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FABRICATE POLYMER COMPOSITES BY DISPERSING ASSURED MATERIALS IN POLYESTER RESIN; CREATE SPECIMENS USING THE RESIN CASTING METHOD

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ABSTRACT:

The aim is to fabricate polymer composites by dispersing assured materials in polyester resin, create specimens using the resin casting method, test them and estimate the fracture toughness and analyse it using finite element analysis. The constituents of a composite are generally arranged so that one or more discontinuous phases are embedded in a continuous phase. The discontinuous phase is reinforcement and continuous phase is the matrix. In general the reinforcements are much stronger than the matrix. Both constituents are required and each must accomplish specific tasks if the composite is to perform as intended. Increasing the volume content of reinforcements can increase the strength and stiffness of a composite.

Keywords: Fabricate polymer composites, polyester resin

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1. INTRODUCTION

1.1 CHARACTERISTICS OF COMPOSITE MATERIALS

Modern living demands materials with excellent properties and the specific requirements are increasing day by day from the modern society[1-3]. Many a times these demands are not satisfied by conventional processing on materials. Hence we need to go for different combinations of materials to get the desired properties and this is termed as composite material.

The type of reinforcement and matrix, the geometric arrangement and volume fraction of each constituent, the anticipated mechanical loads, the operating environment for the composite etc., must all be taken into account[5].

An investigational study of mode-I interlaminar test using the two times cantilever beam. The test procedures and data-analysis methods are presented and critically evaluated. Techniques used to study delamination mechanisms are then described[6].

Fracture mechanics and experimental mechanics approaches used to distinguish mode-Π interlaminar fracture of composites. sample design procedures to maintain linear elastic response and to minimize geometric non-linear ties and friction between crack surfaces are presented[7].

It is observed that such kind of composite presents an elasto– viscoplastic behavior – the rate dependency only occurs for loading levels above a given elasticity limit[8-9]. Strain rate strongly affect the ultimate tensile strength (бu) in addition to the modulus of elasticity is roughly unfeeling to it as temperature only influence the modulus.

It was also found experimentally, that strong interface friction existed for various off-axis angles of AS4/3501-6, especially for small angles. This results in bending waves in the bars and non-uniform stresses and strains in the specimen, which violate the assumptions of the SHPB analysis[10-12]. Improving the interface conditions by lapping and lubricating the composite contacting surfaces was investigated as a means to achieve a nearly frictionless interface condition.

1.1.1. Fiber Reinforced PolymerS (FRP)

Fiber-reinforced polymers (FRP) also (fiber-reinforced plastics) are a composite material made of a polymer matrix reinforced with fibers. The fibers are usually fiberglass, carbon or aramid, while the polymer is usually an epoxy, vinyl ester or polyester thermosetting plastic[13]. FRPs are usually used in the aerospace, automotive, naval and building industries.

1.1.2. Constituent Material of FRP

The major constituents of a fiber reinforced composite materials are reinforcing fiber, matrix, coupling agents, coatings and fillers. Fibers are the principal load carrying members while the matrix medium by which the load is transferred through the fibers by means of shear stress. Matrix protests the fiber from environmental damages caused by elevated temperature and humidity, Coupling agents and coatings applied to the fibers to improve their wetting with the matrix and also facilitate bonding across the fiber- matrix interface.

1.1.3. Fibers

The reinforcement is typically a great deal stronger and stiff than the matrix, and gives the composite its high-quality properties. The matrix holds the reinforcements in an arranged prototype. since the reinforcement are usually discontinuous, the matrix also helps to transport load among the reinforcements.

1.2. GLASS FIBERS

Glass fibers are silica based glass compounds that contain several metal oxides which can be tailored to create different types of glass. The main oxide is silica in the form of silica sand, the other oxides such as Ca, Na and Al are incorporated to reduce melting temperature and impede crystallization. The most important grades of glass are:

1.2.1. E-glass:

E glass has low alkali content of the order of 2%. It is used for general purpose structural applications and it is used in construction industry, it has good heat and electrical resistance.

1.2.2. S-glass:

It is a stronger and stiffer fiber with a greater corrosion resistance than the E-glass fiber.It has good heat resistance capacity.

1.2.3. C-glass:

C glass has good corrosion resistance to acid and bases and has chemical stability in chemically corrosive environments**.**

1.2.4 R-glass:

R glass has a higher tensile strength and tensile modulus and greater resistance to fatigue, aging and temperature corrosion to that of E glass.

Table 1 Typical properties of Glass fibers

Typical properties	E-glass	S-Glass
Density(g/cm^3)	2.60	2.50
Young's Modulus (GPa)	72	87
Tensile Strength (GPa)	1.72	2.53
Tensile Elongation (%)	2.4	2.9

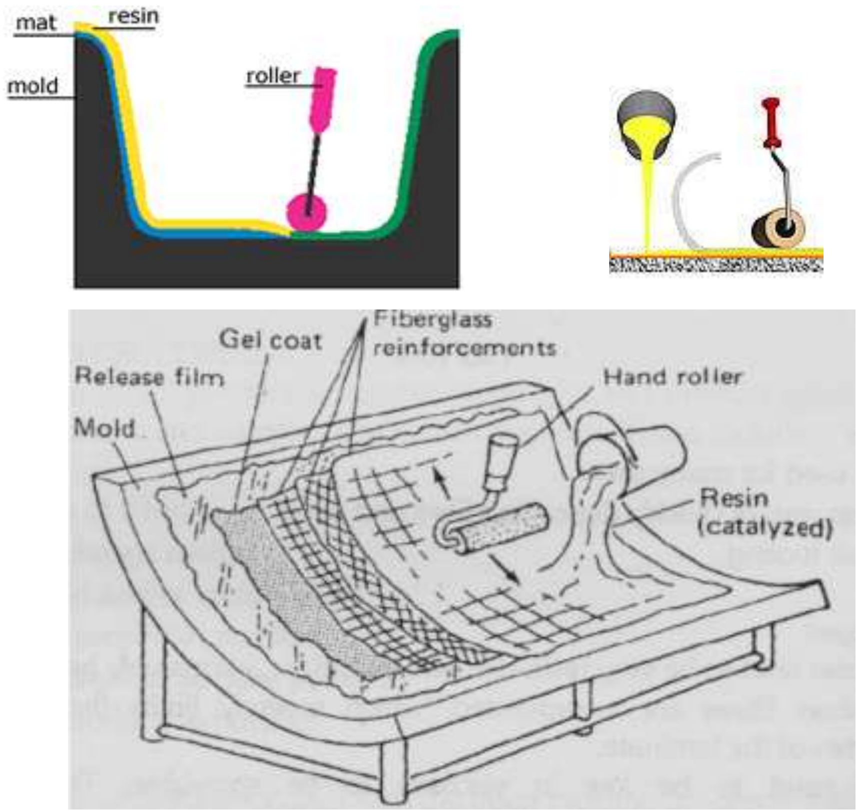

Figure 1 Hand lay-up Method

Resins have to then live catalyzed and added to the fibers. A skirmish, roller or squeegee can be used to saturate the fibers with the resin. The lay-up technician is accountable for controlling the amount of resin and the quality of saturation.

1.3. Carbon Fiber

Carbon fiber be a fabric consisting of very thin fibers about 0.005-0.010 mm in width consists of carbon particle. The carbon atoms are bond jointly in tiny crystals that are more or less allied similar to the long axis of the fiber. The gemstone position makes the fiber very strong for its size. Several carbon fibres are twisted together to form a yarn, which may be used by itself or woven into a fabric.

Figure 2 Carbon Fiber

1.4. Glass Fiber

The composites used today in the industry are made of glass fibers. In fiber glass products the resin or 'matrix' transfers the shear and the glass fibers resist the tensile and compressive loads. Fiber glass composite materials exhibit significant reduction in the weight than the composites made of steel or timber.

Figure 3 Glass Fiber

1.5. Resin and Hardener

Epoxy resin is used to give great obligatory possessions between the fibre layer to form the matrix. The Epoxy resin second-hand at space temperature be LY 556. Hardener (HY 951) is employed to improve the interfacial bond and pass on strength to the composite[14].

Figure 4 Resin-Hardener

1.6. Calculation for Weight Ratio of polymer and fiber

Table 2 Weight Ratio of polymer and fiber

Sl.No	Fiber	Thickness of fiber(mm)	Weight of Fiber (Wf) (gram)	Weight of polymer (Wp) (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) Volume of composite = 25x20x0.3 = 150 cc

(2) Weight of Polymer = 149.9 x 2 = 300g

(3) Weight of hardener = 300 / 10 = 30.0 g

2. COMPOSITE MATERIAL SAMPLE

The composite sample of size 250mm x 200 mm x 4.5 mm was prepared and shown in the figure 5.4 after 24 hours of curing this laminated will be used to testing of mechanical property of sample.

Figure 5 composite sample

2.1. Tensile Test

The composite was cut using a saw cutter to get the dimension of the specimen for mechanical testing. The tensile specimen was prepared according to ASTM D638 the detail dimensions, gauge length and cross-head speeds can be found using ASTM D638 which is shown in figure 6.1 and 6.2

Figure 6 Tensile Samples of glass and Carbon Fiber Before testing

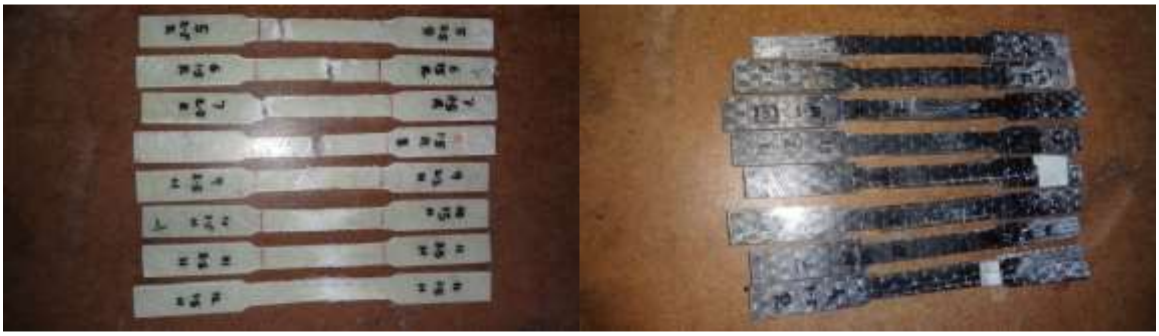

Figure 7 Tensile Samples of glass and Carbon Fiber After testing

The tensile test was performed on the same universal testing machine and 50mm gauge length of the composite specimen and the shoulder is fitted in the jig as shown in figure 6.3.

Figure 8 Tensile testing of specimen

2.2. Flexural Test

The hybrid composite materials are now cut by using a saw cutter to get the dimensions as per the ASTM D790 standards shown in figure-6.4 and 6.5. The flexural test specimen was prepared according to ASTM D790 the detail dimensions, gauge length and cross-head speeds can be found using ASTM D790.

Figure 9 Flexural specimen for glass and carbon fiber after testing

The testing process involves placing the test specimen in the universal testing and applying force to it until it fractures and breaks. The Flexural test were performed on the same universal testing machine, using the 3 point bending fixture according to the ASTM D790 with the cross head speed of 2mm/min

Figure 10 Flexural test for glass and carbon fiber

The strain rate may be studied and analyzed for its effect on fracture. The effect of the impact test can be used to determine the ductility of a material. If the material breaks on a flat plane the fracture was brittle and if the material breaks with jagged edges or shear lips then the fracture was ductile.

2.3. Test Results

Table 2 Test results

Sample	Thickness (mm)	Strain rate (mm/min)	Tensile Strength (N/mm^2)		Flexural Load	
			At 35°C	At 70°C	Load (KN)	Displace Ment (mm)
Glass	4.5	2.5	103.775	11.759	0.475	6.300
Glass	3.5	1.5	109.100	14.423	0.540	5.700
Glass	4.5	2.5	114.149	11.111	0.300	8.300
Glass	3.5	1.5	109.100	14.423	0.285	7.900
Carbon	4.5	2.5	625.958	643.483	1.785	6.100
Carbon	3.5	1.5	913.861	797.154	1.520	6.300
Carbon	4.5	2.5	761.637	418.401	1.135	5.500
Carbon	3.5	1.5	901.515	587.850	1.085	6.700

3. TENSILE TEST RESULT:

3.1. Carbon Fiber Samples for 35°C

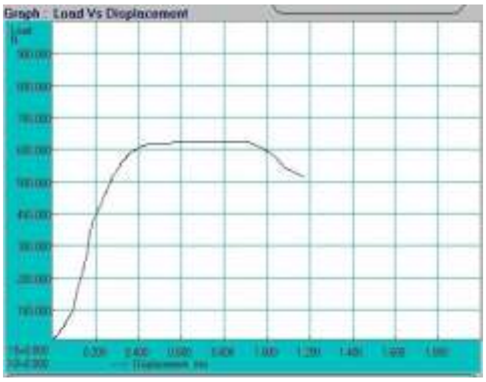

Figure 11 Sample-1 Strain Rating 2.5mm/min

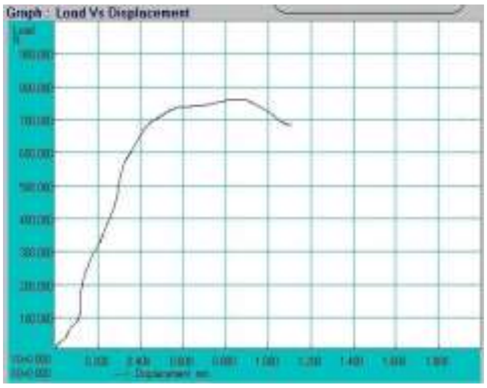

Figure 12 Sample-2 Strain Rating 1.5mm/min

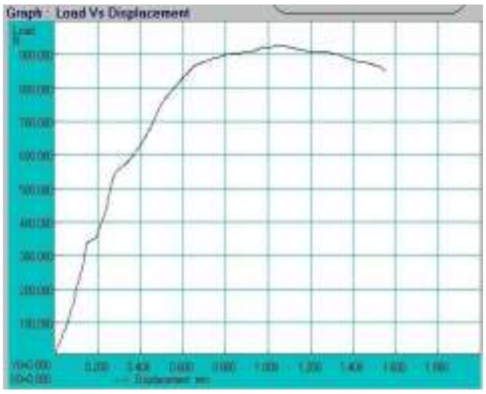

Figure 13 Sample-3 Strain Rating 2.5mm/min

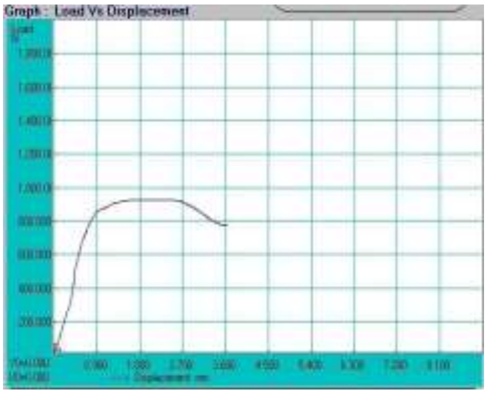

Figure 14 Sample-4 Strain Rating 1.5mm/min

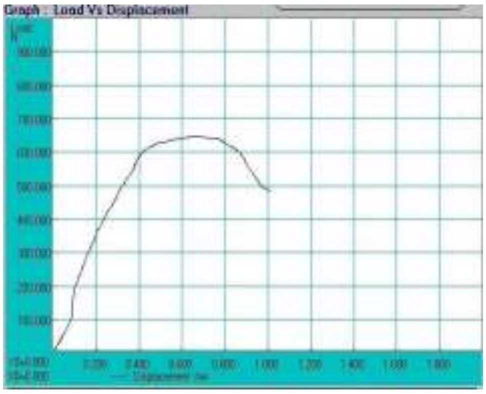

Figure 15 Sample-1 Strain Rating 2.5mm/min

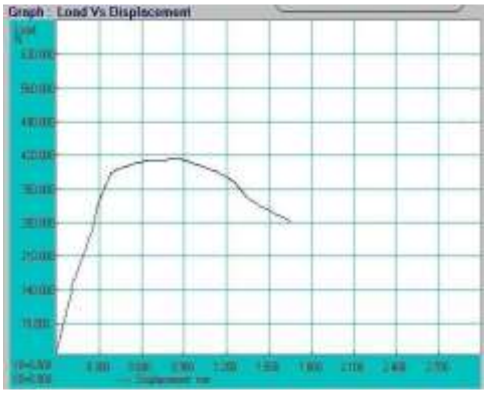

Figure 16 Sample-2 Strain Rating 1.5mm/min

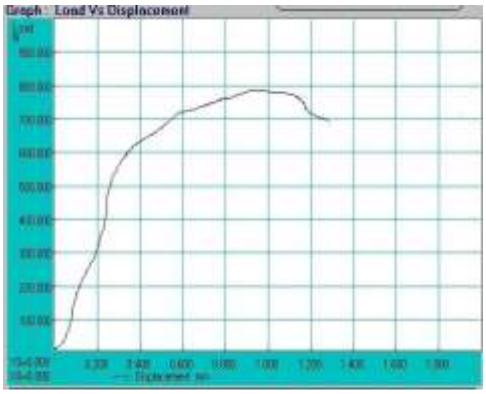

Figure 6 13-Sample-3 Strain Rating 2.5mm/min

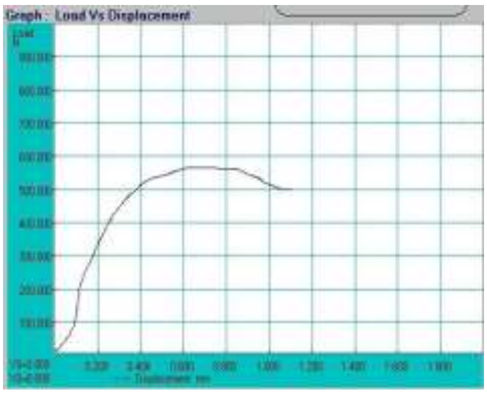

Figure 6 14-Sample-4 Strain Rating 1.5mm/min

3.2. Glass Fiber Samples for 35°C

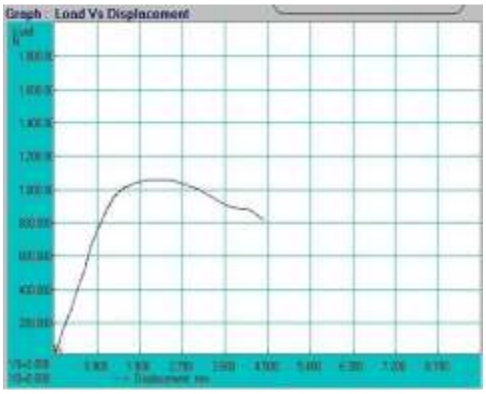

Figure 17 Sample-1 Strain Rating 2.5mm/min

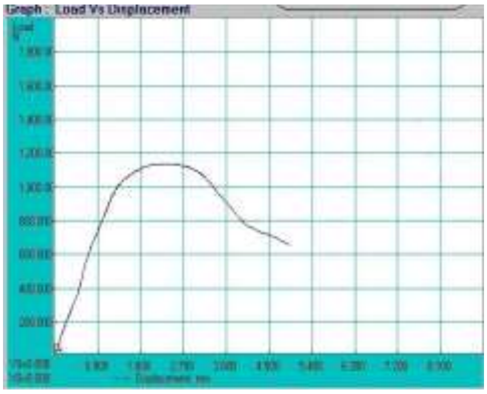

Figure 18 Sample-2 Strain Rating 1.5mm/min

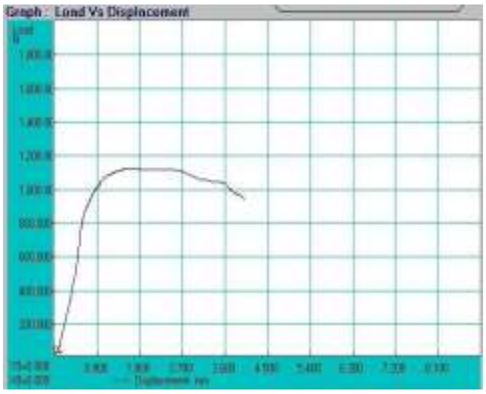

Figure 19 Sample-3 Strain Rating 2.5mm/min

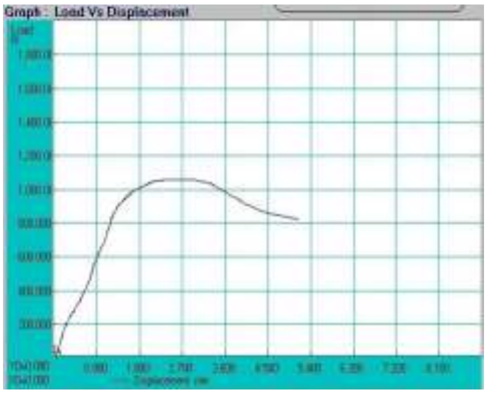

Figure 20 Sample-4 Strain Rating 1.5mm/min

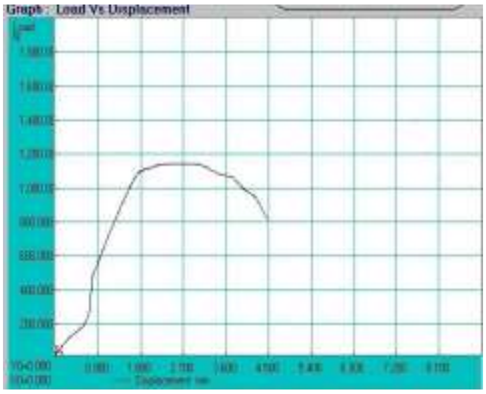

Figure 21 Sample-1 Strain Rating 2.5mm/min

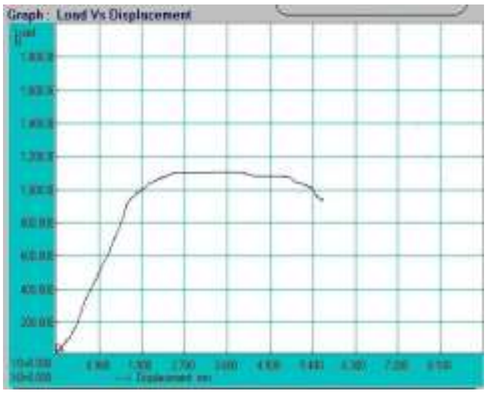

Figure 22 Sample-2 Strain Rating 1.5 mm/min

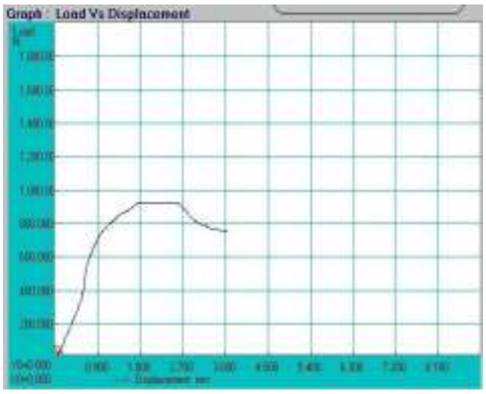

Figure 23 Sample-3 Strain Rating 2.5 mm/min

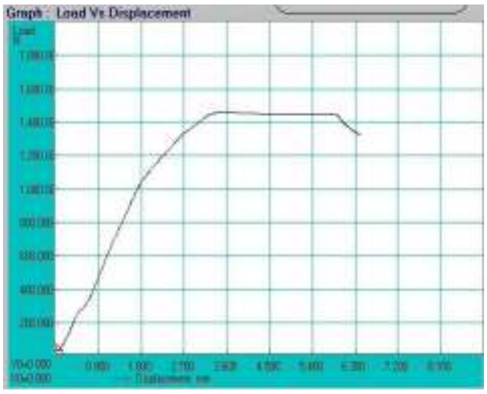

Figure 24 Sample-4 Strain Rating 1.5 mm/min

Morphological analysis was done using Scanning Electron Microscope. The surface characteristics of the composite material were studied through SEM after conducting tests. The samples taken from each test were dried and coated with 15–20 nm thick layer of gold with an Ion - Sputter coater device[15]. Subsequently the specimens were inspected by a scanning electron microscope. The interfacial adhesion between matrix and the fibre is clearly seen from scanning electron micrographs.

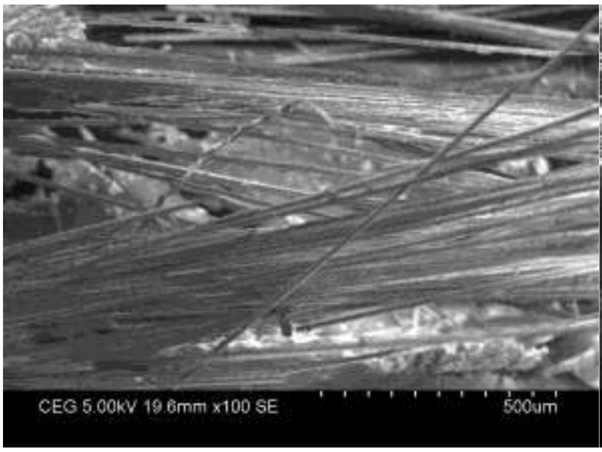

Figure 25 SEM image of GFRP

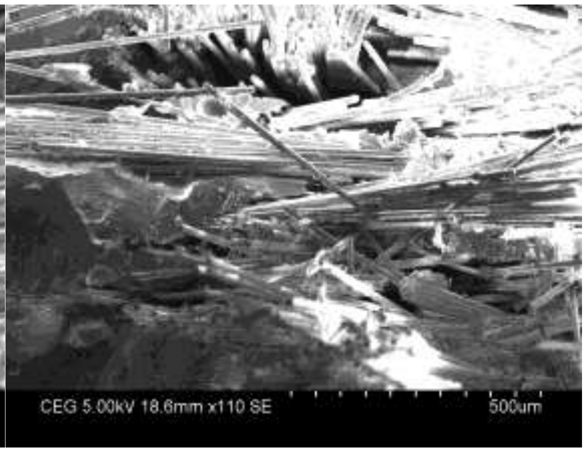

Figure 26 composite after tensile test

4. CONCLUSION:

In this work, fibre composites are fabricated with fibres like CFRP and GFRP. Their mechanical properties like tensile strength (at varying strain rates and temperatures), flexural strength (at varying strain rates) and impact strength are investigated and from the results obtained, the following conclusions were drawn.

- The tensile strength of CFRP composite is the relatively more than GFRP composite and it has a value of 36.262 KN.
- The percentage elongation of CFRP in tensile testing is found to be less than that of the GFRP composite. Therefore, the GFRP composite withstands more strain before failure in tensile testing than the CFRP composite.
- The flexural strength of CFRP composite is the relatively more than GFRP composite and it has an ultimate load value of 1.785KN.

From the above experimental data, it can be concluded that the Carbon Fibre Reinforced composites is stronger than the Glass Fibre Reinforced composites. Hence, it can be extensively used for automotive and marine applications.

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