MECHANICS OF COMPOSITE MATERIALS

EXPERIMENTAL ANALYSIS ON RANDOM ORIENTED CONTINUOUS GLASS FIBER EPOXY COMPOSITE

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Abstract

Glass Fiber Reinforced Composites (GFRP) posses high strength and it is easy to manufacture. Random oriented GFRPs with two different stacking thickness were made and the prepared composites were analysed using UTM to find the Strength and Stiffness.

Keywords
GFRP - Glass Fiber Reinforced Polymer, UTM-Universal Test Machine

1 Introduction

Composites are advanced materials formed by combining two or more constituents with different properties to create a material with enhanced characteristics. The combination of laminated sheets of fabric materials and resin is called laminate composite. In composites, the constituents typically consist of a reinforcement phase and a matrix phase. The reinforcement phase, often in the form of fibers or particles, provides strength and stiffness, while the matrix phase holds the reinforcement in place and transfers loads between the reinforcement elements.

Glass fiber composites (GFC) are one kind of fiber reinforced polymer composites. It holds good properties such as low density, high strength, and easy processing, so widely used in aerospace, automotive, and construction.High strength glass fiber combines high strength, high stability, transparency and resilience at a very reasonable cost-weight performance. The utilities of high strength glass fiber composites are compared by physical, mechanical, electrical, thermal, acoustical, optical and radiation properties.The glass fiber composites strength/weight ratios are higher than those of most other materials and their impact resistance is phenomenal.Further they possess good electrical properties, resistance to moisture and outdoor weathering and resistance to heat and chemicals. These properties are coupled with ease of fabrication.

2 Material Properties

2.1 E-glass fiber

Header 1	Header 2
Density g/cm^3	2.6
Compression Strength (MPa)	1080
Tensile Strength (MPa)	3445
E-Modulus (MPa)	73000

Table 1: Properties of **E-glass fiber**

2.2 Epoxy

Header 1	Header 2
Density g/cm^3	1.16
Compression Strength (MPa)	73
Tesnsile Strength (MPa)	310
E-Modulus (GPa)	30-50

Table 2: Properties of **Epoxy Resin**

3 Composite Fabrication

- Glass fiber was cut into 15x15 cm sheet to fit in the mould.
- Resin and Hardener was weighed and mixed in 5:4 ratio. The total weight ratio equal to that of fiber sheet.
- Teflon Sheet was pasted on the mould for easy removal of composite after curing.
- Starting with a resin layer, fiber and resin are applied alternatively until desired sequence was reached.
- Dead weight was kept on the mould for uniform compression and to avoid voids.
- The composite was cured for 24 hrs in room temperature.

Figure 1: Random oriented glass fiber

Figure 2: Araldite Epoxy Resin and Hardener

4 Tensile Test

The glass fiber reinforced polyester composite material fabricated was cut into required dimension using a saw cutter. For mechanical testing, the edges of this composite are finished by using emery paper. The tensile test was carried out on universal testing machine (UH-F1000kN) with a cross head speed of 5 mm/min as per the ASTM standards. The test specimens

Figure 3: Universal Testing Machine

were prepared as Per ASTM D 3039 (120 x 12) mm; thickness of the specimens being 3.50mm,3.00mm,4.60mm,4.60 mm respectively as shown in Figure. The four specimens,of which two are 3 layer and 5 layer were subjected to tensile test and their values were recorded.

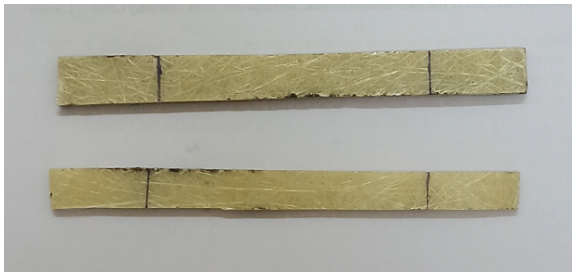

Figure 4: SAMPLE SPECIMENS BEFORE TESTING

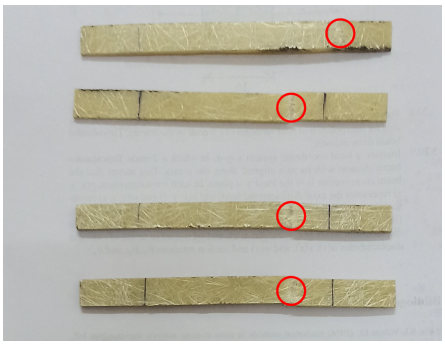

Figure 5: SAMPLE SPECIMENS AFTER TESTING(5layer/5layer/3layer/3layer)

5 Results

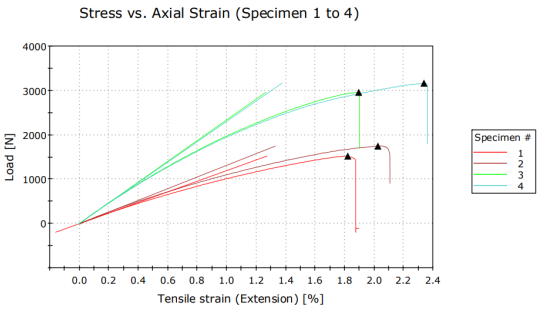

Figure 6: STRESS vs AXIAL STRAIN

	Width [mm]	Thickness [mm]	Length [mm]	Tensile Strength [MPa]	Modulus [MPa]
1	12.0	3.50	120	36.3	2840
2	12.0	3.00	120	48.6	3640
3	12.0	4.60	120	53.6	4230
4	12.0	4.60	120	57.3	4150
Mean	12.0	3.92	120	48.9	3720
S.D.	0.00	0.81	0.00	9.16	641.48
C.O.V.	0.00	20.53	0.00	18.72	17.27

Figure 7: TENSILE STRENGTH AND MODULUS VALUES FOR SPECIMENS

- Location of failure in each specimen is marked in Fig.4.
- The 3 layer specimen had non-uniform thickness along the length which led to failure of the specimen at those points.
- The first specimen which is a 3 layer failed near the gripping part which lead to failure at the holding section.
- The 5-layer specimen had uniform thickness and failed at the location where there were abrasions from the machining process.
- The Youngs Modulus value obtained from the test for 5 layer composite was 4 GPa which is very much lower than the Youngs Modulus of E glass fiber which is 72 GPa.

Conclusions

The Youngs Modulus of 5 layer composite was higher than the 3 layer. Even though the results obtained were too low compared to the standard values, we gained hands-on experience in composites using the hand-lay-up method and compression molding. We were able to learn how to avoid the defects in compodites. The obtained values can be validated using finite element modeling of the representative volume element of composite that has random orientation of the fiber. Analytical Validation can be done by considering the composite as transversely isotropic case.