Post-Impact and Open Hole Tensile Of Kenaf Hybrid Composites

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Abstract. Nowadays, kenaf hybrid glass composites has been used for a vast field of study throughout the globe. There are several compositions and orientation of kenaf hybrid glass composites that has been studied. With regards to the study that has been done, this study will be focussing on a 90FG/0/90/0/90FG orientation of kenaf hybrid glass composites. Polyester resin is used as a matrix to these hybrid composites. Impacted and open hole specimens were then analyzed through tensile test. All specimens were fabricated by using the cold press hand lay-up technique. The results revealed that the hybrid composites were hardly affected by the impact up to 6J. After 6J the impacted specimens experienced a significant damage for both strength and modulus. The same goes to open hole specimens where the same trend of tensile properties were observed as impacted specimens.

Keywords: kenaf hybrid glass composites, polyester resin, cold press hand- lay-up, impact, open hole, tensile test

1. Introduction

Kenaf (Hibiscus cannabinus, L. family Malvacea) has been found to be an important source of fiber for composites and other industrial applications [1,2]. It has been domestically grown in Africa and spread throughout the globe [3]. Later, it was spread to nurture in India and China. Presently, kenaf is commercially grown in the United States of America (USA). There are a lot of advantages in using kenaf in the research field such as economical, recyclable and environmentally harmless. The ecological advantages of the kenaf are their grow condition and also their growth rate speed [4]. Furthermore, the optimum weather condition for kenaf to grow optimally is during high weather temperature which is up to 30°C where the growth rate speed up to 80% faster compared to the low temperature condition [5]. Kenaf has a right future in the composite material field as it can be used in many applications such as in the automotive sector. However, it also has disadvantages that make it less attractive to be used such as having low mechanical properties (eg. strength, compressive, bending etc.) compared to other synthethic fibres (fiberglass, Kevlar, carbon etc.). To hybrid it with fiberglass is one of the popular methods to improve its mechanical properties [6].

Composites material are very sensitive to impact where it can create damage and break the materials. Impact can happen anytime and sometimes undetectable damage cannot be seen such as flying debris, falling tools etc. Thus, it needs to give more attention before it can be fully utilized. There is also another factor that need to be taken care of when using the composite material, as for example when drill hole into it. The damage can happen as the hole can initiate the crack thus material failure will happen. This
is where the studying and analyzing of the impact and hole to the composite materials are important, hence the prediction of the reliability and robustness to that area can be done. Thus, this study will investigate the hybridizations of kenaf with fibreglass in order to improve the mechanical properties of nature fibre composites. The fabrication technique used to prepare this composite is a hand lay-up process as well as cold press method. In this study, 90FG/0/90/0/90FG orientation is chosen and polyester resin is used to hold this hybrid composites. To study its mechanical properties, there are two types of samples prepared before it is going through tensile testing. The first sample, the specimens will undergo many numbers of low velocity impact which were from 2J, 4J, 6J, 8J and 16J. Another samples is open hole specimens which were drilled with the diameter of 2mm, 4mm, 6mm, 8mm and 16mm. The damages resulted from this test were then discussed in the following section.

2. Methodology
Sample preparations

Hybrid composites are made up of long non-treated kenaf fiber (used as received) and woven fibreglass. Both fibres were supplied by a local company. As for the matrix resin, a standard unsaturated polyester resin and polyester hardener which acted as a catalyst are used. Both resins were bought from Mostrong Industries Sdn. Bhd. The sample orientation is shown in Figure 1 and the testing standard used is referred to the ASTM D5766.

![Figure 1: 90FG/0/90/0/90FG hybrid composites orientation](image)

Open hole and post impact specimens

The test was done according to the ASTM D5766 standard. For the open hole specimens, before the specimens undergo the tensile test, it was drilled at the center with a hole size ranging from 2, 4, 6, 8 and 16 mm as shown in Figure 2 (a). For the post impact specimens, the specimens were impacted at 2, 4, 6, 8 and 16J as shown in Figure 2 (b). All specimens were then mounted on the grip of the Instron 3382 universal tester machine with a gauge length of 100 mm. A sandpaper was wrapped around both ends of the specimen to reduce slipping to happen during the testing.
3. Result and Discussion

The mechanical properties of the specimens such as the tensile modulus and tensile strength were determined by referring to the ASTM D5766 standard. There were two types of samples prepared, which were post-impact and open hole tensile specimens. For the post-impact tensile test, a total of 15 to 25 specimens were conducted by using an impactor with a hemispherical nose of diameter 12.7 mm as the drop weight and later the specimens were tested using an Intron 3382 universal tester machine. Meanwhile, for the open hole tensile test, a hole was drilled on the centre of the specimens and later the specimens were tested using an Intron 3382 universal tester machine. The test was carried out at a room temperature and a set of at least three readings for each parameter were taken from both tests.

Figure 3 and Figure 4 shows the result obtained from the open hole tensile test. Based on Figure 3, the tensile modulus of the specimens was decreased gradually but the gap between them increased tremendously after 6 mm hole diameter and decreased after 8 mm hole diameter. The 2 mm hole diameter exhibited the highest values among all of the others with an average value of 3690.667 MPa while the lowest value is at 1706 MPa for the 16 mm hole diameter. The value for tensile modulus was dropped to about 50% of its original value when the hole diameter was at 8 mm. As for Figure 4, the tensile strength also showed the same trend where the value drop was the highest after 6 mm and decreased tremendously after 8 mm hole diameter. The highest value of the tensile strength was at 60.803 MPa for 2 mm hole diameter and the lowest at 18.677 MPa for the 16 mm hole diameter. The tensile strength value dropped to about 40% of its original value when the hole diameter was at 8 mm. This behaviour showed that both properties were affected by the hole diameter in the same manners. It can be concluded that the stress can be distributed to a larger part of the cross-section for the small hole diameter, meanwhile for the larger diameter, there is lesser remaining cross-section part which the stress can be distributed to support the stress [7]. Thus, this behaviour can be simplified that when the load increases, due to stress concentration the damage initiates near the hole and then propagate through the cross-section area near the hole site as the stress or strain until reaches a certain value. [8]
Figure 5 and Figure 6 shows the results for a post-impact tensile test. It showed that the tensile modulus and tensile strength drop dramatically after 6 J of impact energy. The behavior was the same as the open hole tensile test result. Thus, it could be said that the specimens were physically impaired after the impacted of 6 J of impact energy. In Figure 5, the maximum tensile modulus for 2 J of impact energy was at 3055 MPa and the lowest was at 1157 MPa for 16 J of impact energy. When the impact energy reach to 8 J the tensile modulus, it was reduced to about 54% of the original value and as for the tensile strength, it was reduced by about 25%. When the specimens were subjected to 8J of impact energy, matrix cracking, fiber-matrix debonding and delamination could have transpired on the specimens which lead to the drastic drop in the physical properties [9]. Thus, the failures that happened on the specimen contributed to the specimen fracture.
From Figure 7, it was showed the microstructure where the fracture happen at the hole diameter. As we can see, the specimen experience debonding, fibre pull off and there is also a glass fiber pull off. As for the matrix structure, it has undergone a matrix fracture which results in the failure of the matrix structure to withstand further stress. The specimen that is subjected to a higher strain-rate loading shows large areas of interlaminar splitting (delamination) and numerous fiber breakages and pull-out, which could be caused by changes in the local interfacial bonding [10].

4. Conclusion
From the test results that have been analysed and discussed, the kenaf hybrid composite that was fabricated using the hand-lay-up technique and cold press method displayed great mechanical properties. With regard to the open hole tensile and post impact test, we can conclude that the specimen was affected by the hole diameter and impact energy and upon a hole diameter of 8mm and 8 J of impact energy, the specimens were drastically impaired which resulted in the drop of tensile modulus and tensile strength. Furthermore, the results of the mechanical properties could be enhanced by controlling one of the specimen parameters such as a uniform thickness of the kenaf hybrid fibreglass composite.
acknowledgements section (if any) but before the reference list. If there are two or more appendices they should be called appendix A, appendix B, etc. Numbered equations should be in the form (A.1), (A.2), etc, figures should appear as figure A1, figure B1, etc and tables as table A1, table B1, etc.

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