Experimental study on the Mechanical Properties of E-Glass Reinforced Polymer Composite based on carbon nano powder percentage

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Abstract: The current study observes the effect of orientation on the mechanical properties of a Carbon/ E-Glass reinforced polymer based composites. Specimens we are investigated in this study are E-glass/carbon fiber with Polyester resin were prepared by using hand layup technique. The laminated specimens are cut to the ASTM standards. The samples are subjected to elongation & bending load and also the sudden loads causing tensile, flexural and impact stress in this study. The purpose of this work is to experimentally analysis the orientation of fiber in the Reinforced composites subjected to tensile, flexural and also the sudden loading. This project is divided into two phases, Firstly we are calculating the tensile properties of the composite are calculated at different carbon percentages for knowing which percentage of carbon having high reinforcement and also having the high properties. In this paper we are varying the Carbon percentage from 5% to 25% with an interval of 5% each. Secondly the composite is investigated for different fiber directions at constant carbon percentage. In this paper we are changing the direction of the Fiber as 0°, 30°, 45°, 60°, and 90° to investigate the tensile strength, flexural strength and impact strength of the composite.

Key Words: E-Glass/ Carbon Fiber, Fiber Direction, Carbon Percentage, Tensile, Flexural and Impact Strength

1. Introduction

Composite material can be defined as the combination of two or more different materials which having dissimilar property. In this study the fiber used which may be in the form of fabric which is reinforced in the material gives strength to the overall material and the matrix provides rigidity and the fiber glass which are reinforced in polymer are generally popular reinforced plastic material which are used in many industry.

In this study Kevlar and carbon powder used for making composite material vinyl ester resins used as the matrix material in this specimens were making by the hand layup process The mechanical properties of mixture fiber overlaid composites are great and can be utilized to succeed the individual fiber in fortified polymer material [1-2].

In this study focus on preparation and testing of polyester resin using glass fiber for different orientations.1, 2 and 3 Layers of Glass fiber laminate composite for the orientation of 30^0, 60^0 and 90^0 angles reinforced in polyester matrix composite for studying the tensile, compressive and impact behavior [3].

In this study carbon powder and glass fiber are used for making composite materials in this specimens were making by the hand layup process to study the tensile strength and flexural strength of $[G2C2G]_S$ and $[CG3C]_S$ [4] and also the tensile properties such as tensile strength and tensile strain are calculated by [5] .

In this study glass fiber and milled carbon powder was used for making composite reinforced materials and Epoxy resins used as the matrix material. In this specimens were making by the hand layup process for predicting the impact strength, tensile strength, flexural strength by [6]

In this study, the composites were developed by hand lay-up technique with varying fiber percentages (15%, 30%, 45%, and 60% by weight percentage). The mechanical property such as tensile strength and flexural bending strength of polyester resin with the glass fiber are determined by [7].

In this study the mechanical properties and the strain monitoring of a glass-epoxy composites with the grapheme coated fibers are studied in [8].

In this study, various laminate composites based on unsaturated polyester (UP) and vinyl ester (VE) resins reinforced with different woven fabrics (bidirectional and quadric-axial roving’s), prepared by hand lay-up process and studied by [9]

In this study the filler and fiber materials are used as reinforcing elements to determine the mechanical properties of the polymer composite by varying the percentage of the fiber and the filler materials for studying the mechanical properties by [10].

2. Materials

The selection of materials for the experimental work was both glass fiber of mat format and Carbon powder used as filler material reinforced with polyester resin with accelerator (cobalt naphthenate- for speed the chemical reaction), catalyst (methyl ethyl ketone peroxide – for speed the curing of the compound), were used as matrix components.

3. Variation of Carbon powder

The carbon powder is varying from 5% to 25% with an interval of 5% each for calculating which percentage of the filler material having high mechanical properties. The specimens are prepared as per the ASTM standards of the tensile tests and the 15% of the carbon powder shows more load carrying and elongation than other percentages means the reinforcing of carbon powder with the fiber material is high and beyond 15% the reinforcing is low and above 15% the reinforcing is very low. The Tensile properties of the composite with varying the carbon powder as shown in Fig 1(a) & 1(b)

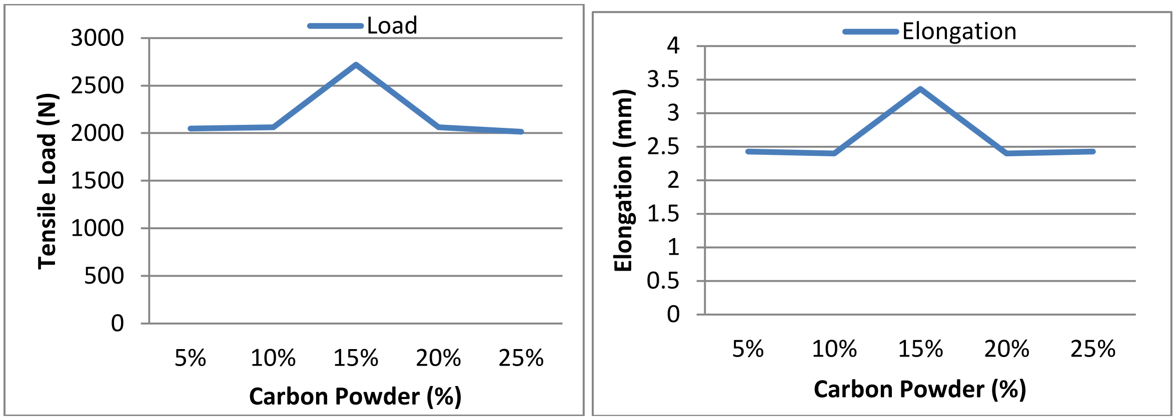

Fig 1(a) Carbon powder Vs Tensile Load (b) Carbon powder Vs Elongation

4. Results and Discussion:

4.1Tensile Test:

The tensile properties of the composite were measured as per the experimentally by using the electronic tensometer to find the tensile properties of the composite specimens. The tensile testing composite specimens are prepared as per the ASTM-D-638M standards. Test specimens having the dimensions of 160 mm length, 12.5 mm wide and 3 mm thickness. Three specimens were tested for each composition to predict the tensile behavior of the Composite.

In structural applications is capacity to resist breaking under tensile load is the best vital and broadly measured properties of materials. The affinity of a material to stretch without breaking is known as tensile strength. It was performed according to ASTM-D-638 standards using UTM, the cross head speed was 0.5 mm/min. The ends of the specimen were clamped between the jaws. The movement of the jaws offers tensile force on the specimen. The results were mentioned as the average value of three test samples. The Fig 2(a) shows the Tensometer which is used to measure the max load and elongation for the tensile specimens and also the tensile specimens as per the ASTM standards in Fig 2(b)

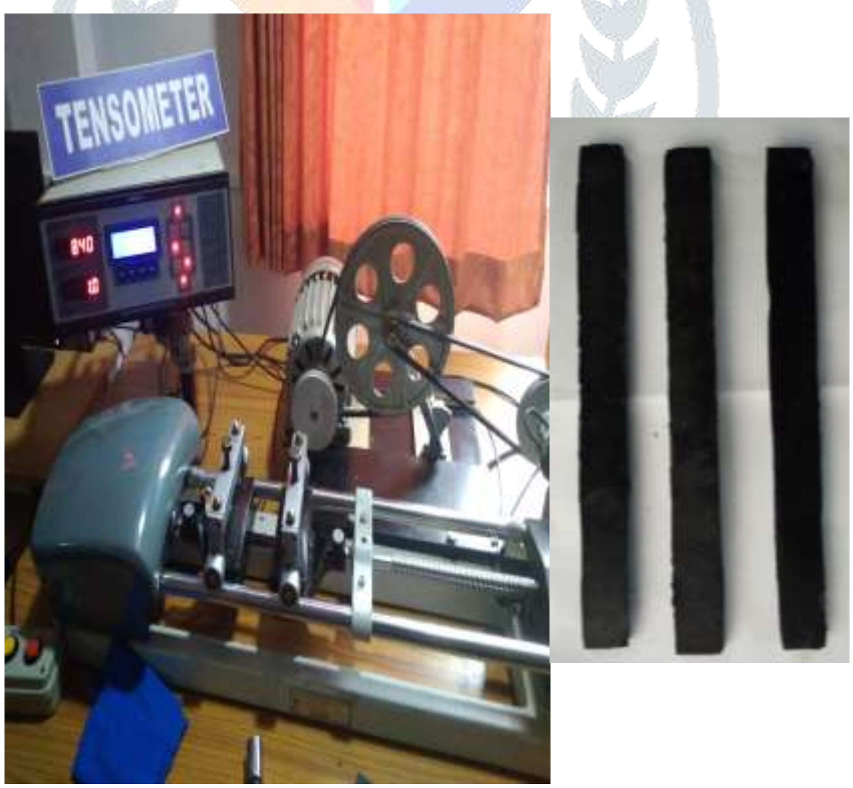

Fig 2: (a) Tensometer for Measuring the Tensile Strength (b) Tensile Specimens As per ASTM standards

Table 1: Tensile Test Results

Direction	Specimens	Max Load (N)	Elongation (mm)	Max Stress (MPa)	Max Strain	Tensile Stress (GPa)
0 Deg	1	2210	2.3	58.933	0.014	4.099
	2	2720	3.2	72.533	0.02	3.626
	3	3230	4.6	86.133	0.028	2.995
30 Deg	1	1160	2.1	30.933	0.013	2.356
	2	1750	2.2	46.666	0.013	3.393
	3	1520	2.3	40.533	0.014	2.819
45 Deg	1	1260	1.6	33.600	0.01	3.36
	2	1500	1.7	40.000	0.010	3.764
	3	1370	1.6	36.533	0.01	3.653
60 Deg	1	870	1.4	23.200	0.008	2.651
	2	1350	2.7	36.000	0.016	2.133
	3	1870	2.5	49.866	0.015	3.874
90 Deg	1	2210	2.3	58.933	0.014	4.099
	2	2720	3.2	72.533	0.020	3.626
	3	3230	4.6	86.133	0.028	2.995

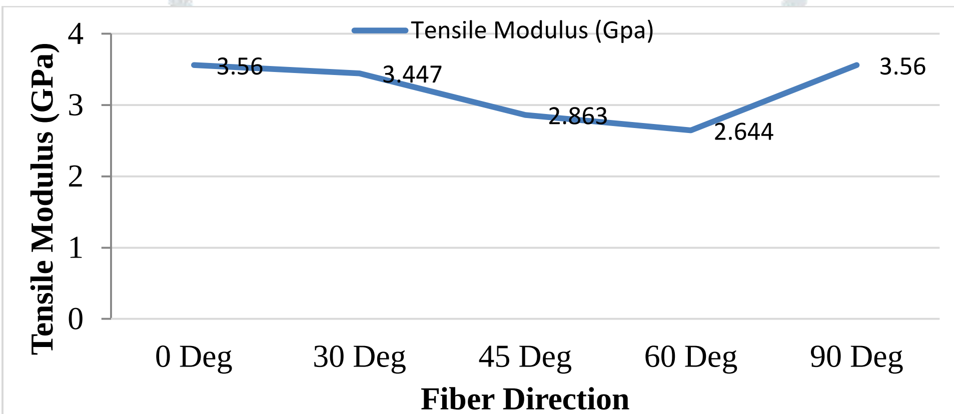

Fig 3: Influence of Fiber Direction with the Tensile Modulus (GPa)

In this study the Specimen having the materials of E-Glass fiber along with the 15% of carbon taken based on the volume fraction of the composite. The fiber direction is changes from 0° to 90° and at constant filler material percentage (Carbon Percentage of 15%) to investigate the tensile modulus of the composite as shown in Fig 3.The Table 1 shows the maximum stress, strain and also the Tensile Modulus of the Composite by using the maximum load and the elongation measured in Tensometer.

In the Fig 3 as the Fiber direction changes the tensile modulus decreases because the reinforcement of the fiber in the direction of load. The Fig shows that the tensile modulus is high at 0^0 & 90^0 because the fiber is in the direction of the load. The results were mentioned as the average value of three test samples and plotted in graph.

4.2 Flexural Test:

Flexural 3-point bend testing specimens are prepared as per the ASTM-D-790M. By using the electronic tensometer to find the flexural properties of the composite specimens. Test specimens having the dimensions of 100 mm length, 25 mm wide and 3mm thickness. Three specimens were tested for each composition to predict the Flexural behavior of the Composite.

As per this test, samples to be verified is subjected to a load at its centre between the backings and until it splits and breaks. This test controls the conduct of the example when it is subjected to beam loading. Flexural quality decides the greatest anxiety actuated in the surface generally fiber. The test was carried out using a proper apparatus which was according to the ASTM- D-790 standard, by using an UTM. The results were mentioned as the average value of three test samples. The Fig 4(a) shows the Flexural specimen which is fixed in the Jaws of the Tensometer and Fig 4(b) shows the Flexural Specimen as per the ASTM standards.

Fig 4: (a) Jaws having the Flexural Specimen (b) Flexural Specimens as per the ASTM standards

Table 2: Flexural Test Results

Direction	Specimens	Max Load (N)	Elongation (mm)	Max Stress (MPa)	Max Strain	Flexural Stress (GPa)
0 Deg	1	390	9.4	5.2	0.094	0.055
	2	230	6.0	3.066	0.06	0.051
	3	320	12.3	4.266	0.123	0.034
30 Deg	1	180	5.2	2.4	0.052	0.046
	2	280	8.8	3.733	0.088	0.042
	3	280	4.3	3.733	0.043	0.086
45 Deg	1	280	14.7	3.733	0.147	0.025
	2	220	5.6	2.933	0.056	0.052
	3	350	4.0	4.666	0.04	0.116
60 Deg	1	330	7.1	4.4	0.071	0.061
	2	280	13.6	3.733	0.136	0.027
	3	170	2.3	2.266	0.023	0.098
90 Deg	1	390	9.4	5.2	0.094	0.055
	2	230	6.0	3.066	0.06	0.051
	3	320	12.3	4.266	0.123	0.034

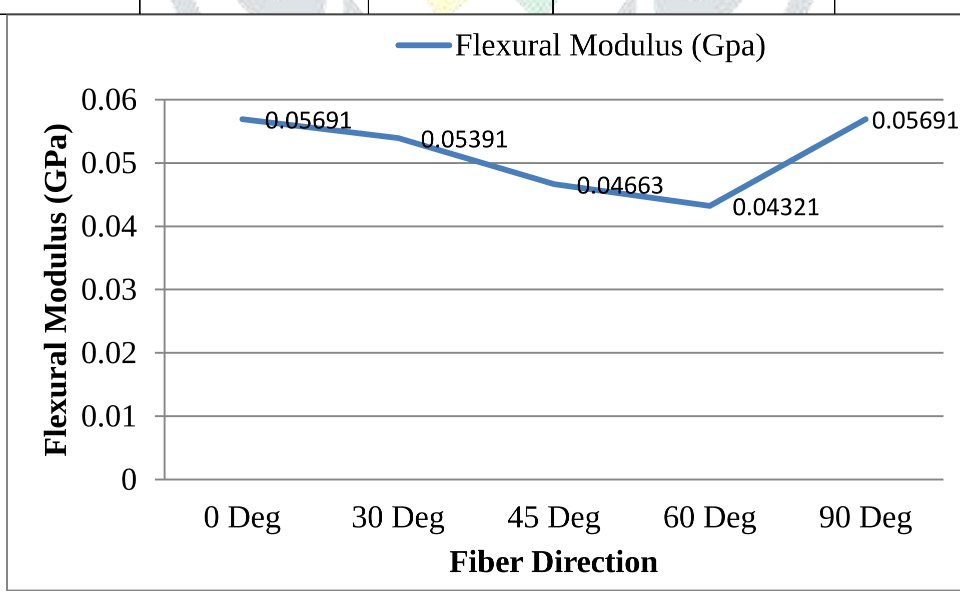

Fig 5: Influence of Fiber Direction with Flexural Modulus

In this study the Flexural Specimen having the materials of E-Glass fiber along with the 15% of carbon taken based on the volume fraction of the composite. The fiber direction is changes from 0° to 90° and at constant filler material percentage (Carbon Percentage of 15%) to investigate the Flexural modulus of the composite as shown in Fig 4. The Table 2 shows the maximum stress, strain and also the Flexural Modulus of the Composite by using the maximum load and the elongation measured in Tensometer.

In the Fig 5 as the Fiber direction changes the Flexural modulus decreases because the reinforcement of the fiber in the direction of load. The Fig shows that the Flexural modulus is high at 0^0 & 90^0 because the fiber is in the direction of the load. The results were mentioned as the average value of three test samples and plotted in graph.

4.3 Impact Test:

Impact testing specimens are prepared as per the ASTM-D-256M. By using the Izod Impact Test to find the Impact properties of the composite specimens. Test specimens having the dimensions of 63.5 mm length, 12.7 mm wide and 10 mm thickness. Three specimens were tested for each composition to predict the Flexural behavior of the Composite.

The Izod Impact test of composite was tested and the cross section having 45^0 V-notch and 2mm deep were used for test. Each test is repeated three times and the average values are taken for calculating the impact strength.

The Fig 6(a) shows the impact tester used to calculate the impact strength and Fig 6(b) shows the impact specimens as per the ASTM standards.

Fig 6: (a) Impact Tester and (b) Impact Specimens as per ASTM standards

Table 3: Impact Test Results

Direction	Specimen	Max Load (Joule)	Impact Strength (GPa)
0 Deg	1	1.8	0.0011160
	2	1.82	0.001128
	3	2.06	0.001277
30 Deg	1	2.02	0.001252
	2	1.6	0.000992
	3	1.66	0.001029
45 Deg	1	1.8	0.001116
	2	1.64	0.001016
	3	1.8	0.001116
60 Deg	1	1.62	0.001004
	2	1.82	0.001128
	3	1.82	0.001128
90 Deg	1	1.8	0.0011160
	2	1.82	0.001128
	3	2.06	0.001277

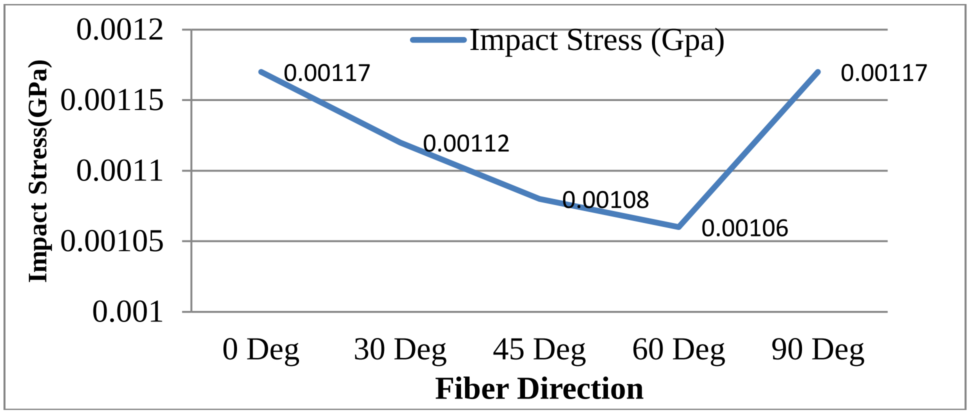

Fig 7: Influence on Fiber Direction with the Impact Stress

In this study the Impact Specimen having the materials of E-Glass fiber along with the 15% of carbon taken based on the volume fraction of the composite. The fiber direction is changes from 0° to 90° and at constant filler material percentage (Carbon Percentage of 15%) to investigate the Impact stress of the composite as shown in Fig 7. The Table 3 shows the maximum stress, strain and also the Impact stress of the Composite by using the maximum load and the elongation measured in Impact tester.

In the Fig 7 as the Fiber direction changes the impact stress decreases because the reinforcement of the fiber in the direction of load. The Fig 6 shows that the Impact stress is high at 0^0 & 90^0 because the numbers of fiber layers are high and reinforcement of the glass fiber is high. The results were mentioned as the average value of three test samples and plotted in graph.

5. Conclusion:

The current study observes the effect of orientation on the mechanical properties of a Carbon/ E-Glass reinforced polymer based composites. Specimens we are investigated in this study are E-glass/carbon fiber with Polyester resin were prepared by using hand layup technique. The laminated specimens are cut to the ASTM standards. The samples are subjected to elongation & bending load and also the sudden loads causing tensile, flexural and impact stress in this study. The purpose of this work is to experimentally analyze the orientation of fiber in the Reinforced composites subjected to tensile, flexural and also the sudden loading.

The following are the observations:

1. The 15% of the carbon powder reinforced with the glass fiber having good mechanical properties than the other percentages i.e., carrying better load and elongation.
2. As the Fiber direction angle increases the mechanical properties such as the tensile strength, Flexural strength and the impact strength decreases.
3. The 60^0 fiber direction having the less magnitude than other directions under tensile, flexural and impact loads because the reinforcement of fibers are low in that direction.
4. The 0^0 and 90^0 having the high magnitude than other directions under tensile, flexural and impact loads because the reinforcement of fibers are high in that direction.

6. References

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