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Mechanical Characterization of Carbon Fibre Reinforced Epoxy Composite

Shanavas S.
Department of Mechanical Engineering, YCEW, Kollam, Kerala - 691538, India.

Abstract

This paper investigates the mechanical properties (tensile strength, compressive strength, shear strength, flexural strength) and density measurement of epoxy resin (F584) reinforced by carbon fibre fabric (PW). The aim of the current work is to replace metals with Carbon fibre epoxy composite where high strength, low weight and damping characteristics are predominant. The specimens are prepared by hand lay-up process with $0/90^0$ orientation and experimentation was performed to determine the mechanical properties. The results show that carbon fibre reinforced epoxy present better mechanical properties, high specific strength and good damping characteristics.

1. Introduction

Composite materials are material which consists of two or more material phase that are combining to produce a material that has superior properties than individual constituent. Technologically the most important among composites are those in which the dispersed phase is in the form of fibre. The common fibres in commercial use are glass, carbon, graphite and Kevlar. Carbon fiber reinforced epoxy composite is an extremely strong and light fiber reinforced polymer which contains carbon fibers. The properties of composite depend on the layouts of the carbon fiber, the proportion of the carbon fibers relative to the polymer and the processing method. Carbon fibre epoxy has high strength and less density compared to cast iron and steel. F584-epoxy matrix laminates have better mechanical properties in the tensile and compressive tests than 8552 composites. Also PW carbon fibre fabric reinforcement has better flexural and interlaminar shear properties than 8HS for both matrices [3] Mechanical properties of carbon fibre epoxy differ with fibre orientation of laminates. The tensile & flexural strengths are superior in case of 90 degree fibre orientation [4]. Multi fibre composites have more strength than single fibre composites [5].

2. Mechanical Characterization

2.1. Tensile Test

The tensile test was performed on circular rod of diameter 15 mm and gauge length of 70 mm. The tensile test was conducted in a universal testing machine (Model UTN 60), hydraulically operated with loading capacity of 600 KN, at room temperature as shown in figure 2.1. An extensometer is used to measure the elongation, thereby found out strain and finally the modulus of elasticity. The ultimate tensile strength and young's modulus were found out by the test.

Figure 2.1: Tensile Test

$$\sigma_T = \frac{\text{External axial tensile load}}{\text{Original cross sectional area of the specimen}}$$

where, σ_T = Ultimate tensile strength.

$$E = \frac{\text{Stress}}{\text{Strain}}$$

where, E = Young's modulus (Tensile modulus).

2. 2. Compression Test

Compression testing was performed on cubic specimen of dimension (45×45×45) mm^3, using compression testing machine (Model AIM – 317E – AN), electrically operated with three load gauges of loading capacity of 2000 KN. Samples were placed between the top and bottom surfaces of a compression fixture as shown in figure 2.2. The compressive strength and poisson's ratio were found out by the test.

Figure 2.2: Compression Test

$$\sigma_c = \frac{\text{Maximum compressive load}}{\text{cross-sectional area}}$$

where, σ_c = compressive strength

$$\text{Poisson's ratio} = \frac{\text{Transverse strain}}{\text{Longitudinal strain}}$$

2.3. Shear Test

The double shear tests were performed on circular rod of diameter 15 mm using double shear test set up and conducted in a universal testing machine (Model UTN 60), hydraulically operated with loading capacity of 600 KN, at room temperature as shown in figure 2.3. The shear strength was found out by the test.

$$\tau = \frac{\text{shear load}}{2A}$$

where, τ = Shear strength,
A = Shear area

Figure 2.3: Shear Test

2.4. Flexural Test

The procedure for the three-point bending tests followed the ASTM standard D790. That standard, however, specifies a length/width ratio of 16. The test was performed on square rod of cross sectional dimension (25×25) mm^2 and span length of 400 mm. The flexural experiment was conducted on an universal testing machine (Model UTN 60), hydraulically operated with loading capacity of 600 KN. Flexural test (3 – point) was conducted at room temperature as shown in figure 2.4. The flexural strength was found out by the test.

Figure 2.4: Flexural Test

$$\sigma_b = \frac{3PL}{2bt^2}$$

where, σ_b = Flexural strength
P = Rupture load

L = Support span
b = width of specimen.
t = thickness of specimen

2. 5. Density Measurement

Cubic specimen of dimension (45×45×45) mm^3 was used for density measurement. The density and specific strength were found out.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Specific strength} = \frac{\text{Strength}}{\text{Density}}$$

Figure 2.5: Density Measurement

3. Results

Table 3.1: Material properties

	Material Name	Cast Iron [2]	Carbon fibre reinforced epoxy
Material Properties	Tensile Strength (MPa)	200	634.11
	Tensile Modulus (GPa)	152	137.92
	Compressive Strength (MPa)	500	520.50
	Shear Strength (MPa)	260	271.76
	Flexural Strength (MPa)	50	483.84
	Poisson's Ratio	0.28	0.25
	Density (gm/cc)	7.34	1.284

Table 3.2: Specific Strength

Material	Density (gm/cc)	Tensile strength (MPa)	Specific Strength (KNm/Kg)
Cast Iron	7.34	200	27.25
Carbon fibre epoxy composite	1.284	634.11	493.86

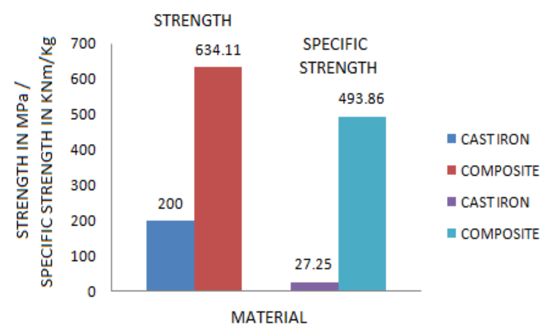

Figure 3.1: Specific strength

4. Conclusion

The objective of the current work is to replace metals with Carbon fibre epoxy composite where high strength, low weight and damping characteristics are predominant. Results show that the mechanical properties (tensile strength, compressive strength, shear strength, flexural strength) are superior for carbon fibre epoxy composite when compared with cast iron. The modulus of elasticity of the fibre reinforced resin is less compared to cast iron, which shows its good damping characteristics. The density of the composite is very less when compared with cast iron, which shows its high strength to weight ratio (specific strength).

5. References

[1] Jane Maria Faulstich De Paiva, Alexandre De Nadai dos Santos, Mirabel Cerqueira Rezende, "Mechanical and morphological characterizations of carbon fiber fabric reinforced epoxy composites used in aeronautical field", *Materials Research*, Vol.12, No.3 (2009), pp. 367-374.
[2] Prashanth Banakar, H.K. Shivananda, "Preparation and characterization of the carbon fiber reinforced epoxy resin composites", *IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE)*, Vol.1, No.2 (2012), pp.15-18.
[3] Prince, Mukesh Verma, Sarabjot Singh, 'Analysis of failure phenomena in multi- fiber polymer composite

material at varying volume fraction using finite element modelling', International Journal of Engineering Research and Applicatio (IJERA), Vol.2, No.2 (2012), pp.287-291.

[4] Daniel C. Davis, Justin W. Wilkerson, Jiang Zhu, Daniel O.O. Ayewah, 'Improvements in mechanical properties of a carbon fiber epoxy composite using nanotube science and technology', Composite Structures, Vol.92, No.11 (2010), pp. 2653-2662.

[5] Smrutisikha Bal, 'Experimental study of mechanical and electrical properties of carbon nanofiber/epoxy composites', Materials & Design, Vol.31, No.5 (2010), pp. 2406-2413.

[6] S.Y. Fu, B. Lauke, E. Mader, C.Y. Yue, X. Hu, 'Tensile properties of short-glass-fiber- and short-carbon-fiber-reinforced polypropylene composites', 'Composites: Part A: Applied Science and Manufacturing'', Vol.31 (2000), pp.1117–1125.

[7] Robert M. Jones, *Mechanics of Composite Materials*, Taylor & Francis, Second Edition 1999.

[8] Faculty of Mechanical Engineering, PSG College of Technology, *Design Data – Data book of engineers*, July 2003.