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Effects of Fiber Orientation Variation on Tensile Strength of Bamboo Fiber Reinforced Composite Using Polyester Resin Type Bqtn-157-EX

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ABSTRACT
This article presents the results of investigations on composite materials reinforced with natural fibers from bamboo trees with variations in fiber direction. Because of the promising potential of the bamboo plant where its availability is abundant and sustainable, research on the mechanical properties of bamboo fiber is still very interesting to do to gain the maximum of it potential. Bamboo fiber is extracted from bamboo stems by beating. Treatment with soaking in 5% alkaline for 120 minutes was carried out before the specimen was made using an epoxy resin matrix. The process of making composite materials is carried out using the resin infusion method. Composition Specimens were prepared with a volume fraction of 40% and 60% for resin and fiber, respectively. And variations in fiber direction are set at 30, 45, and 60 degrees. The characteristics of the mechanical properties were obtained by testing the dance using a universal testing machine, while the bond characteristics between the matrix and the fibers were observed through micro-observation using the SEM tool. The specimen in a fiber orientation of 30° performs the strongest tensile strength of 165.9 MPa.

Keywords: *Composite Material, Natural Fiber, Bamboo, Fiber.*

1. INTRODUCTION

Due to their differences from metal materials, which have a greater strength to weight ratio than composite materials, the latter are more often used in the industry. Natural fiber reinforcing has just started to take over in a variety of sectors.

Additionally, they have great impact strength, low density, a medium weight to strength ratio, and good mechanical properties. Shireesha [1] has comprehensively reviewed the most recent findings in research on the mechanical characteristics of natural fibers and their application, highlighting numerous areas with room for growth. Since cellulose is the primary component of natural fibers, each form of natural fiber has a unique constituent content, including cellulose, lignin, pectin, and other elements, giving each type of natural fiber a unique set of mechanical and chemical characteristics. The principal components of bamboo have been thoroughly examined by Rusch et al [2] in the form of Cellulose, Hemicellulose, Lignin, and Carbon. Due to its biodegradability, the primary issue with Biocomposites materials is a lack of interfacial bonding [3]

The development of polymer composites with outstanding mechanical properties, cheap cost, wear resistance, and recyclable nature has attracted numerous researchers, engineers, and scientists in recent years. One such material is composite reinforced by natural fibers, particularly bamboo fiber. [4]. Manalo et al [5] has treated the fiber by 6% alkali and tested it at different temperature resulting the significant improvement of stiffness up to 25%. In other studies, coconut fiber is used to fortify composite materials. Coconut fiber contains cellulose (27.95 wt%), lignin (41.03 wt%), hemicellulose (19.78 wt%), attractive (8.60 wt%), and ash (1.30 wt%). [6]. To improve the performance of natural fibers used as reinforcement in polymer composite products, a special chemical treatment is required. The chemical shift has an immediate effect on the fibers' structure and composition. The fiber's ability to bind with the matrix's components is improved since it is less likely to absorb moisture. Better mechanical and thermal properties for fiber and composite materials are reported by Abdelmouleh et. al. [7]. Bisanda and Ansell described the physical and mechanical characteristics of epoxy composites reinforced with sisal fiber.[8]. The mechanical behavior of the composite is improved by the bonding at the fiber interface, and as a result, the matrix is higher. As a result of the matrix's straightforward transfer of the load to the fibers [9]. The mechanical testing showed that Dendrocalamus Asper and Bambusa Vulgaris had the greatest endurance under compression and the highest tensile strength, followed by Gigantochloa Scortechinii and Schizostachyum Grande.[10]. The hybrid FRP composites with a 45° orientation shown high tensile strength and the other combinations with 0°/90° orientation and pure bamboo with 0°/90°, 45° orientation, exhibited a very large increase in tensile strength. [11]. According to Boopathi et al [12], the 5% alkali-treated fibers had higher tensile strength and tenacity values than the raw, 10%, and 15% alkali-treated fibers. It was discovered that the 5% alkali treated fibers had higher tensile strength than the raw, 10%, and 15% alkali treated fibers. The toughness value for fibers treated with 5% alkali was greater. The tensile and impact strength of zalacca midrib fiber-HDPE composites was improved by fiber orientation, with 0^o fiber orientation achieving the highest value and 90^o fiber orientation achieving the lowest value [13]. The angles of the fiber orientation have a significant impact on the composites' Young's modulus. Young's modulus achieves its lowest value for experimental instances when the fiber orientation angle is around 45, and for numerical and analytical cases when the fiber orientation angle is around 60. This is due to two factors: (1) the material properties for analytical, simulational, and experimental cases are not quite the same; and (2) numerous factors affect the experimental case's outcomes. However, the model is condensed, and some situations are perfect for simulation and analysis [14]. Kumar and Prakash [15] have demonstrated the effect of the $0^0/90^0$ combination, the fiber orientation of ±45 yield increased ultimate tensile strength and flexural strength. According to the literature, most researchers have failed to provide a clear report on the influence of fiber orientation effects, particularly for Bambusa blumeana fiber. The current study of 0^0, 90^0, and 45^0 on vacuum infusion composites

2. MATERIAL AND METHOD

Bamboo fiber (figure 1) served as the primary reinforcement material. To make composite samples, the resin infusion technique was used. The samples were prepared in accordance with ASTM testing standards. Tensile testing was performed at a test speed of 2 mm/min in accordance with ASTM D638 standards. The materials used in this study, as well as the methods used to process these materials. Epoxy Resin, Bamboo Fiber, and Hardener are the materials used in the current study. Resin infusion is the process of drawing resin into a dry laminate while a sealed flexible membrane holds it under vacuum against a rigid mould. The most common membrane is a disposable film (vacuum bag) that is sealed against the mould edges with sealant tape.

Figure 1 Bamboo fibers from different type of bamboo

Sodium hydroxide (NaOH) pellets were dissolved in distilled water to make an alkali solution. The alkali concentration was varied from 3 to 7% by weight. Alkali concentration was determined based on fibre quality, desired properties, growing area, and climatic conditions. When exposed to higher concentrations, these fibers may degrade. As a result, the alkali concentration was limited to a maximum of 5% by weight.

The bamboo composite plates were then cut into specimens in accordance with ASTM standards. The specimens were made as templates in GI sheets and are drawn on the plates with appropriate angles to obtain different orientations. The plates are then cut into different angles using a milling cutter along the fiber orientation, such as 0°, 90°, or 45°, as shown in figure 2. Tensile tests on bamboo composites were carried out using a computerized servo-controlled UTM machine and specimen standard ASTM D 3909, as shown in figure 3. The cut specimens were mounted in the UTM, and the gauge length and cross head speeds were set to 5 and 2 mm/min, respectively.

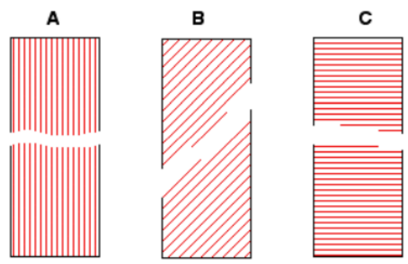

Figure 2 Ilustration of fiber orientation A= 0, B =45, and C = 90

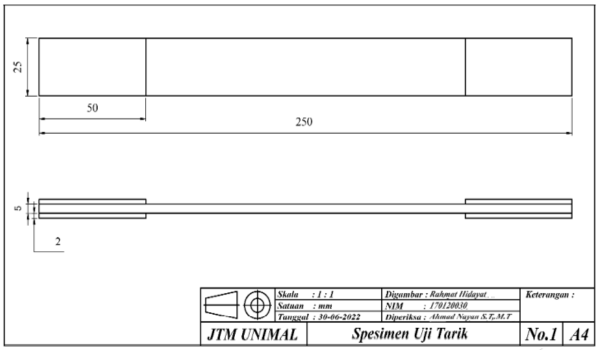

Figure 3 Spesimen Dimension and geometry

3. RESULT AND DISCUSSION

Tensile testing was performed following the fabrication of bamboo fiber composites with BQTN 157 EX polyester resin to determine the magnitude of the tensile strength of composites with different volume fractions on bamboo fiber reinforced composites. A universal machine testing machine is used for tensile testing.

Based on the results of the tensile test on bamboo fiber reinforced composites with alkaline treatment (5% NaOH) optimization of the fiber volume fraction of 20%, with woven variations of 0, 45, and 90 with tensile stress, tensile strain, and The elastic modulus results are shown in Tables 1 through 3.

Table 1. Tensile test result for 0° fiber orientation

Table 2. Tensile test result for 45° fiber orientation

Table 3. Tensile test result for 90° fiber orientation

Based on the results of a tensile test performed on three test specimens with a composite volume fraction of 20% and a webbing variation of 0˚. Test specimen number 3 has the lowest tensile strength of 25.91 MPa and the highest yield strength of 8.82 MPa. Test specimen number 2 has the highest tensile strength of 120.09 MPa and the lowest yield strength of 72.52 MPa. Tensile strength is 83.10 MPa on average, and yield strength is 49.98 MPa on average. The tensile test results for bamboo fiber specimens with a volume fraction of 20% and a webbing variation of 45˚.

Tensile testing on three test specimens with a composite volume fraction of 20% and parallel variations yielded the following results. Test specimen number 1 has the lowest tensile strength of 154.73 MPa and the highest yield strength of 84.28 MPa. Test specimen number 3 has the highest tensile strength of 159.60 MPa and the highest yield strength of 70.56 MPa. Tensile strength is 165.91 MPa on average, and yield strength is 82.32 MPa on average. The graph below depicts the relationship between tensile strength and fiber volume fraction of 20% with 0, 45, and 90 webbing variations.

4. CONCLUSION

Composites reinforced with bamboo with a volume fraction of 20% and woven 0˚, 45˚, and 90˚ fibers have the highest tensile strength in the parallel fiber arrangement with an average value of = 165.9 MPa and tensile strain = 82.32%. The arrangement of 45˚ woven fibers has the lowest tensile strength, with an average value of = 49.36 MPa and a tensile strain of = 49.98%. The tensile strength of the composite has decreased with an average value of = 83.1 MPa, tensile strain = 49.98% in the arrangement of 0˚ woven fibers.

AUTHORS' CONTRIBUTIONS

Ahmad Nayan and Teuku Hafli conceived of the presented idea. Ahmad Nayan developed the theory and performed the experimental process and reporting. Teuku Hafli supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

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