174 and pineapple leaf fiber hybrid -E-glass/Vinyl ester repoxy R 80. Based on tensile test the average value obtained by hybrid composite of pineapple fiber fibers - e-glass / epoxy bakalite EPR 174 using hand ly up method with unidirectional 0 ° direction of 114 N / mm2, bidirectional bidirectional direction of 90 ° 22 N / mm2 and the direction of fiber ± 45 ° for 24 N / mm2. While the result of tensile test of the average value obtained by hybrid composite of pineapple fiber fiber - e-glass / vinyl ester repoxy R 802 using hand ly up method with Unidirectional 0 ° array direction of 86 N / mm2, bidirectional fiber direction direction 90 ° 66 N / mm2 and the direction of fiber ± 45 ° is 37 N / mm2.

Based on the reviews and references above, the author was inspired to research the analysis of impact strength and fracture patterns of hybrid composite materials reinforced with lontar and gebang midrib fibers. With the hope that we can find out how big the effect of the volume fraction variation of the lontar base fiber and the gebang midrib fiber is. to the maximum value of mechanical strength (impact strength) and fracture patterns on hybrid composite materials.

2 RESEARCH METHODOLOGY

This research is an experimental research that aims to determine the impact strength and fracture pattern of a hybrid composite material reinforced with lontar midrib fiber and gebang midrib fiber.

This research utilizes the base fiber of the lontar midrib and the gebang midrib fiber as a composite reinforcement material and polyester as a binder. Previously the fibers were cleaned with pure water, then treated by immersion in a 5% Alkali (NaOH) solution per 1 liter of distilled water in order to increase the adhesive properties so as to increase the impact strength of the fiber composites it forms.

The fiber used has an average diameter of 0.7mm for the gebang midrib fiber and an average diameter of 2mm for the lontar midrib base fiber with the hand lay up printing method and the fiber arrangement, namely continuous fiber composite. This hybrid composite test material will be impact tested to determine the maximum impact energy value and impact strength value.

The types of variables in this study:

- Independent Variables (unbound): are variables that are determined before carrying out the research.
- Volume Fraction Comparison: 80% Polyester, 10% LMF, 10% GMF (8,1,1), 70% Polyester, 20% LMF, 10% GMF (7,2,1), 70% Polyester,10% LMF, 20% GMF (7,1,2), 60% Polyester, 30% LMF, 10% GMF (6.3, 1), 60% Polyester, 20% LMF, 20% GMF (6,2,2), 60% Polyester, 10% LMF, 30% GMF (6,1,3)
- Treatment of alkaline (NaOH) palm midrib fiber 5% per 1 liter of distilled water with an upset time of 120 minutes.
- Dependent Variables are: Impact Strength
- Controlled Variables are:
  - Methyl ethyl ketone peroxide (MEKP) / hardener 1%
  - Resin : Polyester

- Average fiber diameter (d) = 0.7 mm for midrib fiber
- Average fiber diameter (d) = 2 mm for the fiber at the base of the palm frond
- Fiber length L = 125 mm for Impact test specimen
- Dried composite at room temperature until dry.
- Curing fiber at room temperature until dry.

Impact test specimens is made based on the ASTM D6110 standar as the following picture.

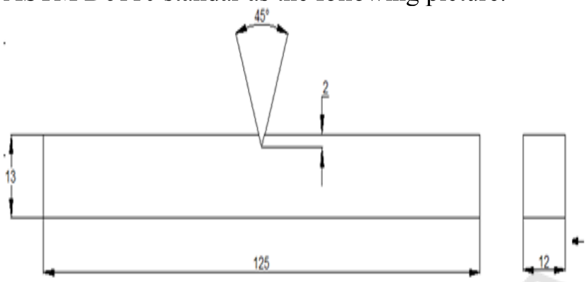

Figure 1: Impact Test Specimens ASTM D6110.

Impact strength is known by using a charpy impact testing machine with ASTM D6110 specimen standard, as shown in Figure. 1. To measure the impact test data used the formulas as follows (Calister and Retwisch, 2007):

$E_{absorption}$ = initial energy – remaining energy
= m.g.h – m.g.h'
= m.g.(R-R cos α) - m.g.(R-R cos β)
$E_{absorption}$ = m.g.R. (cos β – cos α)

with :

$E_{absorption}$ = Energy Absorption (J)
m = Pendulum Weight (kg)
g = Gravitational Acceleration (m/s^2)
R = Sleeve Length (m)
α = The angle of the pendulum before swinging (°)
β = Swing angle of the pendulum after breaking the specimen (°)

The impact price can be calculated by:

$$HI = \frac{E_{srp}}{A_o}$$

with :
HI = Impact's price (J/mm^2)
$E_{absorption}$ = Energy Absorption (J)
A_0 = Cross-sectional area (mm^2)

3 RESULT AND DISCUSSION

3.1 Research Results

From the results of the research that has been carried out, the value of the impact energy and the value of the impact strength of the hybrid composite is obtained from the comparison of each volume fraction variation shown in table 1.

Table 1: Hybrid Composite Impact Strength Test Results Data.

Volume Fraction Ratio	Sample	Impact Energy (Joule)	Impact Strength (J/mm2)
80:10:10	1	7.2	0.0566
	2	8.2	
	3	7	
Average		7.4667	
70:20:10	1	21.6	0.1576
	2	21.6	
	3	19.2	
Average		20.8000	
70:10:20	1	23.4	0.1525
	2	18.8	
	3	18.2	
Average		20.1333	
60:30:10	1	17	0.1111
	2	14	
	3	13	
Average		14.6667	
60:20:20	1	14	0.1313
	2	18	
	3	20	
Average		17.3333	
60:10:30	1	16	0.1217
	2	16.2	
	3	16	
Average		16.0667	

3.2 Discussion on the Impact Strength of Hybrid Composite

Table 1 shows the impact energy data and the impact strength of the hybrid composite shown in Figures 2 and 3.

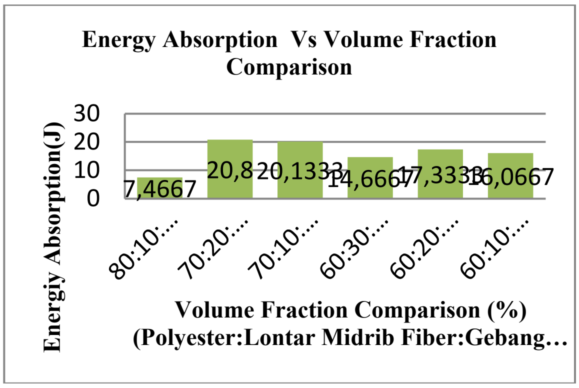

Figure 2: Graph of the correlation between Impact Energy and Gebang Midrib Fiber.

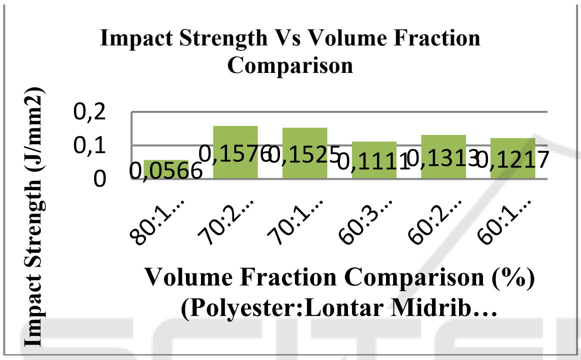

Figure 3: Graph of Impact Strength vs. Volume Fraction Comparison.

From Figures 2 and 3, the graph of the relationship between the impact energy value and the average impact strength with a comparison of the volume fraction variation of the hybrid composite, it is known that the highest average energy value required to break the hybrid composite specimen is 20.8 joules, obtained from the comparison Volume fraction variation is 70% polyester, 20% Pangkal Midrib Lontar Fiber (SPPL), 10% Gebang Midrib Fiber (SPG), and the lowest average energy value required to break the hybrid composite test specimen is 7.4667 Joules, obtained from the ratio of volume fraction variation is 80% polyester, 10% Lontar midrib fiber (SPPL), 10% Gebang midrib fiber (SPG)). The highest average impact strength value is 0.1576 mm2, obtained from the ratio of the volume fraction variation of 70% Polyester, 20% Lontar Midrib Fiber (SPPL), 10% Gebang Midrib Fiber (SPG), and the lowest impact strength is 0 ,0566 joules/mm2, obtained from the ratio of the volume fraction of 80% Polyester, 10% Lontar midrib fiber (SPPL), 10% Gebang midrib fiber (SPG). The comparison of the variation of the volume fraction of the matrix and the variation of the fiber type in the composite material affects the value of the impact energy and the value of the impact strength, where there is a significant increase in impact energy and impact strength along with the increase in the volume fraction of fiber and matrix. The optimum volume fraction ratio occurs at 70%. polyester, 20% midrib fiber and 10% midrib fiber.

There are several other supporting factors that influence the increase and decrease in the value of impact energy and impact strength, namely the adhesion between fiber and matrix, where a strong bond between fiber and matrix will be able to withstand the amount of energy transmitted from the matrix when it gets a sudden load. On the other hand, the weak bond between the matrix and the fiber, so when it gets a sudden load, the absorption energy received will decrease.

3.3 Macro Photo of Composite Fault Surface

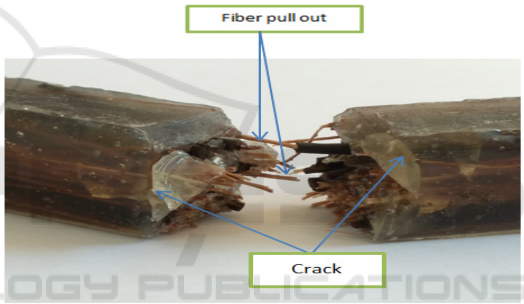

Figure 4: Hybrid Composite 80% Polyester, 10% LMF, 10% GMF.

From Figure 4 macro photos of composite material fractures, it can be seen that there are cracks in some parts of the specimen and there is a fiber pull out mechanism in some parts of the composite material. From Figure 5, it can also be seen that there is a fiber pull out mechanism on the fracture surface of the material, where there are several fibers that are released from the matrix bond due to the adhesive power that is not too strong. Then the arrangement of fibers that are quite a lot and dense and evenly distributed in all parts causes the material to be able to absorb the energy given. The fracture pattern that occurs is brittle fracture, this can be seen on the fracture surface of the composite material which is quite shiny in some parts.

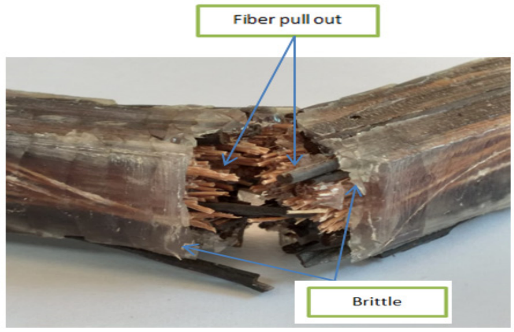

Figure 5: Hybrid Composite 70% Polyester, 20% LMF, 10% GMF.

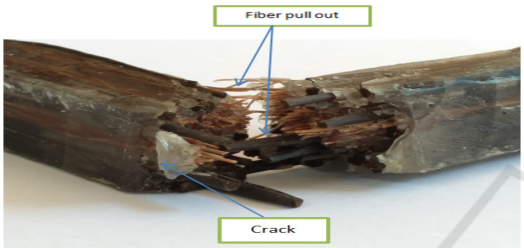

Figure 6: Hybrid Composite 70% Polyester, 10% LMF, 20% GMF.

From Figure 6, there are cracks in several parts of the fracture surface of the composite specimen and fiber pull out on the fracture surface. The fiber bonds are evenly distributed in all parts and have good adhesion. Then in Figure 7, cracks occur in the fibers in the composite material and also experience fiber pull out. The fracture pattern also tends to experience brittle fracture on the fracture surface of composite materials

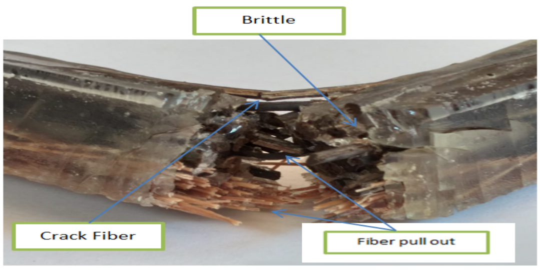

Figure 7: Hybrid Composite 60% Polyester, 30% LMF, 10% GMF.

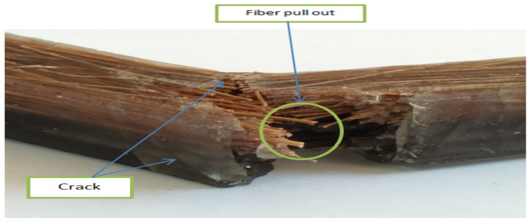

Figure 8: Hybrid Composite 60% Polyester, 20% LMF, 20% GMF.

From Figure 8, there are cracks on some parts of the surface of the composite material and fiber pull out also occurs on the fracture surface. The composition of the fibers is quite evenly distributed throughout the composite. From Figure 9, the fracture pattern that occurs is brittle fracture and also the occurrence of fiber pull out on the fracture surface of the composite material.

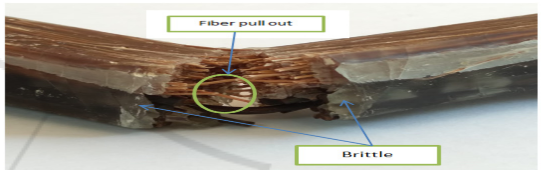

Figure 9: Hybrid Composite 60% Polyester, 10% LMF, 30% GMF.

4 CONCLUSION

There are variations in the volume fraction of polyester, palm stem base fiber and gebang midrib fiber in hybrid composite materials, it will affect the impact strength value. The maximum strength of the hybrid composite material, which is 0.1576 J/mm2, is in the volume fraction variation of 70% polyester, 20% SPPL, 10% SPG. The lowest composite material strength is in the volume fraction variation of 80% polyester, 10% SPPL, 10% SPG, which is 0.0566 J/mm2. The fracture pattern that occurs in the hybrid composite material is brittle fracture.

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