

Comparing The Behaviour of Carbon Fiberreinforced Polymer and Glass Fiber reinforced polymer in Bending

DR. JUSTIN MOSES SELVAMONY
Professor in civil Engineering,
Ponjesly College of Engineering, Nagercoil – 629 003
Mail ID: justinmosesselvamony@gmail.com

Abstract: *Highly efficient conventional elements are employed because of their superior mechanical qualities, stiffness-to-weight ratios, and impact resistance. Epoxy matrices can have their molecular architecture and structure changed to provide high crosslink densities, higher hardness, and good strength. In several of these real-world scenarios, the structures are subjected to heavy impact damage. Materials and constructions react differently when subjected to impact loading situations. It looks at the production and research of composite materials and contrasts them with GFRP and CFRP individually. An analysis is done of a composite structure's tensile, flexing, and contact properties as well as how they react to various strain rates and degrees. By manually laying up the composites. Comparatively speaking, GFRP has inferior tensile and flexural properties to CFRP composites. The composite's interior architecture is inspected for cracks, voids, and fiber debonding using a scanning electron microscope (SEM).*

Keywords: *Mechanical properties, mechanical testing, CFRP, Scanning Electron Microscope*

Introduction

The phrase "composite" refers to any substance that has been produced by fusing two or more distinct substances so that the new substance outperforms each of the constituent substances. Several industries, including aircraft, engineering, sports products, and defence, use fiber-reinforced composites for their exceptional properties. A growing number of people are now interested in FRP composites because of its environmental benefits. Researchers have centred a lot of their work on these FRP composites.

Glass Fibre

Glass fibers are used in the production society to create materials. FIbers in products made of fiber glass withstand tensile and compressive loads because of resin or matrix transmits shear. Compared to steel or wood materials, fiber glass composite materials are significantly lighter. Fiberglass is a light material with strength and durability. Typically, the material is less delicate, and the cost of the raw materials is lower. As compared with metals, it has a lot of advantages in terms of bulk strength, mass, and moulding ability. Fiberglass is often used in a variety of products, including high efficiency airplanes (gliders), ships, vehicles, bathrooms, water reservoirs, roofing, pipelines, and cladding.

Carbon Fibre

Carbon atoms are found in fibers that are 0.005-0.010 mm thick and make up the substance known as carbon fiber. A chain of crystalline holds the carbon atoms, which also are typically aligned parallel to the fiber's long axis, altogether. The fibre is incredibly strong despite its small size because of the alignment of its crystals. To produce a yarn that can be weaved into garments used or on its own, carbon fibers are knotted together.

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Composite materials with a high potency ratio, like carbon fiber - reinforced composites polymer, can be produced by mixing carbon fiber and plastic resin (also referred to as fiber). Carbon composites works well for duties that demand for a light weight materials because it has a lower population density than steel. Carbon fiber is used in the aerospace, construction, military, racing, and other athletic events because of its high strength, low weight, and lower thermal expansions.

ResinandHardener

Since epoxy resin provides excellent binding properties between fibers, it is used to make the matrix. LY 556 epoxy resin is utilized at ambient temperature. To strengthen the composites and increase interfacial adhesion, a hardener (HY 951) is used. Resin and hardeners should be used 10:1 for the best composite.

Fabrication Procedurefor a specimen:

The composite material is created using a hand layup method. Every layer has a coating of resin and hardener. A 10:1 ratio is used to combine the hardener and resin. Table 1 demonstrates that the weight ratios of the polymer and fiber are comparable. Following acetone cleaning of the mold surface, a releasing agent (wax) is added. A thin layer of resin is applied to the mold. Rolling the GFRP releases retained air and spreads epoxy resin uniformly. As a consequence, glass fiber layers are piled on top of each other in order to reach the required depth. Now the mold is cured for 8-12 hours with a load of 8-10 kilograms. Cutting the sides of the laminates gives the required composite laminates. The preparation process for CFRP laminate is identical.

Calculating the weight ratio of the fiber and the polymer:
Table1.Weight ratio of fibre to polymer

Sl.No	Fiber	Thickness of fiber (mm)	Weight of Fibre (W_f) (gram)	Weight of polymer (W_p) (gram)	Weight of hardener (gram)
1	Glass	3.5	149.9	300	30.0
2	Glass	4.5	182	364	36.4
3	Carbon	3.5	136	136	13.6
4	Carbon	4.5	176.8	177	17.7

(1) Composite 's volume=25x20x0.3= 150 cc
(2) Polymer's weight =149.9 x 2=300g
(3) Hardener weight =300/10 =30.0

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COMPOSITE TESTS

Tensiletest

The composite was put through a tensile test in accordance with ASTM D638; figure 1 shows the sample. Each compound sample was marked with the necessary dimensions, and they were then saw-cut according to those marks. An all-purpose testing device was used for the test. At different strain rates—2.5, 1.5—and temperatures—35, 70°C— Eight glass fiber and eight carbon fiber materials were tested in this experiment. Testing was done to measure the composite's thickness at the point of failure and the composite's overall distortion under break pressure. The test is conducted by preparation is done to the specimen in the tensile testing machine's grasp until it fractures. Plotted on the graphs are the relevant loads and displacements.

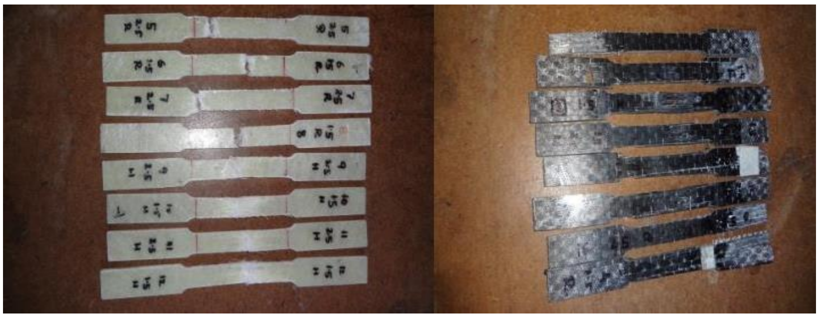

Figure1:Tensiletest specimen

Flexural test

To use a saw cutter, the composites are now cut to the proportions needed by ASTM D790 (50.8mm x 12.7mm), as seen in figure 2. For composites, the three-point test is the flex test which is most frequently employed. The position of the cross-head is commonly used to calculate specimen deflection. Flexural strength and displacement test outcomes are also included. In an all test device, the test specimens are placed, and force applied on it until it breaks and cracks. The ASTM D790 three-point bending structure and a cross head speed of 2 mm per minute were employed in the tensile tests, which was conducted on the same global testing apparatus.

Figure2: Flexuraltestspecimen

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Impacttest

The test is carried out using Charpy arrangement impact diagnostic equipment. The guidelines of ASTM D256 are observed. The amount of energy that the object received is measured when the specimen breaks as a consequence of the pendulum's strokes. The amount of total energy a substance can receive is demonstrated in this experiment.

RESULTSANDDISCUSSIONS

Tensileproperties

To determine the tensile properties, the universal testing equipment is used to evaluate composite specimens such as GFRP and CFRP at various thicknesses and strain rates. Figures 3 to 18 provide an example graph of the relationship between load and movement for CFRP and GFRP.

For meaningful assessments, Tables 2 to 5 provide a summary of the different mechanical characteristics of the created composites (CFRP and GFRP). It is easy to show off the CFRP composite's outstanding tensile strength. At 35 °C and a strain rate of 2.5 mm/min, CFRP exhibits the greatest tensile stress of 913.861N/mm2 and the equivalent extension of 4.761%. The tests yielded a 1.00mm maximum displacement. The samples breaks at a final load of 36262 N. (36.262 KN). The maximum tensile stress measured in N/mm2 for the GFRP sample is 114.149N/mm2, and the corresponding elongation measured in mm/min at 35oC is 5.476%. 2.300 mm was the largest displacement recorded during testing. 5744 N is the maximum load at which the sample snaps (5.744 KN). Tensile test results show that the CFRP composite outperforms other types of composites, which is what can be inferred from them.

TENSILETESTRESULT:

Carbon Fiber Samplesfor 35ºC

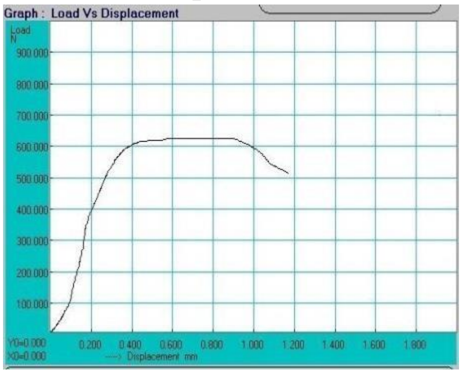

Fig-3-Sample-1Strain Rating2.5mm/min

Fig-4-Sample-2Strain Rating 1.5mm/min

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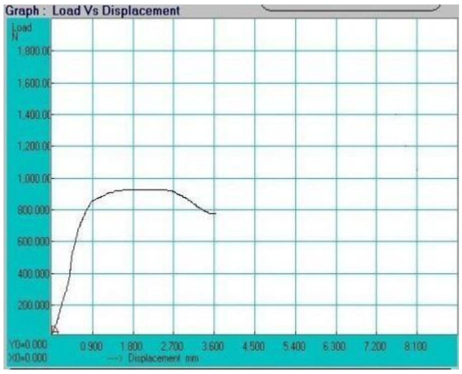
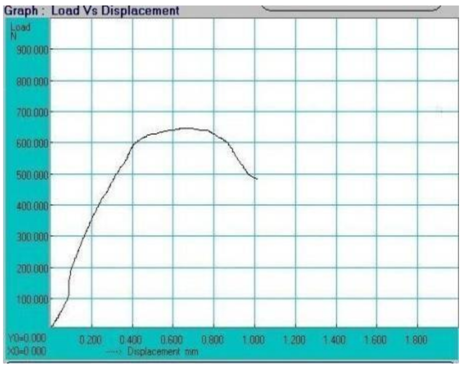


Fig-5-Sample-3StrainRating2.5mm/min
Fig-6-Sample-4StrainRating 1.5mm/min

Carbon FiberSamplesfor 70°C



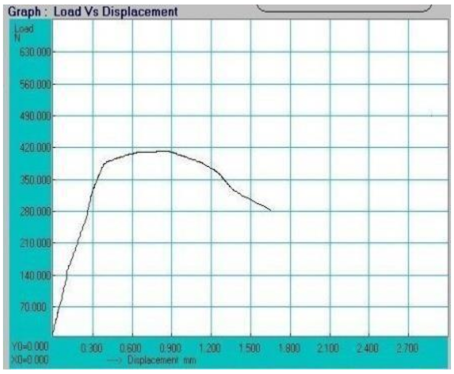
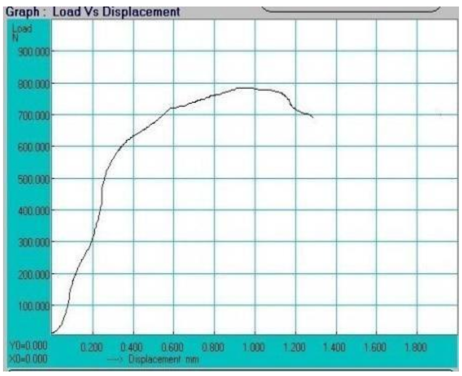


Fig-7-Sample-1 Strain Rating 2.5mm/min
Fig-8-Sample-2StrainRating1.5mm/min



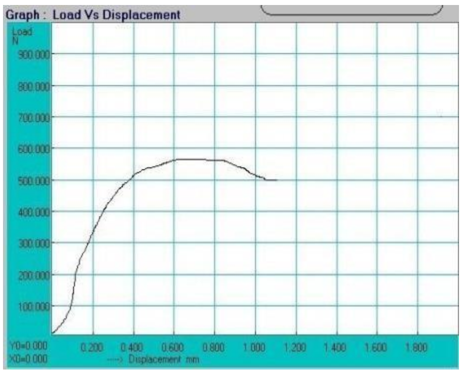


Fig-9-Sample-3 Strain Rating 2.5mm/min
Fig-10-Sample-4StrainRating1.5mm/min

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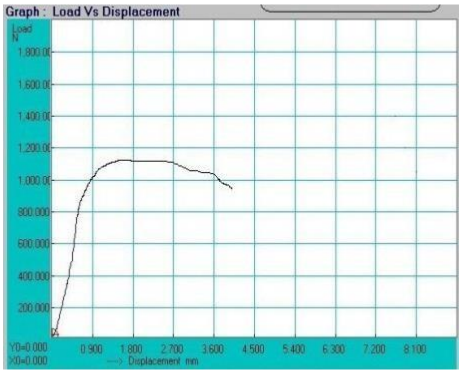
GlassFiberSamples for35ºC

Fig-11-Sample-1StrainRating2.5mm/min
Fig-12-Sample-2Strain Rating 1.5mm/min



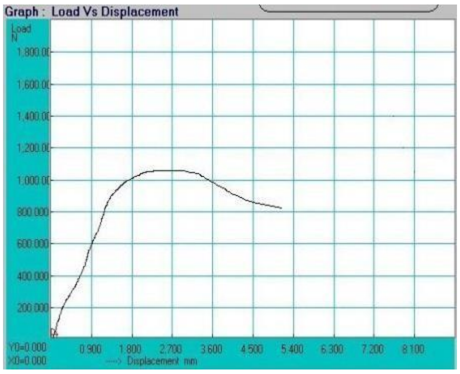


Fig-13-Sample-3StrainRating2.5mm/min
Fig-14-Sample-4Strain Rating 1.5mm/min

GlassFiberSamples for70ºC

Fig-15-Sample-1StrainRating2.5mm/min
Fig-16-Sample-2Strain Rating 1.5 mm/min

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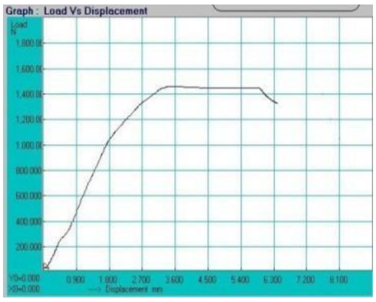

Fig-17-Sample-3 Strain Rating 2.5 mm/min

Fig-18-Sample-4StrainRating 1.5mm/min

Table-2Carbon fibretensiletestat 35ºC

Sample no	Thickness (mm)	Strain Rate (mm/min)	Ultimate stress (N/mm^2)	Maximum Displacement (mm)	Breaking load(N)	Elongation (%)
1	4.5	2.5	625.958	0.700	34648	2.976
2	4.5	1.5	761.637	0.800	41724	2.381
3	3.5	2.5	913.861	1.000	36262	4.761
4	3.5	1.5	901.515	2.400	49980	5.952

Table-3Carbon fibre tensiletest at70ºC

Sample no	Thickness (mm)	Strain Rate (mm/min)	Ultimate stress (N/mm^2)	Maximum Displacement (mm)	Breaking load(N)	Elongation (%)
1	4.5	2.5	643.483	0.700	36694	12.143
2	4.5	1.5	418.401	0.700	24853	13.690
3	3.5	2.5	797.154	0.900	33608	8.571
4	3.5	1.5	587.850	0.700	33625	11.905

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Table-4Glassfibretensiletest at 35°C

Sample no	Thickness (mm)	Strain Rate (mm/ min)	Ultimate stress (N/mm^2)	Maximum Displacement (mm)	Breaking load(N)	Elongation (%)
1	4.5	2.5	103.775	2.400	4838	7.143
2	4.5	1.5	114.149	2.300	5744	5.476
3	3.5	2.5	114.013	2.200	6798	7.5
4	3.5	1.5	109.100	2.700	6726	7.381

Table-5Glassfibretensiletest at 70°C

Sample no	Thickness (mm)	Strain Rate (mm/ min)	Ultimate stress (N/mm^2)	Maximum Displacement (mm)	Breaking load(N)	Elongation (%)
1	4.5	2.5	11.759	2.700	508	8.214
2	4.5	1.5	11.111	3.600	540	6.309
3	3.5	2.5	9.939	2.200	586	6.5
4	3.5	1.5	14.423	4.800	842	7.381

FlexuralProperties

Two distinct types of composites are shown in Figures 19 to 26 together with typical power curves. When the highest flexural load is reached, all of the curves are observed to linearly climb with respect to displacement before starting to decelerate as breakage actually occurs. The material carbon fiber exhibits the highest flexural strength. Tables 6 and 7 display the flexural resistance exhibited by other composites. Epoxy matrix and CFRP have greater adherence as comparing to GFRP and those materials.

The flexural modulus of the composites can be derived however when the force and its position are computed using the linear component of the curve. This demonstrates that flexural modulus of carbon fiber is higher than that of Composite materials. In figures 19 to 26, the break load and displacement of various composites are examined. The maximum flexural strength of the CFRP specimen at a strain rate of 2.5 mm/min is 31.578N/mm2. It was possible to attain a maximum motion of 6.100mm throughout testing. Under such a weight of 1785 N or more, a specimen will fall (1.785 KN). At a stress rate of 1.5 mm/min, the GFRP graph's highest flexural modulus is 9 N/mm2. The specimens can endure a breaking force of 540 N, and during measurements, the highest motion observed was 5.700 mm (0.54 KN). The graph straightens out just after the maximum flexural stress point because the fibers will separate as a composite material ages. This causes the curve in the graph to fluctuate at random points before breaking.

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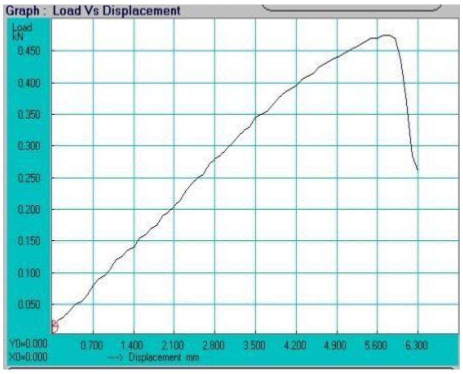
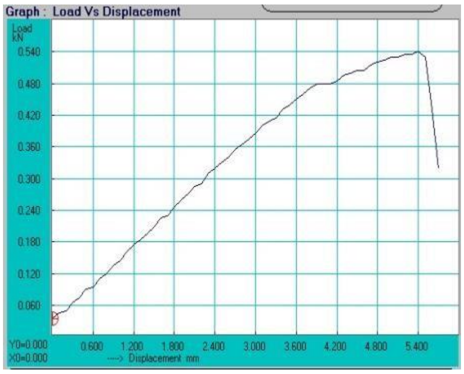
FLEXURALTESTRESULT:





Glassfibre samplesat 35°C

Fig-21-Sample-3Strain Rating2.5mm/min
Fig-22-Sample-4Strain Rating 1.5 mm/min
Carbonfiber samplesat35°C

Fig-23-Sample-5StainRating2.5mm/min

Sample-6StrainRating 1.5 mm/min

Table-6Glassfibreflexuraltest at 35°C

Sampleno	**Thickness(mm)**	**StrainRate(mm/min)**	**Ultimatestress(N/mm²)**	**MaximumDisplacement (mm)**	**Breakingload(N)**
1	4.5	2.5	8	6.300	475
2	4.5	1.5	9	5.700	540
3	3.5	2.5	6	8.300	300
4	3.5	1.5	6	7.900	285

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Table-7Carbonfibre flexuraltestat 35°C

Sampleno	Thickness(mm)	StrainRate(mm/min)	Ultimatestress(N/mm^2)	MaximumDisplacement (mm)	Breakingload(N)
1	4.5	2.5	31.578	6.100	1785
2	4.5	1.5	29	6.300	1520
3	3.5	2.5	26	5.500	1135
4	3.5	1.5	25	6.700	1085

Impact test:
The test method is used to determine the fracture resistance of composites made of CFRP and GFRP. Charpy impact test equipment is used to determine the energy lost. Comparing CFRP composite to GFRP composite, its impact energy is relatively strong at 11J.
Table-8Impacttest

Sample. No	Fiber	cknessmm	idthmm	Actualenergyabsorbed (K_1) Joules	Actualenergyabsorbed (K_2) Joules	Actualenergyabsorbed (K_3) Joule	AverageActualenergyyabsorbbed(K) Joules
1	Glass	4.5	16.00	8	6	4	6
2	Glass	3.5	14.5	4	2	2	2.667
3	Carbon	4.5	16.7	18	8	8	11.333
4	Carbon	3.5	15.6	4	4	4	4

The tables 8 and 9 provide an overview of the energy each sample absorbs when struck hard. As can be observed, carbon fiber outperforms glass fiber in regards to impact durability. The carbon fiber absorbs 11 J of energy.

MORPHOLOGICAL ANALYSIS (SCANNING ELECTRONMICROSCOPYANALYSIS)

The scanning electron microscope was used for histopathological study. After tests, a SEM was used to look at the surface properties of the composite material. Dry test specimens from each operation were coated with a 15-20 nm layer of gold to use an Ion-Sputter coater. The samples were then examined using a “scanning electron microscope”. SEM images clearly

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illustrate the interfacial adhesion between the matrix and fiber.

In Figures 27 to 30, a SEM micrograph of materials reinforced with GFRP and CFRP is displayed. Although the composites was carefully manufactured, there is evidence of intra-fibre delamination, which weakens the combination despite the careful production. Because the stress for the tensile test is done in the horizontal direction, it is discovered that the fibers are destroyed more in that path than another.

The tensile-tested CFRP and GFRP fiber composite is depicted in Figures 27 and 29. Although there may be a few flaws, such as air bubbles and fiber draw-out, the adherence is normally excellent. In contrast to fiber, which has an uneven surface, resin is smooth. Since carbon fibers are so strong, they can break off separately, providing the materials a very excellent durability. The extremely stressful values found during the testing are proof that the fiber and matrix effectively transmit stress in the tensile direction, which causes difficulty. The very modest returns are explained by the extremely low stress transmission from the matrix to the fibres, as shown by flexural strength experiments.

CONCLUSION

Fibers like CFRP and GFRP are used to create composite materials in this work. Here in this work we investigated the mechanical characteristics, including “tensile strength (at various strain rates and temperature conditions), flexural modulus (at various strain rates), and impact strength”. In comparison to composite coating, the tensile modulus of Composite materials is kind of greater at 36.262 KN. When compared to GFRP composite, CFRP exhibits reduced generated by increased tensile testing. Due to this, the GFRP composite outperforms the CFRP composite in tensile tests by withstanding huge stress before breakdown. With a maximum stress value of 1.785KN,CFRP composites has strength development that is considerably higher than GFRP composite durability While the contacting and impacting strengths of composites are 6J and 4J, accordingly, and exceptionally strong CFRP composites have an impact strength of 11J. The impact of various testing is examined, and by employing a scanning electron microscope (SEM), the internal structures of composites have been examined. It is discovered that the orientations angles of the fibers have a significant impact on the mechanical behavior of CFRP and GFRP composites. The source of voids, fiber withdrawal, and fiber breakdown under loading conditions can all be predicted using SEM micrographs of the tensile and flexible tested samples. It also provides information on how the fibre glass cracks spread

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