Study of Tensile and Flexural Strength of Hybrid Polymer Composites

Manjunatha G *[1], Vishnu Kumar K L* [2]

1 Dept. of Mechanical Engg. New Horizon College of Engineering, Bangalore, 560103, India.
2 Dept. of Mechanical Engg. Ramaiah Institute of Technology, Bangalore, 560054, India.

Abstract : Hybrid composite materials consisting of alternatively laminated layers of glass fiber and carbon fibers in an epoxy resin, have been studied. The alternate layers of fibers are bonded together with epoxy resin by hand layup process and cured by electric oven to form hybrid composites. The tensile and flexural behavior of hybrid composites was investigated in accordance with ASTM standards. The results obtained indicate that tensile Strength and flexural strength of carbon laminate is increased than glass fiber laminate and vary nearer to the hybrid fiber laminates. The mechanical properties of hybrid (glass + carbon) fiber laminates is close to carbon fiber laminate. The obtained results causes to replace the carbon fiber by hybrid fiber laminate and can reduce the material cost by at least 40-45%.

Keywords **– Glass fiber, Carbon fiber, Hand Layup.**

1. INTRODUCTION

Composites are attractive materials because of their properties like stiffness and high specific strength which leads to potential application in the area of aerospace, marine and automobile engineering etc. A composite laminate is a structural plate consisting of multiple layers of fiber reinforcement encased in cured resin. The number of layers, the type of fiber (carbon, glass, or other), the fabric configuration (e.g., woven, stitched mat, uni-directional), the type of resin, and other factors can be varied to design a structural element that is suitable for a particular need. Raw materials (fiber, resin, and usually some filler) in themselves are not useful as a structural member, but when combined together, the product takes on new properties that make them desirable for use in structures. Epoxy resins are widely regarded as the high-performance family of composite resins and have grown to dominate aerospace composites and other high-performance application areas, such as motor racing and racing yachts. The reinforcement fibers are the primary load-carrying component of the composite thus, the selection of an appropriate type and form of reinforcement is critical in obtaining a material with the desired engineering properties. Glass fiber reinforcements are the most common synthetic reinforcing fiber available in today's composite industry. The success of glass fibers has been attributed to a number of factors, including cost, availability, handling and processing ability, useful properties and characteristics, and a history of past good experience in service. Carbon fibers offer an exceptional combination of high strength and stiffness, and low weight. . Carbon fiber reinforcements are attractive for their performance under long-term static and cyclic loading. The investigation of the novel properties of hybrid composites has been of deep interest to the researchers for many years as evidenced by excellent reports [1-3].The incorporation of two or more fibers within a single matrix is known as hybridization and the resulting material is referred to as hybrid or hybrid composites. In recent years, there are a few reported studies on the mechanical properties of woven carbon-glass reinforced hybrid composites, which were produced by the traditional method [4-5].In present study, reinforcement of E-glass fibers and carbon fibers with epoxy resin matrix were used to produce hybrid composites via hand layup technique. The fabricated glass composites, carbon composites and carbon-glass hybrid composites were investigated under the tensile and flexural tests.

2. EXPERIMENTAL DETAILS

2.1 Materials and manufacturing method

The material used in preparation of hybrid composites is as shown in table with manufacturing method.

Table 1: Materials and manufacturing method

Sl. no	Material	Types
1	Glass fiber	E-glass, 300GSM
2	Carbon fiber	Carbon 3P,300GSM
3	Resin	Epoxy
4	Hardener	951
5	Manufacturing method	Hand lay up

2.2 Preparation of laminate composite

The E-glass fibers and carbon fibers with epoxy resin matrix were used to produce hybrid composites via hand layup technique in terms of weight 60% of glass fiber and carbon fiber in 40% of epoxy resin. The weight fraction were determined by considering the density, specific gravity and mass.The fabrication of the composite was done at room temperature. The calculated weight ratio of epoxy resin and hardener are mixed using mechanical stirrer for 10 min.The required size of glass and carbon mats are cut as per the required size and each layer is coated by the resin mixture till the required thickness of laminates obtained. Figure 1 shows the steps involved in fabrication of laminated composite and prepared by hand layup technique as per ASTM standard.


Step 1: Mould Preparation


Step 2: Applying Wax on the Mould


Step 3: Mixing and Weighing of Resin


Step 4: Applying Resin Mixture on the hardener (1:10)


Step 5: Applying Glass Fiber On Resin


Step 6: Apply Resin on Glass Fiber Mixture


Step 7: Covering Mould with Plastic Sheet


Step 8: Repeat the Procedure for Carbon fiber & hybrid


Step 9: Applying Weight on Mould


Step 10: Heating Specimen in Hot Air oven


Step 11: Measuring Dimension of a Specimen after Cutting

Figure 1: Steps involved in fabrication of laminated composite

3. TESTING

3.1 Tensile Test

Tensile test technique ASTM D 3039 was used to determine the tensile Strength and modulus of laminated composite. Test specimens were cut from the prepared mould with the help of cutting machine, width of 25 mm, thickness of 2, 3 & 4 mm and length of 220mm. The specimens were prepared using hand layup method exhibits similar behavior for 0° and 90° directions, only one direction is tested. Figure 2 shows the tensile test specimens of 2, 3 & 4 mm thickness. The specimens were tested using universal testing machine at a cross head speed of 2 mm/min.

3.2 Flexural Test

The flexural technique ASTM D 7264 was used to determine the flexural strength and modulus of the composites. The test specimens with 25 mm in width, 2, 3 & 4 mm in thickness and 140 mm in length were cut from the prepared mould panels using a cutting machine. The specimens were tested in 3-point bending apparatus with a span to thickness ratio of 16. Figure 3 shows the flexural test specimen under loading. The three specimens from each material thickness were tested using universal test machine at a crosshead speed of 1.2 mm/min.

Glass fiber specimens

Carbon fiber specimens

Hybrid specimens

Figure 2: Tensile test specimens of 2, 3 & 4 mm thickness

Glass fiber specimen

Carbon fiber specimen

Hybrid specimen

Figure 3: Flexural test specimen of 2, 3 & 4 mm thickness

4. RESULT AND DISCUSSION

4.1 Tensile Test Result

Table 2: Tensile Test Result of Glass fiber reinforced composites

Sample Id.	Glass Thickness 2mm	Glass Thickness 3mm	Glass Thickness 4mm
Tensile Load, KN	15.28	21.56	26.36
Tensile Strength, MPa	226	289	302
Total Elongation, mm	8.41	7.63	11.52
Young's Modulus, MPa	4596	4700	4982
Percentage of elongation (%)	6.007%	5.45%	8.22%

Table 3: Tensile Test Result of Carbon fiber reinforced composites

Sample Id.	Carbon Thickness 2mm	Carbon Thickness 3mm	Carbon Thickness 4mm
Tensile Load, KN	16.84	40.84	62.60
Tensile Strength, MPa	246	498	581
Total Elongation, mm	5.19	9.26	11.63
Young's Modulus, MPa	8113	8150	8190
Percentage of elongation (%)	3.7%	6.61%	8.3%

Table 4: Tensile Test Result of Hybrid fiber reinforced composites

Sample Id.	Hybrid Thickness 2mm	Hybrid Thickness 3mm	Hybrid Thickness 4mm
Tensile Load, KN	16.88	19.44	32.28
Tensile Strength, MPa	253	269	301
Total Elongation, mm	6	7.61	8.78
Young's Modulus, MPa	7494	7500	7550
Percentage of elongation (%)	4.2%	5.43%	6.27%

Tensile test result of Glass fiber, Carbon fiber and Hybrid fiber reinforced composites are shown in table 2, 3 and 4. Tensile strength of carbon reinforced is 8.13% and 48.02% higher than glass reinforced composites of thickness 2mm and 4mm.Tensile strength of hybrid reinforced 10.67% and 32.8% higher than glass reinforced composites of thickness 2mm and 4mm.Tensile strength of carbon reinforced is 2.76% lesser than hybrid reinforced composites of thickness 2mm and carbon reinforced 4mm thickness is 22.5% greater than hybrid reinforced composites. The increased strength of the carbon fiber reinforced epoxy composites depends on the strength and modulus of the fiber, strength and stability of the matrix, fiber matrix interaction and fiber length.

4.2 Flexural Test Result

Table 5: Flexural Test Result of reinforced composites

Material	Thickness (mm)	Peak Load (N)	Max Displacement (mm)	Slope (N/mm)	Flexural Strength (N/mm2)
Glass	2	312	14.5	25.35	325
	3	435	12.54	46.97	332.90
	4	1484	8.30	224.43	386.45
Carbon	2	383	9.31	47.72	474.79
	3	840	6.41	138.68	507.93
	4	2214	4.78	478.68	576
Glass + Carbon	2	325	8.82	42.50	368
	3	544	8.84	75.31	416.26
	4	1698	5.50	347.45	442.18

Flexural test result of Glass fiber, Carbon fiber and Hybrid fiber reinforced composites are shown in table 5. Flexural strength of carbon reinforced is 31.54 and 32.9% % higher than glass reinforced composites of thickness 2mm and 4mm. Flexural strength of glass reinforced is 11.68% and 12.6% lesser than hybrid reinforced composites of thickness 2mm and 4mm.Flexural strength of carbon reinforced is 22.5% and 23.23% higher than hybrid reinforced composites of thickness 2mm and 4mm.

5. CONCLUSION

The carbon fiber and glass fiber reinforced hybrid composites were fabricated by hand layup technique. The mechanical properties such as tensile and flexural strength of hybrid composites were studied as per ASTM standards. The inclusion of carbon fiber mat reinforced polymer composite significantly enhanced the tensile strength and flexural strength compared to hybrid reinforced composites of thickness 4mm.The ductility of carbon fiber reinforced composite is higher than glass fiber and hybrid composites.

6. REFERENCES

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