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MECHANICAL BEHAVIOR OF POTENTIALLY KAPOK HYBRID COMPOSITES IN FIBREGLASS BOAT

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ABSTRACT

The aim of this research is to study the mechanical behavior of natural fiber kapok with fiberglass. In this research, the weight of the kapok is determined by the weight ratio of 1:20 of the woven roving fiberglass weight. The condition of the woven roving and kapok in variation of proper sequence on top of another layer by layer. The sample is then being tested to determine the best mechanical properties of the sample compare to raw fiberglass composites. The sample were undergoing tensile test, impact test and flexural test. The surface morphology properties were done with Scanning Electron Microscopy (SEM). The mechanical properties (flexural strength, flexural modulus, tensile strength) were found to increase as the fibre content and layer increased. Composites loaded with higher fiber content and layer have better fiber-matrix interfacial bonding than those with lower fiber and layer loaded.

Keywords: kapok, chop strand matt, mechanical, composites.

INTRODUCTION

Natural fibers that usually comes from plants and animals plays an important role in our live, sometimes in an unexpected area such as engineering industry. Natural fiberscome from natural source has two types; cellulose from plants and synthetic fibers. Acrylic, polyester and nylon are examples for synthetic while cotton, kapok, and linen are natural fibers. With the intention of replacing synthetic polymer for marine application, extensive research has been carried out to find materials that eco-friendly, low cost and less weight. Natural fibers can be used many times as they not developing mound or decaying [6]. As the product cycle is usually carbon neutral, they do not contribute into global warming. They absorb the same amount of CO_2 as they emit. Unlike synthetic fiber that uses a great deal of energy, generating pollutants in the form of heavy metals that stay in the environment for a long time. Natural fibers are attractive to use as they are light and mechanically strong. They can be used to replace fiberglass in reinforce component. Moulding them into shapes using less energy than fiberglass can reduce production cost. Kapok is a tropical tree that came from the bombacaceae (Bombax Family) and the floss or commonly named fiber obtained from the seed in the ripened pods [5].The kapok fiber is obtained from the fruits of kapok tree [8]. Kapok chemically composed of 64% cellulose, 13% lignin and 23% pentosan on a weight basis [7].

As the kapok known as the natural fibre, a study is carried out to evaluate the mechanical and physical properties of kapok. In this project, kapok was used in substituting layers of Chopped Stranded Matt (CSM) and reinforce with resin, and fibre glass to produce a new hybrid composite by hand lay-up process. The mechanical properties were carried out by conducting several testing which are tensile test, impact testing, flexural, and Scanning Electron Microscopy (SEM). Thus, this study will determine the effectiveness of replacing kapok with CSM for marine application in future. As promoted by the government towards green technology. The main objective of this research is to investigate the strength and potential use of kapok fiber when hybrid with woven rooving in different layer of arrangement.

MATERIALS

Fiberglass type woven roving was used to manufacture composite laminates with kapok natural fiber. Kapok fiber was obtained from kuala kangsar Perak. A hand lay-up method was used to produce the composites as it is widely used in fiberglass boat construction. The weight of the resin and the ratio of the kapok weight percentages was based on the fiberglass which are woven roving types. The materials used in the preparation of composite flat panel represents in the following Table-1.

Table-1. Layers of raw composites materials for sample A.

Sample A (Yellow)	
Layer	**Weight (gram)**
Surfacing Tissue	3.0 gram
CSM 300	38.0 gram
Woven Roving	56.6 gram
CSM 450	52.0 gram
Woven Roving	56.6 gram
CSM 450	52.0 gram
Total Weight	258.2 gram

Table-2. Layers of kapok hybrid composites for sample B.

Sample B (Blue)	
Layer	**Weight (gram)**
1.Tissue kapok	0.67 gram
2.Thick Kapok	10.4 gram
3.Thick Kapok	10.4 gram
4. Woven Roving	56.6 gram
5. Thick Kapok	10.4 gram
Total Weight	88.47 gram

Table-3. Layers of kapok hybrid composites for sample C.

Sample C (Red)	
Layer	**Weight (gram)**
1. Tissue kapok	0.67 gram
2. Thin kapok	7.60 gram
3. Thin kapok	7.60 gram
4. Woven Roving	56.6 gram
5. Thick Kapok	10.4 gram
Total Weight	82.87 gram

Table-4. Layers of kapok hybrid composites for sample D.

Sample D (White)	
Layer	**Weight (gram)**
1. Tissue kapok	0.67 gram
2. Thin kapok	7.60 gram
3. Thick Kapok	10.4 gram
4. Woven Roving	56.6 gram
5. Thick Kapok	10.4 gram
6. Woven Roving	56.6 gram
7. Thick Kapok	10.4 gram
Total Weight	152.67 gram

COMPOSITE PREPARATION

Raw fiberglass

Chopped Stranded Matt were cut and weight to determine the type of CSM. 4 layers of surfacing tissue, 4 layers of CSM 300, 9 layers of CSM 450 and 6 layers of woven roving were weight and cut into 13 inches' x 13 inches mould dimension. A proper amount of resin, catalyst, gel coat and pigment were then prepared according to the ratio required. Mould were inspected and cleaned to ensure free from any form of particles. Wax were applied to the mould surface for best result of sample surfaces and easy to de-mould. A mixture of pigment and gel coat were applied to the mould area and waited approximately 60 minutes for the mould to completely dry. A mixture of resin was applied to the mould. 1 Layers of surfacing tissues, CSM, and woven roving were added layer by layer according to the weight ratio stated. Air bubble were released using roller. The mould were left for drying process at the room temperature. Finally, **s**amples were cut into 280 mm x 30 mm for mechanical testing.

Kapok hybrid preparation

Six Layers of woven roving were weight and cut into 13 inches' x 13 inches mould dimension. A proper amount of resin, catalyst, gel coat, pigment and kapok were then prepared according to the ratio required. Mould were inspected and cleaned to ensure free from any form of particles. Wax were applied to the mould surface for best result of sample surfaces and easy to de-mould. A mixture of pigment and gel coat were applied to the mould area and waited approximately 60 minutes for the mould to completely dry. A mixture of resin was applied to the mould. Layers of kapok and woven roving were added layer by layer according to the weight ratio stated. Air bubble were released using roller. The mould were left for drying process at the room temperature about 2 days. Finally, the samples were cut into dimension of 280 mm x 30 mm.

Figure-1. Dried up the sample on room temperature for two days.

EXPERIMENTAL

Scanning electron microscopy (SEM).

The surface morphology of the manufactured composite was examined by using a table top microscope (TM 3030, Hitachi Technologies Cooperation, Japan). The samples were coated with platinum and observed under the SEM. The micrographs were taken at a magnification of 100x and 300x.

MECHANICAL PROPERTIES.

Tensile test

The tensile test were conducted based on ASTM 3039 D with an electronic Shimadzu Universal Testing Machine. This machine has a loading capacity of 300kN. For each of the specimen, test was performed at a crosshead speed of 2 mm/min. The dimension of the specimen was prepared according to the ASTM 3039 D which is 250 mm x 10 mm. The specimen was labelled as specimen A, B, C and D.

Charpy impact test

The Charpy Impact Test were conducted following ASTM D611-10 by using a Charpy Izod Tester 300J machine. The result obtained based on the Charpy Impact Test Conversion Table. The dimension for each of the specimen was 55mm x 10mm. For each test, five of the replicates specimen were tested and average values were recorded.

Flexural test

Flexural test were conducted following the ASTM D 790-00 by using Instron 600 DX-600kN Universal Testing Machine. The specimen were tested with a cross head speed of 2 mm/min. For each of the specimen were prepared at the dimension of 100 mm x 10

ARPN Journal of Engineering and Applied Sciences

mm. five replicates sample were tested and the average values were recorded.

RESULTS AND DISCUSSION

Scanning electron microscope (SEM)

Microscope results in Figure-2(a) shows the crack propagation in composites with 1 layer of Kapok fiber loading. Extensive fibre fracture, fibre bridging and matrix fracture can be clearly observed. Such fracture mechanisms lead to enhance the mechanical properties in the composites. Figure-2(b) shows the fracture surface of composites loaded with Kapok fibres loading. It can be observed that composites loaded with higher fibre content show better fibre matrix interfacial bonding than those loaded with lower fibre content. Fibred bonding and gaps between fibres and matrix are more prevalent in composites with lower fibre content.

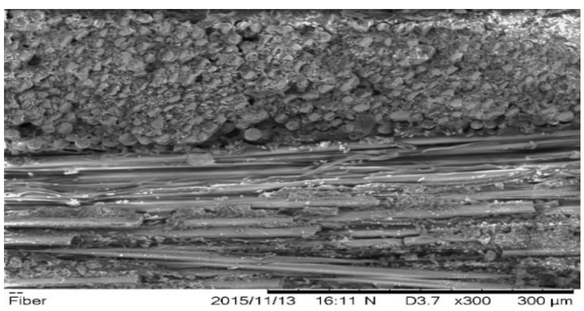

Figure-2. Composite sample A.

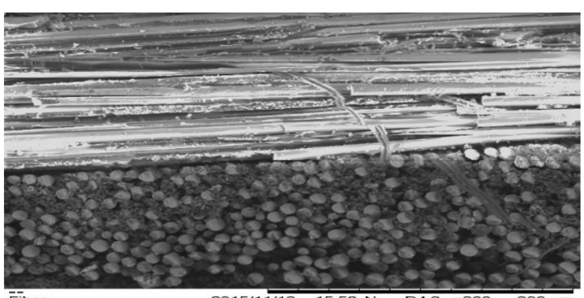

Figure-3. Composite sample D.

Tensile strength

Figure-4 shows the ultimate tensile strength of raw fibreglass and kapok hybrid composites at different fibre layers and loading. The results show that the sample D has the highest tensile strength with 47.46 MPa followed by sample A with 44.67 MPa and the lowest was sample B with 31.96 MPa. From the results obtained, it shows that at all specimen with higher fiberglass and kapok layer loading composite is greater than the lowest. The composites from sample D exhibit highest tensile strength because both kapok and fiberglass are long and have extensive contact areas that are available for better bonding (Somporn Chaiarrekij, 2011). The composites sample B made from 3 thick kapok layer and one woven roving exhibit the lowest tensile strength. The decreasing value of composite tensile strength is due to the improper fibre orientation and weak fibre/matrix interphase [1], [2].

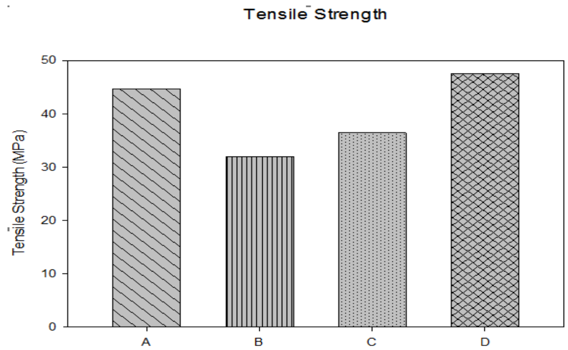

Figure-4. Tensile strength of kapok composites at different loading and layer.

Flexural test

The effect of kapok and fiberglass loading and layers on flexural properties is showed in figure 5. Flexural strength is found to increase as kapok layer and fiberglass layer increases. Flexural strength of sample D increases by 28% after addition of 3 layer of kapok fiber compare to others. These enhancement is in kapok/woven roving fibreglass/epoxy flexural strength is due to the capability of cellulose fiber to resist the bending force [2] and as a result of increased bonding at the fiber matrix interphase. The lower flexural strength at sample C may be attributed to the lower loads transferred from the matrix to the fibers, thus resulting in lower load carried by the composites [2]. The flexural modulus of sample D increased higher compare to other sample. According to previous research, the increase is due to the increase in fiber volume fraction increased in the composite [3].

The flexural modulus of composites were shown in Figure-6. The flexural modulus of composites increased as the kapok fiber were added into composite, showed the sample D exhibit higher compare raw and other samples. This results in accordance with the rule of mixtures due to the greater stiffness of kapok fiber comparing to that fiberglass. Similarly results were reported by others (Xiang Li, 2014).

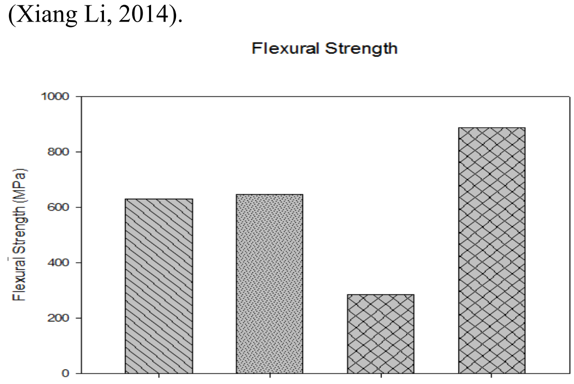

Figure-5. Flexural strength of kapok compositesat different loading and layer.

ARPN Journal of Engineering and Applied Sciences

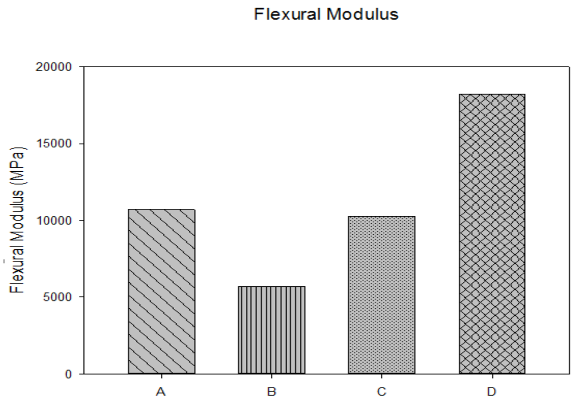

Figure-6. Flexural modulus of kapok composites at different loading and layer.

Impact strength

Impact strength is an important property that gives an indicator of the material toughness. The result in Figure-7 shows sample A, B, and C absorb similar energy at this impact energy level which is 290.97 J, while sample D exhibit the lowest at 287.79 J. This indicate material that absorbed less energy turns out to be brittle prior to fracture while tough material tends to absorb a lot of energy. Impact strength of the fiber is governing by the fiber-matrix interfacial bonding, and properties of matrix and fibers. When the composites undergo a sudden impact of force, the impact energy is degenerate by the combination of fiber pull outs, fiber fracture and matrix deformation [4].

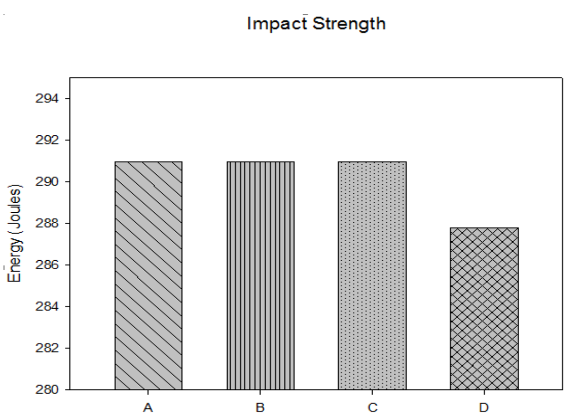

Figure-7. Impact strength of composites at different loading and layer.

CONCLUSIONS

The effect of the arrangement of kapok fiber and fiberglass on the morphology and mechanical properties of kapok/woven roving fiberglass has been investigated for marine application. The kapok fiber has been prepared to reduce the application of fiberglass in boat composites. The mechanical properties (flexural strength, flexural modulus, tensile strength) were found to increase as the fibre content and layer increased. Composites loaded with higher fiber content and layer have better fiber-matrix interfacial bonding than those with lower fiber and layer loaded. However, impact strength was found to decrease slightly at higher kapok fiber loading. Research in this article provides a new method to use and physically modify the kapok arrangement to reduce the application of fiberglass in boat preparation. The research allowed a better understanding of the strength and bonding mechanism in the variation of layer between kapok fibers and woven rooving. It has potential and useful in developing low-cost kapok hybrid fiber boat.

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