Studies on Mechanical Properties of Carbon Epoxy Composites by Hand Layup Process

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Research Article

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ABSTRACT

In this research, fabric reinforced polymer composites materials play an important role for their versatile applications. These materials have good strength, are light weighted and give high strength to weight ratio as compared to the other materials. This paper explains carbon fibre based polymer composites. carbon fibre acts as reinforcement material. This research work mainly focused on finding the strength of the material, tensile and bending properties of carbon epoxy laminates. This research carries symmetric ply, angle ply, cross ply laminates, which are manufactured as of American Society for Testing and Materials (ASTM) standards. This research conducts various mechanical tests for the above-mentioned three types of laminates. Mainly conducted Tensile and Bending tests. These tests were carried out on electronic tensometer. This research extended to conducted Tensile, bending tests for sandwich panel specimen and compare the results with cross, symmetric and angle ply laminates. Finally analyses the results of all three types of laminates. This paper explains the stress, strain and displacement of the symmetric, cross and angle ply with 0, +45/-45 and 90 degrees' angle orientations and young's modulus of the material.

Keywords: Carbon fibre; Composites; Tensile strength; Four-point bending; Bending strength; Tensometer; Polymer composite

INTRODUCTION

High specific strength, stiffness and fatigue are the qualities of a composite material, which help full in structural design [1]. Materials which have more than two physical and chemical phases are known as composite materials [2]. “Composites materials are comprising strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix)” [3]. Most of the composite materials mix with reinforcement which gives high and good strength and rigidity of the materials, these materials give support to the beam [4].

Reinforcement orientation, positions depend on the matrix which is organic and inorganic [5]. Composite materials with reinforcement will retain their physical as well as chemical properties [6]. “The reinforcement may be particles, fibers or platelets and are added to improve mechanical properties such as hardness, stiffness, strength, and toughness of the matrix material” [7]. Continuous filaments are available as most favored fibers, it will be used in high performance composites namely glass, carbon and aramid fibers [8]. Applications of this type of material are used in aerospace, marine, automotive and construction industries [9].

Specimen preparation

In this research specimens were prepared with the help of carbon fiber and resin; this resin acts as infusion. In generally using vinyl ester, polyester and epoxy resin.

This research used epoxy resin. Here taking 1:4 two-part mix ratio at 70º temperature up to 2% elongation. There are different types of methods to fabricate and manufacture fabrics. In that, this work uses hand layup process to prepare specimens.

Preparation of laminates

The laminates consist of ten layers, which are mixed by resin. Here follows the same orientation angle for all the laminates, i.e., 0º unidirectional laminates the θ is 0º for all laminates. Using the hand lay up prepared the laminates for 0º,45º and 90º. After preparation, at 70ºc temperature, keep it in vacuum bag. After curing, fabricated the specimen as per ASTM standards. Here, followed separate ASTM standards for Tensile and bending test. ASTM D412 for Tensile test and ASTM D790 for Bending test are selected. Finally fabricated the specimens as per above mentioned standard dimensions and conducted tests on tensometer.

Table 1. Tensile test specimen dimensions.

S.no	Specimen	Length (mm)	Width (mm)	Thickness (mm)
1	T-(0/0º)	140	6.9	5.15
2	T-(0/90º)	140	5.93	4.13
3	T-(45/-45º)	140	6.13	3.91

Table 2. Bending test specimen dimensions.

S.no	Specimen	Length (mm)	Width (mm)	Thickness (mm)
1	B-(0/0º)	81	26	4.4
2	B-(0/90º)	78	26	4
3	B-(45/-45º)	83	27	3.5

Experimental setup

This research used tensometer to know the tensile properties of the material. The tensile properties of this research material are Ultimate Tensile Strength, Young’s modulus and Poisson’s ratio [10]. To apply a load (force or power) on the prepared specimen UTM stacked with a specimen in the middle of two holds, those grasps are changed naturally or manually [11]. This machine works with the help of hydraulic ram or by driving a screw, the hydraulic ram having good benefit to create high complex loading patterns and cylindrical loads needed for measurement of fatigue strength.

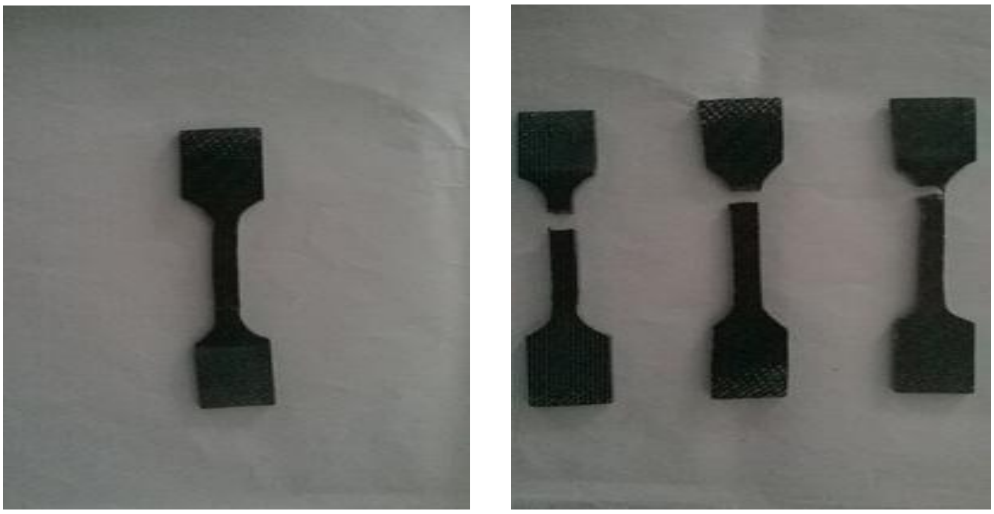
“The tensile strength of a composite material is the estimation of the ability to withstand forces that pull it aside as well as the ability of the material to stretch before failure” [12]. Here the dog-bone type specimen for tensile test was used, this is the most commonly used specimen for tensile test [13]. The tensile strength is conducted according to the ASTM D412 standard on universal testing machine which is fully computerized [14].

Table 3. Tensile test specimen properties.

S.no	Specimen	Fibre	Matrix	Volume ratio of fibre to matrix	No. of layers	Orientation	Weave
1	T-1	Carbon	Epoxy	40/60	10	0°/0°/0°/0°/0°/0°/0°/0°/0 °/0°	2*2 Twill
2	T-2	Carbon	Epoxy	38.8/61.2	10	0°/90°/0°/90°/0°/90°/0°/90°/0°/90°/0°/90°	2*2 Twill
3	T-3	Carbon	Epoxy	37.8/62.2	10	45°/-45°/45°/-45°/45°/-45°/45°/-45°/45°/-45°	2*2 Twill

To obtain tensile properties an experiment was conducted on ASTM D638, using UTM at crosshead speed of 15 mm/minute. “Each specimen which was prepared for tensile test was placed in the INSTRON universal tester after that subjected to tensile load, as the specimen stretched the computer generated the graph as well as all the desired parameters until the specimen fractured” [15]. The experimental setup is attached to the computer; it gives the graphs between stress and strain.

Figure 1. (a) Specimen before conducting test; (b) Specimens after conducting test.

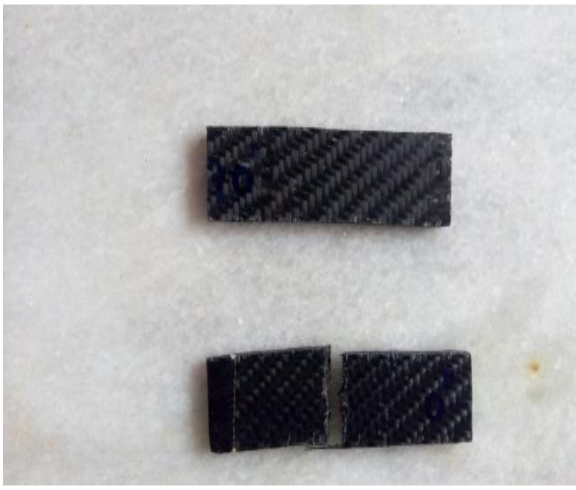


(a) (b)

Four-point bending test

“The 4-point flexure fixture are for peak stresses which is along with an extended region of the substance hence revealing a larger length of the substance with better potential for defects and flaws to be highlighted” [16]. In the same manner, tensile test and bending test were conducted on carbon fabric epoxy laminates with ASTM D790 standards. The prepared specimens were tested on tensometer to find out the bending strength of the laminates. The four-point bending test on tensometer is shown in the figure below. Using a special attachment on tensometer all specimens are tested for four-point bending.

Figure 2. Specimen of carbon fabric reinforced with epoxy.



RESULT AND DISCUSSION

From Tables 4 and 5 indicate the results of tensile test and bending test. Table 5 also indicates the results of sandwich panel. The sandwich panel results explain that it has less deformation, break load and bending strength.

Table 4. Tensile test results.

S.no	Specimen	Type of laminate	Break load (N)	Ultimate tensile strength (N/mm^2)	Elongation (mm)	Young's modulus (MP)
1	T-1	Uni- directional	5963	169.3	7	1426
2	T-2	Cross ply	7434	301.8	5.21	3424
3	T-3	Angle ply	4727	212.6	6.14	2046

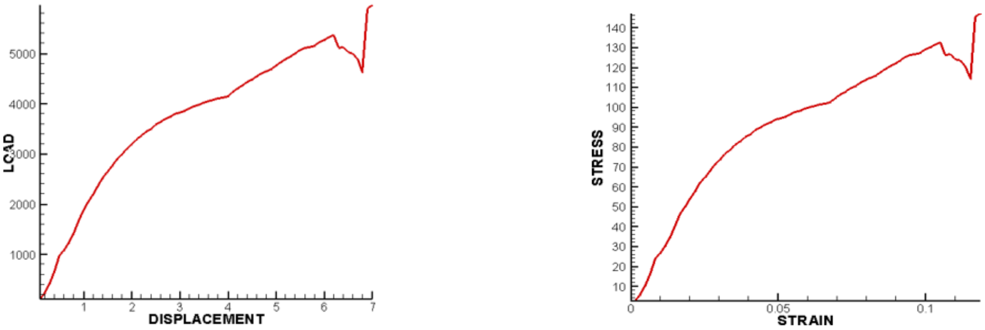
Table 5. Bending test results.

S.no	Specimen	Type of laminate	Break load (N)	Deformation (mm)	Bending strength (N/mm^2)
1	B-1	Uni- directional	1196	4.31	283.6
2	B-2	Cross ply	1079	3.89	304.3
3	B-3	Angle ply	1049	8.49	361.4
4	B-4	Sandwich	404.9	1.88	73.35

Experimental graphs

Symmetric laminates: From the below graphs, cross-ply laminate is given better result as compared to symmetric and angle ply laminates. The graphs indicate the breaking point and stress-strain curves for symmetric, cross-ply, angle ply laminates. Figures 3-5 indicate the graphs of symmetric laminates, cross ply and angle ply laminates. That shows load, displacement and stress-strain curve of symmetric laminate, angle ply and cross ply respectively.

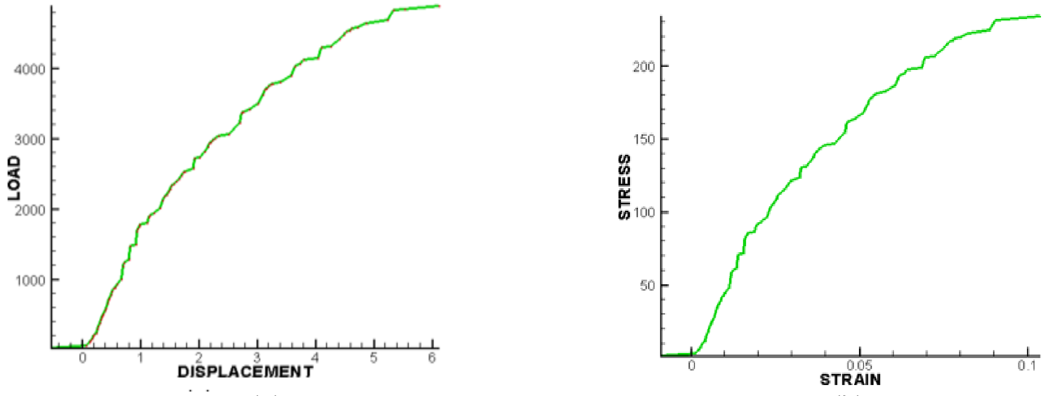
Figure 3. (a) load and displacement **Note:** (—) Load *vs* displacement for symmetric laminates ; (b) Stress and strain graph for symmetric laminates **Note:** (—) Stress *vs* strain for symmetric laminates.



(a) (b)

Angle ply laminates

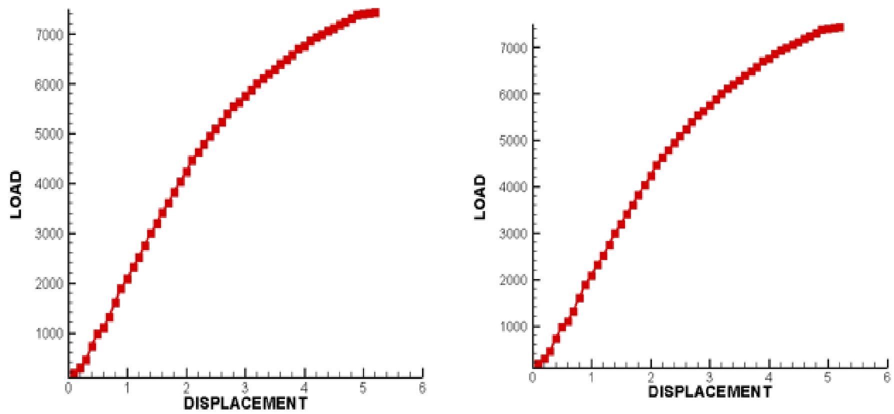
Figure 4. (a) Load and displacement graph **Note:** (—) Load *vs* displacement for angle ply laminates; (b) Stress and strain graph for angle ply laminate **Note:** (—) Stress *vs* strain for angle ply laminate.



(a) (b)

Cross ply laminates

Figure 5. (a) Load and displacement **Note:** (—) Angle orientation for cross ply laminate; (b) Stress and strain graph for cross ply laminates **Note:** (—) Stress *vs* strain for cross ply laminate.



(a) (b)

Figure 6. Comparison graph between load and displacement for symmetric, cross and angle ply laminates.

Note: (—) Angle ply; (—) Cross ply; (—) Symmetric ply.

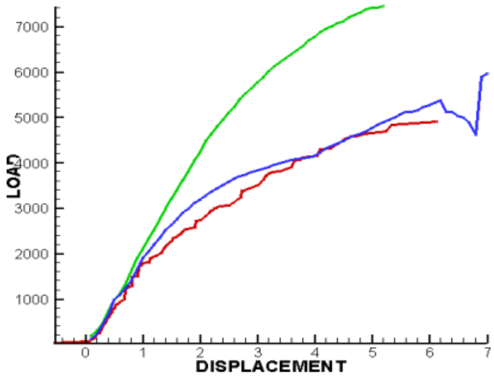
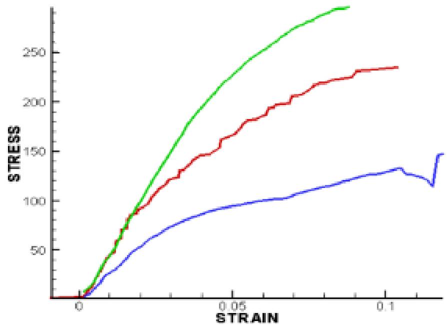


Figure 7. Comparison graph between stress and strain for symmetric, angle and cross ply laminates.

Note: (—) Angle ply; (—) Cross ply; (—) Symmetric ply.



Figures 6 and 7 show the comparison of three types of laminates. From that graph, it is clear that cross-ply laminates give better results than angle play and symmetric laminates. Angle ply laminates give less break load than the symmetric and cross-ply laminates. The young's modulus and bending strength are more for cross ply laminate compared to the other two laminates. This experiment results indicates the cross-ply laminates have more stiffness than symmetric and angle ply laminates.

CONCLUSION

From this research it is clear that cross ply laminates are shown better results than other laminates used in this research. The sandwich panel deformation, break load and bending strength are very low. The angle ply, symmetric ply, cross ply laminates break load, bending strength and deformation are high compared to sandwich panel. Young's modulus, bending strength and ultimate tensile strength are higher than symmetric, angle ply laminates.

Future scope

The main motto of this work is to know the young's modulus and breaking strength of each specimen. This work will be used for further research on hybrid composites. This experiment plays a role in future research work. This investigation was useful to compare hybrid composites, alloys, and different types of materials. All these things lead me to do this work. This research work is further helpful for research scholars, who conduct research on metal matrix composites.

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