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Natural composite of Albizia-Ramie: Effect core pre-heating, and resin type on mechanical properties

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Abstract. In this work, natural composite is made from core of Albizia wood and matrix of ramie fiber. Hand lay-up method is applied to fabricate the composite. Albizia-Ramie composite are made in different ramie layer, i.e. single layer and double layer. The aim of this work is to investigate an effect of core pre-heating and resin type on mechanical properties of the composites. For each variation, 5 samples are tested in Universal Testing Machine and the average of bending stress, bending strain, and Modulus elasticity of the composites are analyzed. The result shows that the use of Albizia pre-heating and Epoxy resin improves the properties of bending stress and stress of the Albizia-Ramie composites.

1. Introduction

Indonesia has huge potential for application of wind turbine based energy conversion system. However, high cost of wind turbine investment and installation are found the problem of this application in rural area. In order to encounter the cost problem, many efforts have been performed, i.e. replacing metal wind turbine propeller with composite based wind turbine propeller. Natural composite, one of many attractive composite materials, is very interesting material for small scale wind turbine propeller.

Suizu, et al. [1] has investigated the use of ramie fiber reinforced materials to produce eco-friendly and strong material. The ramie fiber able to increase composite tensile stress up 2 to 3 time compared with composite without ramie fiber. Other natural fiber of Kenaf was investigated by [2]. Randomly increasing Kenaf fiber content can improve tensile strength and modulus of the composite. Karnani et al [3] have compared Kenaf-Polyester composite with Kenaf-PP composite. The Kenaf composites - polyester in the study had better tensile properties than the composites of Kenaf – PP. Furthermore [4] developed a sandwich composite with Albizia as a composite core. Meanwhile, the effect of life cycle of wood fiber reinforced composites (fiber reinforced wood) and polypropylene on the environment have been observed by Xu, et al. [5]. The test showed that wood fiber-reinforced composite is more environmentally friendly than polypropylene. In the same volume of material, the composite material has a density lower than polypropylene.

Mechanical properties is important parameter in utilization of composite material. The properties, such as bending stress, strain, elasticity, and also volume fraction of fiber in composite have to figure out. Following calculation are used to calculate bending stress, strain, modulus elasticity, and fiber volume fraction, respectively.

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



$$\varepsilon_f = \frac{6Dd}{L^2} \quad (2)$$

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

$$V_f = \frac{\left| V_c - \frac{M_c - M_f}{Q_M} \right|}{V_c} \quad (4)$$

From previous work, only a few observation on effect of core pre-heating and resin type on mechanical properties of the composites have been reported. Hence, this work aims to investigate effect of core pre-heating and resin type on mechanical properties of Albizia- Ramie composite.

2. Methodology

Natural composite is fabricated from *Albizia falcata* wood, ramie (*boehmeria nivea*) fiber, and resin. The Albizia is used as a core of composite and ramie fiber is utilized as composite matrix. The core are varied by unheated and pre-heating. Meanwhile, variation of resin type are Polyester and Epoxy. Hand lay-up method is used in the fabrication. Figure 1 displays fabrication and the sample of single and double ramie layers composites. The samples are tested to investigate their mechanical properties (bending stress, bending strain, and modulus elasticity) of the composite. The tests are conducted at Laboratory of Material Testing-IST AKPRIND Yogyakarta as shown in figure 2. The results are compared to figure out the effect of core pre-heating and resin type on the mechanical properties of the composites.

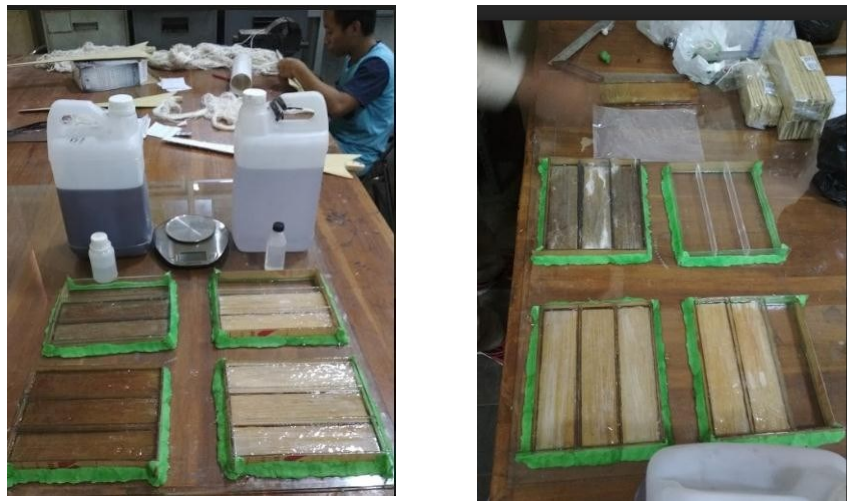


Figure 1. Fabrication of Albizia-Ramie composite.



Figure 2. Experimental work.

3. Results and Discussions

Materials used in this study consisted of 1) Albizia wood as a composite core having mechanical properties: strain of 0.44% and tensile stress 48,927 MPa [6]; 2) Ramie (*Boehmeria nivea*) for reinforcing fibers which has a tensile strength of 206.3 MPa; 3) Whereas polyester resin is used for matrix and has tensile strength 63,2 MPa [7]; and epoxy resin which has tensile strength 85 MPa [8]. In general, the bond strength between matrix and fiber for polyester and epoxy is relatively similar with the research done by [9]. The bond of polyester glass and epoxy were 70 MPa and 70 MPa, respectively [10]. Figure 3 to figure 5 show effect of Albizia pre-heating on the mechanical properties of the composites. Albizia pre-heating in the oven increase bending stress and bending strain of single layer composites and double layer composite. Meanwhile, modulus elasticity improves with pre-heating on single layer composite. But the value reduces for double layer composite. This is due to slow freezing of second layer in the double composite, hence between first layer and second layer is non homogeneous as follows:

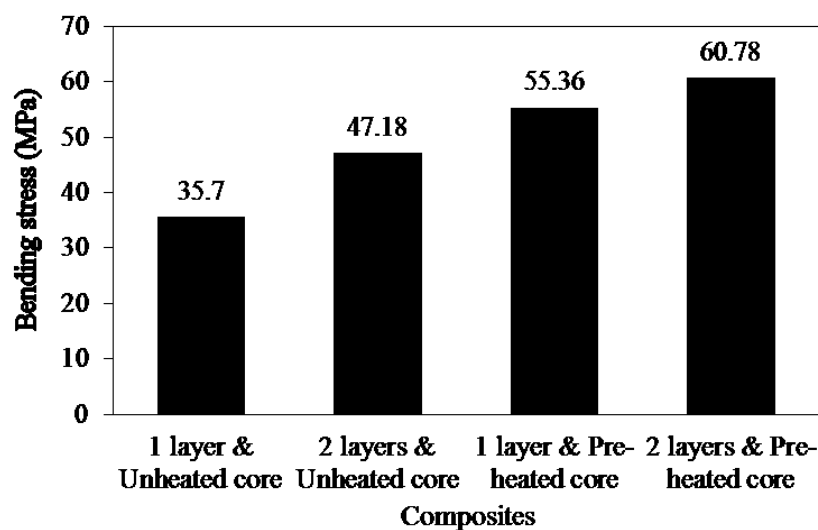


Figure 3. Effect of Albizia pre-heating on bending stress.

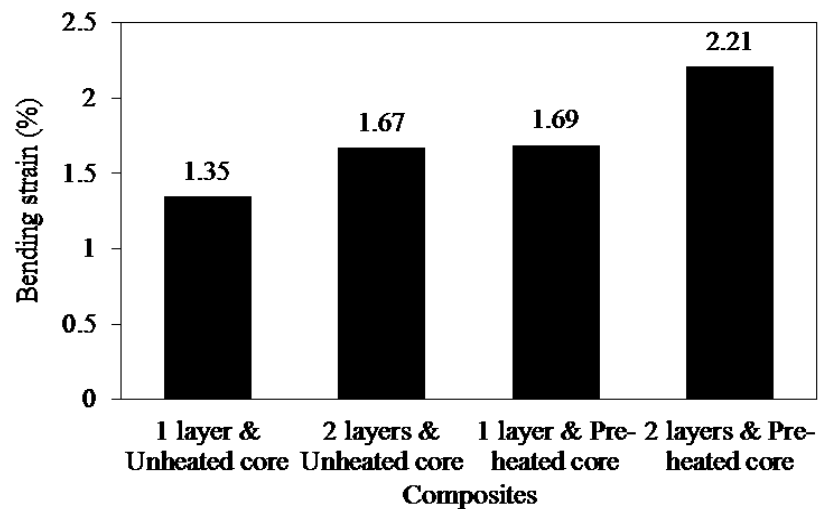


Figure 4. Effect of Albizia pre-heating on bending strain.

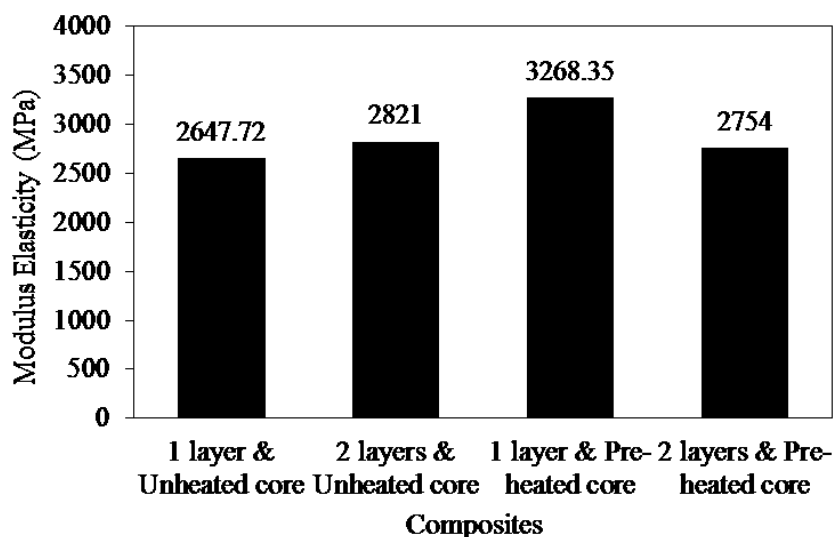


Figure 5. Effect of Albizia pre-heating on Modulus Elasticity.

Effect of resin type on the mechanical properties of the single layer and double layers composites are given in figure 6 to figure 8. The Figures indicate that bending stress and strain are higher with the use of Epoxy resin. On the other, Modulus elasticity is lower when Epoxy resin is used. The trend of modulus elasticity indicates that slow curing occur on the second layer of double composite, thus between first layer and second layer is non homogeneous. Typically as can be observed from figure 5 to figure 8 the double layer composite has higher bending stress and strain. In double layers composite, more ramie and resin are used thus increase the mechanical properties.

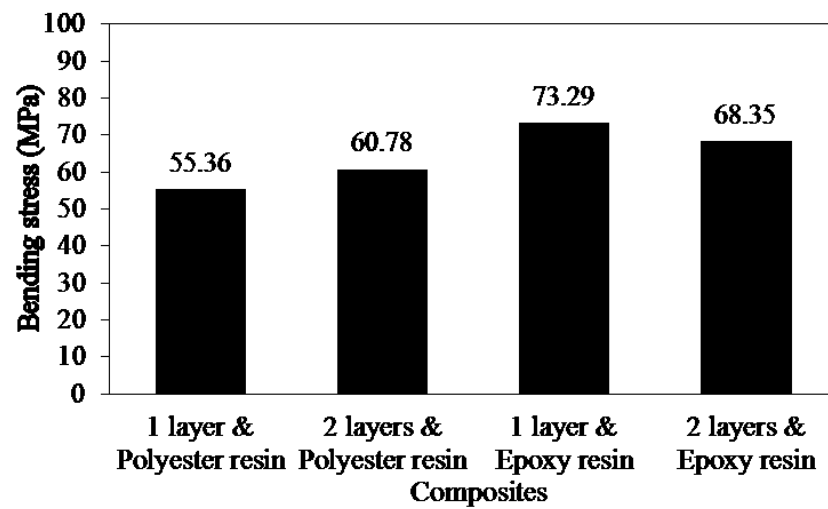


Figure 6. Effect of resin type on bending stress.

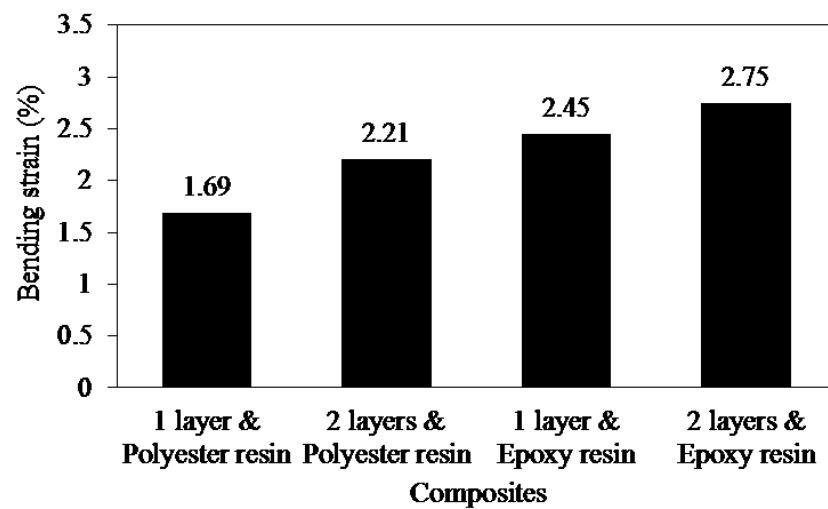


Figure 7. Effect of resin type on bending strain.

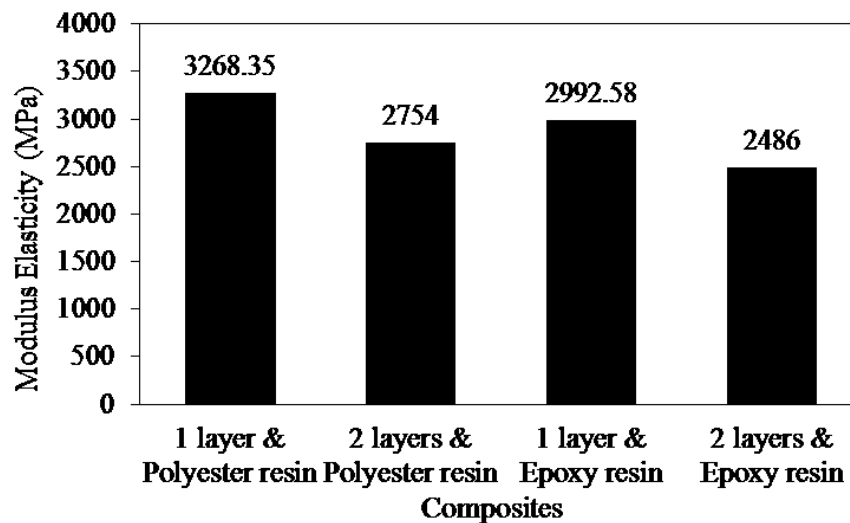


Figure 8. Effect of resin type on Modulus elasticity.

4. Conclusions

It can be concluded that hand lay-up method is applicable for fabrication of Albizia- Ramie composite. The properties of bending stress and stress of Albizia-Ramie composite can be improved with pre-heating Albizia wood prior to fabrication and the use of Epoxy resin as well.

Acknowledgements

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