Tensile Properties Comparison of Cassava Peel/Lycal, E-Glass 135/Lycal and Hybrid Cassava Peel+E-Glass 135/Lycal Composite with Hand Lay up Manufacturing Method

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Abstract. The use of composite materials in UAV development has increased significantly. The chosen of composite material for the UAV structure is due to the advantage of composite both from the strength and the light side of material that good for improving structure performance because it can be reducing the weight of the structure. Nowadays, research in material not only focus on reducing weight but also focus on reducing undegradable waste to environment. Tensile test has been carried out for Cassava Peel/Lycal composite and E-Glass/Lycal Composite. The comparison results showed that the cassava/lycal composite has modulus elasticity average value (3445,3 ± 0.36 MPa) smaller than Hybrid Cassava Peel+E-Glass 135/Lycal Composite (4704.28 ±0,67 MPa) and E-Glass 135/Lycal Composite (5916,5 ± 1,24 MPa). This trend is happened also for tensile strength value with average 44,63 ± 5,11 MPa for Cassava Peel/Lycal, 143,01 ± 15,82 MPa for E Glass 135/Lycal composite and 109.68 ± 7,05 MPa for Hybrid Cassava Peel+E-Glass 135/Lycal Composite. This result showed that the strength of E Glass 135/Lycal Composite still much bigger than Cassava Peel/Lycal Composite with but not really higher than Hybrid Cassava Peel+E-Glass 135/Lycal Composite. It means the cassava composite can't be the alternative material for UAV skin but it can be used for another part inside the UAV that not directly touching from outside impact.

Keywords: Composite · UAV · Cassava Peel · E-glass · Hand lay-up

1 Introduction

Composite material is a material that widely used in Unmanned Aerial Vehicle (UAV). Composite materials has used for the main structures of aircraft such as wings, fuselage etc. [1]. The selection of this type of material is to reduce the weight of the aircraft structure.

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E-glass composite with thermoset resin is the material that mostly used in unmanned aircraft. Nowadays, environmental friendly materials are needed and it is also very important for reducing the environmental harmness, enhancing the public awareness of environmental concerns and make new environment regulation for sustainability consumption [2]. Materials from natural fibers are needed to replace synthetic materials that are difficult to decompose. In a review of Natural Fiber Reinforced Polymer Composite (NFPCs) and Its Application, Mohammed and coworkers said that NFPCs was getting attention from many researcher due to the environmental advantages (eco-friendly and sustainability) [3]. Some specific design parameters that meet an airplane models specification are not available for public deployment. Specific design parameters such as mechanical properties (skin-core adhesion, flexural strength, impact resistance), Acoustical Properties (transmission loss), Resistance to cabin environment (vibration, humidity, fluid susceptibility, etc.) and weight are important information to design a structural material of airplane. There are some advantages of natural fiber if it chosen for aircraft structure such as replace the hazardous materials, Replace the non-renewable resources, and weight reduction that can be reduce fuel consumption/CO2 emissions [4].

Cassava peel fiber is one of some choices in this study that easy to obtain and easy to produce the composite using thermoset resin. Research that has been conducted by Ahmed Edirej et al., about the addition of cassava bagasse (CB) and cassava peel (CP) in bio-composite cassava films, the addition of both fibers increases tensile strength and modulus while reducing the breakthrough of bio-composite films [5]. Previous research has been conducted on the preparation and characterization of cassava starch/peel for composite film. Cassava starch was extracted and the peel was added as a fiber film to the composite. The addition of 6% cassava peel to the composite increased the elastic modulus and tensile stress up to 449.74 and 9.62 MPa [6].

The purpose of this study is to find out the comparison between the tensile strength of E-glass fiber composites, cassava peel fiber composites and hybrids both with lycal thermoset resin. The results of this comparison will be used as a database of material for making UAV at National Institute of Aeronautics and Space (LAPAN). The material database is used as reference for UAV's part manufacture where the strength of each part is adjusted to the type of UAV and its regulation [7, 8].

1.1 Composite Specimens

The specimens made by 3 sample plats of composite, the 1^{st} plat was using cassava peel fiber with Lycal, the 2^{nd} plat was using woven- E glass type WR135 with Lycal, and the 3^{rd} plat was using Hybrid composite both Cassava Peel and E Glass WR 135 fiber with Lycal as Table 1 below:

Figure 1 shows the specimens before test. The Lycal resin was Lycal GLR 1011 (N) that mix with its hardener, this is a thermoset resin type. The ratio of the resin and fiber mixture was 60:40. The manufacturing method was a standard hand lay-up technique. The sample plats of composite were cured in room temperature for 24 h, and cut with geometry of 250 mm × 25 mm as mentioned in ASTM D3039 standard test.

Table 1. Sample information

Specimen code	Specimen content	Fiber orientation
A	Cassava Peel/Lycal	–
B	E-Glass 135/Lycal	[0/90]
C	Cassava Peel+E-Glass 135/Lycal	[0/90] E-Glass

(A) (B) (C)

Fig. 1. Specimens before test

1.2 Tensile Testing Method

The testing method was all refer to ASTM D3039 standard tensile test of composite material. The test has done using Universal Testing Machine (UTM) Tensilon RTF - 2410 with crosshead speed of 2.0 mm/min. Figure 2 shows the research methodology, and the tensile test arrangement can be show as Fig. 3 below.

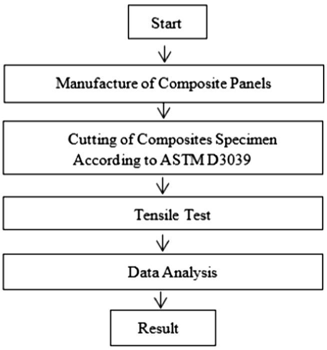


Fig. 2. Research methodology

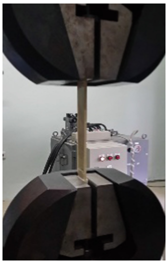


Fig. 3. Tensile test of composite material using universal testing machine

2 Data Analysis

The tensile test has been held using ASTM D3039 procedure standard [9]. This test is used to obtain the composite tensile stiffness and strength. The maximum stress (σ) of the specimen can be determined by the following equation:

$$\sigma i = Pi/A \quad (1)$$

The maximum strain (ε) on the mid-span of the specimen can be determined by the following equation:

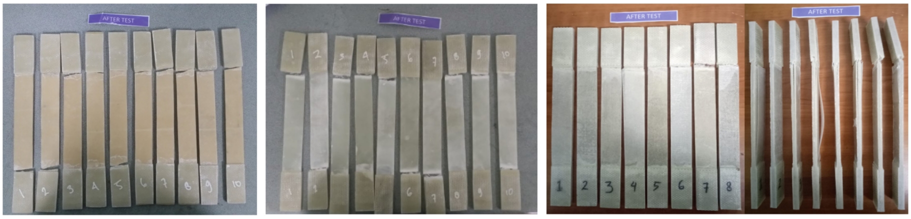
$$\varepsilon i = \delta i/Lg \quad (2)$$

The modulus of elasticity E is comparison between stress and strain as following equation:

$$E^{chord} = \Delta\sigma/\Delta\gamma \quad (3)$$

3 Result and Discussion

The failure specimen after test are shown in Fig. 4. From the figure we can see that most of failures both for Cassava Peel/Lycal and E-glass WR135/Lycal sample occur at the top and bottom near the grip of the specimen, typical modes based on ASTM D3039 are LAT (Lateral, at grip/tab, Top) and LAB (Lateral, At grip/tab, Bottom). Different with other, the failure of Hybrid Cassava Peel+Eglass WR135/Lycal sample occur not only in the top/bottom near the grip side but also there are some delamination failure in the middle of the specimen gage between E-Glass and Cassava Peel fiber, it means there are two typical modes that represent this sample failure based on ASTM D3039 that is LAT (Lateral, at grip/tab, Top) and DGM (Edge Delamination, Gage, Middle). The Density of each specimen are 1.12 g/cm^3 for Cassava Peel/Lycal, 1.55 g/cm^3 for E-glass WR135/Lycal Composite and 1.32 g/cm^3 for Hybrid Cassava Peel+Eglass WR135/Lycal Composite. From this result, we can said that Cassava/Lycal composite has a lowest density than others.



(A) (B) (C)

Fig. 4. The failure composite specimen after test

The results are given in Fig. 5. It shows that all of the sample failed in elastic mode.

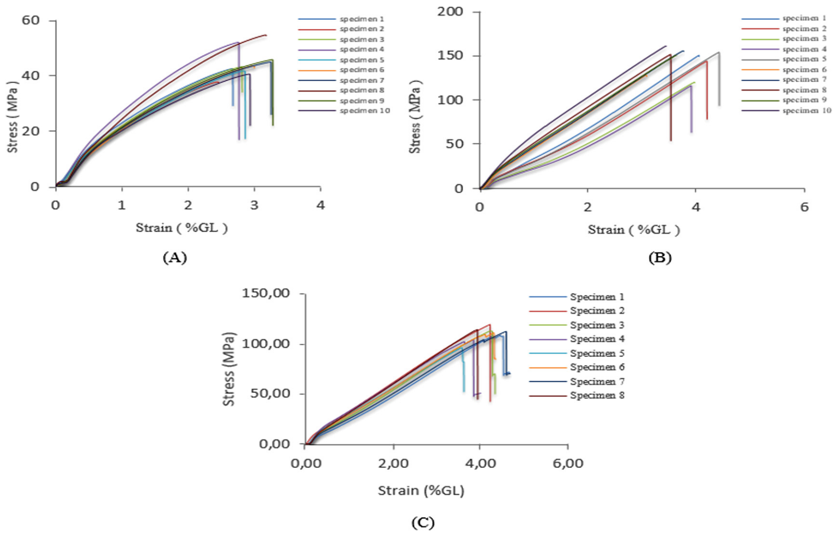


Fig. 5. Stress-strain graph of tensile test

Elastic modulus determines the film stiffness, so its indicates the high stiffness of a material [10]. From the result, we can see that the highest elastic modulus 3445.3 ± 0.36 MPa was recorded for Cassava Peel/Lycal, 5916.5 ± 1,24 MPa for Eglass WR135/Lycal and 4704.28 ± 0,67 MPa for hybrid cassava peel+E glass 135/Lycal composite.

The smallest strength value that occur in cassava peel composite is due to the poor adhesion of the hydrophilic group in its own fibers to the hydrophobic group in polymer matrix. The porous structure of most natural fibers causes water absorption, which leads to a change in the mechanical properties [11]. The hydrophilic character in the surface of Cassava peel is due to this fiber is principally made up of lignin and cellulose, it is refer to research by Syazwani *et al.* that demonstrated it from the FTIR spectra of each samples that consist of carboxyl (C = O) and hydroxyl (H = O) groups [12]. The hybrid composite has the middle strength value compare with other composite is due to the hydrophilic group of this composite has fewer than Cassava peel composite along with half of its compound consist of E-Glass fiber.

Refer to Table 2, the ultimate tensile strength (UTS) average of Cassava Peel+E-Glass 135/Lycal 44.63 ± 5,11 MPa, this result is still smaller than the tensile value of e-glass epoxy with 346.15 MPa where this type of composite has been applied by Nur et al. as LSU-02 NG LD wing skin. The result showed that its composite has failed when the load is 2.5 g [13]. Refer to FAR 23 for the normal category of UAV, the load of maneuver limits that must be met is between 1,52 to 3,8 g [7]. Further research is needed regarding the application of this material in UAV components.

Table 2. Tensile test result comparison

Data	A	B	C
	Average	Average	Average
Stress (Mpa)	44.63 ± 5,11	143.01 ± 15,82	109.68 ± 7,05
Elastic modulus (Mpa)	3445.3 ± 0.36	5916.5 ± 1,24	4704.28 ± 0,67
Break point strain (%GL)	2.91 ± 1.13	3.81 ± 1,39	4.14 ± 2.06
Density (g/cm^3)	1.12	1.55	1.32

The average stress value comparison shows in the following graph (Fig. 6):

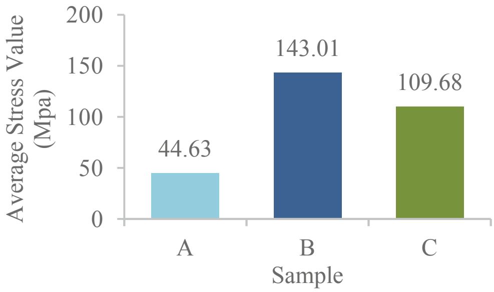


Fig. 6. Tensile strength average comparison

4 Conclusion

The comparison results showed that the Cassava Peel/lycal composite has modulus elasticity average value (3445,3 ± 0.36 MPa) smaller than Hybrid Cassava Peel+E-Glass 135/Lycal Composite (4704.28 ± 0,67 MPa) and E-Glass 135/Lycal Composite (5916,5 ± 1,24 MPa).

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Peel/Lycal Composite but not really higher than Hybrid Cassava Peel+E-Glass 135/Lycal Composite. It means the cassava composite can't be the alternative material for UAV skin but it can be used for another part inside the UAV that not directly touching from outside impact.

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