

## Failure analysis of two serial holes bolted joint hybrid composite

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**ABSTRACT** – This study investigates the effect of different geometry parameters to the behavior of bolted-joint hybrid composites. The hot compression method is used to fabricate the hybrid composite. The composites were fabricated with three layers of woven fibers which are two layers of woven glass fiber and a layer of woven kenaf fiber with polypropylene matrix making a composite panel. The nominal thickness of these composites is 3mm and the bearing test is done by using Universal Testing Machine. The test were conducted according to ASTM D5961. The results show the different geometry parameters affect the behavior of hybrid composites.

### 1. INTRODUCTION

Natural fiber have many significant advantages over synthetic fiber. Past research state that the advantages of natural fiber over man-made fiber include low density, low cost, recyclability and biodegradability. These advantages make natural fiber potential replacement for glass fiber in composite materials. Mechanical properties of natural fiber are very good and may compete with glass fiber in specific strength and modulus [1]. Natural fiber-reinforced composites can be applied in the plastics, automobile and packaging industries to cut down on material cost [2].

Kenaf, *Hibiscus cannabinus* [3,4], a member of hibiscus family is also a biodegradable and environmentally friendly crop. It has been found to be an important source of fiber for composites and other industrial applications. The fiber is fully biodegradable, is non-toxic and may be recycled. Based on research paper of Abdul Khalil (2010), Malaysian kenaf is composed of two distinct fiber, bast and core, with a makeup of about 35% and 65%, respectively. The usage of the two different fiber is not same. Thus, separation of the fiber produces higher monetary returns over whole-stalk kenaf. Main factors involved in separation of kenaf into its two fractions include size and amount of each portion, type and number of separation machinery, processing rate through separation machinery, moisture content of whole-stalk kenaf and humidity of ambient air [5].

Fiber reinforced composites consist of fiber as reinforcement and a polymer as a matrix. Natural fiber composites such as hemp fiber-epoxy, flax fiber-polypropylene (PP), and China reed fiber-PP are

commonly used in automotive applications since it has lower cost and lower density which is 35% to 40% less compared to glass fiber [6].

This study will investigate the behavior of the hybrid composite. The effect of three layers of woven glass/kenaf/PP composite with different geometry parameters which are edge distance-to-upper hole centre/hole diameter (E/D) and distance between centres of two holes/hole diameter (K/D) were tested and the failure was analyzed.

### 2. METHODOLOGY

The woven glass and kenaf fiber reinforced polypropylene composites panel consists of three layers contain of woven kenaf and glass fiber in polypropylene matrix forming 3 mm thick composite panel.

The fabrication process starts with the production of PP sheet. In mean time, the woven kenaf which already cut to 170×250mm (width × length) are dried in the oven for 24 hours at 40°C. The fiber reinforcements and the matrix then are layered simultaneously glass fiber-PP-kenaf fiber-PP-glass fiber into a picture frame mold 250×170× 3 mm (length ×width ×thickness). The PP sheets is placed in 1-2-1-1 order respectively. The mold is placed in the hot press to reheat it to about 180°C for 5 minutes. Followed by increase in pressure progressively until reaching 30kg/cm<sup>2</sup>. Finally the pressure is maintained for 4 minutes before cooling it down. The composite panel is cut into specimens and drilled according to ASTM D5961 as shown in Figure 1 and Table 1. The crosshead speed used is 2mm/min as recommended in ASTM D5961 for the two serial holes testing.

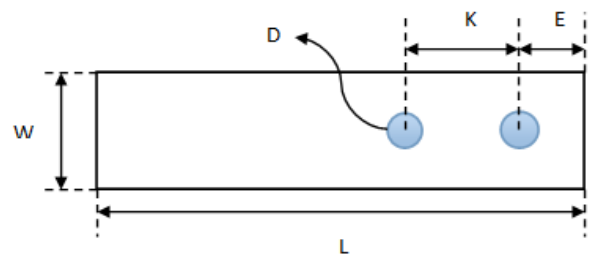


Figure 1 The standard dimension based on ASTM D5961[7].

Table 1 Double-shear and single-shear one-piece test specimen dimensions [7].

Parameter	Standard Dimension (mm)
Fastener or pin diameter, d	6 + 0.00/-0.03
Hole diameter, D	6 + 0.03/-0.00
Length, L	3-5
Width, W	36±1
Edge distance, E	18±1
Countersink	non

### 3. RESULTS AND DISCUSSION

Based on figure 2, the maximum load of K/D=3 and E/D=3 has a higher maximum load compared to K/D=2 and E/D=3. The higher ratio of E/D and K/D, the failure loads tend to increase[8]. The failure behavior occur during this study are net tension, shear out and bearing. The increasing of E/D ratio causes the composite to shear out become bearing. Meanwhile, the increasing of K/D ratio causes the composites shear out to net tension [9].

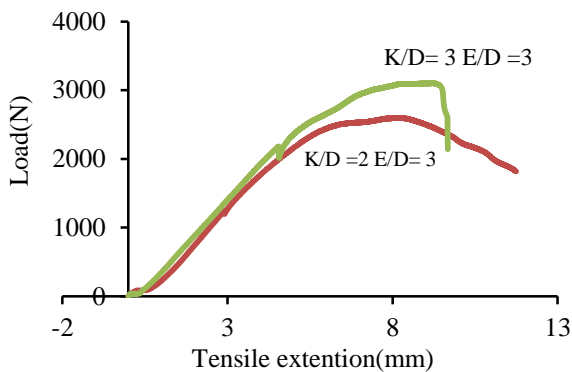


Figure 2 Load-tensile extension graph.

### 4. CONCLUSION

The different of geometry parameters of bolted joint composites show the different behavior. The larger the ratio of E/D and K/D, the larger the failure load of composite. The bearing occurs when the smaller ratio applied to the specimen, while shear out and net tension occur when the ratio is higher.

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