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Study of Fatigue Test on Kenaf Fiber Composite Using Co-Cured in Line Fiber Joint

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ABSTRACT

This research is about a study of fatigue test on kenaf fiber composite by using co-cured in line fiber joint. The main objective of this study the effect of the fatigue resistance of treated kenaf fiber reinforced plastic composite at different overlapping length when cyclically loaded which based on tension cyclic load (R = 0.1). The study mainly focused on the usage of kenaf fiber to determine the strength of mixed composite in terms of resistance force towards types of joint which includes single lap joint, double lap joint, double scarf joint and double stepped lap joint. A total of 6 samples for each controlled sample, 0mm lap joint, 10mm lap joint, 20mm lap joint and 30mm lap joint which contains a mixed kenaf and resin in the ratio 70:30. The result of the study shows that controlled kenaf are strong and durable with fatigue test,and the tensile test are 17.528kN and 14.093kN respectively. From these tests, it can be concluded that for tensile strength kenaf fibre reinforced polymer (KFRP)which manufactured by using control sample can carry load transfer on the composite. It has a good bonding between each other with sequence of 30mm lapping then 20mm and 10mm lapping.
KEYWORDS: Fatigue Test, Kenaf Fiber Composite, Co-Cured In Line Fiber Joint.

INTRODUCTION

In recent years, the requests of the uses fibre reinforced polymer (FRP) have become popular in application of technology. Fiber reinforced polymer are almost be used in the engineering structure as a composites such as aircraft, spacecraft passing to boats and helicopters, sports good, offshore and ships platform to automobiles, civil infrastructure and equipment of chemical processing like buildings and bridges. FRPs give various advantages than steel which including electrochemical corrosion of resistance, speed and case of application [1] lighter in weight, higher strength, longer lasting, higher performance, seismic upgrades, space system, rehabilitate the existing structures and extending their life and defences systems [2].

Epoxy resins give environmental degradation of resistance and high performance. The reacting between bisphenol-A and epichlorohydrin with hardeners like anhydrides or amines are common in industry [3].

Table 1: The typical properties thermoset polymers for composite of natural fiber

Property	Polyester resin	Vinylester resin	Epoxy
Density (g/cc)	1.2-1.5	1.2-1.4	1.1-1.4
Elastic modulus (GPa)	2-4.5	3.1-3.8	3-6
Tensile strength (MPa)	40-90	69-83	35-100
Compressive strength (MPa)	90-250	100	100-200
Curve shrinkage (%)	4-8	-	1-2
Water absorption (24 h @ 20°C)	0.1-0.3	0.1	0.1-0.4
Izod impact notched (J/cm)	0.15-3.2	2.5	0.3

Fiber reinforced polymer consists of synthetic fiber and natural fiber. The example of synthetic fiber is glass fiber, carbon fiber and others. For the natural fiber, it consists of jute, sisal, flax, kenaf, hemp, papyrus kapok, cane, wood, rice husk and many more. There are renewable resources and appeal of marketing. This is one of the advantages of the natural fiber. Other advantages of natural fiber that interest in the applications area like housing, construction, packaging, electronics product and automotive [4] are low density, low cost, renewability, low energy consumption, bio- degradability and recyclability, less health risk and non-abrasive to equipment.

Kenaf or Hibiscus cannabinus, L family Malvacea[5] is be selected in this research. In Malaysia, it is a grown fiber crop and also important source of composite and application for other industrial [6]. Kenaf is a main material that be used in this experiment. The development in worldwide countries increasing rapidly, and it will increase the demand of the material inthe development process. The natural fiber from the mechanical properties view, it is a very strong fiber which it is subjected to tension force. The synthetic fiber cannot compete the amount of variability in natural fiber's properties and strength.

The fiber reinforced polymer composite is processed by using fiber with long directional. It offers a good performance compared to the random and short contributed fiber. However, the length bast of kenaf fiber

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available is less than 5 feet. For specific uses like a plate of FRP and pultrusion required a long fiber, so the fibers has to be jointed. The quality bonding joint is important for composite structure of integrity. In the manufacturing of natural fiber, the joining of unidirectional natural fiber has to be observedwith high attention. Because of that, the study on different length of overlapping of joining fiber has been worked out in order to determine its quality.

The objective of this study is to determine fatigue resistance of treated kenaf fiber reinforced plastic composite by using co-cured in-line joint at different overlapping length when cyclically loaded which based on tension cyclic load (R = 0.1).

RESEARCH METHODOLOGY AND PROCEDURE

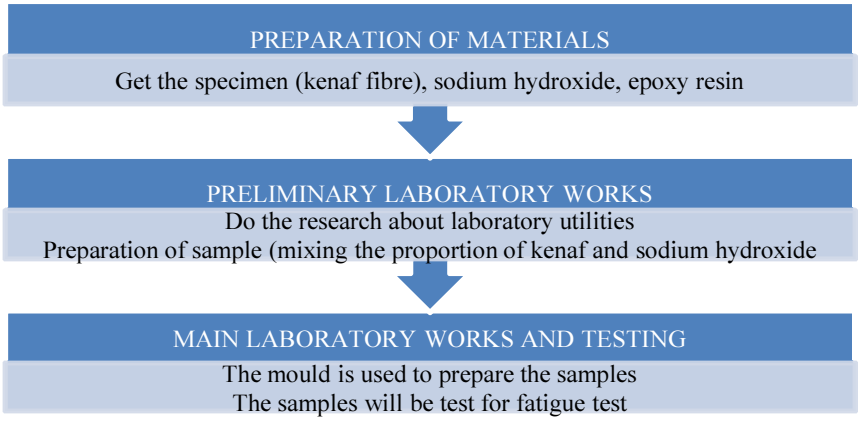

Figure 1: Experiment procedure of kenaf fiber composite using co-cured

RESULTS AND DISCUSSION

The flow chart of the experiment was expressed as shown in Figure 1.The data are presented in the table and the graph is plotted to analyze the pattern of the tested result. The results of fatigue test are depending on the tensile test result. Five specimens in each sample are produced, and kenaf KFRP comparisons between overlapping length are namely such as:

- KFRP control-Kenaf fiber reinforced polymer without overlapping length
- KFRP 0-Kenaf fiber reinforced polymer with 0mm overlapping length
- KFRP10-Kenaf fiber reinforced polymer with 10mm overlapping length
- KFRP20-Kenaf fiber reinforced polymer with 20mm overlapping length
- KFRP 30-Kenaf fiber reinforced polymer with 30mm overlapping length

Tensile Test

The tensile test is conducted in order to determine the maximum load and tensile stress at the maximum load. The purpose of this test is to determine the tensile strength of composites, and also to establish the stress level for fatigue test. The values of maximum and minimum load of the tensile test are used in order to conduct the fatigue test. The results are obtained from five samples for each length of lapping with control of 0mm, 10mm, 20mm and 30mm. Each specimenis tested by using a uniform speed rate of 2mm/min with dimension sizesof length is 150mm, 20mm width and 4mm thickness. The length becomes 150mm where 100mm is more in the grip area. The result of the tensile test is shown in Figure 2 which according to the lapping length.

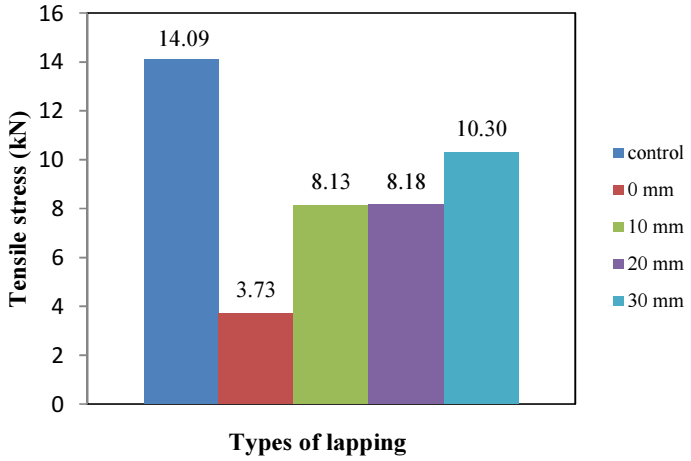

Figure 2: Tensile stress at maximum load against types of lapping

From Figure 2, itis obviously showingthe differences of the result among the type of lapping. The highest tensile stress is for the control sample which is without any lapping length. It gives a value of 14.093kN of the maximum load. The control sample gives the highest value compared to the others sample. There is no cutting or lapping area in the middle, with the addition of the mixture of epoxy resin and hardener on the long fiber of the composite. The epoxy resin and the hardener give the strong of adhesive binding to the fiber. For the sample of 0mm lapping gives the lowest value in the maximum load which is 3.726kN. There is no lapping in 0mm sample where the sample is cut in the middle of the composite, and every layer it lay with the mixture of the resin and hardener. When the test is conducted in the 0mm sample, it is easy to break due to no joint in the middle of the sample.

Fatigue Test

The fatigue test is conducted on the fiber composite in order to know their performance under cyclic loading. The relationship between the applied load and the numbers of cycles for the composite to fail is established by using maximum and minimum load from the tensile test. In this test, the frequency that be used is 25Hz. About 70% of the stress level of maximum load is used, and the ratio between maximum and minimum applied stress is 0.1 where the result is given in Table 2.

Table 2: Fatigue result from the different lapping

Specimen	F.ult (kN)	F max (kN)	F min(0.1 x F max)	Total no. of cycles
Control (without lapping)	17.528	(70%) 12.269	1.226	8592, 916, 205,79, 3690
0mm	4.634	(70%) 3.243	0.324	-
10mm	10.452	(70%) 7.316	0.731	604, 16042
20mm	10.319	(70%) 7.223	0.722	879, 18901, 118,2828, 3430
30mm	13.736	(70%) 9.615	0.961	43, 3067, 190

F = Force (kN)

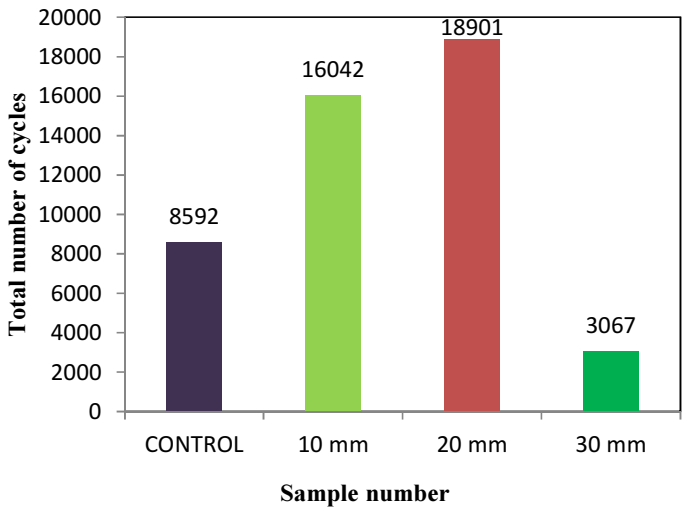

Figure 3: Total number of cycles versus the sample number

Figure 3 shows the total number of cycles versus the sample number which consists of control 10mm lapping, 20mm lapping and 30mm lapping. The 0mm lapping is excluded where its maximum load is too small, so the fatigue test cannot be done on it. The bar chart showed that the sample two which consist of the 20mm lapping produce the highest number of cycles to composite fail which is 18901. The second highest is also sample two, but for 10mm lapping which the number of cyclesis 16042. For the sample one of control gives the value of the number of cycles to fail is 16042. For the lowest of the number of cyclesof composite fail is for 30mm lapping which is 3067.

The fatigue test and the tensile test are two testings that have a relationship to each other. According to the tensile result, the result is good where the control sample gives the highest value in maximum load and the second highest is 30mm lapping. It is due to the fiber itself, added to the mixture of the epoxy resin and the hardener which gives strength to the composite. The good bonding on the control sample is where the control sample is a line coupon sample. Without cutting and lapping add to the good binder, it gives the high maximum load result compared to the others sample. The 30mm lapping gives a second highest in the maximum load where the lapping length is more than 0mm, 10mm and 20mm. It gives the strength of the sample when testing where the sample is hard to break.

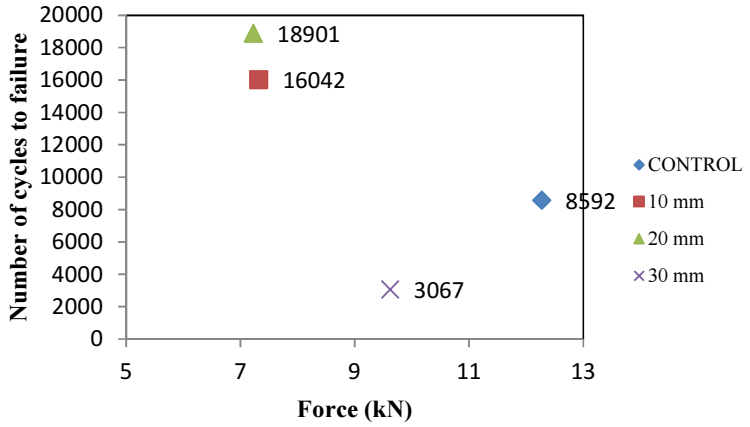

Figure 4: The number of cycles to fail versus force

Figure 4 shows the overall fatigue test result.It indicates that the control sample offers the highest value in shear stress, but not in the number of cycles to composite to fail. The 20mm lapping length of the sample produces the highest value in the number of cycles which is 18901. The second highest of the number of cycles to fail is 10mm lapping, and the lowest is 30mm lapping length. The result is not consistent well where a big difference between each specimen maybe due to the some errors during the manufacturing sample, human error which seemslike not soak well the fiber into the mixture of the sodium hydroxide and distilled water, not dried it well, not align the kenaf properly into the mold, the resin and the hardener do not mix equally which it affects the bonded in each part of the specimen and the parallax error of the weigher. Therefore, it influences the result of the testing.

CONCLUSION AND RECOMMENDATION

The tensile test and the fatigue test have been done for kenaf fiber reinforced composite. It can be concluded that for tensile strength of KFRP which manufactured by using control sample, it can carry load transfer on the composite. It has a good bonding between each other with 30mm, 20mm and 10mm lapping.

The tensile strength for each overlapping length sample were different and do not proportionally following the increases number of overlapping lengths. The 0mm sample is not a good choice to apply where it gives the worst result. The control specimens have better overall performances compared to the specimens that have overlapped joints. The numbers of cycle to composite to fail for the samples are not consistentdue to human error.

For better performance of KFR composites, it is recommended that a little attention has to give to the manufactured stage when pouring the epoxy resin into mold. Every surface of specimens must be fully covered to obtain better performance strength of kenaf fibers. Avoid cracksin the tapping area which the handle grip not to loosen or too tight during conduct the testing. The idea of breaking point at the center or in gauge length has been stated in the standard for tensile test.

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