Jurnal Teknologi

Full Paper

Fatigue Life of Kenaf Woven Hybrid Composite

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Article history
Received
31 January 2015
Received in revised form
30 April 2015
Accepted
31 May 2015

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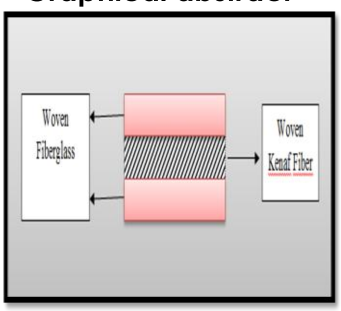
Graphical abstract



Abstract

Among natural fibers used to make composite structure, kenaf has been selected in this study due to its excellent mechanical and physical properties. The use of kenaf reinforced composites is not only limited to the lightweight applications such as laptop and mobile phone casing but also in heavy duty applications such as truck bodies and marine structures. Hence, this study investigates on the woven kenaf hybrid composites through fatigue test in order to understand their mechanical properties. The results revealed that the composite material had a significant degradation of fatigue life when increasing the stress percentage.

Keywords: Kenaf; fiberglass; hybrid; tensile; fatigue

1.0 INTRODUCTION

Over the past decade, the use of natural fibers composite in so many applications is gaining attention due to their superior mechanical and physical properties. Natural fiber composite has their own advantages compared to synthetic fibers such as low cost, availability, low density, and biodegradability. Kenaf or its scientific name, Hibiscus L`Canabinus is a warm season annual fiber crop closely related to cotton and jute [1].

Previously, kenaf has been used as a plant to produce twine, rope and sackcloth. However, nowadays it can also be used in more advance applications such as in automotive, marine and many other heavy duty products [2].In order to improve the mechanical properties of kenaf reinforced composites, glass fiber were added to strengthen this composite material. Fiber arrangement, fiber orientation and size of fiber also plays an important role as it will affect the properties of this hybrid composite. As a result, hybrid composite offers more positive impact for engineering applications to enhance their role in various applications. However, there are limitations in using fiber composites where the failure can occur due to its cyclic loading. Cracks will occur where it cannot be seen by the naked eye, which will cause the structure to fracture. This is the main disadvantage in using these composite materials.

Thus, this study aims to analyze the fatigue life of these composite materials through fatigue test. Fatigue test was measured according to the stress level applied obtained from tensile test. Several stress level was applied which were 90%, 80%, 70%, and 60% of its strength. A Scanning electron microscope will also be used to examine the microstructure at failure.

2.0 METHODOLOGY

2.1 Material Selection

Kenaf, glass fiber and epoxy were the materials used in this project. The material was fabricated using a cold press technique. Kenaf were supplied by Innovative Pultration Sdn.Bhd and used without any surface treatment. The epoxy was supplied by Miracon Sdn. Bhd and woven fiberglass were supplied by Mostrong Industries Sdn.Bhd.

2.2 Material Preparation

Long thread kenaf was manually sewed into woven form by using a wood frame and other tools. Then, the woven kenaf was laminated with two other layers of woven fiberglass which were placed in the mould. The arrangement of these fibers are shown in Figure 1. The matrix used were epoxy and hardener with a ratio of 10:3 which were then poured into the mould. All bubbles were removed by using cold press machine. Finally, after the specimen was taken out from the mould, the specimens were placed at room temperature for 24 hours before cutting according to its standard measurement for further testing. The specimens were cut into dimensions of 200mm x 25mm according to the BS EN ISO 527:1997 standard [3].

2.3 Mechanical Testing

The specimens underwent 2 different tests; which were tensile and fatigue testing. Fatigue testing was done at 6 different stress level ranging from a maximum tensile of 90%, 80%, 70%, 60%, 55% and 50%. The tensile testing machine wes operated at a crosshead speed of 1mm/min with 25 mm extensometer attached to the specimen.

3.0 RESULTS AND DISCUSSION

After the first testing, which is tensile test, there were 5 specimens that need to be done before undergoing fatigue test. This is because an average maximum stress value needs to be obtained in order to be used in determining each stress level for the fatigue test. All specimens were fractured at their gauge length area as shown in Figure 2. The graph of this composite material was also shown in Figure 3.

Tensile test wes carried out at a crosshead speed of 1mm/min with a 25 mm extensometer attached to the specimen in order to get an average tensile stress at the maximum load. When the test was conducted, all specimens showed the appearance of a white crack. The white cracks grew more rapidly before failure occurred. This may due to the bond between fiberglass and epoxy that sustained the load at maximum level. Overall results showed similarities between all five specimens. Previous research indicates that the hybrid composite improved in terms of their tensile stress[4].

After the testing had been done, the average tensile stress was recorded to perform the fatigue test. For the fatigue test, there were a few variables that needed to be controlled such as the maximum and minimum stress, frequency and stress ratio. For this test, the frequency used was 10 Hz and stress ratio (R) of 0.1 was chosen. Woven fiberglass and Araldite epoxy were used as a function of tabs to avoid friction between the clamp and specimen. Table 1 shows the fractured specimens after undergoing fatigue test. The results of fatigue test were also tabulated in Table 2.

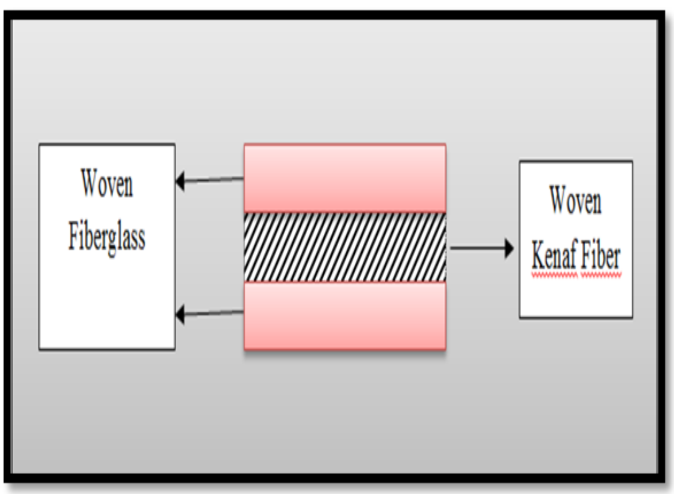


Figure 1 Arrangement of woven kenaf fiberglass hybrid composite

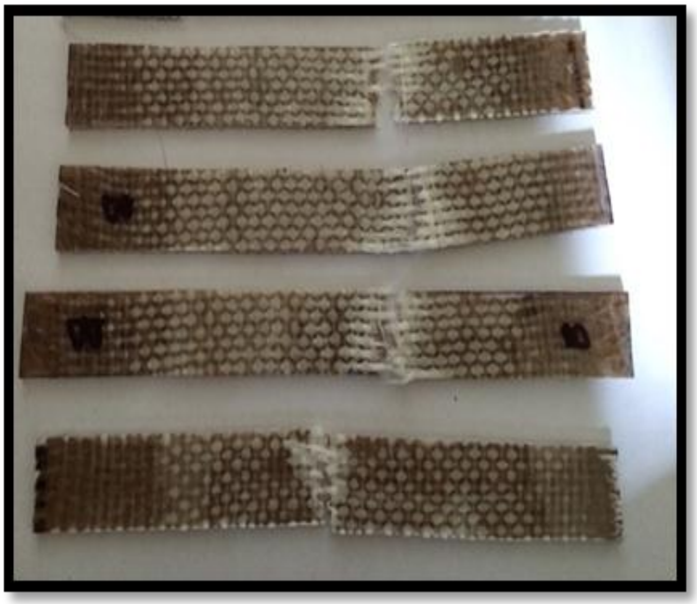


Figure 2 Specimens after tensile test

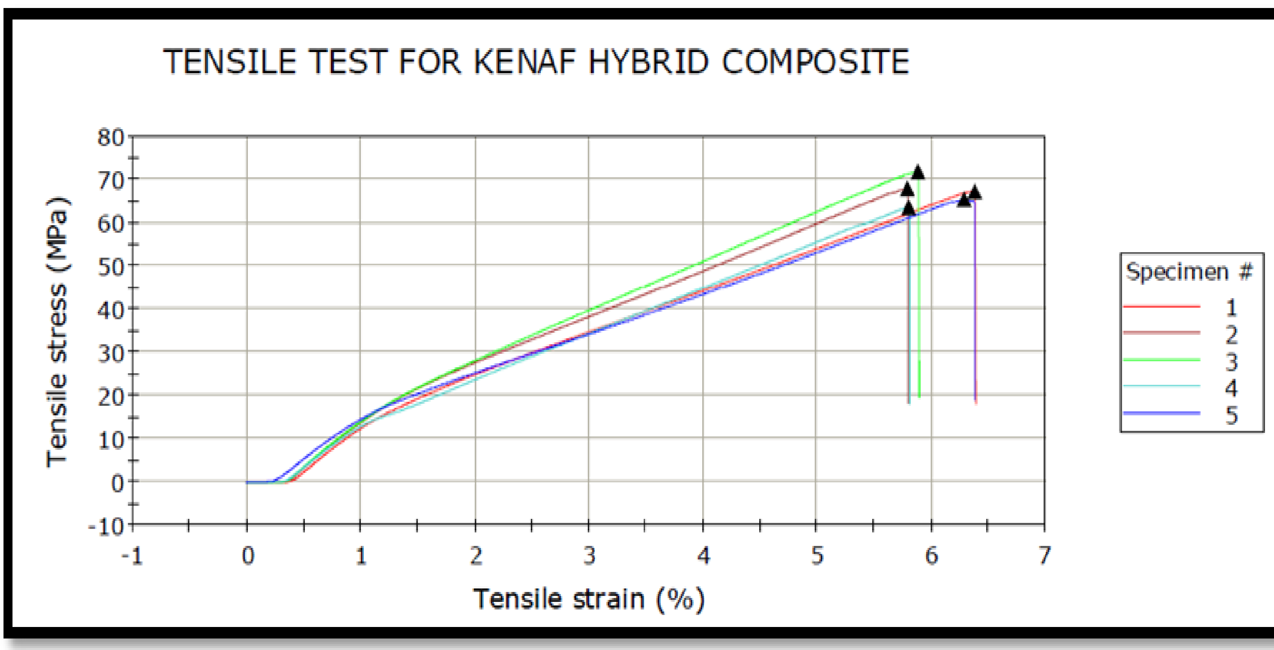


Figure 3 Graph of Tensile Stress (MPa) against Tensile Strain (%)

Table 1 Specimens after fatigue test

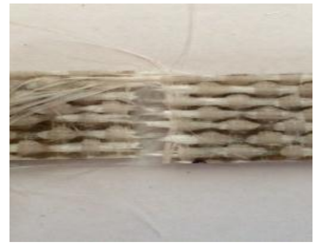
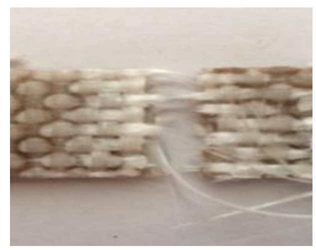
Stress level	Fractured surfaces	Stress level	Fractured surfaces
90%		60%	
80%		55%	
70%		50%	

Table 2 Specimens after fatigue test

Stress level	Maximum Stress, Smax (MPa)	Minimum Stress, Smin (MPa)	Fatigue life (Nf)
90%	60.593	6.0593	445
80%	53.860	5.3860	3120
70%	47.128	4.7128	5 048
60%	40.395	4.0395	47 754
55%	37.029	3.7029	540 337
50%	33.663	3.3663	1 000031

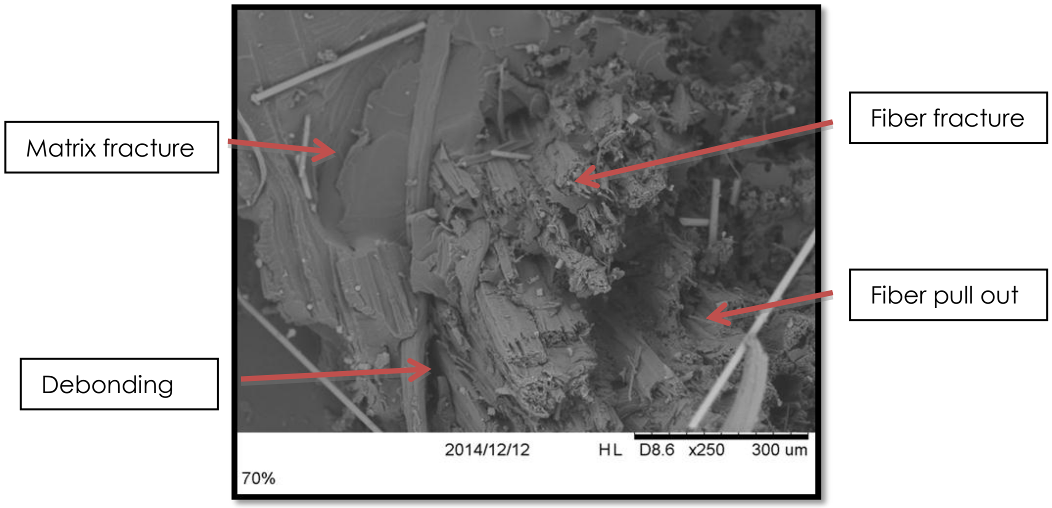


Figure 4 SEM microstructure of fatigue specimen

Table 2, shows the values of maximum and minimum stress and cycle life after the fatigue test. It can be clearly seen that with higher stress levels applied, the less fatigue life result was obtained. From 1.0 until 1x10^3 fatigue life are categorized as low cycle fatigue and 1.1x10^3 until 1x10^6 fatigue cycle are known as high cycle fatigue. Furthermore, the max of 90% of the fatigue life seems to be sensitive and could not be used for longer period. This result corresponds to the previous research done which indicate that lower stress level applied will significantly increase fatigue life [5].

It also indicates that by adding synthetic fibers in the composite will strengthen and increase the usage life of natural fibers. Previous research also indicates that stress ratio, or increase fatigue life and resistance. This means that if the value of R is more than 0.1, it may result in more fatigue life degradation on this composite. [6] Figure 4 illustrates the fatigue surface of woven kenaf hybrid composite. The microstructure of failure represents a pull out, debonding, matrix fracture and fiber fracture [7]. Previous research also indicated the same phenomenon of pull out, depending, matrix fracture and fiber fracture. This occurs for all composite materials which are not limited to only short and long fibers [4].

4.0 CONCLUSION

As a conclusion, woven kenaf hybrid composite was successfully fabricated. The strength and fatigue life were investigated in this project. As expected, the different stress level applied to affect the fatigue life.

Acknowledgement

The authors gratefully acknowledge the Ministry of Higher Education (MOHE) of Malaysia for the financial support through grant awards, Faculty of Mechanical Engineering (UiTM) and MyBrain PhD, and also to Research Management Institute (RMI) of Universiti Teknologi Mara, Malaysia for facilitating this project.

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