Effect of Carbon Fiber, Cenosphere Composition on Mechanical Properties of Reinforced Polyester Composites

Mr. K H Pulikeshi
Assistant Professor
Department of Mechanical Engineering,
Tontadarya College of Engineering, Gadag, Karnataka, India

Mrs. G P Kumbar
Assistant Professor
Department of Textile Technology,
Rural Engineering College, Hulkoti, Gadag, Karnataka, India

Abstract. Polymer composites can be made by combining two are more fibers as well as with Nano particles. As it increases the strength as well as its properties of the polymer composites in this research work the carbon fiber and glass fiber are used with constant wt. % of glass fiber with 50% and carbon fiber of 0,2.5,5,7.5 and 10 wt.% are used with a varying polyester resin content. With the varying content of glass fiber, carbon fiber and resin material due to the content of carbon fiber the strength as well as the properties of the composite is increased. In recent polymer composite applications these types of content as well as materials are used regularly.

Index Terms- carbon, glass fiber reinforced Polyester composite, tensile, flexural properties, cenosphere etc.

1. INTRODUCTION

POLYMER MATRIX COMPOSITE

A polymer matrix composite material is made by combining two or more materials often ones that have very different properties. The two materials work together to give the composite unique properties. However, within the composite you can easily tell the different materials apart as they do not dissolve or blend into each other. Most composites are made of just two materials. One is the matrix or binder. It surrounds and binds together fibers or fragments of the other material, which is called the reinforcement. Composite materials are generally used for buildings, bridges and structures like boar hulls, swimming pool panels, racing car bodies, etc.

Author Details

Mr. K H Pulikeshi
Assistant Professor
Department of Mechanical Engineering,
Tontadarya College of Engineering, Gadag, Karnataka, India

Mrs. G P Kumbar
Assistant Professor
Department of Textile Technology,
Rural Engineering College, Hulkoti, Gadag, Karnataka, India

2. MATERIALS SELECTION

2.1 POLYESTER RESIN (MATRIX)

Polyester resins are unsaturated synthetic resins formed by the reaction of dibasic organic acids and polyhydric alcohols. Maleic Anhydride is a commonly used raw material with di-acid functionality. Polyester resins are used in sheet moulding compound, bulk moulding compound and the toner of laser printers. Wall panels fabricated from polyester resins reinforced with fiberglass so called fiberglass reinforced plastic (FRP) are typically used in restaurants, kitchens, restrooms and other areas that require washable low-maintenance walls. They are also used extensively in cured-in-place pipe applications. Departments of Transportation in the USA also specify them for use as overlays on roads and bridges. In this application they are known as PCO Polyester Concrete Overlays. These are usually based on isophthalic acid and cut with styrene at high levels usually up to 50%.Polyesters are also used in anchor bolt adhesives though epoxy based materials are also used. Many companies have and continue to introduce styrene free systems mainly due to odor issues.

2.2 CARBON FIBERS

Carbon fibers (alternatively CF, graphite fiber or graphite fiber) are fibers about 5–10 micrometers in diameter and composed mostly of carbon atoms. Carbon fibers have several advantages including high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion. These properties have made carbon fiber very popular in aerospace, civil engineering, military, and motorsports, along with other competition sports. However, they are relatively expensive when compared with similar fibers, such as glass fibers or plastic fibers.

To produce a carbon fiber, the carbon atoms are bonded together in crystals that are more or less aligned parallel to the long axis of the fiber as the crystal alignment gives the fiber high strength to volume ratio (making it strong for its size). Several thousand carbon fibers are bundled together to form a tow, which may be used by itself or woven into a fabric.

2.3 Glass fibers

Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber. Although not as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fiber-reinforced polymer(FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fiberglass". This material contains little or no air or gas, is denser, and is a much poorer thermal insulator than is glass wool Unidirectional Glass Fiber Uniaxial glass fiber made of 220 gsm; containing diameter of 15 μm has been employed. The matrix system used is a medium viscosity epoxy resin (LY556) and a room temperature curing polyamine hardener (HY951). The fillers that has been used is Nano clay.

Fiber properties	Glass fiber	Carbon fiber
1.Density (gm/ m^3)	2.59	1.77
2.Tensile strength(mpa)	1380-2070	3950
3.Tensile modulus(gpa)	72.45	2.38
4.Linear co-efficient of thermal Expansion (106-6/ k)	5.0-6.0	-0.1
5. Elongation at break (%)	3.4	1.5

TABLE: 1: Thermal and Mechanical Properties of Glass and Carbon Fiber

3. Literature Survey

Buket Okutan et.al [1] Conducted experimental studies to determine strength of mechanically fastened Fibre –reinforced E-glass/ epoxy composites. Various Mechanical properties and strength was determined experimentally. The laminates manufactured had different orientations of the Fibres. Parametric study was conducted considering the geometry of the Fibre orientation and failure characteristics for the pin-loaded Fibre reinforced laminated composites were analyzed.

M. Davallo et.al[2] Investigated the Mechanical behaviour of unidirectional glass polyester composites to identify performance differences of composites with different glass lay-ups and laminate thicknesses during flexure and tensile testing formed by hand lay-up moulding (HLU). The damage generated in the composites exhibited matrix cracking on the lower face followed by the coalescence of delaminations formed within the reinforcing plies.

Slimane Metiche and Radhouane Masmoudi [3] Studied the flexural behaviour of light weight fibre reinforced polymer (FRP) poles. Experimental results show that the use of low linear density glass-Fibres could provide an increase of the ultimate load carrying capacity up to 38 % for some fibre reinforced polymer poles. This is mainly due to the stacking sequence and the stress states generated around the hole.

Pegoretti, E. Fabbri, C. Migliaresi, F. Pilati [4] investigated the flexural loading causes stresses in the polymer laminated composites that may vary through the thickness. These flexural stresses are the maximum at the outer surfaces and are minimum (zero) in the middle at the neutral axis. In the laminates subjected to pure bending, the composite failure initiates on either the tensile or compressive side depending upon whether the composite is stronger in compression or tension respectively. The stress in an individual ply depends upon the stiffness of that ply and its distance from the laminate's neutral axis. By including, one or more extra components having relatively better elastic properties in the laminate can help in improving the flexural properties of the composite structures. This class of composite materials consisting of more than two types of constituents is commonly known as a hybrid composite.

G.Kertsis[5] investigated Hybrid composites having two or more types of reinforcing Fibres in a polymer matrix can be classified according to the way their constituent Fibres are mixed such as; sandwich hybrids, interply hybrids, and intermittently mixed hybrid composites. Interply hybrid composites are gaining attention because hybridization facilitates the tailoring of mechanical properties according to need by having a selective amount of extra reinforcement at some selective position in the laminate. The relative volume fraction of reinforcing Fibres and their positioning in the hybrid layup act as the determining factors in the enhancement of flexural properties.

4. Objectives

- Fabrication of hybrid polymer composite
- To understand and characterize the various mechanical properties of the hybrid polymer laminated composites
- To carry out the flexural and tensile testing of composite specimen as per ASTM standards.

5. Methodology

5.1 Fabrication of composite material by Hand lay-up

Hand lay-up is an open molding method suitable for making a wide variety of composites products from very small to very large. Production volume per mold is low; however, it is feasible to produce substantial production quantities using multiple molds. Hand lay-up is the simplest composites molding method, offering low cost tooling, simple processing, and a wide range of part sizes. Design changes are readily made. There is a minimum investment in equipment. With skilled operators, good production rates and consistent quality are obtainable.

Matrix Epoxy, polyester, polyvinyl ester, phenolic resin, unsaturated polyester, polyurethane resin Reinforcement Glass fiber, carbon fiber, aramid fiber, natural plant fibers (sisal, banana, nettle, hemp, flax etc.) (All these fibers are in the form of unidirectional mat, bidirectional (woven) mat, stitched into a fabric form, mat of randomly oriented fibers)

The fibres are first put in place in the mould. The fibres can be in the form of woven, knitted, stitched or bonded fabrics. Then the resin is impregnated. The impregnation of resin is done by using rollers, brushes or a nip-roller type impregnator. The impregnation helps in forcing the resin inside the fabric. The laminates fabricated by this process are then cured under standard atmospheric conditions.

5.2 Mechanical Testing

Tensile test The tensile test of the composite was done in accordance with ASTM D638 and specimen .Each composite specimen was prepared by marking the required dimensions and cut with the help of a saw cutter. A universal testing machine was used to carry out the test. This test was done for 8 specimens of glass fiber and 8 specimens of carbon fiber at varying strain rates (2.5, 1.5) and temperature (35ºC, 700ºC) to get average mechanical properties. The thickness of the composite was measured at the point of failure by testing along with the maximum displacement of the composite at break load. The specimen was placed in the grip of the tensile testing machine and the test is performed by applying tension until it undergoes fracture. The corresponding load and displacement obtained are plotted on the graphs.

5.3 Tensile Test

- The tensile strength is determined by the tensile test which is generally performed on flat specimen using UTM.
- During the test a uni-axial load is applied through both the ends of the specimen.

5.4 Flexural Test

- The test measures the force required to bend a beam under three point loading conditions.
- The test provides values for the modulus of elasticity in bending, flexural stress and the flexural strain of the material.

6. Results and Calculations

No.	Content (%)	Width (mm)	Thickness (mm)	Breaking load (KN)	Ultimate load (KN)	Tensile strength (MPa)
Control Sample	0%	2.5	4.2	53.44	53.44	0.509
1	2.5%	2.5	2.9	41.68	41.68	0.575
2	5%	2.5	3.1	42.86	42.86	0.553
3	7.5%	2.5	3.5	32.78	39.78	0.453
4	10%	2.5	3.4	46.78	46.78	0.55
Control Sample	90%	2.5	5.7	83.92	85.14	0.597

TABLE: 2: Effect of carbon fiber contents on tensile strength of fabricated composites.

Tensile properties of the composites are mostly affected by the materials, method, specimen condition and preparation and also by percentage of the reinforced. It was found from the tensile strength increased from 0.453 MPa to 0.575 MPa with the maximum tensile strength being for the composite with 2.5% carbon fiber percentage which shown in table:2. The tensile strength of the fabricated composite depends to a large extent on the interfacial bonding strength between the matrix reinforcement and also on the inherent properties of the composite ingredients.

No	Content (%)	Width (MM)	Thickness (MM)	Max. Load (KN)	Bending strength (MPa)
Control Sample	0%	2.5	5	14.70	0.196

1	2.5%	2.5	2.9	14.35	0.191
2	5%	2.5	3.1	14.40	0.192
3	7.5%	2.5	3.8	14.45	0.190
4	10%	2.5	3.9	14.55	0.194
Control Sample	90%	2.5	4.1	14.50	0.193

TABLE: 3: Effect of carbon fiber contents on bending strength of fabricated composites

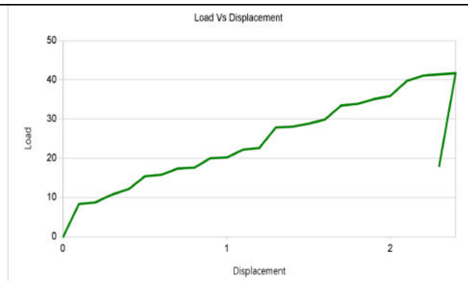
Bending properties of the composites are mostly affected by the materials, method, specimen condition and preparation and also by percentage of the reinforced. It was found from the bending strength increased from 0.190 MPa to 0.196 MPa with the maximum bending strength being for the composite with 10% carbon fiber percentage which shown in table :3. The bending strength of the fabricated composite depends to a large extent on the interfacial bonding strength between the matrix reinforcement and also on the inherent properties of the composite ingredients.

7. CONCLUSION

1) This experimental investigation of mechanical behavior of glass fiber reinforced polyester resin composites leads to the following conclusions:
2) This work shows that successful fabrication of glass fiber with random oriented reinforced polyester composites with different fiber contents is possible and very cost effective by simple hand lay-up technique.
3) It was found that the tensile strength varies from 0.453 MPa to 0.575 MPa flexural strength varies 0.190 MPa to 0.196 MPa.
4) As the amount of carbon fiber increased gradually, load carrying capacity of the composite material increases and amount of resin will not add to the strength.

7.1 TENSILE TEST GRAPH:

Sample No. 1
Composition: Glass fiber: 51.85%
Carbon fiber: 2.5%
Polyester Resin: 45.65%
%Elongation : 2 %
Displacement@FMax : 2.400 mm
Ultimate Load : 41.68 kN
Breaking Stress : 0.575 kN/ mm²
Breaking Load: 41.68 kN
Thickness: 2.9mm



Graph:1

Sample No.2
Composition: Glass fiber: 51.85%
Carbon fiber: 5%
Polyester Resin: 43.15%
%Elongation : 1.2 %
Displacement @FMax : 1.400 mm
Ultimate Load : 42.86 kN
Breaking Stress : 0.553 kN/ mm²
Breaking Load : 42.86 kN
Thickness: 3.1 mm

Sample No.3
Composition: Glass fiber: 51.85%
Carbon fiber: 7.5%
Polyester Resin: 40.65%
%Elongation : 0.8 %
Displacement@FMax : 3.500 mm
Ultimate Load : 39.62 kN
Breaking Stress : 0.375 kN/ mm²
Breaking Load : 32.78 kN
Thickness 3.5 mm

Sample No.4
Composition: Glass fiber: 51.85%
Carbon fiber: 10%
Polyester Resin: 38.15%
%Elongation : 1.6 %
Displacement@FMax : 1.000 mm
Ultimate Load : 46.78 kN
Breaking Stress : 0.55 kN/ mm²
Breaking Load : 46.78 kN
Thickness 3.4 mm

Sample No.5
Composition: Glass fiber: 90%
Carbon fiber: 0%
Polyester Resin: 10%
%Elongation : 1.6 %
Displacement@FMax : 3.100 mm
Ultimate Load : 53.44 kN
Breaking Stress : 0.509 kN/ mm²
Breaking Load : 53.44 kN

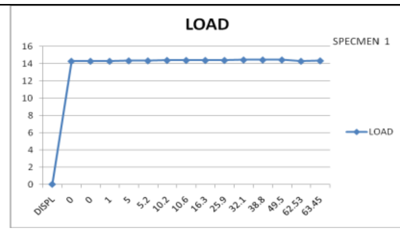
Thickness 4.2 mm

Sample No.6
Composition: Glass fiber: 0%
Carbon fiber: 90%
Polyester Resin: 10%

%Elongation : 1.6 %
Displacement@FMax : 3.000 mm
Ultimate Load : 85.14 kN
Breaking Stress : 0.589 kN/ mm²
Breaking Load : 83.92 kN
Thickness 5.7 mm

7.2 Bending Test Graph:

Sample No.1:
Composition: Glass fiber: 51.85%
Carbon fiber: 2.5%
Polyester Resin: 45.65%
Thickness: 2.9 mm
Displacement: 70.3 mm
Breaking load: 14.35 KN
Ultimate load: 14.45 KN



Graph:7

Sample No.2
Composition: Glass fiber: 51.85%
Carbon fiber: 5%
Polyester Resin: 43.15%
Thickness (mm): 3.1 mm
Displacement (mm): 48.7 mm
Breaking load: 14.4 kN
Ultimate load: 14.45 kN

Sample No.3
Composition: Glass fiber: 51.85%
Carbon fiber: 7.5%
Polyester Resin: 40.65%
Thickness : 3.8 mm
Displacement : 36.1 mm
Breaking load : 14.25 kN
Ultimate load : 14.5 kN

Sample No.4
Composition: Glass fiber: 51.85%
Carbon fiber: 10%
Polyester Resin: 38.15%
Thickness: 3.9 mm
Displacement: 24.5 mm
Breaking load: 14.35 kN
Ultimate load: 15.55 kN

Sample No.5
Composition: Glass fiber: 90%
Carbon fiber: 0%
Polyester Resin: 10%
Thickness (mm) : 5 mm
Displacement (mm) : 36.8 mm
Breaking load (kN) : 14.5 kN
Ultimate load (kN) : 14.7 kN

Sample No.6
Composition: Glass fiber: 0%
Carbon fiber: 90%
Polyester Resin: 10%
Thickness(mm): 4.1 mm
Displacement(mm): 32 mm
Breaking load(kN): 14.5 kN
Ultimate load(kN): 14.6 kN

7.3 Comparison of Ultimate Load for Tensile Test:

Specimen	Without Cenosphere		With Cenosphere	
	Ultimate Load (KN)	Displacement (MM)	Ultimate Load (KN)	Displacement(MM)

1	43.88	1.588	44.08	2.2
2	42.86	1.40	45.30	2
3	42.34	0.60	40.62	2
4 Glass fiber	53.44	3.10	42.38	3
5 Carbon Fiber	85.14	3.00	36.28	2.3

Table: 4: Comparison of Ultimate Load for Tensile Test

Table: 4 which show the specimens 1, 2 and 3 without cenosphere have glass fiber constant of 51.85% with varying carbon fiber. Specimen 1 contains carbon fiber of 2.5% and polyester resin of 45.65%. Specimen 2 contains carbon fiber of 5% and polyester resin of 43.15%. Specimen 3 contains carbon fiber of 10% and polyester resin of 38.15%. Specimen 4 contains glass fiber of 90% and resin 10%. Specimen 5 contains carbon fiber of 90% and resin of 10%.

All the specimens containing cenosphere have glass fiber constant of 50% and carbon fiber of 10% with varying amount of cenosphere. Specimen 1 contains cenosphere of 0% and resin of 40%. Specimen 2 contains cenosphere of 2.5% and resin of 37.5%. Specimen 3 contains cenosphere of 5% and resin of 35%. Specimen 4 contains cenosphere of 7.5% and resin of 32.5%. Specimen 5 contains cenosphere of 10% and resin of 30%.

7.4 Conclusion:

Comparing the ultimate loads of all the specimens as given in the above table, we can see that in specimens 1 and 2 show constant varying load carrying capacity. But in specimen 3 without cenosphere has more load carrying capacity compared to specimen with cenosphere. Hence specimens without cenosphere have more strength to withstand high loads without breaking compared to the specimens with cenosphere.

In specimens without cenosphere, as carbon fiber content increases the load carrying capacity of the specimen increases. The resin has no influence on the strength of the specimen.

In specimens with cenosphere, as cenosphere content increases the amount of resin decreases. Hence strength of the specimens with cenosphere decreases.

7.5 Comparison of Breaking Load for Tensile Tests:

Specimen	Without Cenosphere		With Cenosphere	
	Breaking Load (KN)	Displacement (MM)	Breaking Load (KN)	Displacement(MM)
1	43.8	1.588	35.78	2.2
2	42.86	1.4	22.7	2
3	42.34	0.6	24.04	2
4 (Glass fiber)	53.44	3.1	42.38	3
5 (Carbon fiber)	83.92	3	20.62	2.3

Table: 5: Comparison of Breaking Load For Tensile Tests

Table: 5 which represent the specimens 1, 2 and 3 without cenosphere have glass fiber constant of 51.85% with varying carbon fiber. Specimen 1 contains carbon fiber of 2.5% and polyester resin of 45.65%. Specimen 2 contains carbon fiber of 5% and polyester resin of 43.15%. Specimen 3 contains carbon fiber of 10% and polyester resin of 38.15%. Specimen 4 contains glass fiber of 90% and resin 10%. Specimen 5 contains carbon fiber of 90% and resin of 10%.

All the specimens containing cenosphere have glass fiber constant of 50% and carbon fiber of 10% with varying amount of cenosphere. Specimen 1 contains cenosphere of 0% and resin of 40%. Specimen 2 contains cenosphere of 2.5% and resin of 37.5%. Specimen 3 contains cenosphere of 5% and resin of 35%. Specimen 4 contains cenosphere of 7.5% and resin of 32.5%. Specimen 5 contains cenosphere of 10% and resin of 30%.

7.6 Conclusion:

Comparing the ultimate loads of all the specimens as given in the above table, we can see that in specimens 1 and 2 show constant decrease in breaking load capacity. But in specimen 3 without cenosphere has more breaking load capacity compared to specimen with cenosphere. Hence specimens without cenosphere have more strength to withstand high loads without breaking compared to the specimens with cenosphere.

In specimens without cenosphere, as carbon fiber content increases the breaking load capacity of the specimen decreases. The resin has no influence on the strength of the specimen.

In specimens with cenosphere, as cenosphere content increases the amount of resin decreases. Hence strength of the specimens with cenosphere decreases.

7.7 Comparison of Ultimate Load for Bending Tests

Specimen	Without Cenosphere		With Cenosphere	
	Ultimate Load (KN)	Displacement (MM)	Ultimate Load (KN)	Displacement (MM)
1	14.45	62.53	7.58	24.9
2	14.55	39.3	7.56	23.0
3	15.55	21.9	7.74	14.0
4 (Glass fiber)	14.7	24.3	7.78	19.2
5 (Carbon fiber)	14.6	19.6	7.82	13.6

TABLE: 6: Comparison of Ultimate Load for Bending Tests

By table: 6 we come to know that Specimens 1, 2 and 3 without cenosphere have glass fiber constant of 51.85% with varying carbon fiber. Specimen 1 contains carbon fiber of 2.5% and polyester resin of 45.65%. Specimen 2 contains carbon fiber of 5% and polyester resin of 43.15%. Specimen 3 contains carbon fiber of 10% and polyester resin of 38.15%. Specimen 4 contains glass fiber of 90% and resin 10%. Specimen 5 contains carbon fiber of 90% and resin of 10%.

All the specimens containing cenosphere have glass fiber constant of 50% and carbon fiber of 10% with varying amount of cenosphere. Specimen 1 contains cenosphere of 0% and resin of 40%. Specimen 2 contains cenosphere of 2.5% and resin of 37.5%. Specimen 3 contains cenosphere of 5% and resin of 35%. Specimen 4 contains cenosphere of 7.5% and resin of 32.5%. Specimen 5 contains cenosphere of 10% and resin of 30%.

7.9 Comparison of Breaking Load for Bending Test without Cenosphere.

Specimen	Without Cenosphere	
	Breaking Load (KN)	Displacement (MM)
1	14.35	70.3
2	14.4	48.7
3	14.35	24.5
4	14.4	32.0
5	14.4	36.80

TABLE: 7: comparison of breaking load for bending test without cenosphere

8. Conclusion

Improved the mechanical properties such as Tensile strength Flexural strength of composite by fabrication.

7.8 Conclusion:

Comparing the ultimate loads of all the specimens as given in the above table, we can see that all the specimens without cenosphere have more ultimate loads comparing to the respective specimens containing cenosphere. Hence specimens without cenosphere have more strength to withstand bending loads without breaking compared to the specimens with cenosphere.

In specimens without cenosphere, as carbon fiber content increases the load carrying capacity of the specimen increases. The resin has no influence on the strength of the specimen.

In specimens with cenosphere, as cenosphere content increases the strength of the specimen's increases.

By comparing the values of the tensile and flexural strength, as the carbon fiber content goes on increasing the load carrying capacity also increases and the amount of resin goes on decreasing.

Considering glass fiber of 90% and resin of 10% the ultimate load carrying capacity of the material is 53.44 KN with displacement of 3.100 mm.

Considering carbon fiber of 90% and resin of 10% the ultimate load carrying capacity of the material is 85.14 KN with displacement of 3.00 mm.

By comparing the ultimate load carrying capacity of glass fiber and carbon fiber, therefore carbon fiber has more strength.

By comparing carbon fiber of 0% content with 2.5% of carbon fiber content ,the ultimate load carrying capacity of the material is 53.44 kN with displacement of 3.100 mm under tensile test

Comparing carbon fiber of 0% content with 2.5% of carbon fiber content, the breaking load carrying capacity of the material is 83.92 KN and displacement of 3.00 mm under tensile test.

Comparing carbon fiber of 0% content with 2.5% of carbon fiber content, the ultimate load carrying capacity of the material is 14.45 KN and displacement of 62.53 mm under flexural test.

Comparing carbon fiber of 2.5% content with 5% of carbon fiber content, the ultimate load carrying capacity of the material with carbon content of 2.5% is 43.88 kN with displacement of 1.588 mm have more strength under tensile test

Comparing carbon fiber of 2.5% content with 5% of carbon fiber content, the breaking load carrying capacity of the material with carbon content of 2.5% is 42.86 KN with displacement of 1.40 mm have more strength under tensile test.

Comparing carbon fiber of 2.5% content with 5% of carbon fiber content, the ultimate load carrying capacity of the material with carbon content of 5% is 14.55 KN with displacement of 39.30 mm have more strength under flexural test.

Comparing carbon fiber of 5% content with 10% of carbon fiber content, the ultimate load carrying capacity of the material with carbon content of 5% is 42.86 KN with displacement of 1.4 mm have more strength under tensile test.

Comparing carbon fiber of 5% content with 10% of carbon fiber content, the breaking load carrying capacity of the material with carbon content of 5% is 42.86 KN with displacement of 1.40 mm have more strength under tensile test.

Comparing carbon fiber of 5% content with 10% of carbon fiber content, the ultimate load carrying capacity of the material with carbon content of 5% is 15.55 KN with displacement of 21.99 mm have more strength under flexural test.

By this comparison, the ultimate load carrying capacity under tensile test is 43.88 KN with displacement of 1.588 mm which has 2.5% of carbon fiber content.

By the above result the breaking load carrying capacity under tensile test is 43.88 KN with displacement of 1.588 mm which has 2.5% of carbon fiber content.

By the above result the ultimate load carrying capacity under tensile test is 43.88 KN with displacement of 1.588 mm which has 2.5% of carbon fiber content.

By the above result the ultimate load carrying capacity under flexural test is 15.55 KN with displacement of 21.99 mm which has 10% of carbon fiber.

Comparing the composition of glass fiber of 90% and carbon fiber of 90%, the ultimate load carrying capacity of the material is 85.14 KN with displacement of 3.00 mm under tensile test which has 90% carbon fiber.

9. REFERENCES

1. Buket Okutan, "Effects of geometric parameters on the failure strength for pin loaded multi-loaded multi-directional fibre-glass reinforced epoxy laminate, composites" part B, engineering, vol.33, issue 8, 2002, pp.567-578
2. M. Davallo, H. Pasdar and M. Mohseni, "Effects of Laminate Thickness and Ply Stacking Sequence on the Mechanical Properties and Failure Mechanism of Unidirectional Glass-Polyester Composites", International Journal of Chem Tech 41 Research, CODEN (USA): IJCRGG ISSN: 0974-4290, Vol.2, No.4, Oct-Dec 2010, pp 2118-2124.
3. Slimane Metiche and Radhouane Masmoudi, "full-Scale Flexural Testing on Fiber-Reinforced Polymer (FRP) Poles", The Open Civil Engineering Journal, 1, 37-50, 2007, pp. 37-50.
4. Pegoretti, E. Fabbri, C. Migliaresi, F. Pilati;"Intraply and interply hybrid composites based on E-glass and poly(vinyl alcohol) woven fabrics: tensile and impact properties", Polym Int 53, 2004, 1290–1297.
5. G.Kertsis; "A review of the tensile, compressive, flexural, and shear properties of hybrid reinforced plastics", Composites vol.18, No.1, 1987.