Properties Evaluation of Chopped, Bi-Directional and Uni-Directional Glass Fibre Reinforced Epoxy based Composites

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Abstract

Composites materials are used in almost all aspects of the industrial and commercial fields in aircraft, ships, common vehicles, etc. Their most attractive properties are the high strength-to-weight ratio. Polymer composites are used because overall properties of the composites are superior to those of the individual polymers. Glass Fiber composites are considered to have potential use as a reinforcing material in epoxy polymer based composites because of their good strength, stiffness etc., The aim of the present work is to investigate the mechanical properties of Glass Fibre Reinforced Epoxy Based Composites. Here, Glass fiber is the fiber reinforcement and epoxy polymer resin as a matrix material. Composites were prepared with longitudinal (Unidirectional) cross (Bidirectional) and chopped glass fiber reinforced with epoxy based polymer. Mechanical test i.e. tensile test was performed on UTM and flexural test was done on flexural testing machine and the results are reported in the conclusion.
Keywords: Glass Fibre, Unidirectional, Bidirectional, chopped

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I. Introduction

As humans has great effort for million years together to use readily available resources like clay, mud, stone, and wood for survival. Later on during early 1960's man discovered the secrets of nature and learned to exploit. There has been an increasing demand for materials that are stiffer and stronger yet lighter in fields as diverse as aerospace, energy and civil constructions by using synthetic materials. There by gradual decline of the direct application of natural resources has come in to existence. The demands made on materials for better overall performance are so great and diverse that no one material can satisfy them. This naturally led to a resurgence of the ancient concept of combining different materials in an integral-composite material to satisfy the user requirement.

As natural composites had wide applications in day to day life of humans, they are synthesized from different kinds of fibers, such as: glass, aramid, graphite, carbon, boron, etc., and matrix materials such as polyester and epoxy resins. They have excellent properties but they are not biodegradable. Disposal of these material pose adverse effect on the environment releasing hazardous gases soil impermeability. Thus scientists and engineers for reviving the use of natural materials and development of composites called green composites that can be disposed easily without posing problems to the environment.

In present study, mechanical properties for glass fiber composites were evaluated. Here, Glass fiber is the fiber reinforcement and epoxy polymer resin as a matrix material. Composites were prepared with longitudinal (Unidirectional) cross (Bidirectional) and chopped glass fiber reinforced with epoxy based polymer. Mechanical test i.e. tensile test was performed on UTM and flexural test was done on flexural testing machine the results are reported.

II. Preparation of Lamina

Hand lay-up technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple. First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to the surface. Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product. Reinforcement in the form of woven mats or chopped strand mats are cut as per the mold size and placed at the surface of mold after perspex sheet. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardner (curing agent) and poured onto the surface of mat already placed in the mold. The polymer is uniformly spread with the help of brush. Second layer of mat is then placed on the polymer surface and a roller is moved with a mild pressure on the mat-polymer layer to remove any air trapped as well as the excess polymer present. The process is repeated for each layer of polymer and mat, till the required layers are stacked. After placing the plastic sheet, release gel is sprayed on the inner surface of the top mold plate which is then kept on the stacked layers and the pressure is applied. After curing either at room temperature or at some specific temperature, mold is opened and the developed composite part is taken out and further processed.

The fiber piles were cut to size from the Kenaf and thespesia lampas. The appropriate numbers of fiber plies were taken: two for each. Then the fibers were weighed and accordingly the resin and hardeners were weighed. Isopathlic and hardener were mixed by using glass rod in a bowl. Care was taken to avoid formation of bubbles. Because the air bubbles were trapped in matrix may result failure in the material. The subsequent fabrication process consisted of first putting a releasing film on the mould surface. Next a polymer coating was applied on the sheets. Then fiber ply of one kind was put and proper rolling was done. Then resin was again applied, next to it fiber ply of another kind was put and rolled. Rolling was done using cylindrical mild steel rod. This procedure was repeated until eight alternating fibers have been laid. On the top of the last ply a polymer coating is done which serves to ensure a god surface finish. Finally a releasing sheet was put on the top; a light rolling was carried out. Then a 20 kgf weight was applied on the composite. It was left for 24 hrs to allow sufficient time for curing and subsequent hardening.

Fig. 1: Cutting of glass fiber and hand lay technique set up

Fig. 2: Uni-directional and Bi-directional Glass fiber composite

III. Preparation of Specimens

Specimens for the Tensile Test, Flexural Test, and Water Absorption Tests are cut on a band saw machine as per ASTM standards. The dimensional details of each type of specimen were presented in respective figures.

A. *Tensile Test Specimen:*

Specimens are cut from laminas on a jig saw machine as per ASTM D 638 Standards. The standard Type IV dumbbell shaped specimens are used in the testing. The dimensions of the tensile test specimen are shown in the Fig.4.10 and the actual specimens are shown in Fig.4.11

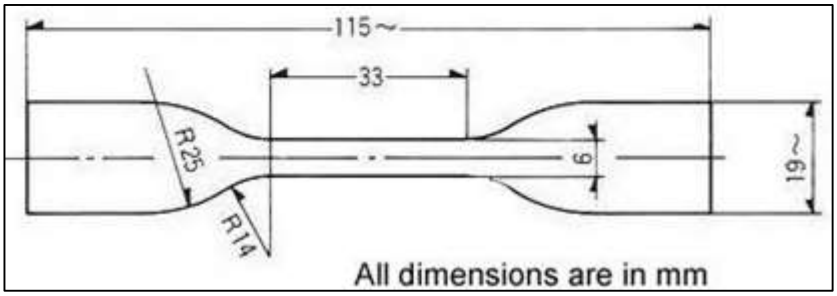

Fig. 3: ASTM – D638 Type IV Tensile Test Specimen Details.

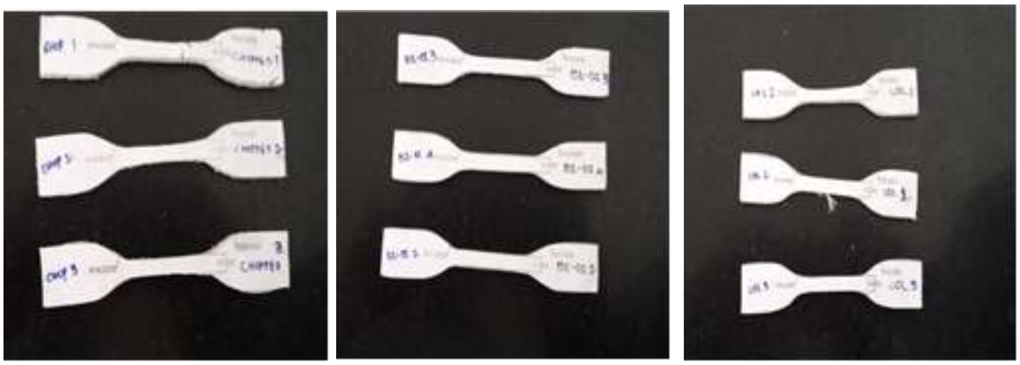

Fig. 4: Tensile Test Specimens. Chopped, Bi-directional and uni-directional

B. Flexural Test Specimen:

Specimens for flexural test are cut from laminas as per ASTM D790 standards. The standard dimensions for test specimen are shown in the Figure 4012 and the actual specimens are shown in Figure

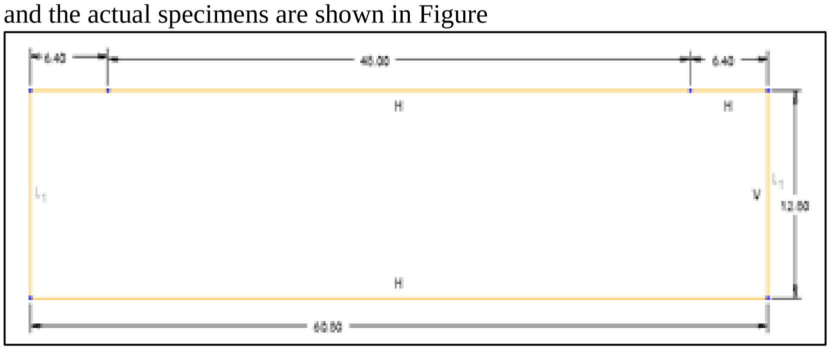

Fig. 5: ASTM – D790 Flexural Test Specimen Details.

Fig. 6: Flexural Test Specimens

IV. MECHANICAL PROPERTIES EVALUATION

A. Tensile Testing:

Table – 1
Tensile properties of different orientation of Glass fiber composites

Fiber	*Ultimate tensile strength (MPa)*	*Specific tensile strength (MPa/ g/cm³)*	*% of Elongation*
Uni-directional	*74.27*	*61.89*	*1.2*
Chopped	*90.32*	*75.266*	*12.2*
Bi-directional	*246*	*205*	*4.9*

Experimental results of epoxy Glass fiber composites are prepared with different fiber orientation. It is obvious strength increases when uni-directional glass fiber is impregnated with epoxy matrix. Mechanical properties (i.e. tensile) increased when epoxy matrix impregnated with bi-directional glass fiber of each as mentioned above. Tensile property is increased when the orientation of the glass fiber is bi-directional compared to uni-directional and chopped glass fiber.

B. Flexural Testing:

Table – 2
Flexure Test observations for uni-directional fiber Glass composite

Deflection (mm)	*Load(N)*		
	Specimen 1	*Specimen 2*	*Specimen 3*
0.5	*43*	*40*	*35*
1.0	*90*	*100*	*75*
1.5	*140*	*135*	*125*
2.0	*190*	*283*	*170*
2.5	*235*	*325*	*210*
3.0	*273*	*360*	*255*
3.5	*315*	*-*	*295*
4	*-*	*-*	*330*

Table – 3
Mean values of flexure test observations for Glass fiber 4mm composite.

Deflection (mm)	*Mean Load (1 Div=3.75N)*	*Flexural stress (N/mm²)*
0.5	*39.3*	*92.106*
1	*88*	*206.25*
1.5	*133*	*311.71*
2	*214.1*	*501.79*
2.5	*256.65*	*601.51*
3	*296*	*693.75*
3.5	*305*	*714.81*
4	*330*	*773.45*

Table – 4
Flexure Test observations for chopped Glass fiber composite

Deflection (mm)	*Load(N)*		
	Specimen 1	*Specimen 2*	*Specimen 3*
0.5	*25*	*25*	*20*
1.0	*50*	*60*	*43*
1.5	*90*	*85*	*64*
2.0	*105*	*120*	*85*
2.5	*133*	*152*	*107*
3.0	*155*	*180*	*125*
3.5	*175*	*200*	*143*
4	*190*	*-*	*154*
4.5	*200*	*-*	*160*

Table – 5
Mean values of flexure test observations for chopped Glass fiber composite.

Deflection (mm)	*Mean Load (1 Div=3.75N)*	*Flexural stress (N/mm²)*
0.5	*23.3*	*54.68*
1	*51*	*119.53*
1.5	*79.5*	*186.32*
2	*103.3*	*242.10*
2.5	*130.5*	*305.85*
3	*172.5*	*404.29*
3.5	*172*	*408.75*
4	*180*	*421.87*

Table – 6
Flexure Test observations for bi-directional Glass fiber composite

Deflection (mm)	*Load(N)*		
	Specimen 1	*Specimen 2*	*Specimen 3*
0.5	*19*	*18*	*25*
1.0	*41*	*47*	*51*
1.5	*74*	*74*	*79*
2.0	*107*	*100*	*120*
2.5	*138*	*120*	*135*
3.0	*175*	*139*	*148*
3.5	-	*152*	*153*
4	-	*168*	*169*
4.5	-	*174*	*164*
5	_	*181*	_

Table – 7
Mean values of flexure test observations for bi-directional Glass fiber composite.

Deflection (mm)	*Mean Load (1 Div=3.75N)*	*Flexural stress (N/mm^2)*
0.5	*20.65*	*48.39*
1	*46.3*	*108.51*
1.5	*75.5*	*176.95*
2	*109*	*255.43*
2.5	*131*	*307*
3	*154*	*360.93*
3.5	*152*	*356.25*
4	*163*	*383.2*
4.5	*169*	*396.09*

Table – 8
Flexural strength, Specific flexural strength, Flexural Modulus and specific Flexural Modulus for different composites

Fiber	*type*	*Flexural Strength (MPa)*	*Specific Flexural strength (MPa/ g/cm³)*	*Flexural Modulus (MPa)*	*Specific Flexural Modulus (MPa/ g/cm³)*
Glass	*Uni-directional*	*773.45*	*644.54*	*13040*	*10866.66*
	Chopped	*421.87*	*351.55*	*7170*	*5975.41*
	Bi-directional	*396.09*	*330.07*	*5714.4*	*4762*

It is observed that uni-directional glass fiber composites were optimal flexural strength than chopped and bi-directional fiber length composite. This surface offers the excellent fiber-matrix interface adhesion as a results improved mechanical properties.

V. Conclusions

The Glass fibers was successfully used to fabricate synthetic composites with 50% fiber and 50 % resin, these fibers are non-degradable and highly crystalline with well aligned structure. So it has been known that they also have higher tensile strength than other composites and in turn it would not induce any serious environmental problem. The variation of mechanical properties like tensile strength, flexural strength, of epoxy based Glass fiber composites has been studied as function of orientation. It is observed that composites fibers are observed optimal tensile and flexural strength. These composites may find applications as structural materials where higher strength and cost considerations are important. Glass fiber epoxy composites (50% fiber/weight) were successfully fabricated using hand lay technique and the mechanical properties were evaluated.

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