Effect of temperature to fracture toughness of coir fiber composite

Meor Syazalee Meor Sha[1,2,*], Rozli Zulkifli[1], Muhamad Shahirul Mat Jusoh[2]

[1]MERCU, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia
[2]Department of Polymer Composite Processing, Kolej Kemahiran Tinggi MARA Masjid Tanah, Melaka

[*]Corresponding e-mail: syazalee@mara.gov.my

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ABSTRACT – Coir fibers were used as reinforcement for natural fiber composites for various applications. This study is intended to analyze the effect of temperature on the quality of fracture toughness in mode II, G_{IIC} for coir fiber composites. Samples are fabricated by using cold press and polyester resins are used as matrix. End Notched Flexural (ENF) test was performed to investigate the effect on G_{IIC} with the addition of heat during tests which is performed at ambient temperature, 60^0C and 100^0C. Results from tests conducted found that effect of temperature cause the critical energy release rate decreased with increasing of temperature.

1. INTRODUCTION

The use of natural fibers to replace the synthetic fibers such as carbon, glass and aramid in reinforcing materials can lead to new ventures in industrial composites. This is due to the understanding of environmental awareness about the limitations of recycled, but it is also due to the potential of such materials in reducing costs. Besides that, properties of natural fibers such as lightweight, low manufacturing costs and low thermal mass increase opportunity of the usage [1-2].

From previous study, it is show that presence of high temperature cause reduction in mechanical properties of coir fiber [3-4]. It is also noted that the fracture toughness will decreases with increase in temperature. Fracture toughness or delamination between laminar is one of the main failures for laminated composites [5-7]. This defect causes failure in the stiffness and finally failure of composite structures.

In this study, the main reinforcement use is coir fiber as a natural fiber. Coir fiber is one of the natural fibers that has good mechanical and physical properties such as cheap, renewable, and easy to recycle. Additionally, the source of this material selected for the study is due to the large number of availability in Malaysia [8]. The desired results in this study are the behavior of flexural properties of coir fiber/polyester composite effect from temperature differences. Temperature difference is because generally fibers extracted from plants are more sensitive to temperature changes than fiber synthetic fibers.

2. METHODOLOGY

2.1 Material

Coir fiber in a form of random mat use then cut with size of 300mm x 300mm. This size corresponds to the size of the mold used on the cold press machine. Before that, coir fiber was treated using silane treatment to improve adhesion bonding with matrix. The matrix was used is polyester resin.

2.2 Silane treatment

3-aminopropyl triethoxysilane is used as a silane agent for the treatment of coir fibers. The preparation of silane coupling agent, 3-aminopropyl triethoxysilane is mixed into 50% ethanol solution and 50% water with the percentage 5% of silane. The coir fiber is then immersed into the solution for 24 hours and then wash with tap water and dried at ambient temperature for 24 hours and in the oven at 40^{o}C for 24 hours.

2.3 Sample preparation

The process used to prepare the sample is using a cold press machine. Coir fiber composite sample was constructed with two reinforcement layers with a weight ratio of 30:70 to the matrix. Polyester resin used as a matrix which is mixed with the MEKP catalyst before it is inserted into the cold press machine. 40 metrics tons of load applied and left for 2 hours. During this period, the sample was completely cured.

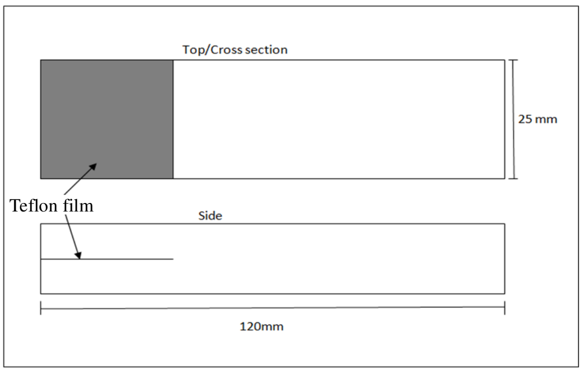

Figure 1 Schematic orientation of coir fiber and Teflon film

The arrangement of the sample for this test is shown in Figure 1 with a length of 120mm length and 25mm width. Teflon films of 30 mm in length are placed in the center of the sample layer at one end of the sample. This teflon film works as precrack of composite.

2.4 End notched flexure test (ENF)

ENF test is used according to ASTM D790-03 standard to identify the fracture toughness in Mode II. The test machine used is the Universal Testing Machine (UTM).

The sample was placed at 3 bending points with a distance of 100mm between 2 points with the rate of speed used during the test was 5.00mm/min. The test performed inside the heat chamber to supply the temperature during test, 3 reading temperature was exposed to the test, ambient, 60^0c and 100^0c. The result of ENF test data will be used to find Mod II value, G_{IIC} by using formula;

$$G_{IIC} = \frac{9a^2 P\delta}{2W\,(2L^3 + 3a^3)}$$

Where a is the length of Teflon film from the beam, P is the maximum load, δ is the sample elongation at the maximum load, W is the sample width and L is the sample length[9].

3. RESULT AND DISCUSSION

3.1 Critical energy release rate, G_{IIC}

From the ENF test, the required parameters are the maximum load value, *P* and the elongation rate at the maximum load, d. The G_{IIC} values at ambient temperature were the highest at 227.58J/m^2 and the lowest was at 100^0C at 89.96J /m^2 as result in Table 1.

From these results, the difference of more than 50% reduction in energy release rate occurs when the presence of temperature of 100^OC. This shows that the presence of high temperatures showed in figure 2 causes the bond strength between coir and polyester to be very weak compared to ambient temperatures.

Table 1 Energy Release, G_{IIC} by sample group

Temperature, ^{0}C	G_{IIC}, J/m^2
Ambient	227.58
60	150.69
100	89.96

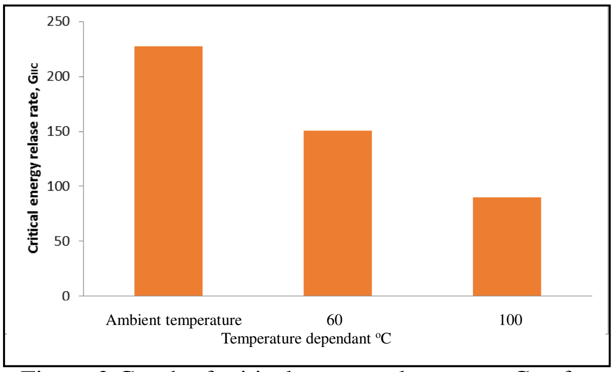

Figure 2 Graph of critical energy release rate, G_{IIC} for each composite sample of coir fiber

4. CONCLUSIONS

The effect of this temperature affects the value of the energy release rate where the higher the temperature the lower the energy release rate, G_{IIC}. This shows that the increase in temperature will lead to lower energy levels. This is because the temperature change affects the interlaminar bond between coir fiber and polyester resin, this will causes the spread of the fracture to propagate larger.

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