The effect of hybrid kenaf/glass fiber composite on crashworthiness performances

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ABSTRACT – The effect of layering materials of hybrid kenaf/ glass fiber epoxy composite was investigated via quasi-static compression experiment. Three types of thickness at two different laying angles are employed in this paper. The samples were fabricated via combination hand lay-up and winding process. The thickest composite with 45° laying angle exhibits the best performance in Specific Energy Absorption (SEA). The main failure mechanism observed after the experiment are failure of transverse composites and compression of tubes.

1. INTRODUCTION

Significant attention has been given to hybridizing composite fibre in the application of tube composite. It includes the use of two or more forms of fiber in composite material like synthetic fiber and natural fiber. The hybridization of fibers would produce a new form of composite with the additional enhancement of material properties such as strength, rigidity and energy absorption [1,2]. Renewable resources are increasingly gaining more and more position due to the growing environmental awareness. Kenaf is one of the natural fibers used in the manufacture of composites. Among other types of natural fiber reinforcement material [3–6] it is comparatively commercially available and economically cost-effective. The combination of high strength and modulus kenaf fiber but lower density and cost with glass fiber has allowed better load efficiency for the new hybrid. In addition, glass fiber dependence can be minimized, thereby creating a cleaner environment, minimizing workers' emissions and toxicity [7,8]. To analyse the composite structure, crashworthiness becomes the main focus of investigation particularly in energy absorption [9–11]. In order to apply the composite to transport exterior components, crashworthiness tests should be carried out and the mechanical properties should be equal to the existing parts. The goal of this study is therefore to investigate the energy response of quasi-static compression at different layering thickness on hybrid cylindrical kenaf/fibreglass-reinforced composites.

2. METHODOLOGY

For the fabrication of hybrid composite, kenaf yarn with a diameter of 1 mm and woven glass fiber were employed. Figure 1 displays a schematic diagram of the composite and mould size. The layer fiber are denoted with K for kenaf and G for glass fiber and tabulated in Table 1. This mixture of hand lay-up and winding method. The proportion of epoxy and hardener is 2:1, respectively. The sample was treated in room temperature for 24 hours.

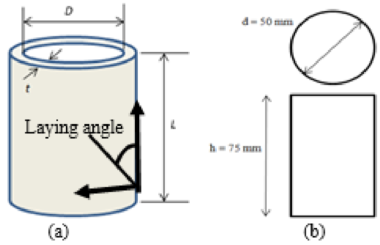

Figure 1 The schematic of (a) cylindrical hollow composite and (b) mould size

Table 1 The specification of kenaf/glass fiber reinforced epoxy composite

Inner	Middle 1	Middle 2	Outer	Layers thickness	Lay up (°)
G	-	-	K	2	30°, 45°
K	G	-	K	3	30°, 45°
K	G	G	K	4	30°, 45°

Samples were analysed using a Universal Testing Machine (UTM) nearly dynamically compressed samples. The speed of the compress was set at 10 mm/ min. The load-displacement data and the special energy absorption (SEA) data were automatically recorded in the device. After the crushing process, the structure morphology was studied extensively to understand the mechanism of failure occurring during the experiment.

3. RESULT AND DISCUSSION

Figure 2 shows the Peak Load of hybrid kenaf/glass fiber composite at difference thickness and laying angle. The peak load is increased with the increase of thickness and laying angle. Thickest composite and laying angle 45° present highest value of peak load. It shows that laying angle of 45° can sustain the highest load as compared to laying angle of 30°.

The capability to absorb load energy is

representing by SEA. The higher the value indicate better performance. The energy absorption values are calculated from the area under the Load-displacement graph. Figure 3 shows the SEA value of hybrid kenaf/glass fiber composite. Hybrid kenaf/glass fiber at laying angle of 45° and thickest composite shows the best capability. The results show that the laying angle and composite thickness influence the energy capability for specimens.

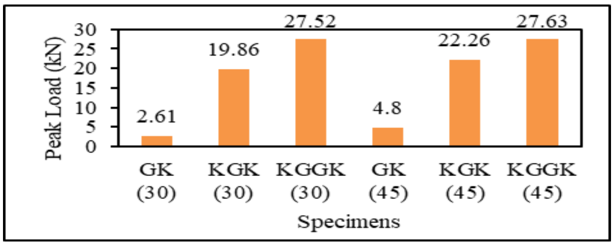

Figure 2 The peak load of hybrid kenaf/glass fiber composite at different thickness and laying angle.

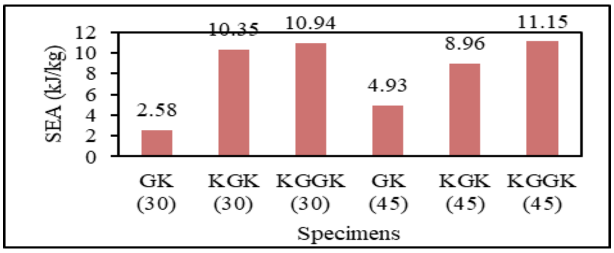

Figure 3 The SEA of hybrid kenaf/glass

The failure mechanism occur after the crushing experiment is exhibited in Figure 4. The details of failure mechanism in Figure 4 is (i) Formation of fold, (ii) Fracture of composites, (iii) Compression of Tubes, (iv) Failure of transverse composites.

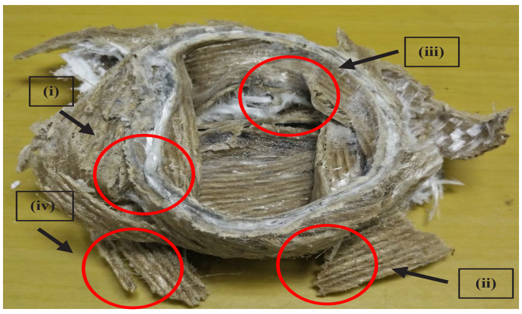

Figure 4 Failure mechanism observed after the test

4. CONCLUSIONS

From experimental results conducted on the hybrid composite tubes subjected to quasi-static compression, several conclusions can be listed as below:

1. It is found that layering thickness and laying angle played an important role in determining the specific energy absorption (SEA) capability.
2. The thickest composite and laying angle 45^{o} is the best parameters which can absorb the highest load.

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REFERENCES

[1] A.E. Ismail, M.F. Sahrom, Lateral crushing energy absorption of cylindrical kenaf fiber reinforced composites, Int. J. Appl. Eng. Res., 2015.

[2] N. Abdullah, A.E. Ismail, Axial quasi-static crushing behaviour of cylindrical woven kenaf fiber reinforced composites, in: IOP Conf. Ser. Mater. Sci. Eng., 2017.

[3] M.F.B. Ismail, M.T.H. Sultan, A. Hamdan Ariffin, A.U.M. Shah, M. Jawaid, S.N.A. Safri, Kenaf/glass hybrid composites, Int. J. Recent Technol. Eng. vol. 8, pp. 456–461, 2019.

[4] M.F. Ismail, M.T.H. Sultan, A. Hamdan, A.U.M. Shah, A Study on the Low Velocity Impact Response of Hybrid Kenaf-Kevlar Composite Laminates through Drop Test Rig Technique, BioResources, vol. 13, pp. 3045–3060, 2018.

[5] Mohammed, A.R.A. Talib, M.T. Hameed Sultan, M. Jawaid, A.H. Ariffin, S. Saadon, Mechanical properties of Fibre-metal laminates made of natural/synthetic fibre composites, BioResources, vol. 13, pp. 3045–3060, 2018.

[6] M.H. Hamidon, M.T.H. Sultan, A. Hamdan, A.U.M. Shah, Effects of fibre orientation on mechanical properties of glass/kenaf hybrid composites, *Int. J. Recent Technol. Eng.* vol. 8, pp. 453–455, 2019.

[7] M.F.M. Alkbir, S.M. Sapuan, A.A. Nuraini, M.R. Ishak, Fibre properties and crashworthiness parameters of natural fibre-reinforced composite structure: A literature review, *Compos. Struct.* vol. 148, pp. 59–73, 2016.

[8] R. Yahaya, S.M. Sapuan, M. Jawaid, Z. Leman, E.S. Zainudin, Quasi-static penetration and ballistic properties of kenaf-aramid hybrid composite, *Mater. Des*. vol. 63, pp. 775–782, 2014.

[9] Z.F. Albahash, M.N.M. Ansari, Investigation on energy absorption of natural and hybrid fiber under axial static crushing, *Compos. Sci. Technol*, 2017.

[10] L. Mohammed, M.N.M. Ansari, G. Pua, M. Jawaid, M.S. Islam, A Review on Natural Fiber Reinforced Polymer Composite and Its Applications, *Int. J. Polym. Sci.* 2015.

[11] M.S. Abu Bakar, M.S. Salit, M.Z. Mohamad Yusoff, E.S. Zainudin, H.H. Ya, The crashworthiness performance of stacking sequence on filament wound hybrid composite energy absorption tube subjected to quasi-static compression load, *J. Mater. Res. Technol*. vol. 9, pp. 654–666, 2020.