Characterization and Comparing The Flexural Strength of E-Glass/Epoxy matrix Composite Hybridised with E-Glass Powder

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Abstract: The high Strength to weight ratio of Composites making it unique and got a royal role to play in multidisciplinary sections of Engineering .Many studies have been carried out to study the flexural strength of hybrid composites. This attempt was done to study the effect of E glass powder on the Flexural strength of Glass fiber reinforced epoxy composites. E-Glass powder is mixed by varying the weight percentage to the resin bath to prepare composite laminate. In this laminate the reinforcement is in both fiber form that is E-Glass fiber and particulate form which is E-Glass powder. The composite with different fiber orientation and different weight percentage of E glass powder were evaluated and compared. It has been observed that there is a significant decrease in flexural strength with increase in wt% of E glass powder in both (0°/30°) &(0°/60°) fiber orientation, but in case of (0°/90°) fiber orientation, there is an increase in flexural strength with the increase in wt% of E glass powder.

Index Terms: **Flexural strength, E-Glass fiber, E-glass powder, Fiber Orientation, Epoxy.**

I. INTRODUCTION

In today's life ,usage of composite materials have been rapidly increased because corrosion resistance properties relative to metals which increased the demand for composites made of E-Glass fiber in the field of automotives, aerospace, construction and household. A material system compose of two or more physically & chemically distinct phases whose combination produces aggregate properties that are different from those of its constituents is known as composite. As flexural strength is an important design parameter which has to be increased, a hybrid composite with different fiber orientation to evaluate the flexural strength is studied .Flexural strength is also known as bending strength or modulus of rupture or fracture strength. Flexural strength identifies the amount of stress and force an element can withstand So that it can resist failure due to bending. Through proper selection of Fiber ,resin and fiber orientation the performance of composites can be increased.

E-glass fiber which is electrically resistant and low alkali along with epoxy resin make up a high strength composite. Epoxy resins are used on a large scale because of their excellent adhesive, dielectric and mechanical properties which alone gives the properties required for composites. The E-glass fiber reinforced epoxy matrix composite in which fiber is the primary load bearing element are mostly used in military and aerospace applications because of its high specific strength, high stiffness.

Parameters such as type of fiber, orientation of fiber ,type of resin, fiber and resin volume percentage, types of reinforcement for hybrid composite, reinforcement and resin inter phase will influence the mechanical properties of the composite. This has laid the main motivation to carry out this work.

II. LITERATURE SURVEY

H Ku[4] et al. studied the effect of glass powder on flexural properties of Epoxy composites. In this study composite with 25% by weight of the glass powder acquired highest flexural strength but highest flexural strain was achieved in case of composite with 10% by weight of glass powder. Sandeep M B[5] et al, reported the effect of Fiber orientation on flexural strength of E-Glass/Epoxy matrix composites which says that specimen with 4mm thickness and fiber orientation of 0/90° & -45+45° the flexural strength percentage varies by 16.36 and in case of 6mm thickness specimen it varies by 32.G Rathnakar [6] et al. investigated the influence of fiber orientation on flexural strength of glass fiber & graphite fiber reinforced polymer matrix composites,.The composite specimens are made up of hand layup processes which resulted that for same fiber reinforcement 0/45° orientation composite have more flexural strength than 0/90° fiber orientation and for same thickness graphite fiber have more flexural strength than glass fiber. Ramesh Chandra Mohapatra[9] et al, investigated the tensile and flexural properties of wood glass fiber and wood dust filled epoxy hybrid composites which resulted that both the flexural strength ,tensile property & thermal insulation capability has increased due to fusion of wood dust and glass fiber in epoxy matrix.

III. MATERIAL USED:

As Reinforcement will be in both fiber form and particulate form, (in this present work also reinforcement is taken in both fiber and particulate form that is E-glass fiber as well as E-glass powder. Matrix material used is epoxy resin LY556 and hardener LY5200 and E-Glass powder size is 30 microns.

IV. COMPOSITE FABRICATION:

The Composite laminate is prepared by using E-Glass fiber, this fiber is passed through resin bath of Epoxy mixed with corresponding hardener in 10:1 by weight ratio. In this resin bath E-Glass powder is added in different weight percentages. The fiber is wounded on a rotating drum with 12 rpm. After completing the winding process it is cut and opened then laid on a flat table. Then leaving it for almost 48 hours to atmospheric conditions for drying up then it is cut into required dimension and placed one over the other in the required fiber orientation and the desired thickness of the laminate. All the overlapped layers are placed between two flat plates with stainless steel spacers of required thickness. The flat plates are clamped with nuts and bolts with washers and placed in a oven for 8 hours where first four hours at 80° C and next four hours at 120°C so that volatile gases will escape in first four hours and Epoxy-harder chemical reaction takes place in last four hours which gives a perfect composite laminate. The specimens were cut into required dimensions. Total 12 samples were considered for testing and samples with E-glass powder and without E-Glass powder are taken.

According to ASTM D790, The length of specimen includes a span of sixteen times the thickness. For fixing the specimen on UTM for carrying out a Three point bend test a length of 15mm was on both sides was utilized.

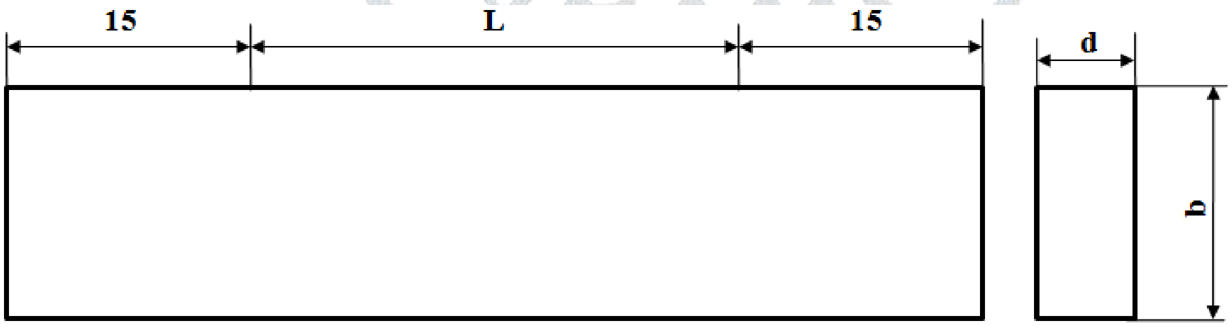


Figure 1: Test Specimen

V. FLEXURAL STRENGTH

Flexural strength is defined as a material's ability to resist deformation under load. The flexural strength represents the highest stress experienced within the material at its moment of rupture. Specimens are subjected to Three point bend test on a Universal Testing Machine according to ASTM D790 to study the flexural behavior of the composites. Three point bending test is more advantageous because of its ease of specimen preparation and testing. The samples are tested to a cross head speed of 2mm/min on a UTM machine. The specimen is deflected until the outermost layer of the composite specimen ruptures or breaks.

For each specimen, the initial dimensions were measured, and then maximum load (F), i.e. the force causing the flexural stress in the specimen, was determined by means of three point bending test. Based upon this value and the geometry of the tested specimen (width and thickness) the flexural strength is found out as follows

Calculation of the flexural strength for rectangular cross-section is as follows:

$$\sigma = 3PL/2bd^2$$

In the above formula the following parameters are used:

- σ = Flexural strength, (MPa)
- P = load at a given point on the load deflection curve, (N)
- L = Support span, (mm)
- b = Width of test beam, (mm)

- d = Depth of tested beam, (mm).

Figure 2: Dimensions & Flexural strength values of composite specimen

S.NO	Fiber orientation	P(Force)	Width (b)	Depth (d)	Flexural Strength (σ)
Units	Degrees	(N)	(MM)	(MM)	MPa
1	$0^0/30^0$	1498.5	11.1	4.0	810
2	$0^0/60^0$	1386.21	11.2	4.1	717.8734
3	$0^0/90^0$	1033.88	12.68	4.65	367.66272
4	$0^0/30^0$/0.5% powder	385.14	11.15	4.7	176.38316
5	$0^0/30^0$/1% powder	169.32	10.34	4.21	93.35054
6	$0^0/30^0$/1.5% powder	142.54	10.9	4.14	75.80906
7	$0^0/60^0$/0.5% powder	1185.67	10.35	4.20	654.61421
8	$0^0/60^0$/1% powder	947.68	11.32	4.3	467.25942
9	$0^0/60^0$/1.5% powder	383.2	10.47	4.22	208.15057
10	$0^0/90^0$/0.5% powder	1054.08	10.56	4.24	565.00857
11	$0^0/90^0$/1.0% powder	1095.90	11.1	4.10	577.93012
12	$0^0/90^0$/1.5% powder	1177.79	10.47	4.16	648.99162

VI. RESULTS& DISCUSSIONS:

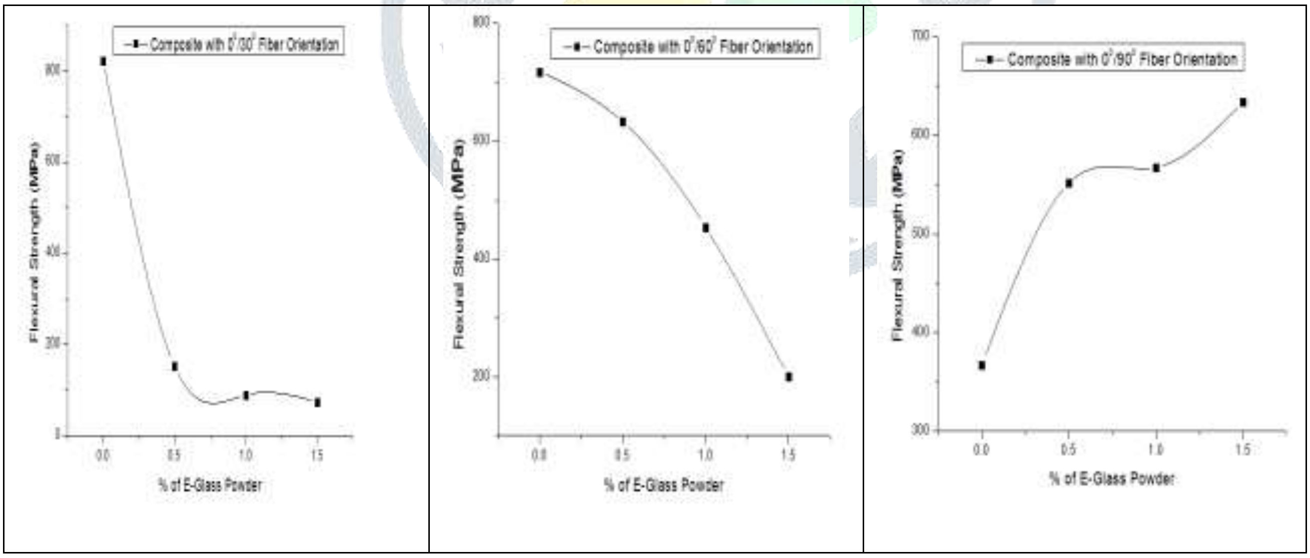
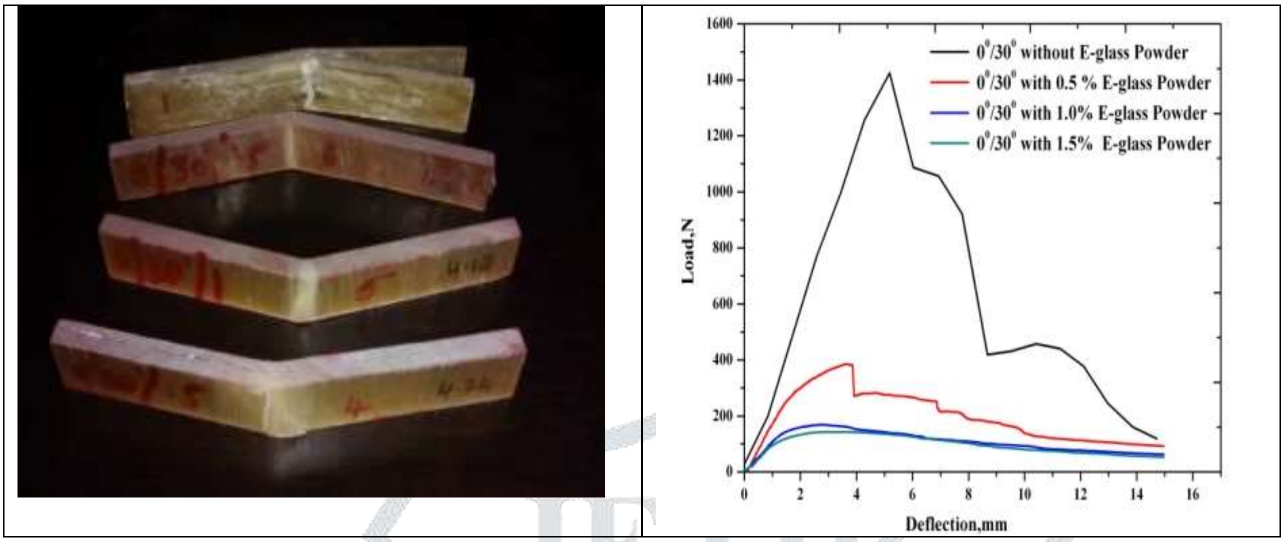


Figure 3:Chart representing wt% of E glass powder and flexural strength

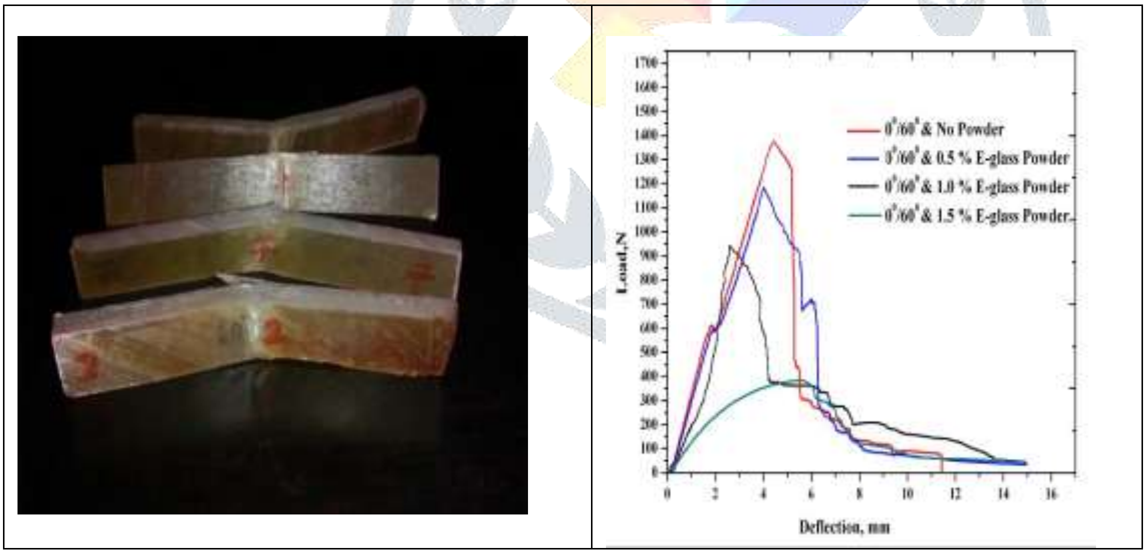
In 0°/30° fiber orientation specimen, the composite without the addition of E-Glass powder has shown maximum flexural strength. This may be due to the fact that with the addition of E-Glass powder the brittleness of epoxy matrix may be increased. As the wt.% of E-Glass powder increases ,the value of flexural strength decreases due to the brittleness and/or agglomeration of powder particles in epoxy resin. In 0°/60° fiber orientation composite, the specimen zero percentage of E-Glass powder has maximum flexural strength. This shows the significant effect of powder. In this composite also, the flexural strength decreases as the wt.% of E-Glass powder increases. In 0°/90° fiber orientation composite,the fiber orientation plays a major role & the marginal influence of E-Glass powder resulted in all the specimens.

Figure 4:Composites with 0°/30° fiber orientation & different wt.% of E-Glass powder



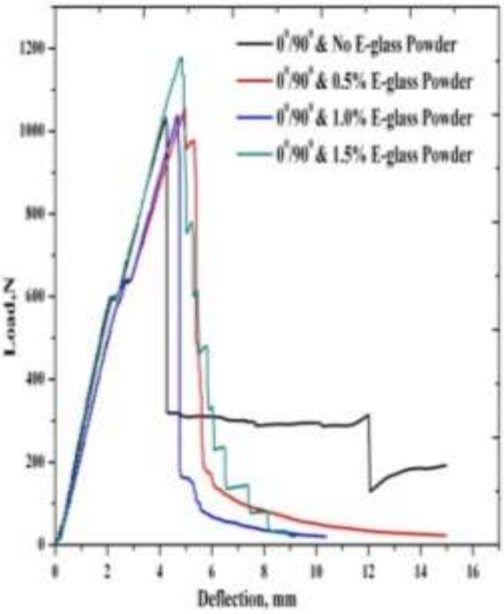
In this load Vs deflection graph for $0^0/30^0$ fiber orientation, it clearly shows that load bearing capacity for composite with zero wt % of E glass powder is more and attained a maximum load of 1498.5 N and then decreased . Composites with increase of wt % of E glass powder resulted in decrease of load withstanding capacity. Composite specimen with 0 wt % E-Glass powder the fracture of outer most layer of composite occurred at 5.8 mm deflection.

Figure 5:Composites with 0°/60° fiber orientation & Different wt.% of E-Glass powder



In this load Vs deflection graph for $0^0/60^0$ fiber orientation, the specimen with zero wt% of E-glass powder has withstand maximum load of 1386.21 N compared with others.Composites with increase of wt % of E glass powder resulted in decrease of load withstanding capacity. Composite specimen with 0 wt % E-Glass powder the fracture of outer most layer of composite occurred at 4.9 mm deflection.

Figure 6:Composites with 0°/90° fiber orientation & different wt.% of E-Glass powder



In this load vs deflection graph for $0^0/90^0$ fiber orientation, composite with 1.5 wt% of E-glass powder is taking the maximum load of 1177.79 N compared with others and deflection rate is almost same for both composite with no E-glass powder and 0.5 wt% of E glass powder.

VII. :

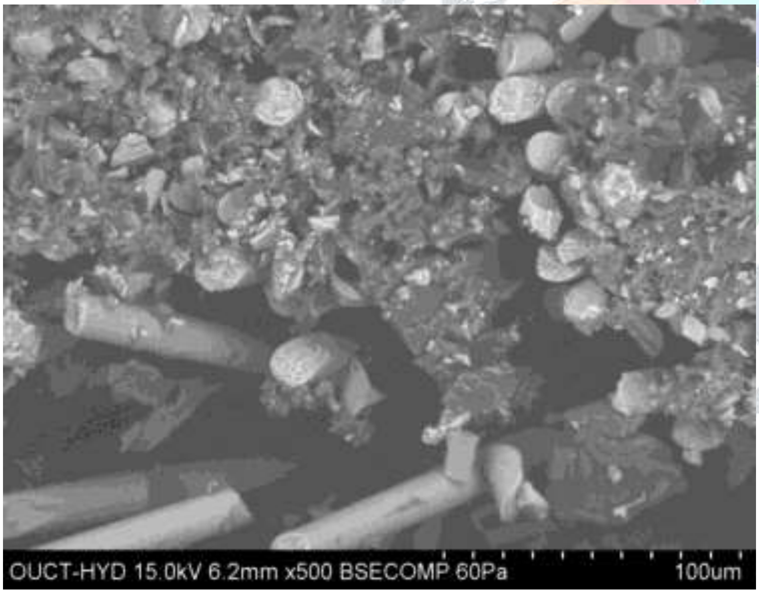


Figure 7: SEM photograph for $0^{\circ}/60^{\circ}$ fiber orientation with 1.5 wt.% of E-Glass powder which has undergone Flexural Test**.**

To understand the gain the mechanical properties of composites, the fracture surfaces were investigated by using Scanning electron microscopy (SEM). The SEM micrographs shown in figure 7 of fracture surface taken at 500x. The sample exhibited poor fiber-matrix bonding as fiber breakage with distinct pullout scene or interface de-bonding was observed..

VIII. CONCLUSIONS

The following conclusions were observed, from the flexural test.

1. In this study 0º/30º fiber orientation composite resulted with maximum flexural strength compared to 0º/60º & 0º/90º without E-Glass powder material. This may be due to the crack propogation takes place perpendicular to direction of fibers.

2. In 0°/30° fiber orientation specimen, there is a sudden drop in potential of the specimen having 0.5 wt% of E-Glass powder with that of 0% of E-Glass powder.

3. In 0°/60° fiber orientation composite, the percentage decrease in flexural strength of specimen of 0.5% of E-Glass powder with that of 0 % of E-Glass powder is 8.9%.

4. In 0°/90° fiber orientation composite, the percentage increase in flexural strength of specimen with 0.5% of E-Glass powder with that of 0% of E-Glass powder is 65%.

5. In overall, the specimens with 0 wt. % of E-Glass powder shown maximum flexural strength as compared to 1 wt.% & 1.5 wt.% E-Glass powder specimens in both 0º/30º & 0º/60º fiber orientation . As the % of E-Glass powder increases the matrix becomes brittle due to non functionalization of E-Glass powder particles the agglomaration of powder particles may take place

6. In 0º/90º fiber orientation specimen as the % wt of E-Glass powder increases the flexural strength increases because the fiber orientation plays a major role than E-Glass powder concentration.

IX. SCOPE FOR FUTURE WORK

1. The flexural strength of 1% & 1.5 wt.% of E-Glass powder shown lesser values as compared to 0.5 wt.% specimens. As already explained this is due to agglomeration of powder particles. This can be overcome by using homogenization dispersion techniques such as ultrasonication or calendaring techniques to disperse powder particle in Epoxy matrix.

2. The above said properties can also be enhanced by using functionalization of E-Glass powder particles.

3. Higher values of flexural strength of the present composites can be obtained by employing 2D fiber weaving or by designing the component in such a way that orientation of fibers in longitudinal direction.

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