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Analysis of Sandwich Core Fiber Composite Subjected to Different Skin Reinforcement Materials

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Abstract: The aim of this project was to determine the maximum force needed to rupture a composite and the total energy absorption. A typical composite material is a system of materials composing of two or more materials (mixed and bonded) on a microscopic scale. Generally, a composite material was composed of reinforcement (fibers, particles, flakes, and/or fillers) embedded in a matrix. This project was using an aluminum, plastic and steel that act as the skin reinforcement. In order to get the composite material, bamboo fiber was been chosen to be impregnated into the reinforcement with the aid of epoxy that act as a resin. The sample were been cut into dimension of ten centimeters times ten centimeters. Once the samples become a composite, it undergoes compression testing to obtain the curve line behaviors, maximum force and total energy absorption

Keywords: Reinforced Composite, Compression Testing, Curve Line Behaviors, Maximum Force, Total Energy Absorption

1. Introduction

A typical composite material is a system of materials consisting of two or more materials (mixed and bonded) on a microscopic scale. The new material is then called an alloy for metals or a polymer for plastics if the composition takes place on a microscopic scale (molecule level). [1]. Generally, the composite material consists of reinforcements (fibers, particles, flakes and/or fillers) integrated in the matrix. Low-speed impact is a common phenomenon in fiber reinforced polymer composite products. [2]. As a result of the low velocity impact, there will be significant damage and, ultimately, a preterm failure of the structure. The literature survey shows that the response of polymer composites subjected to quasi-static loading is similar to that of low velocity impacts. [3]. Polymer reinforced composites are poor in damage tolerance with better strength to weight ratio than conventional materials [4]. It is shown that the energy absorption in the spread of delamination is spent on two ways of creating a new fracture

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surface (delamination) and nonlinear shear deformation in composite folds adjacent to the delamination interface [5]. Therefore, the nonlinear process zone is not restricted to the resin-rich interface between the layers, but also extend into the fiber/epoxy composite layers. The addition of different skin reinforcement materials to composite considerably improves its structural such as static flexural strength, impact strength, ductility and fracture toughness [6].

2. Materials

This study involved with three types of reinforcement that been impregnated with the fiber bamboo to achieve the composite material that will undergo compression testing to obtain the value of energy dissipation in each reinforcement. The reinforcement used is aluminum, plastic and steel. Characteristic of reinforcement selected and bamboo fiber shows at Table 1.

Table 1: Physical characteristic of reinforcement and bamboo fiber

Type of sample	Thickness (mm)	Size of the piece (cm)	Amount of sample
Bamboo fiber	4	10 x 10	3
Aluminum	8	10 x 10	2
Plastic	8	10 x 10	2
Steel	8	10 x 10	2

Fiber

Fiber

Fiber

Figure 1: Layout configuration of composite

2.1 Methodology

All the sample was cut into measurement of 10 x 10 (cm). After that, each type of reinforcement was been bonded with a layer of bamboo fiber. The next step, epoxy that act as the resin was applied on each layer of sample. Thus, the composite was been made which consist of two layer of reinforcement and a layer of a bamboo fiber. In the process of making the composite, all the sample will undergo vacuum bagging process to get rid the unnecessary epoxy resin and avoid air bubble to occur. This process took an hour to ensure all the unnecessary resin been removed. After that, the composite was been left for twenty-four hours due to curing process duration of epoxy resin. For the last process, all the composite was undergoing a compression testing by using the universal tensile machine to obtain the result.

2.2 Preparation of the bamboo fiber

Figure 2: Bamboo Fiber

Figure 3: Bamboo fiber undergoes opening process

Figure 4: Physical of bamboo fiber after undergoes opening process

2.3 Compression testing

Figure 5: Universal Tensile Machine

Figure 6: Front view of sample in compression testing

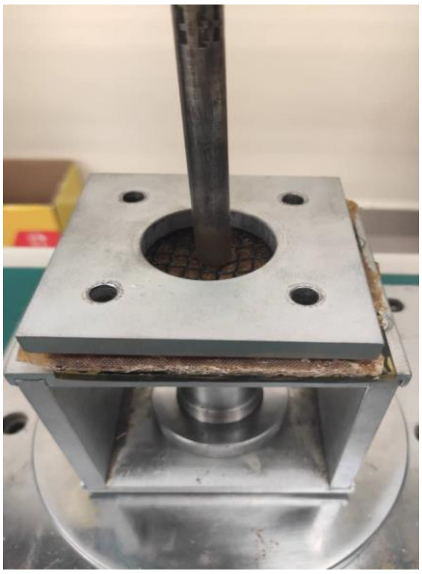

Figure 7: Top view of the sample in compression testing

3. Results

Table 2 below shows the result of maximum force and total energy absorption in compression strength test of sandwich composite material

Table 2: Compression strength test in sandwich composite reinforced

Item	Parameter Name	Maximum force (Mpa)	Total energy absorption (kJ/m^3)
1	Aluminum	1402.35	13861.1
2	Plastic	921.83	10119.99
3	Steel	2883.16	30725.13

The curve line graph force – elongation behaviors for three sample shown in figure 5. The data collected was focused on the elastic regime of deformation of the three reinforcement. As we can see, the curve line for plastic sample tends to be longer compare to others sample. This shown that the properties of plastic which is more elasticity compare to aluminum and steel. Thus, elongations data is obtained for plastic (18.31 mm), steel (14.51 mm) and aluminum(13.74 mm) respectively. The failure mechanism of steel appears to be more prolonged than those of the other two reinforcement, which underwent buckling more immediately and, as evident in the lower slope of plastic deformation, offered less resistance to applied stress after yielding.

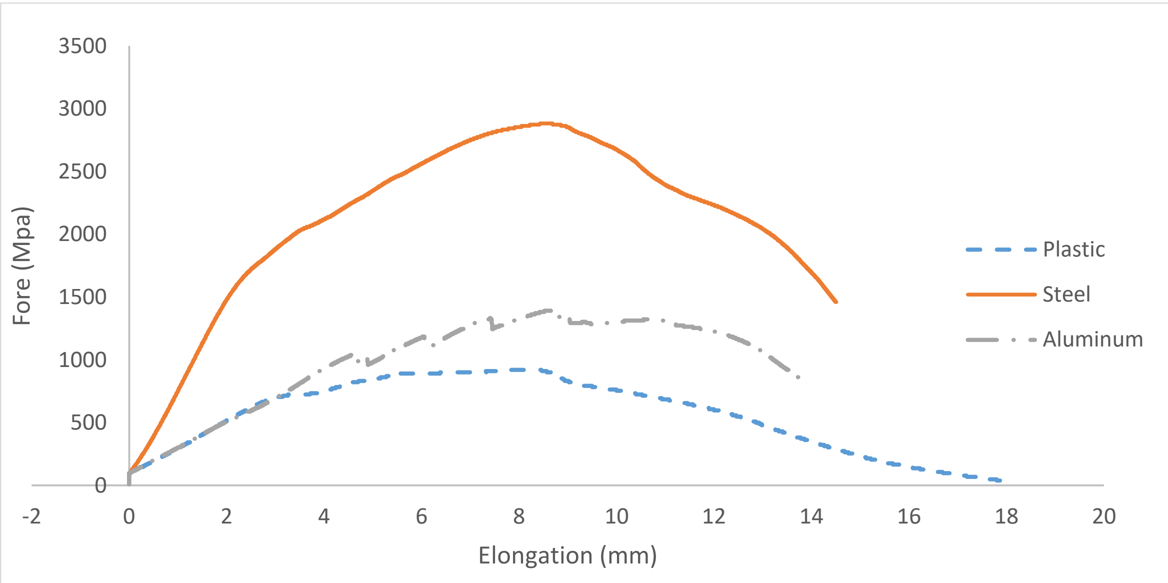

Figure 8: Force-elongation curve for sandwich composite reinforcement

The data for maximum force needed to rupture the sample shown in figure 8. Figure 9 presents data from the broader regime of compressive deformation, and demonstrates that steel by far is the strongest of the three reinforcement with a compressive yield stress of 2883.16 MPa. Plastic (921.83 MPa) were found to be the weakest, with aluminum being slightly stronger with a yield stress of 1402.45 MPa. Figure 10 shows that concordantly, steel absorbed the greatest amount of elastic compressive energy (30725.13 kJ/m^3); aluminum (13861.10 kJ/m^3) and plastic (10119.99 kJ/m^3) tolerated the least amount of compressive energy before yielding.

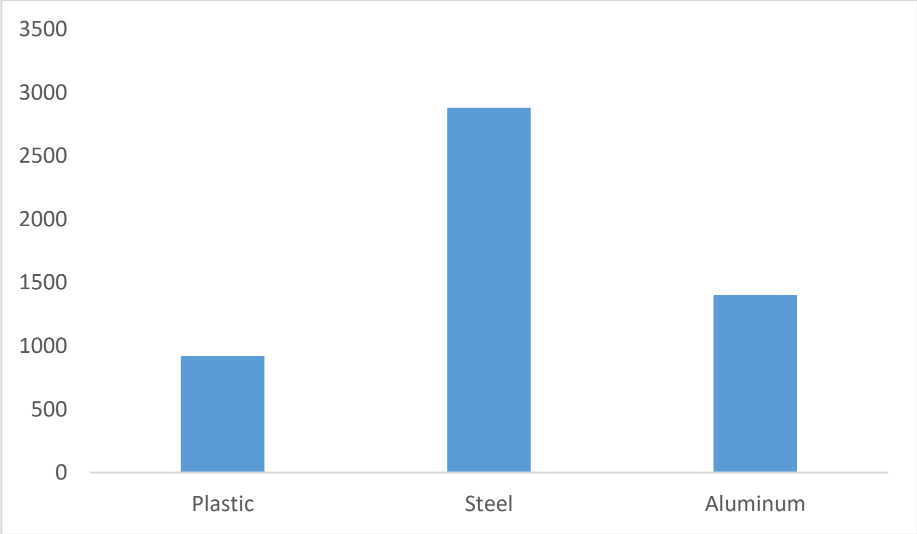

Figure 9: Maximum force obtain from sandwich composite reinforcement

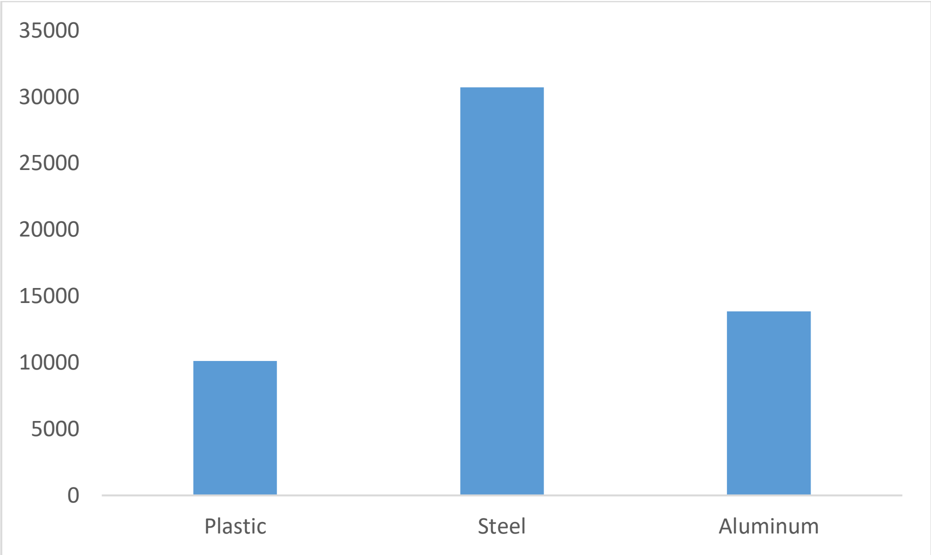

Figure 10: Total energy absorption obtain from sandwich composite reinforcements

3.1 Discussion

For the sandwich composite reinforcement, the data generated force-elongation profiles that reflect their theoretical properties, exhibiting distinct regimes of elastic behavior. The differences in the reinforcement mechanical properties are most evident the plastic regimes of the force-elongation plots, where properties including energy absorption, compressive strength and maximum force to break the yield stress of the composites are determined. The curve lines in Figure 8 shows clearly that the reinforcement of plastic (highest elasticity) had the longest elongation of fracture strain, while materials with pure aluminum or a binary phase system (steel) showed much lower elongation values.

From the curve, we can conclude that steel is both strong and tough sandwich composite reinforcement. The area underneath its curve is a lot larger compare to aluminum and plastic. Thus, it proven when steel have the greatest energy absorption(toughness) and the highest value in compression strength. This can be attributed to the fact that steel have a number of substitutional atoms that are larger than the primary atom in plastic and aluminum. This allows the crystal to swell locally, which consumes extra strain energy and prevents all slip planes and the proliferation of cracks, thus increasing the resistance to fracture.

4. Conclusion

This study had successfully achieved the objective that have been stated which is analysis of sandwich core fiber composite subjected to different skin reinforcement materials. The results from the compression strength test showed that the usage of steel as a skin reinforcement material with bamboo fiber as the sandwich core obtain the highest value of force needed to rupture the sample. Steel reinforcement also determined the largest energy absorption compare to others type of reinforcement. The factor that contributes to the value obtained is due to the properties of steel that is more durable and stronger material. In the case of a composite material, bamboo fiber is been using as a sandwich core to reinforce a thermoset. The fiber increases the tensile strength of the composite, while the thermoset gives it compressional strength and toughness. Lastly, the laboratory experiment provided a more physical understanding of material mechanics, as well as significant experience in materials testing.

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