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Design and Analysis of Luffa Fiber Natural Composite-Foam Core Sandwich for Aerospace Application

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Abstract: A Sandwich structure is a type of composite consists of two or more separated components with different material properties, which together constitute a high performance material. The sandwich structure has a discrete structure in which the base material is glued and covered with a surface material. The material has high compressive and shear strength. When bounded to each other, this combination provides a high flexural modulus of the sandwich structure. Here a Luffa fiber and epoxy resin natural composite using compression moulding is fabricated to find the mechanical properties of a composite laminate. As per ASTM standard UTM tests and point bending test conducted to assess the tensile and bending strength. A sandwich structure is fabricated using luffa fiber natural composite as a face materials and polyurethane foam as a core. The sandwich structures are tested for its bending and shear strengths as per the ASTM standards. The experimental results are validated using the Numerical analysis done by ANSYS. The results are more favorable for the aircraft applications.

I. INTRODUCTION

A sandwich type is one tpes of composite material. A Sandwich structure usually made up of double twin slender,rigid and strong plates of composite material or metallic material divided by comparatively softcore.Front and core are combined to design an efficient load carrying assembly. Lightweight sandwich structure is used to raise the specific stiffness, which formulate a strengthening the development structure. The face carries tensile and compressive stresses, the core support both side force and the shear stress. The principle of sandwich composite is developed well in a fields of shipbuilding and aerospace technology.Today, sandwich panels can be used in many other technological areas such as high-speed trains, shipbuilding construction or automobile. Especially in shipbuilding there is strong tendency to use multilayer shells in a structure of hull.

II. LUFFA FIBER PROPERTIES

Luffa has a density of 0.56 to 0.92 g/cm^3, an average diameter of 270 µm, and a fine fiber angle of about 12°. 63 percent cellulose, 20.88 percent hemicellulose, 11.69 percent lignin, and 0.4 percent ash make up the chemical composition of luffa. It should be noted that luffa is not only used as a vegetable , herbal medicine, military filters and shock absorbers all use it.

Figure 2.1 Luffa and its internal structure.

The tensile test specimens are obtained from the composite plate using the water jet cutting techniques.

Figure-2.2 Luffa fiber- epoxy composite test specimen

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III. EXPERIMENTATION

The prepared luffa fiber natural composite tested for its mechanical properties as per the ASTM standards. Tensile tests are carried out in a computerized Universal Testing Machine ASTM D3039-76 are shown in figure 3.1. The sample was used with dimensions of 300mm in length and 25 mm in width . The test was performed with a 10kg load cell and a bonding speed of 5mm/min. Three samples were used and the average recorded

Figure 3.1- Tensile testing of luffa fiber composite.

IV. RESULT AND DISCUSSION

4.1.TENSION TEST ON COMPOSITE FACING

Type of specimen = Rectangular bar
Initial gauge length of the specimen = 442 mm
Width of the specimen = 70 mm
Thickness of the specimen = 1.8 mm
Final gauge length of the specimen = 445 mm

Figure-4.1 Tensile specimen before and after the test

Table 4.1 Test results

Specimen No	Young's Modulus (E) MPa	Failure load (N)	Max. Stress (MPa)	Strain at Failure %
1	339	585	7.8	1.6
2	535	780	10.4	2.3

4.2 BENDING TEST – SANDWICH SPECIMEN

$$\delta = \frac{PL^3}{24\, bt_c^2 t_f E_f}$$

Where
b –The sandwich specimen's width
t_f –The fiber's thickness
t_c – The core's thickness
E_f – Young's modulus of the fiber

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Table 4.2. 3 point bending test results.

S. No	Weights (grams)	Experimental Deflection (mm)	Theoretical Deflection (mm)
1	50	0.92	0.82
2	100	2.12	1.93
3	150	3.42	3.10
4	200	5.25	4.92
5	250	7.08	6.85
6	300	9.15	8.74
		Average Deflection = 4.65 mm	**Average Deflection = 4.39 mm**

V. NUMERICAL ANALYSIS

5.1 Finite Element Analysis

The sandwich panel being analyzed has a Polyurethane core with Young`s modulus is 25 Mpa and Poisson's ratio is 0.28. The other hand, an face materials were 6 plies of luffa fibre reinforced epoxy resin with the modulus of elasticity is 3.4 GPa and Poisson`s ratio is 0.37.

In the case of 3-point bending test, a 3-D model was constructed with the dimensions of 440×30×12.6 mm.

Solid – Brick node 45
Facing material thickness (6 ply) = 3.6 mm
Thickness of core material = 9 mm
Facing material has orthotropic property
Core material has Isotropic property

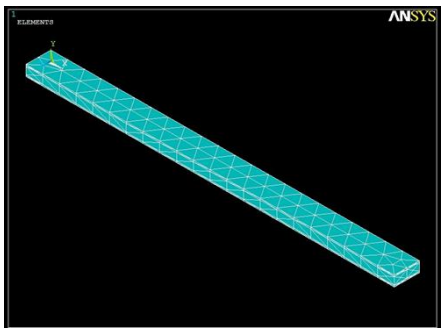

Figure-5.1 3-D meshed model of sandwich panel

5.2 Results of experiments

3-point bending test simulation

Table-5.1 Deflection result in 3 – Point bending

S. No	Weights (grams)	Experimental Deflection (mm)	Theoretical Deflection (mm)	Numerical Deflection (mm)
1	50	0.92	0.82	1.31
2	100	2.12	1.93	2.42
3	150	3.42	3.1	3.73
4	200	5.25	4.92	5.43
5	250	7.08	6.85	7.25
6	300	9.15	8.74	9.35

VI. CONCLUSION

Foam core Sandwich composite with facing made up of natural Luffa fiber / epoxy ais investigated experimentally and numerically. The composite facing and sandwich panel is manufactured by using compression molding method. Material properties of the composite facing are obtained analytically by using micro-mechanics approach.

The experimental results are close to the expected theoretical results for all test specimens. There are may be a variety explanations for other minor variations in the experimental results.

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Finally, the finding and research on the subject were accurate when the experimental result were compared to the theoretical results.

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