MECHANICAL PROPERTIES OF HYBRID WOVEN KENAF/GLASS COMPOSITES

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ABSTRACT

Mechanical properties are an important property to explore such as tensile and flexural properties. The awareness for the greener world has led to the applications of natural fibre in composites application. Aiming for reducing in usage of synthetic fibre, this study reveals the potential reinforcement of hybrid woven kenaf and glass composite. The specific objective of this study is to discover the tensile and flexural strength and modulus properties of hybrid woven kenaf/glass polyester composites respectively. Cold Compression moulding method was selected for composites fabrication at 35% fibre-resin percentage. Fibre involved was Kenaf long fibre 1000 tex size manually plain weave into 1500 g/m^2 area weight and interlayer by E-glass mat area weight 30 g/m^2. Unsaturated polyester resin used matrix resin usually used as a binder. Tensile and flexural test perform according to ASTM D3039 and ASTM D7264 respectively. Increased in mechanical properties of hybrid composites observed compared to kenaf composites. The tensile modulus of hybrid composites shows increased by 10%, measured at 9.88 GPa. However flexural modulus and interlaminar shear modulus shows slightly decreasing, reduce by 7% and 12.7% respectively. The fracture observed from flexural specimen identified glass fibre reduce the composites interface bonding.

Keywords:

Hybrid Kenaf/Glass, Mechanical Properties, Tensile test, Flexural Test, Interlaminar Shear test

1. INTRODUCTION

Natural fibers are fiber sources from plants, animals, and mineral. Plant fibres are the most preferred natural fibres due to its abundance and are able to produce different types of fibres which can be applied as reinforcement or fillers [1-3]. Review from natural fiber studies exhibit that the natural fibers are more cost-effective in terms of raw material due to its renewable resources and results in cost reductions [4-6]. In natural fibre composites, the combination of natural–natural and artificial–natural fibres are potential for hybridization [7]. The hybridization is a potential solution for natural fibre drawback of possessing low mechanical properties [8].

Hybrid polymer composites are fabricated by amalgamation of at least two or more different types of fibres in a polymer matrix. Hybrid composites can be a combination of artificial-artificial fibres, natural-natural fibres, or combination of artificial-natural fibres. The synergistic effect offered by hybrid fibre composites enables the properties to be tailored [9]. In engineering application, hybrid composites are preferable owing to the few advantages they offer such as low cost, high strength-to-weight ratio, and ease of fabrication. The advantages of hybrid composites are ability to modify the mechanical properties such as stiffness, ductility, and strength; thus increasing fatigue life, higher fracture toughness, and lower notch sensitivity compared to mono fibre reinforced composites. Gradual failure altered for brittle material is namely called pseudo-ductility [10].

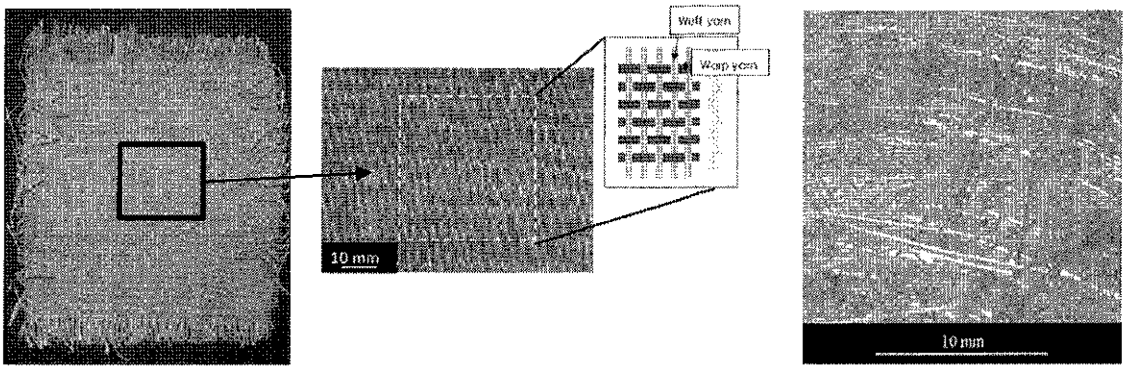
Kenaf plants (Hibiscus cannabinus L., family Malvaceae) originated from Africa and grow in wide-range of weather conditions. Currently, kenaf is one of the Malaysian crops intentionally grown to replace tobacco supported under government agencies, The National Kenaf and Tobacco Board (LKTN) [9]. Kenaf cultivation is introduced to Malaysian farmers due to it fast growth. Since kenaf are abundantly available as Malaysian commodity, it is significantly viable for researcher to study the potential of kenaf for economic reasons [10]. Hybrid Kenaf and glass is one method for increasing the field of application for natural fibers is by increasing their mechanical properties through hybridizing process.

2. METHODOLOGY

The following section describes the properties of all materials and process used in this research.

2.1 Materials and Fabrication

The fibres involved in this research are woven kenaf and C-glass fibre (CSM-chop strand mat). Kenaf polyester composites and kenaf/glass composites data will be compared respectively. Unsaturated polyester 1.3 g/cm^3 density was selected for matrix binder in the composites. Kenaf fibre supplies in yarn type by Innovative Pultrusion Sdn. Bhd, Seremban, Malaysia. Kenaf yarn then weaves using a lab scale self-designed handloom. The resin and glass fibre used in this study was supplied by S&N Chemicals Sdn Bhd.



(a) Woven kenaf (b) CSM Glass Fiber

Fig. 1. Reinforced Fiber Material

Closed mould compression moulding method was selected for fabrication with Methyl ethyl ketone peroxide (MEKP) hardener with 1% wt percentage by the resin were mix prior of fabrication process. Hybrid kenaf/glass composites sample fabricated as illustrated in Figure 2.

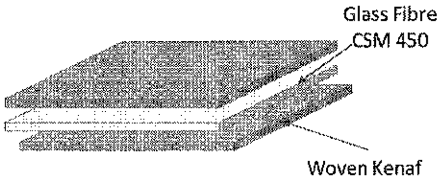
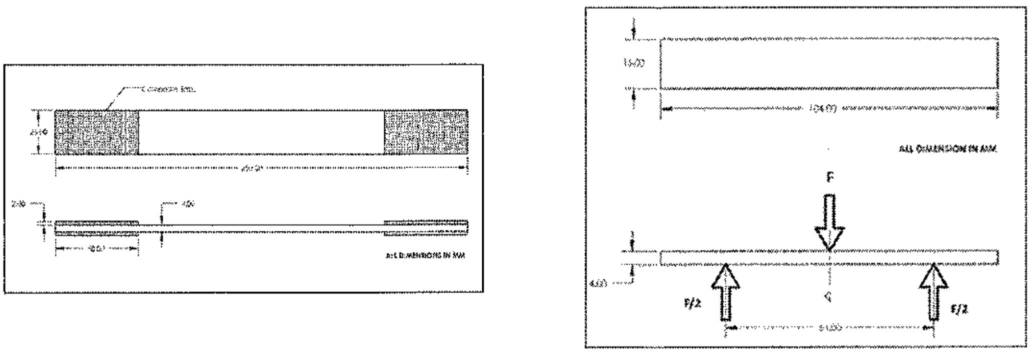


Fig. 2. Sample fabrication

Pressure was applied to the closed mould by hydraulic compressor at one bar pressure. The average composite fibre-resin fraction is 38% weight percentage and average composites thickness measured at 4 mm.

2.2 Testing Procedure

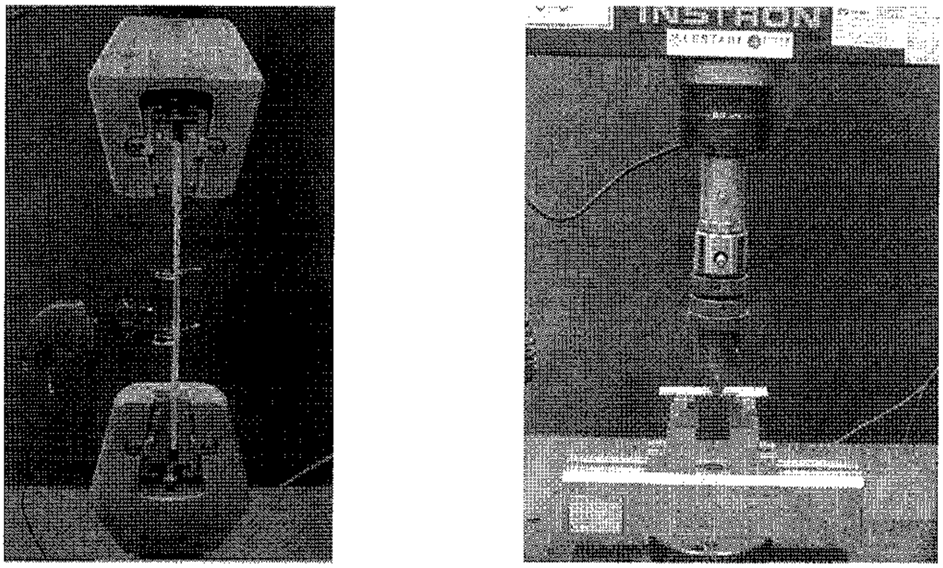


(a) Tensile specimen (b) Flexural specimen

Fig. 3. Testing Sample Configuration

The composites cooled in room temperature for 24 hours under pressure. The cured composite plate was cut in the weft direction using band saw into samples of 250 mm x 25 mm, 104 mm x 15 mm as shown in Fig. 3. Tensile flexural and Flexural tests was performed according to the recommendation by ASTM D3039[12] and ASTM D 7264 [13], respectively.

Tensile test was performed at the crosshead speed of 2 mm/min with gauge length of 50 mm to measure the elongation of the specimen by extensometer. Meanwhile three-point flexural test was performed at span to depth ratio of 16:1 tested at a crosshead speed of 1.5 mm/min. Both tests executed using the same universal testing machine with five repeated tests.



(a) Tensile test (b) Flexural Test

Fig. 4. Testing Configuration

3. RESULTS AND DISCUSSIONS

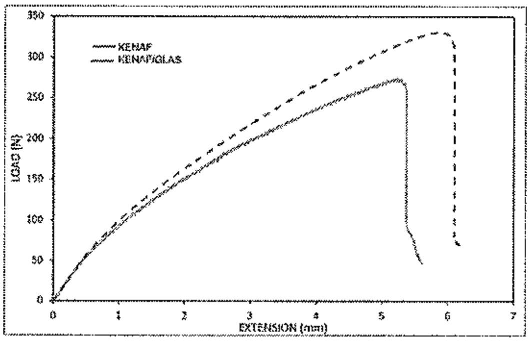
Fabricated composites cut, polish and measure its average thickness observed under optical microscope Ziess S2000. The mechanical properties obtained from flexural and tensile tests are presented in Table 1.

Sample	Tensile Strength (MPa)	Tensile Modulus (GPa)	Elongation (mm)	Flexural Strength (MPa)	Flexural Modulus (GPa)	Deflection (mm)
Kenaf	81.82	8.96	4.28	118.09	4.90	5.19
Kenaf/glass	85.49	9.88	3.69	123.85	4.51	5.42

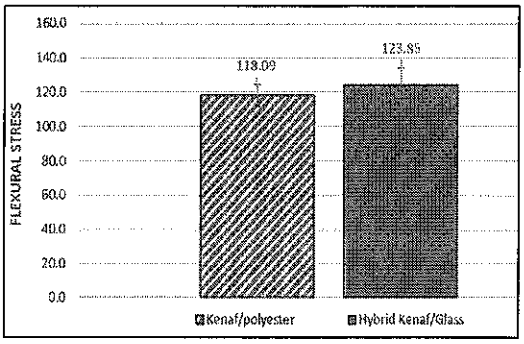
Table 1: Tensile and Flexural Test Data

3.1 Flexural strength and Modulus

The flexural strength and flexural deflection measured by three-point flexural test shows kenaf/glass composites performed slightly higher compared to kenaf composites. Flexural strength recorded at 118.09 MPa and 123.85 MPa with 4.88% increment. Comparing flexural deflection for kenaf/glass and kenaf composites exhibit 4.43% elevation measure at 5.42 MPa and 5.19 MPa, respectively. Hence, the flexural modulus shows slightly reduce by 8% comparing between 4.90 MPa for kenaf composites and 4.51 GPa for kenaf/glass composites. Flexural strength was calculated as; $\sigma_f = \frac{3FL}{2bt^2}$;Flexural Modulus, $E_f = \frac{L^3\, m}{4bt^3}$; Figure 5 shows the comparison on flexural curvature behaviour and composites flexural strength.



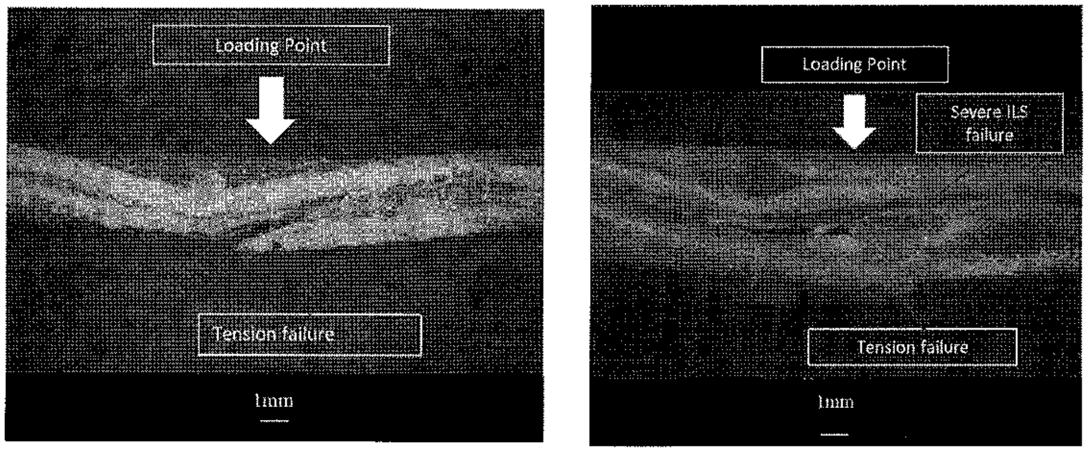
a)Flexural Load vs Flexural Extension curve



b.) Comparison on Flexural strength

Fig. 5. Flexural Test Results

The average flexural strength considering the standard deviation shows in Figure 5 (b), Kenaf and Kenaf/glass composites exhibited comparable values. The results seem to comply with the work of Swolfs et al. [2]; they found that the flexural strength depends on the outer layer fibre in which the interleaf glass fibre in between does not give significant effects to flexural strength due to its orientation near the neutral line.

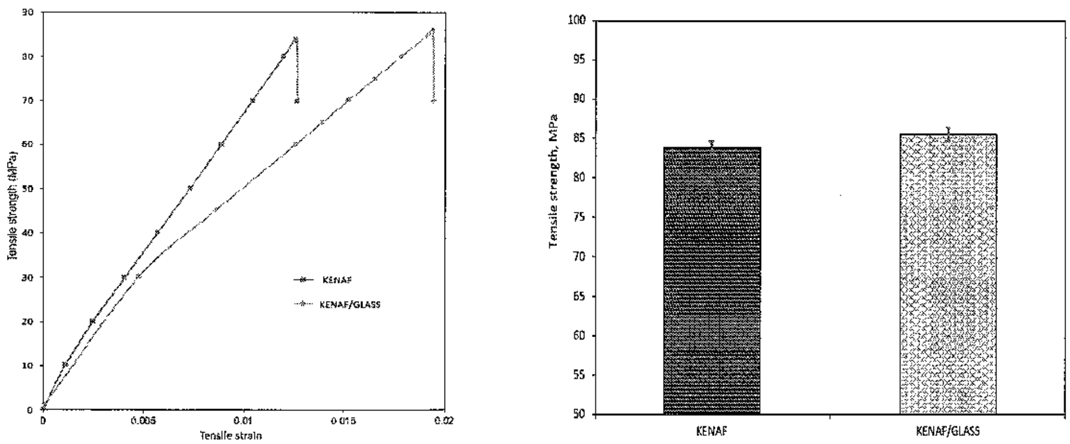


(a) Kenaf specimen (b) Kenaf/glass

Fig. 6. Morphology of flexural test specimen

From the image observed under an optical microscope see Figure 6. It can be observed there are two types of failure observed on flexural test fracture. Kenaf composites seen face severe damage due to compression failure as shows in Figure 6(a). Meanwhile, Kenaf/glass fibre composites flexural failure dominated by interlaminar shear failure with minor compression failure also observed in the fracture, Figure 6(b).

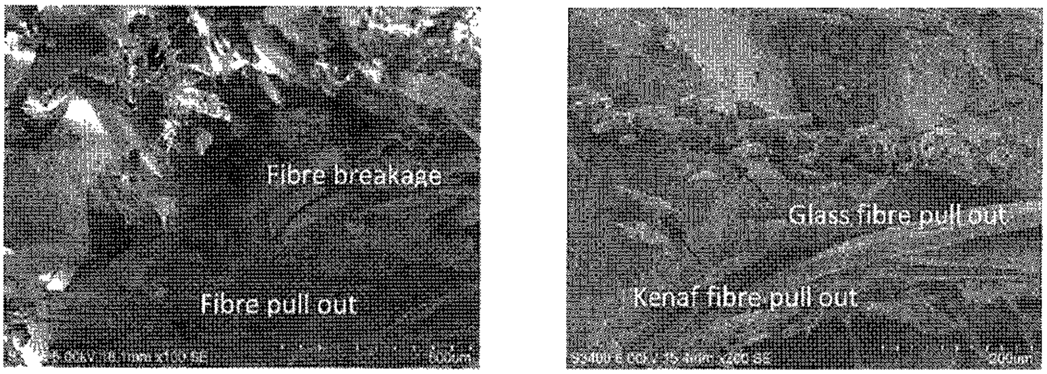
3.2 Tensile strength and Modulus



a) Tensile stress vs tensile strain curve b) Comparison on Tensile strength

Fig. 7. Tensile Test Results

A comparable curvature is observed for tensile behaviour Figure 7(a), the graph shows linear increment up to failure. The linear plot shows a sudden drop when peak load is attained signifying brittle behaviour of the composites. For Kenaf/glass composites, the hybridization effect is observed with higher maximum stress and strain [14]. The tensile strength and modulus show 4.29% and 10.27% increment respectively effect on glass hybridization.



a) Kenaf Composite b) Kenaf/Glass Composite

Fig. 8. Morphology of Tensile test specimen

The morphology studies on tensile specimen as Figure 8 shows, both composites fail due to fibre breakage and fibre pull out. Thus, proved that both composites were dominantly influenced by fibre reinforcement.

4. CONCLUSIONS

Glass interleaf kenaf reinforcement has been successfully studied and their performance was compared to control sample kenaf composites. The incorporation of glass proved to increased composites flexural strength and elongation. However, decreasing on flexural modulus was observed. The failure fracture from flexural test revealed that decreased flexural modulus of kenaf/glass composites is because of interlaminar shear failure. Tensile properties illustrate a slightly increment in tensile strength and modulus. On the basis of the results obtained, the following conclusions can be drawn, Glass fibre hybrid woven kenaf composites had proven to give less significant effect on tensile properties. Furthermore, interlaminar failure observe in bending behaviour its mechanical properties thus reduce composite laminate integrity.

1. Kenaf/glass composites shows higher in flexural strength, and flexural modulus compare to kenaf composites.
2. Comparable Tensile strength of kenaf/glass composites compared to the control sample.
3. Kenaf/Glass composites experiences shows severe damage due to interlaminar shear on flexural fracture compared to kenaf composites.

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