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THE STUDY OF MECHANICAL PROPERTIES OF LAMINATED BAMBOO STRIP (LBS) FROM GIGANTOCHLOA LEVIS TYPE MIXED WITH EPOXY

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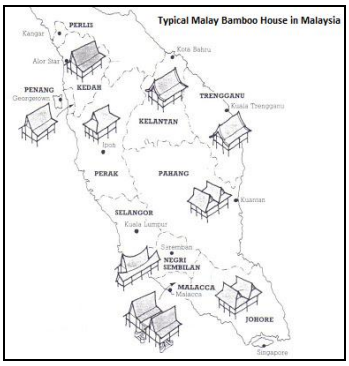
Graphical abstract



Abstract

This study about laminated bamboo strip from *gigantochloa levis* type mixed with epoxy composite. Due to the existence of demand for products that are comfortable, healthy and environmentally friendly, this research has focused on the use of renewable sources that is bamboo. Bamboos are some of fastest growing plant in the world and also have a higher compressive strength than wood, brick or concrete and a tensile strength that rivals steel. Certain species of bamboo can grow 35 inchies within 24 hour period, at a rate of 3 cm/h. That means bamboos can growth of approximately 1 mm every 2 minutes. In this study, the bamboo strip reinforced with epoxy was processed through hand lay-out method. Bamboo strips are combined with epoxy for a total sample thickness of 3 mm. This study is performed using the impact test that is Charpy (ASTM D-6110) and Izod (ASTM D-256) to measure the mechanical properties of energy absorbtion, followed by hardness test (ASTM D-1037). The 0, 60 and 90 degree of laminated bamboo strip epoxy composite with two types of load 7 kg and 14 kg has been tested. It is found that the 0 degree specimen Charpy test give the best value is 4.79 Joule energy absorbtion for 14 kg load. While for the Izod test, the best composition is also 0 degree with 4.51 Joule energy absorbtion for 14 kg load. It is shown that when the degree of bamboo laminate configuration increases, the impact absorbtion decrease. The result also shown that, when the load is increase the impact also increases. It means that got relative significant between bamboo strip configuration and load. The impact properties relate to the loading weight. The hardness test also shown that the laminated bamboo strip for 14 kg load resulting 91 rating, that is more higher than 7 kg load that is 84. It is shown that more loads will result more hardness rating for the laminated bamboo strip.

Keywords: Laminated bamboo strip (LBS), epoxy composite, impact test, mechanical properties

Abstrak

Kajian ini adalah tentang buluh dari jenis *gigantochloa levis* yang dicampurkan dengan komposit epoksi. Penggunaan sumber boleh baharu iaitu buluh diberikan tumpuan sepenuhnya dalam kajian ini kerana terdapat permintaan yang tinggi untuk produk ini dari segi keselesaan, kesihatan dan juga mesra alam. Buluh antara tumbuhan yang paling cepat berkembang di dunia dan juga mempunyai kekuatan mampatan yang lebih tinggi daripada kayu, bata atau konkrit dan juga kekuatan tegangan pesaingnya iaitu keluli. Sesetengah spesies buluh boleh berkembang sehingga 35 inci dalam tempoh 24 jam pada kadar 3 cm/j. Ini bermakna buluh boleh membesar sekitar 1 mm setiap 2 minit. Dalam kajian ini, jalur buluh yang diperkuatkan dengan epoksi akan disediakan melalui teknik sapuan tangan. Jalur buluh akan disapukan dengan epoksi dengan ketebalan sampel sebanyak 3 mm. Kajian ini dilakukan dengan menggunakan ujian hentaman Charpy (ASTM D-6110) dan Izod (ASTM D-256) untuk mengukur sifat-sifat mekanikalnya, diikuti dengan ujian kekerasan (ASTM D-1037). Buluh berlapis komposit epoksi iaitu bersudut 0, 60 dan 90 darjah yang telah disediakan, akan diletakkan dengan dua jenis beban iaitu 7 kg dan 14 kg

sebagai ujikaji. Didapati sampel bersudut 0 darjah yang diletakkan beban 14 kg dalam ujian Charpy memberikan kadar penyerapan tenaga yang tinggi iaitu sebanyak 4.79 Joule. Manakala bagi ujian Izod, sampel bersudut 0 darjah dengan beban 14 kg mempunyai kadar penyerapan tenaga yang tinggi iaitu 4.51 Joule. Ini menunjukkan bahawa apabila sudut konfigurasi buluh bertambah ianya akan mengurangan kadar penyerapan tenaga. Hasil kajian juga menunjukkan apabila beban meningkat, kadar penyerapan tenaga juga akan meningkat. Ini bermakna terdapat hubungan yang ketara di antara konfigurasi buluh dengan beban yang dikenakan. Kadar penyerapan tenaga adalah berkait rapat dengan beban. Ujian kekerasan juga menunjukkan bahawa buluh berlapis untuk beban 14 kg memberikan nilai kekerasan 91 iaitu lebih tinggi daripada buluh berlapis dengan 7 kg beban yang mana nilainya adalah 84. Ini juga menunjukkan bahawa buluh berlapis dengan beban yang tinggi akan menghasilkan lebih kekuatan kekerasan.

Kata kunci: Jalur buluh berlapis, komposit epoxy, ujian hentaman, sifat-sifat mekanikal

1.0 INTRODUCTION

In the recent years there is requirement of materials with unusual combination of properties, the main objective is not only to improve the strength but also the high performance for the materials. In order to fill the above requirement the researchers are developing the new materials finally composites are developed for attain the required properties. Composite means "two or more distinct parts bound together. Thus a material having two or more constituent materials or phases may be considered as a composite material.

Polymer composite is a two or more material combination at the atomic level where the applications, such as in fibers, films, packaging, membranes, resins engineering, biomedical uses, adhesives, emulsions, coatings, and elastomers, cannot be denied. The values added of composite materials are to replace synthetic fiber, such as carbon or glass fiber with natural fiber. In addition, the advantages of natural fiber composite are due to as non-abrasive to equipment, cost, biodegradability, renewability, low specific gravity, abundancy, high specific strength, nonabrasiveness, and freedom from health problems due to skin irritation during handling and processing the use of natural fiber composites [1-2].

Bamboo is one of the oldest building materials used by mankind in tropical and subtropical regions. Bamboo is a kind of fast- growing and renewable resource, which is cheap and widely available. Since the 20th century, bamboo has received increasing attention for industrial applications, especially as raw material for wood-based composites [3-4]. Moreover, it has the advantages of straight grain, beautiful colour, high strength and toughness, and excellent abrasion resistance. According to the mechanical properties, appropriate for composite products should be considered based on their strength to weight ratio [5-6]. As a result, bamboo has a low strength to weight ratio, it is desirable for some applications. Bamboo composites have similar properties to wood composites. Then, bamboo-based composites become a highly competitive alternative to wood-based composites and become an important forest based product in the future[7-8]. In general, bamboo is stronger than wood in bending strength, compression strength parallel to grain and is similar in shear strength parallel to grain. The strength of bamboo in grain direction is extremely high. Due to the thick wall and long culm, bamboo can be processed into many forms of particles, such as flour, fibers, flakes, chips, excelsior, strips, strands and veneer. Moreover, bamboo has a long straight grain which can compensate the potential shortcoming [9-10].

2.0 LITERATURE REVIEW

A review on natural fibre reinforced composites by Ku *et. al.* [11] stated certain drawbacks of natural fibers/polymers composites are the incompatibility between the hydrophilic natural fibres and the hydrophobic thermoplastic matrices. This leads to undesirable properties of the composites. There are many factors that can influence the performance of natural fibre reinforced composites. Apart from the hydrophilic nature of fibre, the properties of the natural fibre reinforced composites can also be influenced by fibre content /amount of filler.

Ahmad *et. al.* [12] stated that generally high fibre content is required to achieve high performance of the composites. Therefore, the effect of fibre content on the properties of natural fibre reinforced composites is particularly significant. It is often observed that the increase in fibre loading leads to an increase in tensile properties. Furthremore if the tensile properties increase it also will increase the impact test for both Charpy and Izod.

Ratnaprasad [13] stated the composites prepared by using fibre with maximum volume fraction has shown the better mechanical properties compared to less volume fraction of the composites. Cristaldi *et. al.* [14] have proposed the chemical treatment as one of the method to improve the mechanical properties. The utilization of bamboo fiber as a

reinforcement of a polymeric material is provided several advantages, such as improved strength and durability properties, reduced materials costs, and environmental benefits related to the disposal of waste materials and to reduce carbon dioxide emissions [15].

This study aim to investigate and understanding the properties of laminated LBS strip composites as strong fiber in composite. In this work, the charpy, izod and hardness test with different properties of three degrees with two weights were analysed. The materials used in this study are epoxy as the matrix material and bamboo fiber is in strip form.

3.0 METHODOLOGY

Analysis of mechanical properties is the investigation of behavior of the materials under different loading conditions. Information about the deformation behavior, stress state and the failure behavior of different bamboo species in different forms is an important requirement for the effective use of these bamboo species for different engineering applications. Generally, bamboo is an orthotropic material. Below are specimen preparation, different test techniques and test data have been presented for Charpy test, Izod test and hardness test.

3.1 Material and Method of Preparation

Bamboo stems were collected and made in to number of thin strips by means of cutting process. In this process the bamboos were cut using knifes followed by the procedure:

[1] Cut a stick of length in size (400 mm–500 mm)
[2] Cut the diameter of the central bamboos.
[3] Slice each channel up to the sheet/strip.
[4] Sliced bamboo sheets/strip was cut to a prescribed size (4 mm wide, 3 mm thickness and 200 mm long).
[5] This sheet was cut by 3000 pieces.

Figure 1 Bamboo Strip

3.2 Preparation of Adhesive Glue

The type of epoxy specification was EPOLAM 2008/S RESIN and the type of hardener is EPOLAM 2008/S HARDENER and both epoxy are prepared and mixed with ratio 10:1. After the bamboo strips are done cutting, the next step is to attach each strand bamboo structured with six pieces of bamboo are glued together using glue adhesive that is epoxy resin and epoxy hardener.

Figure 2 Epoxy Resin and Epoxy Hardener

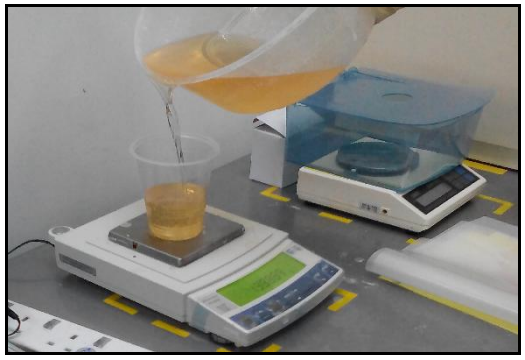


Figure 3 Glue Adhesive Preparation

3.3 Hand-Lay-Up Technique

Hand-lay-up technique is the simplest method of composites processing. The processing steps are quite simple. First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to the surface. Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener and bamboo fiber placed on the mould and then polymer poured onto the mold. The polymer is uniformly spread with the help of brush. A roller is moved with a little pressure on the mold-polymer layer to remove any air trapped as well as the excess polymer present. After placing the plastic sheet, release gel is sprayed on the inner surface of the top mold plate which is then kept on the stacked layers and the pressure is

applied. After curing at room temperature for 24 hour mold is opened and the developed composite part is taken out.

Figure 4 Hand-Lay-Up Technique

3.4 Load Technique

The next step after the bamboo strip that has been attached using adhesive glue (epoxy), it will be allowed to dry at room temperature for 4 hours with load of 7 kg and 14 kg for different speciment. The load are placed gently to the matter due to evade trapped air between epoxy and bamboo strip and also to strengthen the bond between the strips.

Figure 5 Room Temperature Drying

Figure 6 Sample of Laminate Composites

3.5 Impact Test

Impact is a very important phenomenon in governing the life of a structure. Impact tests are used in studying the toughness of material. A material's toughness is a factor of its ability to absorb energy during plastic deformation. Brittle materials have low toughness as a result of the small amount of plastic deformation that they can endure. The impact value of a material can also change with temperature. Generally, at lower temperatures, the impact energy of a material is decreased. The size of the specimen may also affect the value of the impact test because it may allow a different number of imperfections in the material, which can act as stress risers and lower the impact energy.

There are two types of impact test were used in this study that is Charpy and Izod impact test. Charpy and Izod impact test notched specimens were prepared in accordance with ASTM D-6110 and ASTM D-256 to measure impact strength. According to ASTM D-6110 and ASTM D-256 the Figure 7 & 8 shown charpy/izod test configuration for the specimens 63.5mm x 12.7mm x 3mm.

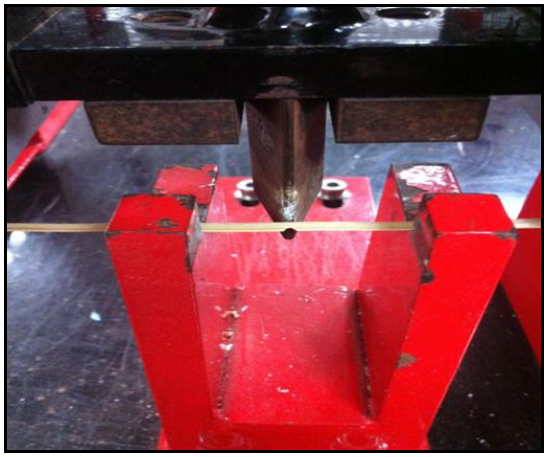


Figure 7 Charpy Impact Test

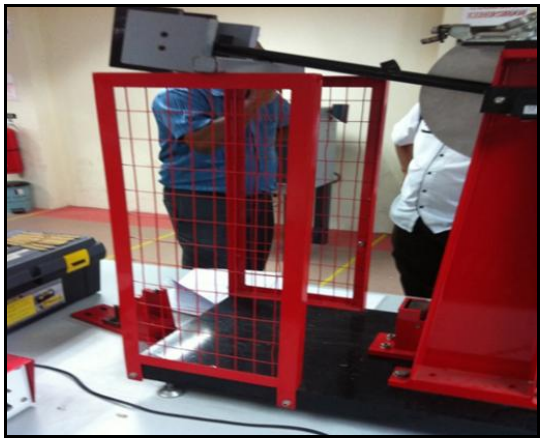


Figure 8 Izod Impact Test

3.6 Hardness Test

Hardness refers to the nature of the material that can withstand the wear, deformation, puncture and abrasion. An example of products is a cutting tool, wheel and rail stations as well as parts of the engine friction. Among the various mechanical tests used to determine the characteristics of a material and its suitability, hardness testing is one of the most important to the determination of part quality in a wide range of application.

Research on this project, this test is used to record the results of bamboo laminate using the epoxy adhesive glue using ASTM D-1037 standard. The test was carried out by applying the force on to the specimen. The rate of penetration of the Janka ball of 11.3 mm diameter was used for determining hardness modulus. The minimum thickness of specimen used was 3 mm.

Figure 9 Hardness Test

4.0 RESULTS AND DISCUSSION

4.1 Charpy Impact Test

Figure 10 demonstrates the effect of different configuration bamboo strip on the impact property of laminate bamboo strip composite for 7 kg and 14 kg load. It can be seen from the result obtained that 0 degree of laminated bamboo strip composite increase when loading increased. This result shows that reaction between increments of degree decrease the impact strength property of composite. The highest charpy impact value of bamboo strip with 14 kg load is 4.79 Joule and meanwhile the highest value for 7 kg load is 4.21 Joule. The lowest average charpy impact strength of bamboo strip with 14 kg load is 4.2 Joule and meanwhile the lowest value for 7 kg load is 3.6 Joule. The highest range of percentage different for 14 kg and 7 kg is 12.11%. The composite materials consist of cellulose fibers embedded in a lignin that is aligned along the length of the bamboo providing maximum mechanical properties [17-18].

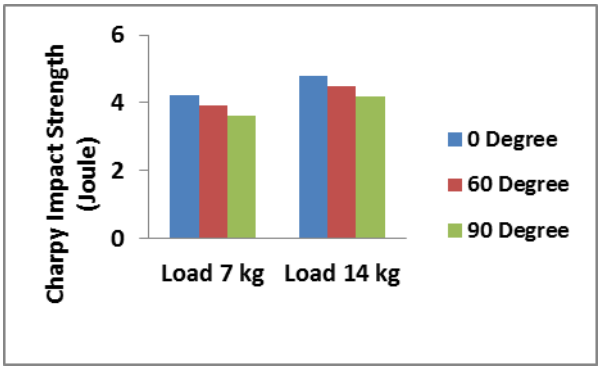


Figure 10 Graph of Charpy Impact Strength against Load 7 kg and 14 kg

4.2 Izod Impact Test

Figure 11 demonstrates the effect of different configuration bamboo strip on the impact property of laminate bamboo strip composite for 7 kg and 14 kg load. It can be seen from the result obtained that 0 degree of laminated bamboo strip composite increase when loading increased. This result shows that reaction between increments of degree decrease the impact strength property of composite. The highest izod impact value of bamboo strip with 14 kg load is 4.51 Joule and meanwhile the highest value for 7 kg load is 4.1 Joule. The lowest average izod impact strength of bamboo strip with 14 kg load is 4.2 kg and meanwhile the lowest value for 7 kg load is 3.5 kg. The highest range of percentage different for 14 kg and 7 kg is 9.09 %. The composite materials consist of cellulose fibers embedded in a lignin that is aligned along the length of the bamboo providing maximum mechanical properties [17-18].

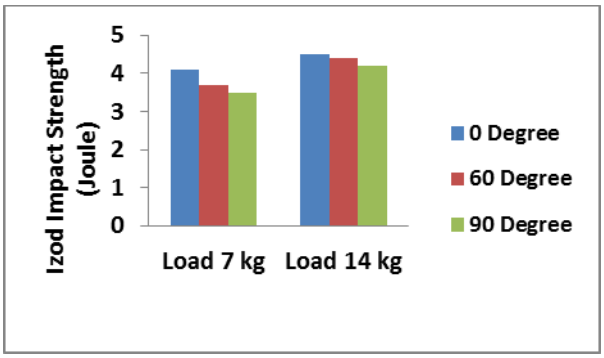


Figure 11 Graph of Izod Impact Strength against Load 7 kg and 14 kg

4.3 Hardness Test

The hardness test also shown that the laminated bamboo strip for 14 kg load resulting 91 rating, that is more higher than 7 kg load that is 84. It is shown that more loads will result more hardness rating for the laminated bamboo strip.

5.0 CONCLUSION

The possibility of using various degree bamboo strip laminate in epoxy was studied by 7 kg and 14 kg load. In this study, the performance of the 0 degree laminate bamboo strip composite energy absorbtion improves with increasing load. It means that got relative significant between bamboo strip configuration and load. The impact properties relate to the loading weight. It also shows the greater load would result in considerable hardness because the closed air cavities between the bamboo strips become smaller and fewer. When the matrix of epoxy is left to cool at room temperature, shrinkage will occur and the surface bonding between matrix and reinforcement of bamboo will be stronger among them. Therefore, the composite will have strong bond interface indirectly improve the mechanical properties of the composite itself.

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