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Short Beam Shear Testing Of Glass Fiber Reinforced Composite

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Abstract: Polymer composites have wide-ranging engineering applications where strength to weight ratio, low cost and ease of fabrication are required. The properties of composites provide cannot be realized in monolithic materials. In recent times polymer composites have been established as highly efficient, high performance materials and their use is increasing rapidly. Polymer composites are usually used when combinations of properties of different types of fibers have to be achieved, or when longitudinal as well as lateral mechanical performances are required. In this study, the interlaminar shear strength (ILSS) of glass fiber reinforced epoxy matrix composite was studied. The results show that the shear mechanism is the root cause for the failure of glass fiber reinforced composite.
Index Terms-Polymer Composites, Short Beam, ILSS, Filament Winding.

1. INTRODUCTION

A composite is a structural material that consists of two or more constituents that are combined at a macroscopic level and are not soluble in each other. The constituents are matrix material and reinforcement. High strength reinforcement such as fibers are reinforced in to soft and ductile matrix. The reinforcing phase material may be in the form of flakes, fibers or particles. The matrix phase is generally continuous [1, 2]. In recent years, the glass fiber reinforced polymer composites are now finding suitable materials for various application in automobile, building, electrical, and packaging sectors because of their several practical advantages like ease of processing, fast production cycling, and low processing cost over traditional materials [3]. One of the major sciatic challenges for the composite engineers is the development of higher strength to weight materials supporting latest technologies and design concepts for the complex shaped structures like aircraft, automotive structures, and large wind turbine blade structures [4]. Composites materials consisting of two or more constituents at the nanometer size or molecular level. Commonly one of these compounds is inorganic and the other one organic in nature. Thus, they differ from traditional composites where the constituents are at the macroscopic (micrometer to millimeter level). Mixing at the microscopic scale leads to a more homogeneous material that either shows characteristics in between the two original phases or even new properties.

The inter-laminar shear strength (ILSS) is one of the most critical parameters in determining the ability of a fiber reinforced polymer composite to resist failure by delamination. Many experimental procedures are available to calculate the exact value of ILSS. Standardized test methods are the three-point-bending tests according to ASTM D2344 for Inter-laminar Shear Strength of parallel fiber composites by Short-Beam-Shear (SBS). During bending in SBS, the load increases proportionally with displacement, until a maximum/peak load is reached. If the load drop by 30% or more immediately after the peak load is reached, it is assumed that the specimen failed in lamina shear and the peak load is then used to determine the ILSS. The prime advantage of the SBS is its simplicity. The test specimens are relatively easy to prepare and the test itself is simple to conduct and requires little tooling. However, the SBS gives an accurate measure of ILSS value only if pure interlaminar shear failure takes place [5, 6]. In this study glass fiber reinforced composite is manufactured by filament winding process with a curing in a hydraulic press. This paper aimed to study the ILSS of glass fiber reinforced epoxy matrix composite.

2. EXPERIMENTAL

2.1. Materials

In this present study glass fiber reinforced epoxy matrix composite is fabricated and tested according to ASTM standard D2344. The present composite has unidirectional layers of glass fibers. The laminas in a composite laminate can be laid up in longitudinal orientation to get the maximum value of ILSS. In longitudinal orientation the fibers aligned in the length axis. The constituents used in the manufacturing of composite are listed in the Table 1.

Table 1: Materials Used in the preparation of composite

Constituent	**Specification**
Glass Fiber	E-Glass 12000Tex
Epoxy	LY 556
Hardener	5200

2.2. Specimen Preparation

E-glass Fibers in the form of spools were used as fiber reinforcement. Epoxy resin with specifications mentioned in Table 1 was used as the matrix material. The composite lamina was prepared using the filament winding technique. The lamina was initially subjected to an environment drying for tackiness at ambient temperature for a period of 24 hours. Thickness of glass fiber reinforced lamina was approximately 3 mm and these lamina are cut in to pieces of 380 X 340 mm which is the tool size, to prepare a laminate of thickness 3 mm, depending on laminate number of plies are stacked to attain desired thickness. The mould is then placed in a hydraulic press under a pressure of 15 bar for the to drain the excess resin along with exposure to a second environment with a two-step increase in temperature with 80^{o}C for 60 minutes and 120^{o}C for next 360 minutes. The time of polymerization for all the samples was 360 min, at 120^{o}C. After samples were formed, test specimens were cutout, which were tested. ILSS specimen dimensions are shown in the Table 2 and the length of specimen includes a span of six times the thickness.

Table 2: Specimen dimension according to ASTM standrad D2344

Specimen	**Dimensions (W x T x L) in mm**
Glass Fiber composite	10 x 3.0 x 72

2.3. Testing configuration

The short beam shear test subjects a beam to pure bending, the beam is very short relative to its thickness. For example, ASTM standard D 2344 specifies a support-span-length-to-specimen-thickness ratio of only 6:1. The objective is to minimize the flexural (tensile and compressive) stresses and to maximize the induced shear stress. The specimen testing configuration are shown in the Fig. 1.

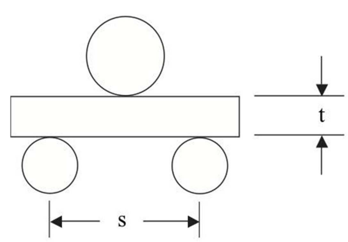

Fig. 1: ASTM D 2344 Short Beam Specimen Configuration.

3. RESULTS AND DISCUSSION

The ILSS values were evaluated from the SBS test according to the following relation:

$$ILSS = \frac{0.75P_b}{bd}$$

Where P_b = breaking load,
b = width and
d = thickness of the specimen.

The average ILSS value of hybrid composite is obtained as 10.43 MPa. This is due to the longitudinal orientation of fibers and all the results of ILSS values of different specimens are listed in Table 3.

Table 3: ILSS values of various glass fiber reinforced composite specimens

Specimen	Width(mm)	Thickness(mm)	Length(mm)	Maximum Load(N)	ILSS(MPa)
ILSS1	10.35	3.08	70.34	406.97	10.17
ILSS2	10.11	3.01	72.32	414.82	10.35
ILSS3	10.31	3.06	70.92	412.25	10.30
ILSS4	10.23	3.04	73.37	420.25	10.25
ILSS5	10.25	3.04	75.52	442.80	11.07

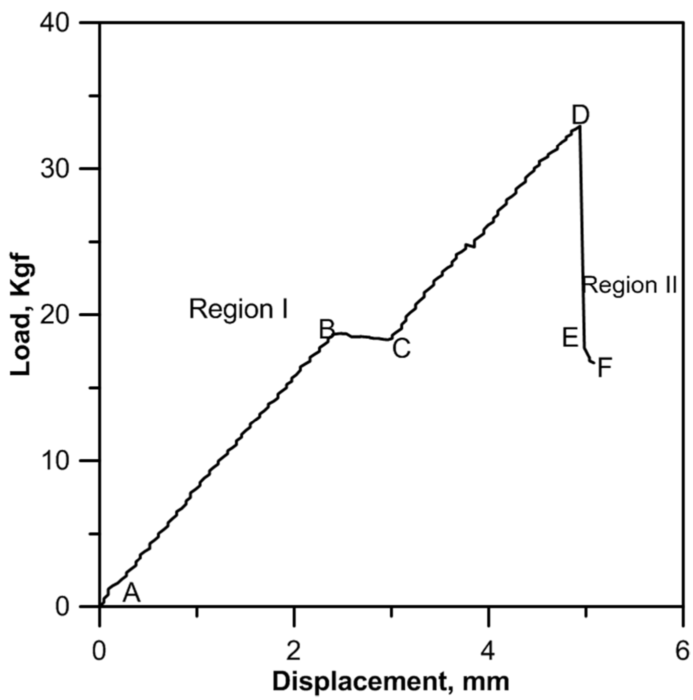

Figure 2: Load Vs Displacement curve of SBS specimen

The ILSS value of glass fiber reinforced epoxy matrix composite is evaluated. The average ILSS value in glass fiber composite was obtained as 10.43 MPa (Table 3). Minimum five specimens were tested as per the ASTM D2344.

As shown in the figure 2, the load increases with displacement (AB). Then, the displacement increases at constant load. Major fiber bundle fracture takes place at point D. Then, the load decreases at constant displacement (DE) and then the load increases slightly due to stress induced in the surrounding fibers (EF).

4. FRACTOGRAPHY

The fractographs (Figure 3) clearly shows fracture of matrix and fiber surface. The fractured morphologies indicate that the Inter laminar failure mainly resulted from the delamination of layers. The fracture of the matrix and debonding of fibre/matrix interface are the main fracture mechanisms in these glass fibre reinforced epoxy matrix composites. The SEM fractograph clearly shows good bonding between epoxy matrix and glass fibers.

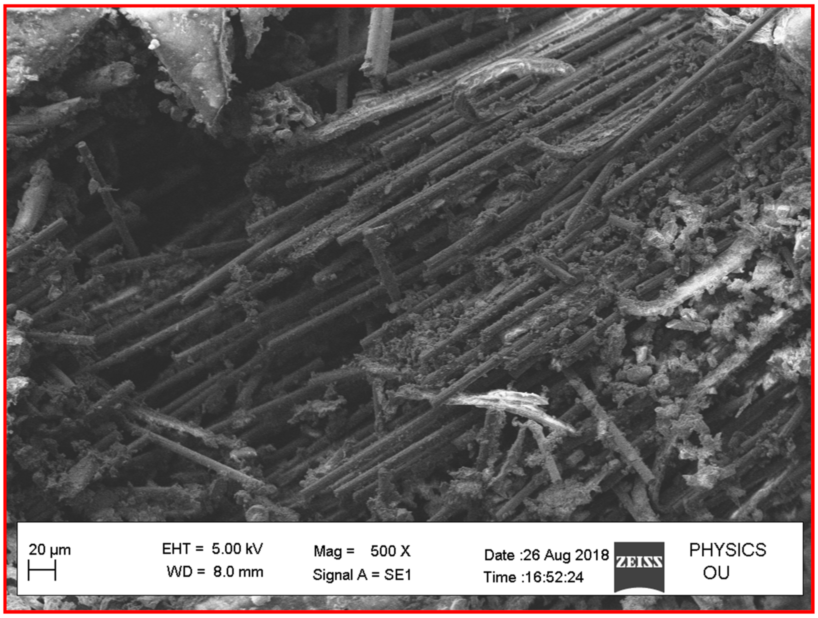

Figure 3: Fractograph of glass fiber reinforced epoxy matrix composite

5. CONCLUSIONS

The composite was successfully fabricated by using filament winding technique. The inter laminar shear strength of the composite was calculated by using short beam shear test (SBS). The higher value of ILSS in this composite is due to the fact that crack propagation is perpendicular to the orientation of fibers. The failure of the composites is due to the shear mechanism. The SEM fractograph clearly reveals that good bonding between the constituents.

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