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THE MECHANICAL CHARACTERISTIC OF JUTE FIBER AND GLASS FIBER (HYBRID) AS REINFORCEMENT FOR POLYMER MATRIX POLYESTER IN HYBRID TABLE

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ABSTRACT

The present study of the hybridization of natural fibers (e.g jute) and glass fibre will promise better mechanical and physical properties of polymer matrix. The present study attempted to hybridize the jute fibre and glass fibre to be reinforced with polyester as biocomposite material in replace of the conventional composite materials. The application of biobased polyester as biocomposite matrix contributes to the development of “green” high performance materials. The mechanical characteristics in terms of tensile test and flexural strength were then compared after the reinforcement of jute fibre. Results showed that jute fiber reinforced polyester has high tensile stress to withstand maximum load at 11.30 MPa. The development of hybrid table with honeycomb proved it has higher tensile modulus than honeycomb alone. It means that it has higher flexure extension and lower flexure stress. The jute- honeycomb flexure result shows that its tensile modulus, 117.58 MPa was much higher than the honeycomb at 24.66 MPa. This hybrid table actual force can withstand up to 1164.32 N with two beams. The introduction of newly hybrid material, jute and glass fibre had proven can improve the mechanical properties of the biocomposite material.

Keywords: hybrid polymer; Polyester; tensile test; flexural test; actual force;

INTRODUCTION

Composites, the wonder material with lightweight, high strength-to-weight ratio and stiffness properties have come a long way in replacing the conventional material likes metal and woods. The uses of natural fibre as reinforced polymer composite have gained attention due to their environment, economic benefits and low energy consumption. One of the well-known natural fibre is jute which enjoy their excellent potential as wood substitute in biocomposite [1]. Jute, *Corchorus spp (Tilaceae)* is a bast fiber which is a long, soft, shiny fiber that can be spun into coarse, strong threads. Jute can promised biodegradable, cheap, non-toxic and environment-friendly [2].

Jute composite materials consist of jute fibers of high strength and modulus embedded in or bonded to a matrix with distinct interfaces (boundary) between them. Jute fiber for composites provides many advantages. Firstly, it has wood like characteristic but has much lower density 1.3-1.45 g/ccm which is suitable for production of lightweight material. Jute has high specific properties, less abrasive behavior to the processing equipment, good dimensional stability and harmlessness. Jute possess no threat to the environment which will not cause the problem like other synthetic material in the waste management cycles through emitting hazardous gases during incineration of landfill sites [3].

Most of the time, furniture was all made from materials such as wood or iron which have several limitations. They are easily broken and easily eaten by termites whereas metal furniture is easily rust and heavier. To be worst, it is also easily warping if exposed to water or some any other conditions. Meanwhile, if the synthetic fiber is used as reinforced in furniture production, it will involve of higher cost and not environmental friendly. Thus, industries are in constant search of new materials with promising lower costs and profit margins due to the challenges of petroleum based products and the need to find renewable resources. Natural fibers have cost and energy advantages over traditional reinforcing fibers such as glass and carbon. The hybridization of natural fibers will promise better mechanical and physical properties. Therefore, the aims of the present study are to evaluate the effect of the reinforcement of jute fiber in jute-glass fiber hybrid incorporated in polyester on their mechanical properties (i.e tensile strength and flexural strength) and to evaluate the actual force on the jute-glass fibre hybrid table.

EXPERIMENTAL

Materials and Apparatus.
Polyester, jute fiber mat, glass fiber, catalyst, and epoxy resin were used for hybrid table preparation which are purchased from local resources. Woven jute mat produce from tossa jute (*C.olitorius*) fibres. Honeycomb polypropylene was used to support the hybrid composite from the bottom. The table mould with dimensions (length: 1200 mm, the width = 570 mm and the depth = 14 mm) were prepared. The rollers, brushes, tupperware were additional tools used during hand layout process.

Biocomposite Fabrication.
In the biocomposite fabrication process, polyester was filled on the woven roving fabrics glass fibers using nip-roller type impregnators. The purpose is to increase forcing resin into the fabrics by means of rotating rollers and a bath of resin. After laminates, it was left to cure under standard atmospheric conditions. Impregnation of the reinforcement was done by hand using a roller or a brush. This operation was

repeated for each layer of reinforcement in order to obtain the desired thickness of the structure.

Biocomposite Furniture.
The mould cavity was coated with either polyvinyl alcohol or a non- silicon wax to aid of component release. The reinforcement was placed into or against the mould, and the resin was forced between the jute fibers by the use of brushes or rollers. The liquid resin (polyester) was poured over the fiber and rolled to ensure completely wetting of the fiber and removal air bubbles. Then, a few layer of glass fiber was put around the jute fiber mat layer to support the strength of jute fiber until desired thickness was obtained by repeating with layers of resin. Release was simply achieved by tapping wedges between mould and component or by the use of compressed air to gently force the pieces apart. A gel coat was applied to the mould surface to produce a resin rich smooth surface for aesthetic and environmental protection purposes.

Lay-Up Process.
Hand lay-up moulding was done by laying down fabrics made of reinforcement and painting with the matrix resin layer by layer until the desired thickness and controlled orientation quality was obtained. The jute and glass fiber were cut according to the shape of mould. Firstly, the resin and the hardener were mix before spread on the mould using brush or roller. The ratio was based on the volume percentages of resin to jute fiber at 70:30. The first layer of fiber reinforcement was then laid. This layer was wetted with resin and then softly pressing using a brush or a roller make the resin that was added in the previous step wick up through the jute fiber cloth until it was completely wet. At this stage, a second layer of jute fiber was added and special care must be taken to eliminate all air bubbles. This was accomplish by either rolling any air bubbles out with a small hand rolling tool or brushing out the air bubbles with a paintbrush. This step was repeated until the desired thickness was obtained. As the glass fibers layers were added to build laminate and total part thickness, the individual layer may be oriented at varying angle to accomplish specific strength in the direction of the reinforcement weave called ‘clocking’. The curing time was done using oven for 4-5 hours at a room temperature and then moved to an adequate location.

Mechanical Testing.
Tensile test and flexural strength on the hybrid table were conducted using the Universal Testing Machine (UTM) in American Standard Testing Materials, ASTM D3039. Tensile testing on composite was done in a thin flat strip of material having a constant rectangular cross section. It is mounted in the grips of a mechanical testing machine and monotonically loaded in tension while recording the force used to break a polymer composite of jute fiber and the extent to which the jute fiber stretches or elongates to that breaking point. A typical test speed for standard test specimens is 2 mm/min. Tensile test produce a stress-strain diagram, which is used to determine tensile modulus. The data was used to specify a material, to design parts to withstand application force and as a quality control chart of materials. At least five specimens were tested. Specimens were placed in the grips of a UTM at a specified grip

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separation and pulled until failure and the data obtained is the maximum load (N). Flexural test being conducted on simply supported beams of constant cross-section area using three-point test. The data obtained is extension at maximum load (mm). After that, actual force was calculated based on the equation 1:

$$\sigma_i = P_i / A \qquad (1)$$

where :
σ_i = tensile stress at *i*th datapoint, MPa [psi];
P_i = force at *i*th data point, N [lbf]; and
A = average cross-sectional area, mm^2 [in^2]

RESULTS AND DISCUSSION

Tensile Strength.

The addition of jute promoted a decrease in a tensile strength of the biocomposite. Tensile test on five samples of jute fiber reinforced polyester were represent by Sample 1, Sample 2, Sample 3, Sample 4 and Sample 5 as shown in Figure 1. Tensile test will show results which are tensile strain at maximum load, tensile stress at maximum load and tensile modulus.

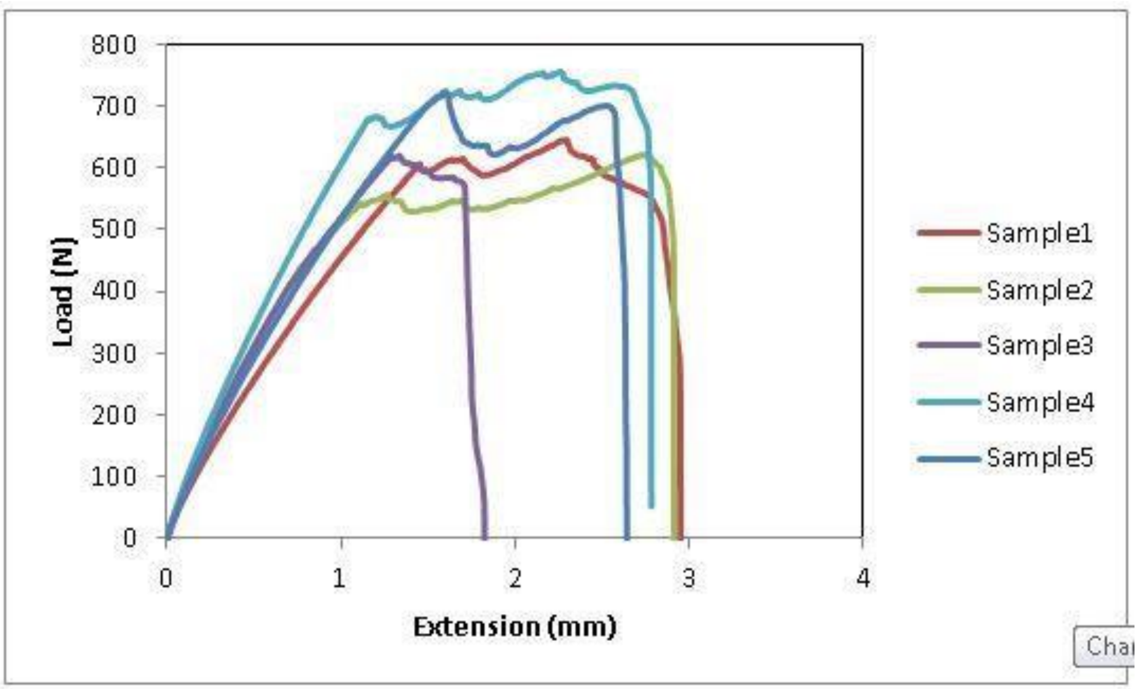

Figure 1: Overall Tensile Test Samples

Figure 1 shows that Sample 1 and 5 provide the best result of the tensile test among the others samples. Natural fiber reinforced polymer matrix composites are very sensitive to the influences from environment agents such as water. The tensile strength of the jute fiber is directly proportional to the cross sectional area of the fiber and delamination of layer is possible [4]. It is proved that jute reinforcement has a good ability to withstand the force been load on it as much as 674.37 N to the maximum during the tensile test. Moreover, the tensile test shows that the jute has high tensile stress to maximum load which is 11.30 MPa. The tensile properties seem to be influenced by the fibre volume fraction, matrix properties and the fibre/matrix bond strength [5]. The results of the mechanical properties of the jute-fiber and glass fiber (hybrid) reinforced polyester has showed that it have high potential to be used as fabrication material.

Fluxural Test.

The flexural test (bending) of jute fiber reinforced polyester was done on two different samples of hybrid table of honeycomb and jute-honeycomb. Sample thickness and width were taken around 9.85 to 9.95 mm and 49.30 to 50.00 mm. Flexural test of honeycomb has produced four kinds of results which are maximum load, flexure extension at maximum load, flexure stress at maximum load and modulus. The result of flexure extension at maximum load gives the mean average of 10.82 mm. The mean average of flexure stress at maximum load is 0.98 MPa. Based on the results, the stress is increasing with the strain until it reaches the maximum load at 28.77 N, averagely.

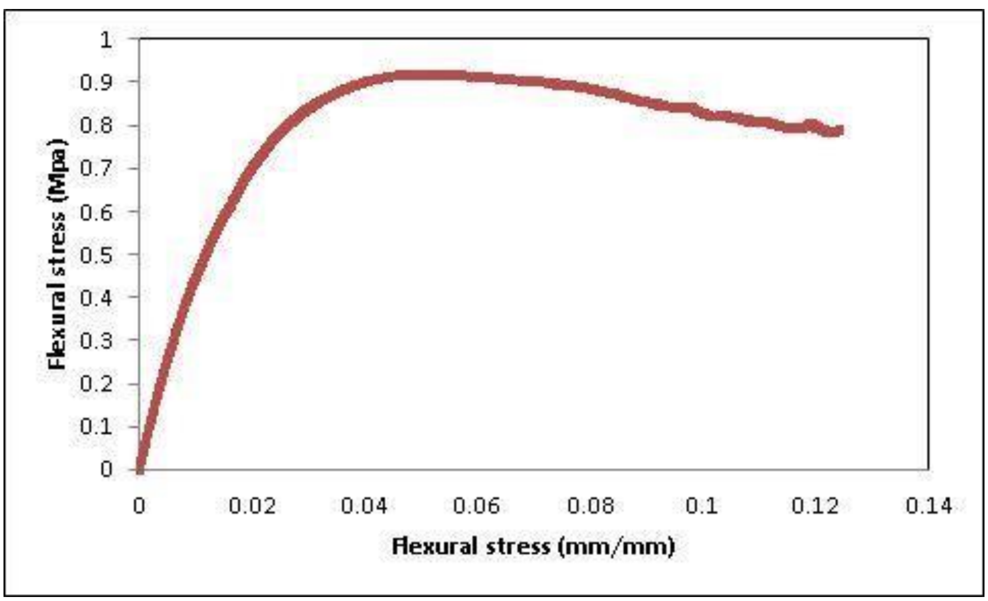

Figure 2: The Flexural Test on the Sample Honeycomb

As for jute-honeycomb, this test was conducted using two samples of jute-honeycomb with different thickness and width between 14.0 to 14.1 mm and 50 to 53 mm. The result of flexure extension at maximum load at 385.61 N and 384.43 N which give the mean average of 385.02 mm. Next, the result of flexure stress at maximum load of these two samples is 6.12 and 6.38 MPa. The mean average of flexure stress at maximum load is 6.25 MPa. The mean average of modulus is 117.58 GPa. Figure 2 shows that the stress is increasing with the strain until it reaches the maximum load at 385.02 N, averagely.

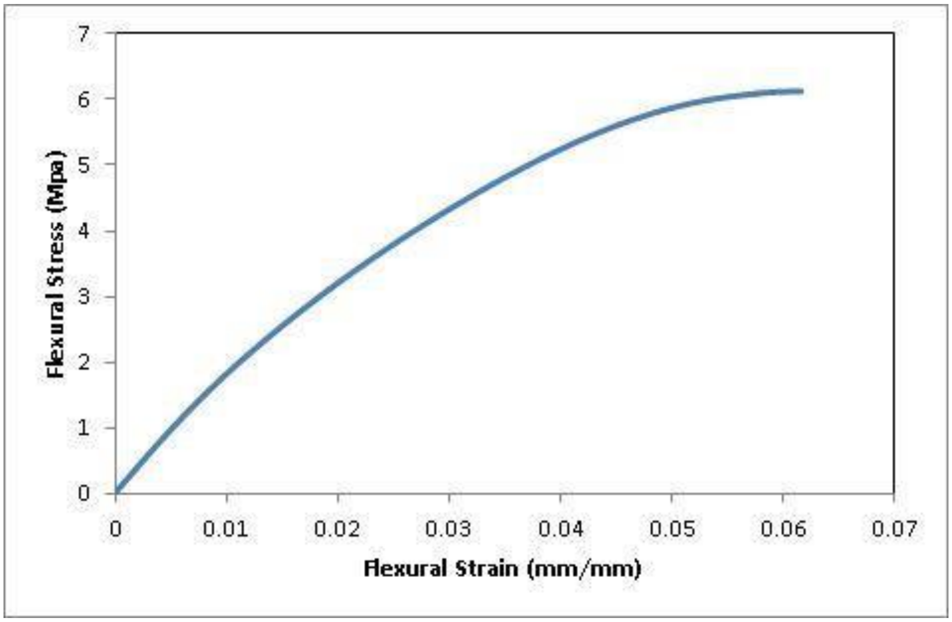

Figure 3: The Flexural Test on the Sample Jute-honeycomb

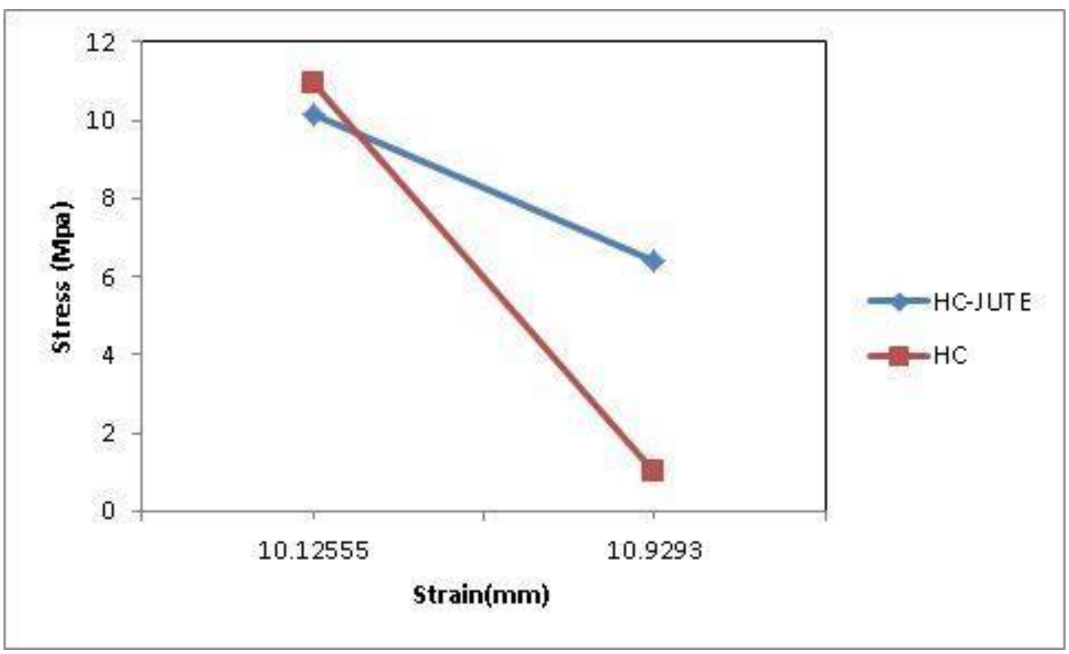

Figure 4: The Stress - strain of samples Honeycomb and Jute-Honeycomb

The flexural test on the honeycomb is first tested to observe its bending without the jute. Results of flexural shows that the honeycomb has the lowest modulus which is 24.66 GPa which means it has higher flexure extension and lower flexure stress. However when jute was combined with honeycomb, flexure result shows that its modulus is 117.58 GPa which is much more higher than single honeycomb. It can be conclude that, the bending of the honeycomb is higher than the bending of jute-honeycomb as shown in Figure 2, Figure 3 and Figure 4. Therefore, jute-honeycomb is mostly suitable to be used as a supporter in the production of furniture such as table.

The strength properties of natural fiber composites, jute fiber alone was lower, because of less stiffness and typically less brittle. Previous study proved that reinforcing glass fiber into the jute and polyester composites will enhance the tensile and flexural properties without any effect on tensile and flexural module and water resistance also can be improved [6, 7]. Previous study had shown that the mechanical properties of jute/polyester composites do not possess strengths and module as high as those of other conventional composites. However, they can possess better strengths than wood composites and some plastics [9]. The hybridization with glass fiber which can improve the mechanical properties of the composite due to hybrid fiber is used to reinforce the composite. The present study shows that the hybridization of the reinforcement in the composite shows greater tensile strength than individual type of natural fibers reinforced. Due to the low density of the natural fibers used compared to the synthetic fibers such as glass fiber, carbon fibers and etc. The composites can be regarded as a useful light weight engineering material [10].

Actual Force

The actual force on the hybrid table can be varies when different amount of beam used. Even though the In this case, two different table samples were tested without beam and with two beams. The measurement of the hybrid table is equal to 1200 mm, the width of the table is 570 mm and the depth of the table is equal to 14 mm. By using the information of equation 1, the actual force obtained was 388.11 N (40kg). If the table has one beam at the center of hybrid table, the force that can be load to the table will divide into two parts. So, the new length for each part is 600 mm. While the other information is remain constant. The value of force for each part is 776.21 N (79kg). Furthermore, if two beams are equally placed below the hybrid table, the length of the table is divided to three parts with the length of 400 mm for each part. The force obtained from the calculation is 1164.32 N (119kg) for each part. The present study proved that the most effective hybrid table is using two beams which can support actual force of 357 kg in total. The used of hand lay up process can accommodate irregular-shaped products. Such advantages are utilized in low performance composites including fiber glass boat and bath tub manufacturing. The advantage of the hand lay-up is that it is simple technique requiring low capital investment and no requirement for highly skilled labor. The disadvantage are that it is not suited for strength or weight critical primary structure such as fiber orientation and local resin content cannot be well controlled. The nature of the wet lay-up also has health and safety implications since the vapor from low molecular weight and low monomers can be harmful. If some improvements are being implemented to this composite, it will have a brighter future in many applications such as the production of furniture with characteristics of light weight, strong, and not easily broken which attracts demand from customers. The overall tensile and flexural properties of natural fiber reinforced polymer hybrid can be improved on the variation of aspect ratio, moisture absorption tendency, morphology and dimensional stability of the fibers used. Other than that, the chemical treatment on natural fibre can increase their tensile and flexural properties [5].

CONCLUSION

The present study was to fabricate of jute fiber and glass fiber (hybrid) reinforced in the polyester composites in replace of synthetic fibre as a hybrid table. The mechanical characteristics of the fabrication were analysed in terms of tensile and flexural behavior. The investigation had found that the jute fibre and glass fibre reinforced polyester composite exhibit high tensile strength. The tensile strength show that jute reinforcement has a good ability to withstand the force been load on it. The result show that jute fibre reinforced polyester has high tensile stress to maximum load which is 11.30 MPa. The flexural test on honeycomb and jute-honeycomb shows that the honeycomb has the lowest modulus thus, has higher flexure extension and lower flexure stress. While the jute-honeycomb flexure result shows that its modulus is 117.58 GPa better than honeycomb which is 24.66 GPa. The study showed that the most effective hybrid table is by using two beams which can support actual force up to 357 kg in total. Several limitations must be overcome in order to exploit the full potential of natural fibers. At first, proper fiber surface treatment should be developed and implemented. Secondly, properties of composites are greatly depended on the volume percentages of fibers and resin which need to be improved. The quality at fiber matrix interface must also be improved. Finally, the current challenge is to make them cost effective to meet the demand of the composites industry. Fiber reinforced polymer composites have many applications because their ease of fabrication, relatively affordable and higher mechanical properties. Hybridization of natural fiber and glass fiber are suitable for low cost applications, impact resistance and low maintenance requirements.

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