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The Critical Load Measurements of Pineapple Leaf Fibre Reinforced Polyester Composite Using Single Edge Notched Beam (SENB) Testing

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Abstract

Pineapple leaf fibre has potential as reinforcement in composite material due to their advantages such as renewable fibre and abundantly available. Some studies have been conducted relating to their mechanical properties using tensile, impact and bending testing. However the analysis of crack propagation in pineapple leaf fibre reinforced polyester composite is still limited. In this paper, the main attention is therefore the critical load leading to crack propagation in the composite material for two different fibre orientations. The crack propagation is investigated using single edge notched beam (SENB) testing. The composite material was manufactured by hand lay-up with two different nonwoven fibre orientations i.e. 0°/90° and +45°/-45°. Then, five different initial crack lengths are given in experimental specimen. The result reveals that increasing initial crack length will decrease the value of critical load for both fibre orientations. Furthermore, the fibre orientation influences the critical loading. In general the critical load leading to crack propagation for composite with +45°/-45° orientation has higher value than composite with 0°/90° orientation. It can be concluded that the composite material with +45°/-45° orientation has good resistance to the crack growth.

Keywords: Natural fibre composites, pineapple leaf fibre, crack propagation

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1. Introduction

The using of natural fibre reinforced polymer composite materials is significantly increasing in industrial applications and fundamental research. The natural fibres are emerging as realistic alternative solution to replace the glass reinforced composite in many applications due to their advantages such as renewable, low cost, low density [1] and low environmental impact [2].

The one of natural fibres is pineapple leaf fibre which has potential as reinforcement in composite material due to their advantages such as renewable fibre and abundantly available [1]. Some studies have been conducted relating to mechanical properties of pineapple leaf fibre reinforced composite materials using tensile and bending testing [3]. However the studies of crack propagation in pineapple leaf fibre reinforced polyester composite is still lack of data. Some studies regarding to fracture criteria

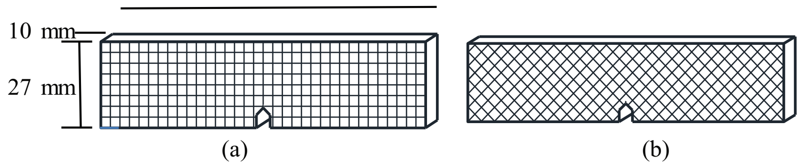


Figure 1: Fibre orientation (a) 0°/90°, (b) +45°/-45°.

have been conducted to other natural fibres such as bamboo[4], coconut fibre [5], sisal [5,6] and etc.

The studies of crack propagation relate to how relationship between the critical load and initial crack length. The critical load is required to be observed to prevent the catastrophic crack propagation occur in structure. The main attention in this paper is therefore the critical load leading to crack propagation for the pineapple leaf fibre reinforced polyester composite. Thus the effect of fibre orientation in composite in crack propagation also investigated regarding to critical load and initial crack length.

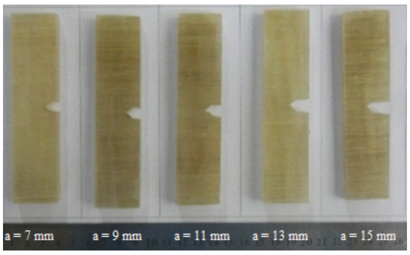
2. Experimental

The dimension of test specimen in this research are illustrated in Fig. 1. The composite material was manufactured by hand lay-up with two different nonwoven fibre orientations i.e., 0°/90° and +45°/-45° as shown in Fig. 1. The composite materials was fabricated using polyester as matrix and layer of pineapple leaf fibre as reinforcement. The fibre layer and polyester was put in mould and then wait until 4-6 h for dismolding. The mass fraction of fibre layer is 3.2%. The whole process was performed at room temperature. In sequence the composite materials was cut and polished based on size of test specimen. Thus five different initial crack lengths (a) are given using blade cutter manually in test specimen namely 7 mm, 9 mm, 11 mm, 13 mm and 15 mm for each type of fibre orientation as shown in Fig. 2.

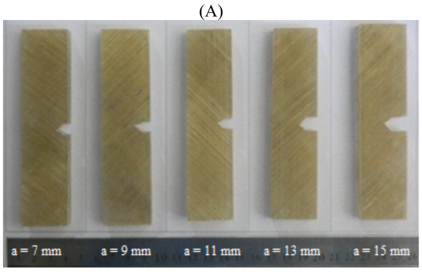
The experiment are conducted using Com-ten testing. The test uses the single edge notches beam (SENB) testing with three point flexure. The tests are performed at room temperature. Five test specimens are performed for each type of test specimen. Load–displacement curves are recorded for all tests and then the average values are determined for each type of test specimen.

3. Results and Discussion

Fig. 3 shows the critical load on average occuring at five different initial crack length for two variations in fibre orientation. In this figure can be seen that the loading experienced by the test specimen is inversely proportional to the given initial cracks value. The larger initial crack length is given, then the smaller the load needed to crack growth. In general, specimens with 0°/90° orientation has critical loading lower than specimens with +45°/-45° orientation except at the given first crack length (7 mm) has a larger critical loads than +45°/-45° orientation. This deviation occurs because of the



(A)



(B)

Figure 2: Test specimens (a) 0°/90° orientation and (b) +45°/-45° orientation.

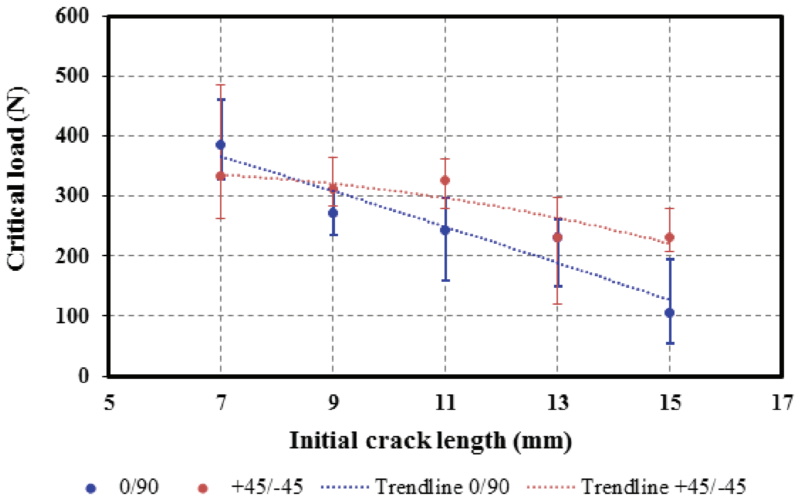


Figure 3: The critical load (N) versus initial crack length (mm) for 0°/90° and +45°/-45° orientation.

given initial crack length using blade cutter manually so that the initial crack length is not exactly same size for both fibre orientation.

The fibre orientation affect significantly to propagate the crack. For the composite material with 0°/90° orientation, the critical load will sharply decrease along with increasing initial crack length. In contrast, for composite material with +45°/-45° orientation, the critical load will gradually decrease along with increasing initial crack length. This shows that composite material with +45°/-45° orientation has good resistance to the crack growth.

The crack propagation path after testing is shown in Fig. 4. It can be seen from figure that the crack propagation follow opening mode in which the direction of crack growth is perpendicular to normal stress direction for both fibre orientation.

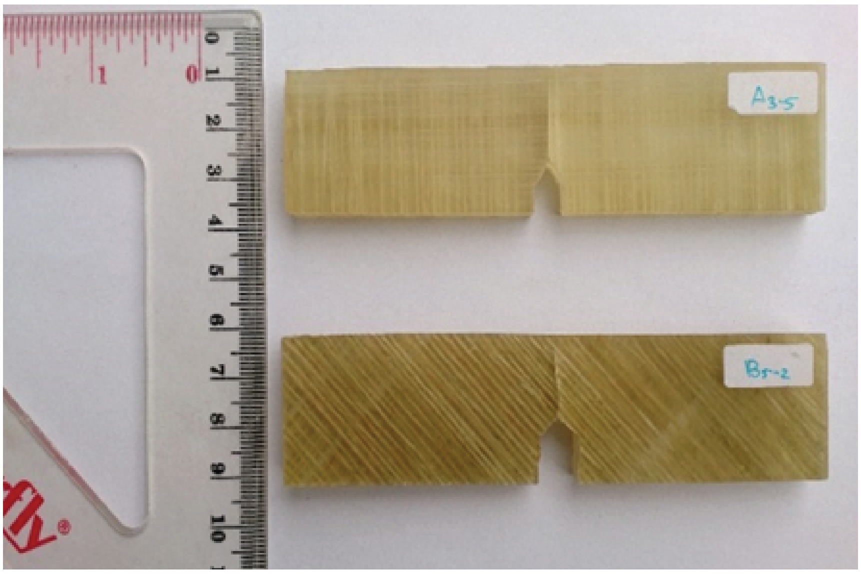


Figure 4: SENB test specimen after testing.

4. Summary

The result reveals that increasing initial crack length will decrease the value of critical load for both fibre orientations. Furthermore, the fibre orientation influences the critical loading. In general the critical load leading to crack propagation for composite with +45°/-45° orientation has higher value than composite with 0°/90° orientation. It can be concluded that the composite material with +45°/-45° orientation has good resistance to the crack growth.

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