International Journal of Advanced and Applied Sciences, 5(2) 2018, Pages: 161-164

Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: http://www.science-gate.com/IJAAS.html

Oblique impact behavior of unidirectional natural fiber reinforced composites

Yusuf Salim [1, *], M. Y. Yahya [1], H. A. Israr [1], S. Azwan [1], M. N. Roslan [1, 2], M. N. Abdullah [1]

[1]*Centre for Composite, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, Malaysia*
[2]*Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia*

A R T I C L E   I N F O

Article history:
Received 29 December 2016
Received in revised form
1 November 2017
Accepted 1 December 2017

Keywords:
Unidirectional composite
Kenaf fiber
Low velocity impact
Oblique impact
Unidirectional orientation

A B S T R A C T

This research focuses on the low velocity oblique impact on unidirectional (UD) kenaf reinforces composite plate. This study summarizes oblique impacts testing with angle 0°, 8° and 13° on three laminated layers of UD kenaf fiber with orientation structures of [0°, 30°, 0°] and [0°, 60°, 0°]. Nowadays, market ready composites mostly made-up using synthetic fibers, one of main problem when using synthetic fiber is hard to decompose and make its harms to environment. Natural fibers have high potential for replacing synthetic fibers as main composite materials. Kenaf fibers were chosen in this study due to relatively good mechanical properties with environmental friendly advantages. Kenaf yarn with the size of 855 Tex (1.0 mm diameter) is being used for UD kenaf fabric on the composite. Compression technique was used to prepare the composite with epoxy polymer as its resin. UD kenaf composite was tested using high speed puncher machine at speed 1 m/s. Total energy absorption, load over displacement curves and fragmentation profile of the UD Kenaf composite are analyzed. By increasing oblique angle, the total energy absorption will decrease, load over displacement curves become fall off and the fragmentation profile of the composite become smaller had been revealed.

1. Introduction

Over the years, composite materials have successfully substituted the conventional materials in high strength and light weight applications such as aerospace, automotive and sport industries. High strength fiber such as aramid, carbon and glass fiber is well known materials as reinforcement in composites due to its excellent mechanical properties and high strength-to-weight ratio, but these fibers or specifically synthetic fibers have serious drawbacks in term of non-renewability and non-biodegradability (Alkbir et al., 2016; Ramesh, 2016). Environmental awareness and new regulations related to the environment has prompted the researchers to develop an alternative eco-friendly composite to replace synthetic fiber composites.

Natural fiber composites have gained researchers interests in recent years considering the potential substitution products to existing synthetic fiber composites (Zannen et al., 2016). One of the most widely used natural fibers in reinforced composites is kenaf fiber. Kenaf provides significant advantages such as short harvest cycle period, good mechanical properties, ecological adaptability and biodegradability (Safri et al., 2014). Kenaf has become subject of research for potential applications such as insulation board, paper, absorbent materials and composites reinforcement (Ashori et al., 2008; Hasselbruch et al., 2015; Ismail and Aziz, 2015; Berardi and Lannace, 2015).

Local impact penetration of fiber reinforced plastics has been the subject of much experimental and analytical investigation and has been well documented. Khalid et al. (2015) investigated the effect of low velocity impact on different density of woven kenaf fiber reinforced composites, the result comparable total energy absorption between low and high density of woven reinforced composites (Safri et al., 2014). Xie et al. (2016) carried out high velocity impact on Carbon Fiber Reinforced Plastics (CFRPs) using gas gun at various speed and angle of impact. It shows that at given impact velocity, increment of impact angle resulting increasing energy dissipated. Meanwhile, Roslan et al. (2014)

* Corresponding Author.
Email Address: yusufsalim.daud@gmail.com (Y. Salim)
https://doi.org/10.21833/ijaas.2018.02.023

studied the oblique impact loadings on short kenaf fiber reinforced composites, it reported the oblique angles affected the maximum penetration load and validated by using simulation. On real impact phenomena, the projectile strikes direction is not vertically to the target (90^0 towards plane). It is usually occurs at oblique angles.

This research aims to investigate the behavior of Unidirectional (UD) kenaf reinforced composites subjected to the oblique impact. Experimental studies on the low velocity impact on UD kenaf composites are performed to provide evidences regarding the maximum penetration load, and total energy absorption on different laminated composite orientation structures and oblique angles of impact.

2. Experimental setup

2.1. Sample preparations

Kenaf fiber in yarn form with a size of 855 Tex (approximately 1.0 mm diameter) was used as fabrics in this research. Kenaf yarn was arranged in UD structures before cutting into the desired sample size. Total three layers of UD structures fabrics with different orientation are needed for preparing laminates composites for this study. Orientation of intermediate or second layer of the laminated composites was manipulated to two orientations; 30^0 and 60^0, meanwhile first and third layers will have 0^0 orientations as illustrated on Fig. 1. Therefore, two types of samples with different intermediate UD orientations fabrics; [0°, 30°, 0°] and [0°, 60°, 0°] are used on this research. Compression technique being practiced for preparing composites. Unsaturated epoxy was poured and spread into laminated UD kenaf fabric on mold and compressed at 1000kPa for 8 hours. Fig. 2 shows the UD kenaf fabric being cut into rectangular shape to fit into the mold. Finished product thickness is 3 mm. UD Kenaf reinforced composite cut down to the 100 mm x 100 mm according to ASTM D3763 standard for impact puncture test.

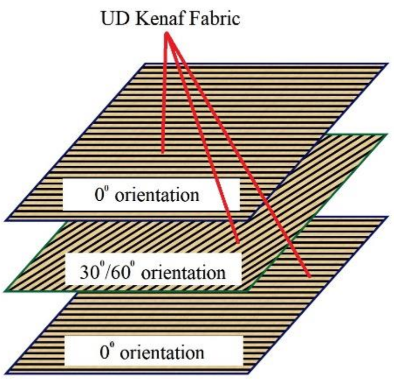

Fig. 1: Orientation of UD kenaf fibre

2.2. Experimental procedure

Test specimens were subjected to impact test as per ASTM D3763 standard. Hydroshot HITS-T10 Shimadzu machine was used for this purpose. Impact testing being conducted to obtain force propagation over stroke, and low velocity impact was selected for this research with speed of 1 m/s. Oblique jigs used to hold the specimen for oblique impact testing as shown in Fig. 3. Three oblique angles used for this research; 0°, 8° and 13°.

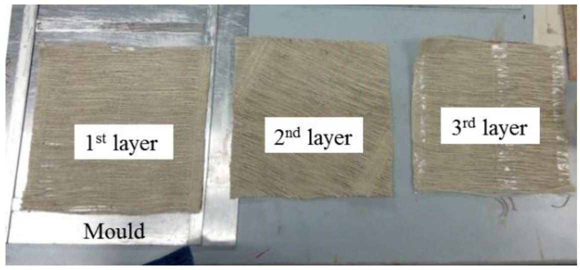

Fig. 2: UD kenaf fibre after cut down to fit into the mould

UD kenaf fiber composites directions on first and third layer of the composites placed parallel to the inclination of the oblique jigs as illustrated on Fig. 4. Hemispherical puncher shape with a diameter of 12.7 mm is used for this testing.

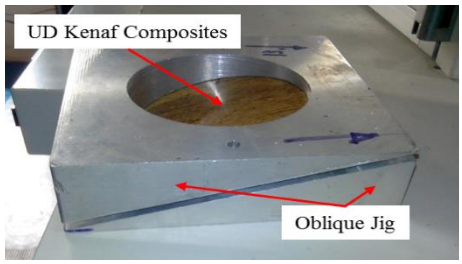

Fig. 3: Oblique jig used on testing

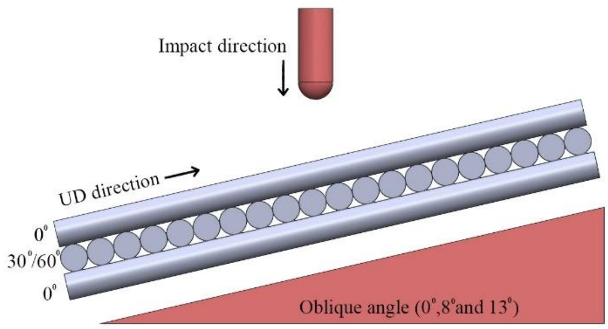

Fig. 4: Illustration of UD direction to oblique angle

Two different orientations structure of UD kenaf composites and three different oblique impact angles are used in this experiment, which means six experiments being conducted in this research and labelled with sample name as shown in Table 1. Maximum load of penetration, total energy absorption and load over displacement curves was recorded from low velocity impact testing.

3. Results and discussion

From the experiments, highest maximum penetration load was shown by S30-0 with value 1.240 kN, followed by S60-0, S30-8, S60-8, S30-13 with values of 1.090 kN, 0.725 kN, 0.695 kN, 0.578

kN and lowest maximum penetration load shown is 0.540 kN from sample S60-13 based on the bar graph on Fig. 5. On the same oblique impact angle, but different UD kenaf composites orientations generate different maximum penetration load. UD kenaf composites with orientations [0°, 30°, 0°] provide higher penetration load than [0°, 60°, 0°]. UD kenaf composites with orientation [0°, 30°, 0°] has an intermediate layer that is angled close to first and third layers of the laminated samples than orientation 0°, 60°, 0°]. On the other hand, from the impact test of both orientation structures with different angle of impact, the maximum penetration load is decreased with increasing impact angles.

Table 1: Sample name for each parameter tested

No.	Sample Name	UD Kenaf Composite Orientations	Oblique Impact Angle
1	S30-0	[0°, 30°, 0°]	0°
2	S30-8	[0°, 30°, 0°]	8°
3	S30-13	[0°, 30°, 0°]	13°
4	S60-0	[0°, 60°, 0°]	0°
5	S60-8	[0°, 60°, 0°]	8°
6	S60-13	[0°, 60°, 0°]	13°

The total energy absorptions are obtained from total area under the graph of load over displacement curves (Fig. 6). The highest total energy absorption as indicated on a bar graph in Fig. 3 was shown by S30-0 with value 11.467J, followed by S60-0, S30-8, S30-13, S60-8 with value of 9.086J, 8.919J, 7.796J, 5.047J and the lowest total energy absorption shown is 2.990J from sample S60-13. The trend for total energy absorption and maximum load are similar for all parameters tested. UD kenaf composites with orientation [0°, 30°, 0°] show superior total energy absorption than orientation [0°,60°,0°] at the same angle of impact. Moreover, increasing angle of impact yield to descending total energy absorption for both sample orientations. The declining trend of total energy absorption of orientation [0°, 60°, 0°] are sharper than the orientation of [0°, 30°, 0°] thanks to the orientations of intermediate layer as discussed before.

From the graph load over displacement as illustrated at Fig. 6, by comparing the orientation structure of UD kenaf composites with same impact angle, orientation structure [0°, 60°, 0°] have lower maximum load than orientation [0°, 30°, 0°]. Furthermore, UD kenaf orientation structure [0°, 60°, 0°] also take shorter displacement to reach maximum load compare to orientation [0°, 30°, 0°]. At displacement range of 0mm to 8mm, the puncher begins to touch the sample and deformation of sample occurs without any permanent damages. After maximum load is achieved, the matrix cracking starts to propagate across the sample. At displacement range of 8 mm to 14 mm, the puncher starts to penetrate through the sample and delamination occurs. On this stage, there is significant drop in the penetration load. Afterward, fluctuation curve is observed due to the friction between puncher and sample.

Fragmentation profile was observed after impact testing and analyzed. The fragmentation profile for orientation structures [0°, 30°, 0°] and [0°, 60°, 0°] are almost identical, hence only one orientation structures being studied. From Fig. 7, individual fragmentation for samples tested on different impact angle are shown. At impact angle 0^0, the fragmentation along X-axis and Y-axis is symmetry.

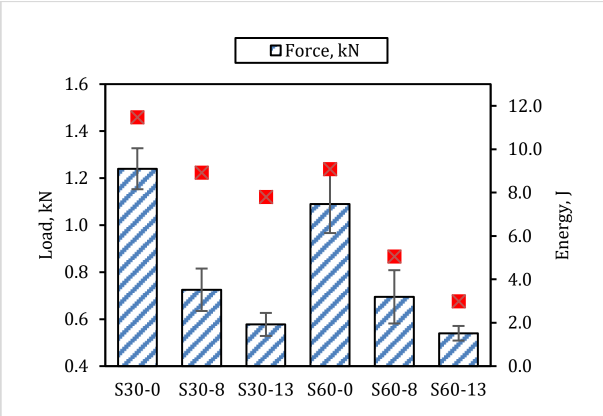

Fig. 5: Maximum load and total energy absorption for all samples

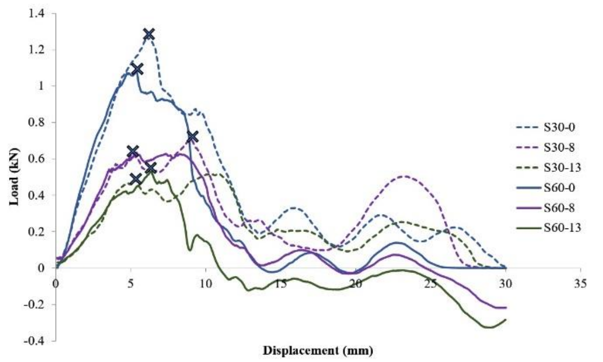

Fig. 6: Graph load over displacement

Y-axis fragmentation is longer than X-axis due to UD structures that runs parallel to the axis. By contrast, the X-axis *fragmentation takes* the size of puncher (red circle) and remains same for all oblique angles tested. When the angle of impact increased, the Y-axis fragmentation become non-symmetry, +Y region take the size of puncher while the -Y region show fragmentation length become shorter, thus affecting the total energy absorbed by the samples. The outline of fragmentation profile for all three oblique impact angles are summarized as illustrated on Fig. 8.

4. Conclusion

An investigation has been conducted to study the effect of UD kenaf reinforcement composite on the low velocity impact response. Significant different outcome in maximum penetration load, total energy absorption and fragmentation profile failure have been found at different oblique impact angles and at different orientation structures of the UD kenaf composites. As the impact angle increased, the maximum penetration load decreased as well as the total energy absorbed. This behavior is clearly observed by analyzed the fragmentation profiles on composites after the testing. 13^0 impact angles have smaller fragmentation profile compared to 0^0 impact angle, resulting the 13^0 impact angle has lower energy absorption than 0^0 impact angle.

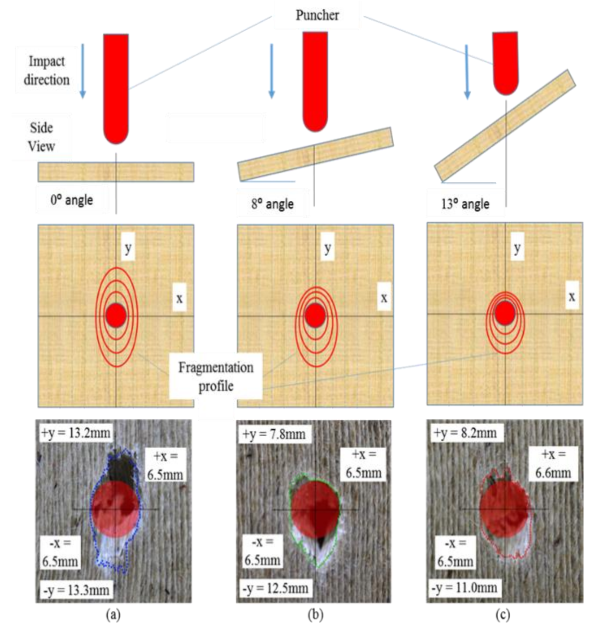

Fig. 7: Fragmentation profile of UD kenaf composites after impact

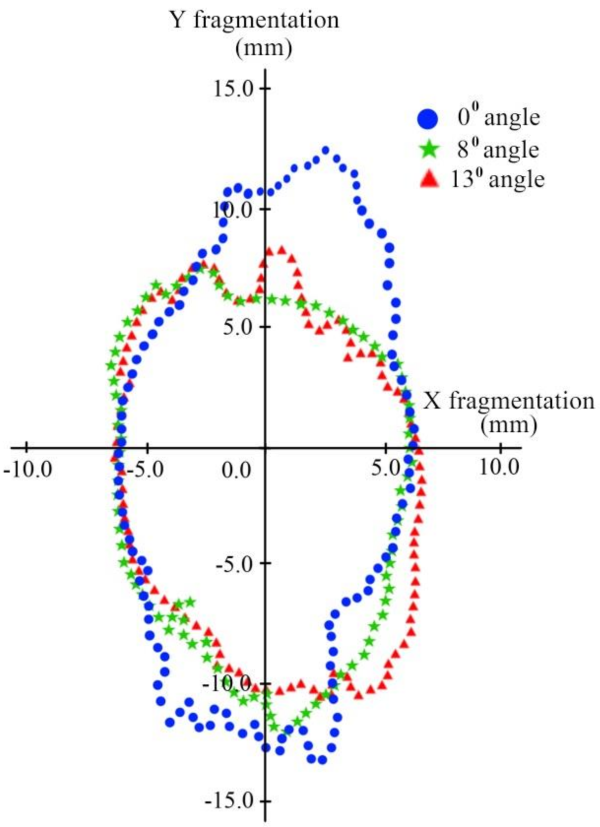

Fig. 8: Fragmentation profile outline for all three oblique impact angles

At the same angle of impact, the orientation structures [0°, 30°, 0°] show greater energy absorption than [0°, 60°, 0°], these phenomena can be explained by the influence of orientation on intermediate layers. Orientation structure [0°, 30°, 0°] has intermediate layer that angled closed to first and third layer of the composites, thus the total energy absorption of [0°, 30°, 0°] is much higher than [0°, 60°, 0°] structure.

Acknowledgment

The authors would like to thanks to the Research Management Centre (RMC), Universiti Teknologi Malaysia for financial support under GUP-UTM Vot.09H63.

References

Alkbir MFM, Sapuan SM, Nuraini AA, and Ishak MR (2016). Fibre properties and crashworthiness parameters of natural fibre-reinforced composite structure: A literature review. Composite Structures, 148: 59-73.

Ashori A, Raverty WD, Vanderhoek N, and Ward JV (2008). Surface topography of kenaf (Hibiscus cannabinus) sized papers. Bioresource Technology, 99(2): 404-410.

Berardi U and Lannace G (2015). Acoustic characterization of natural fibers for sound absorption applications. Building and Environment, 94: 840-852.

Hasselbruch H, Hehl AV, and Zoch H (2015). Properties and failure behavior of hybrid wire mesh/carbon fiber reinforced thermoplastic composites under quasi-static tensile load. Materials and Design, 66: 429-436.

Ismail AE and Aziz MACA (2015). Tensile strength of woven yarn kenaf fiber reinforced polyester composites. Journal of Mechanical Engineering and Sciences, 9: 1695-1704.

Khalid SN, Ismail AE, and Zainulabidin MH (2015). A Review on effect of orientation fabric on mechanical energy absorption natural fibres reinforced composites. Applied Mechanics and Materials, 773: 134-138.

Ramesh M (2016). Kenaf (Hibiscus cannabinus L.) fibre based bio-materials: A review on processing and properties. Progress in Materials Science, 78: 1-92.

Roslan MN, Ismail AE, Hashim MY, Zainulabidin MH, and Khalid SNA (2014). Modelling analysis on mechanical damage of kenaf reinforced composite plates under oblique impact loadings. Applied Mechanics and Material, 465: 1324-1328.

Safri SNA, Sultan MTH, Yidris N, and Mustapha F (2014). Low velocity and high velocity impact test on composite materials-A review. International Journal of Engineering and Science, 3(9): 50-60.

Xie W, Zhang W, Kuang N, Li D, Huang W, Gao Y, Ye N, Guo L, and Ren P (2016). Experimental investigation of normal and oblique impacts on CFRPs by high velocity steel sphere. Composites Part B: Engineering, 99: 483-493.

Zannen S, Ghali L, Halimi MT, and Hassen MB (2016). Effect of fiber weight ratio and fiber modification on flexural properties of posidonia. Open Journal of Composite Materials, 6(3): 69-77.