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The influence of *Arenga pinnata* fibres – reinforced orientation on tensile and fextural strength of epoxy matrix based composite

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The influence of *Arenga pinnata* fibres – reinforced orientation on tensile and fextural strength of epoxy matrix – based composite

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Abstract. The purpose of this study is to determine the tensile and flexural strength of Arenga pinnata fibres-epoxy as composite material. The Arenga pinnata fibres were soaked in 5 % NaOH solution for 2 hours. The specimens of the composite were prepared with different orientations Arenga pinnata fibres (i.e. 0° + 0°, 0° + 45°, 0° + 90°, and 45° + 90°). The Arenga pinnata fibres were mixed with epoxy and hardener also at the fibres volume percentage of 40%. The hand lay-up (HLU) process in this experiment was to produce a specimen test. The dimension of the specimen test for the tensile and flexural test was adapted from the ASTM D-3039 and ASTM D-7090 03 respectively. Results from the tensile test and flexural test of Arenga pinnata fibres reinforced epoxy composite, show the orientation 0° + 0° has the maximum of tensile and flexural strength, which are the value of tensile and flexural strength are 77.385 MPa and 76.38 MPa respectively. The tensile test shows that the fibres orientation parallel to the tensile force will give a maximum strengthening effect. The bending test shows that the orientation of the fibres across the compression force will produce maximum flexural strength.

1. Introduction

The current development of technology engineering is not only aimed at helping mankind but must consider environmental aspects, even many countries in the world seek to make environmentally friendly products without reducing the purpose of the initial product created. Environmentally friendly materials have easily recycled properties, are degradable, easy to obtain, not corrosive, environmentally friendly, and support policies on environmental regulations and waste [1-7]. Eco-friendly material uses One of them is in the manufacture of composite, the type of environmentally friendly material used in the form of fibre sugar palm (Arenga Pinata), the fibre is obtained from palm sugar trees which are found in Southeast Asia such as Indonesia, Malaysia, and Myanmar, the tree is often used for construction materials, sugar, sago, alcohol, and others [8].

The use of fibre sugar palm (*Arenga pinata*) on composite in making automotive components such as door panels, trim panels. And several other applications on construction in the form of panels, bulkheads, etc. [9]. The mechanical strength of fibre with a single fibre is the tensile strength of 190.29 MPa, Tensile modulus 3.69 GPA, and strain 19.6% [10], One treatment for cleaning the surface of the fibre, namely with the treatment of alkali, so that there is an adjure bond between fibre sugar palm with a polymer matrix [11-12], besides that several variations can increase the mechanical strength, namely: composition of coupling agents-hardener, fibre angle orientation, and type of coupling agents [1]. Fibre sugar palm is often used as a groin wrapping material of wood planted in the soil to slow down the weathering of wood and prevent termites, This study uses sugar palm fibre as an reinforced while the matrix uses epoxy resin, Its applying to make a motorbike body, from research that has been done using polyester resin is obtained with tensile strength value of 27.09 MPa [13]. This research focuses on the effect of the direction of fibre sugar palm (Arenga Pinata) against tensile strength and bending, with the type of coupling agents, namely epoxy, to compare tensile strength from previous research using polyester resin in the application of motorbike body.

2. Experiments

The material used in this study is the fibre sugar palm that has been soaked in a 5% NaOH solution for 2 hours and epoxy matrix type Bisphenol A and Hardener type polyaminoamide brand epoch on. Percentage of 40% fibre volume and 60% epoxy resin. The variation in the direction of the fibre used is 0° + 0°, 0° + 45°, 0° + 90°, and 45° + 90°. Test bending and tensile test using the Hydraulic Universal Testing Machine (UTM) servo tool capacity of 600 KN. Bending test standards (Three-point bending methods) use ASTM D-790 03 [14] with dimensions of 150 mm x 25 mm x 6 mm and tensile test standards using ASTM D-3039 [15] with dimensions of 250 mm x 25 mm x 6 mm specimens. This specimen can be seen in figures 1 and 2.

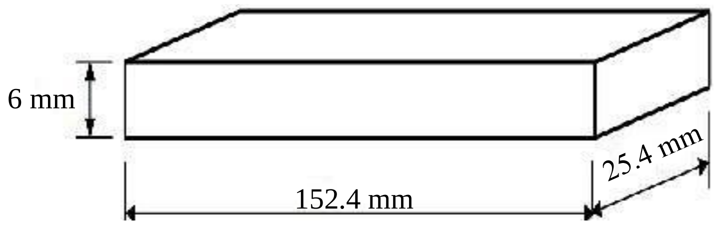

Figure 1. ASTM D-790 03 Bending Test Specimen

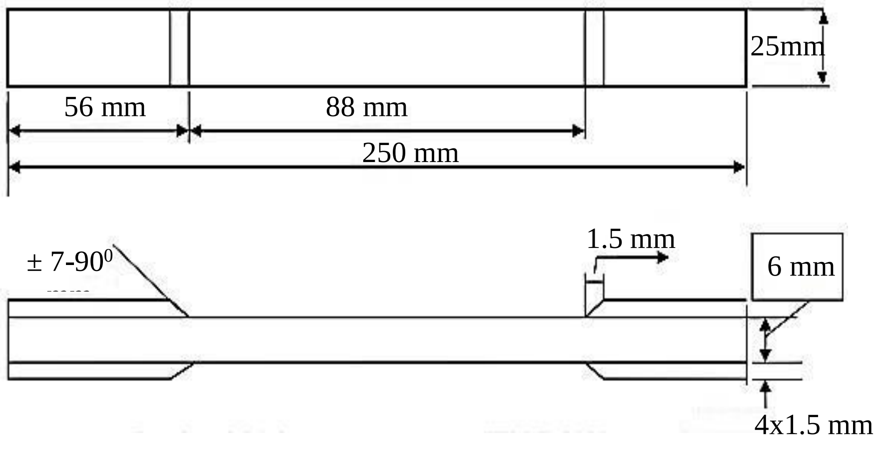

Figure 2. ASTM D-3039 Tensile Test Specimen

The equation for calculating bending strength [14]:

$$\sigma_b = \frac{3\ PL}{2\ bd^2}. \quad (1)$$

Description:
σ_b = Bending strength (MPa)
P = Pressure (N)
L = The distance between 2 spans (mm)
b = Specimen width (mm)
d = Specimen thickness (mm)

The equation to calculate the modulus bending elasticity [14]:

$$E_b = \frac{L^3\ x\ m}{4x\ b\ x\ d^3} \quad (2)$$

Description:
E_b = Modulus bending elasticity (GPa)
L = Distance 2 support span (mm)
b = a width of test specimens (mm)
d = Thickness specimens (mm)
m = Slope intentional tangent on deflection load curve (N/mm)

The equation to calculate maximum tensile strength [15]:

$$\sigma_t = \frac{P^{max}}{A} \quad (3)$$

Description:
σ_t = Maximum tensile strength (MPa)
P^{max} = Maximum tensile force (N)
A = Cross-sectional area (mm)

Modulus tensile elasticity can be calculated by the equation [15]:

$$E_t = \frac{\Delta\sigma}{\Delta\varepsilon} \quad (4)$$

Description:
E_t = Modulus tensile elasticity (GPa)
$\Delta\sigma$ = Difference value between 2 stress points (MPa)
$\Delta\epsilon$ = The value between 2 long added points

3. Result and discussion

3.1. Bending and modulus of bending elasticity

The results of the bending strength and modulus of bending elasticity from the fibre composite can be seen in Figures 3 and 4.

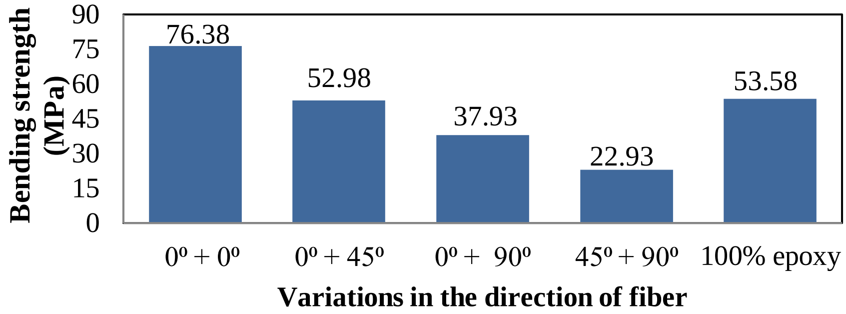

Figure 3. Graph of composite bending strength

Figure 3 shows the strength of composite bending with the influence of variations in the direction of the fibre to the strength of the composite bending, where the bending power of the variation in the direction of fibre 0° + 0° resulted in the largest average bending value of 76.38 MPa.

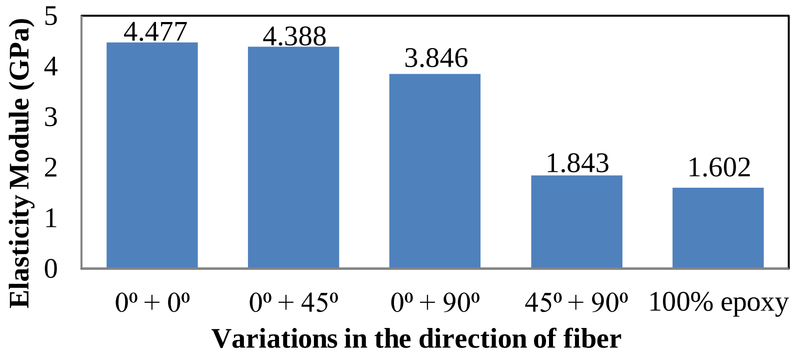

Figure 4. Graph Modulus Composite Bending Elasticity

Figure 4 shows the value of the modulus of composite bending elasticity with the effect of variations in the direction of fibre to the modulus value of the composite bending elasticity, where the modulus value of the bending elasticity of the variation in the direction of fibre 0° + 0° resulted in the average value of the largest bending elasticity which is 4.477 GPA, from the data The fibre forms the direction of 0° or increasingly perpendicular to the press section of the press, then the value of the strength and modulus of bending elasticity will be higher

The data shows the largest strength and modulus of bending elasticity exist in the orientation of 0 ° + 0 ° with a value of 76.38 MPa and 4.477 GPA. This shows the strength and modulus of bending elasticity in this study is higher if compared to previous research of Widodo et al. [1]

3.2. Tensile strength and modulus of tensile elasticity

The result of tensile strength and modulus of tensile elasticity from the fibre composite of the fibre can be seen in Figures 5 and 6.

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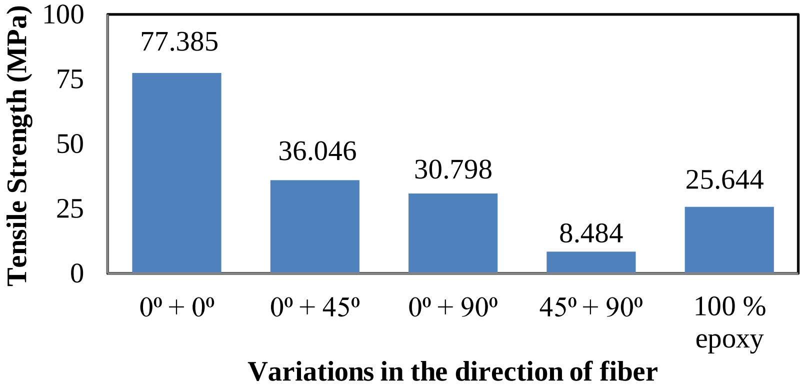

Figure 5. Graph of composite tensile strength

Figure 5 shows composite tensile strength with the effect of fibre direction variations to composite tensile strength, where the tensile strength of the variation in the direction of fibre 0° + 0° produces the largest average reduction value of 77.385 MPa

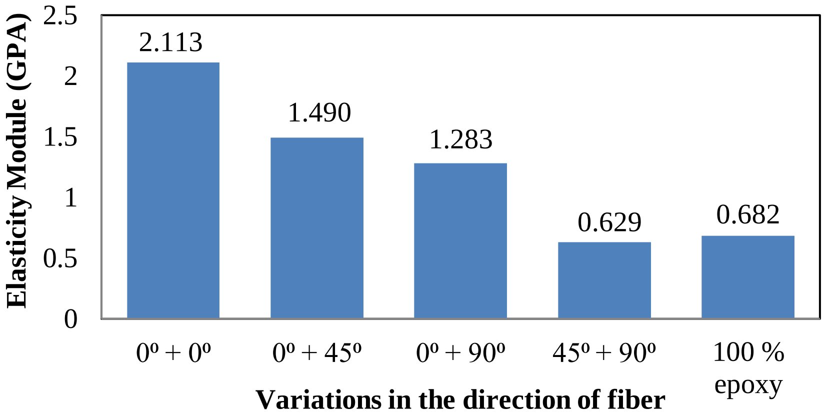

Figure 6. Graph of composite tensile elasticity

Figure 6 shows the modulus value of composite tensile elasticity with the effect of variations in the direction of fibre to the modulus value of composite elasticity, where the modulus value of the tensile elasticity of the variation in the direction of fibre 0° + 0° produces the average value of the modulus of the biggest tensile elasticity which is 2.113 GPA.

The dat shows the biggest tensile strength is in orientation 0 ° + 0 ° with a value of 77,385 MPa. This shows that the tensile strength in this study is higher than previous research of Bachtiar et al. [5]

3.3. Comparison of tensile test results with motorcycle body made from resin polyester

The results of this study are compared with the results of existing research where the research is also the application to make a motorcycle body, from research that has been carried out using a polyester resin obtained a value of tensile strength of 27.09 MPa [13], still below the existing comparison material, which is equal to the highest tensile strength with an orientation of fibre 0° + 0° with value 77.385 MPa. To find out the comparison of the value of test results with research that has been done, it can be seen in the figure 7.

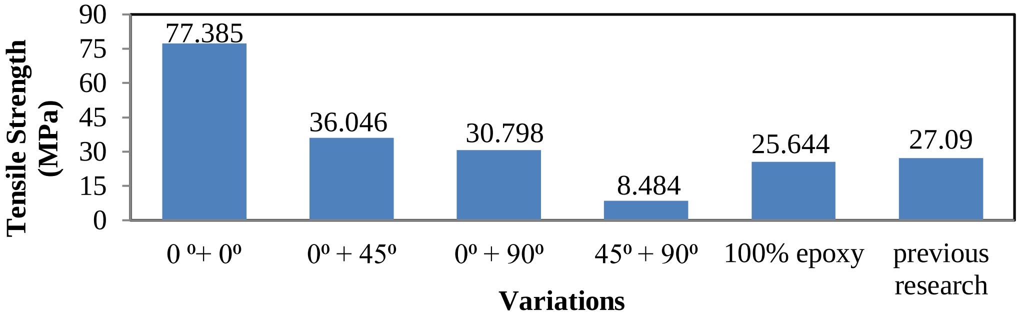

Figure 7. Graph Comparison of Tensile Strength on Body Motorcycle Made from Polyester Resin

Based on Figure 7 it can be concluded that variations in the direction of fibre $0^0 + 0^0$, $0^0 + 45^0$, and $0^0 + 90^0$ the value of tensile strength is greater than the previous research of Samlawi et al. [13], it is feasible to be attended by the alternative motorbike body.

4. Conclusion

Based on research from the bending strength and tensile strength of Arenga Pinnata fibre composite shows the highest results of the orientation of 0° + 0° with the value of bending strength and tensile strength, 76.38 MPa, and 77.385 MPa. The fibre forms the direction of 0° or increasingly perpendicular to the press sectional field, the strength value and modulus of bending elasticity will be higher, when compared to previous research, it can be used as an alternative material for making a motorbike body.

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