https://dx.doi.org/10.22161/ijaems.4.8.2 *ISSN: 2454-1311*

Experimental study of tensile Strength of Glass-epoxy Composites at different Laminate Orientations

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Abstract*—One of the most important requirement from the materials is to provide more strength at the expense of less weight. E-glass fiber is the material which satisfy this requirement. E-glass fiber has various applications in fields such as aerospace, automobile, marine, piping industries etc., that's make it is most versatile material of today's industries. In the present research work, attempt is made to fabricate the E-glass/epoxy composites at three different laminate orientations: 0º/0º/0º/0º/0º, 0º/45º/0º/-45º/0º and 0º/90º/0/90º/0º. Fabricated E-glass/epoxy composite specimens were tested for tensile strength, flexural strength and the experimental results had been validated through ANSYS software.*

Keywords*— *E-glass fiber, epoxy, composite, laminate orientation, tensile strength, ANSYS.

I. INTRODUCTION

At present the composite materials are widely usedworldwide because of their high strength to weight ratio, corrosion resistance and ease of fabrication.These advantages helps composite materials to replace conventional materials in various advance applications. In addition to the properties of the fiber, mechanical properties of fiber-reinforced composites also depends on the degree at which load is transmitted, length of fibers their orientation and volume fraction. In recent years glass fiber composites have gained the attentions and interests among researchers due its environmental friendly reflections.

A detailed literature study [1- 12] illustrate that the glass fiber composites have a lot of potential in numerous advanced sectors such as automotive, structural, aerospace and marine applications. The researches also show that not much work has been done on the effects of the fiber parameters such as fiber orientation, fiber length and fiber loading on the mechanical performance of the composites.

Thepresent research work E-glass/epoxy composite materials are fabricated at different laminate orientation and mechanical testing were performed to found out theinfluence of glass reinforcement at different orientations on the tensile strength of fabricated compositematerials. ANSYS software had been used to obtain numerical value of tensile strength of glass-epoxy composite material at different laminate orientations for validation of experimentally obtained results.

II. MATERIALS AND METHODOLOGY

Materials

E- Glass is used as fabric. Epoxy resin and hardener are used as matrix material. The hardener (10% by weight of epoxy) was mixed with epoxy resin (30% by weight of fabric). Mixing of epoxy resin and hardener were take place with the help of mechanical stirrer until clear solution is appeared.

Fabrication Method

The specimens are fabricated using the hand lay-up technique. Hand lay-up is the oldest and simplest method used for producing reinforced plastic laminates. Resins were impregnated into fibers using roller type impregnator. Prepared laminated layers were placed between two acrylic plates and kept inside press instrument at the pressure of 40-45 kgf/cm^{2}for 24 hours at room temperature for curing.

Testing of Composite

The specimens (composites) were tested for tensile strength.The universal testing machine of 100 kN capacity was used to find out the tensile strength.

Tensile test specimens (246 × 19 × 8 mm) were made in accordance with ASTM D638 to measure the tensile properties. Figure 1 shows the test specimens.

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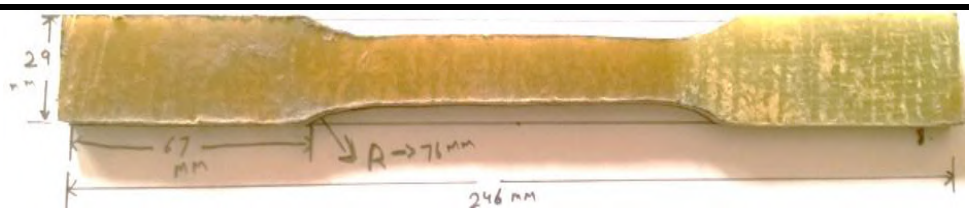

Fig.1: Tensile test specimen

III. RESULTS AND DISCUSSION

The Glass fiber epoxy composite at different laminate code i.e. 0º/0º/0º/0º/0º, 0º/90º/0º/90º/0º and 0º/45º/0º/-45º/0º was tested to evaluate the tensile strength.

Tensile Test Results

The tensile test was conducted on the two identical sample and average values of composite laminate at different laminate code are listed in Table 1. At laminate code 0º/0º/0º/0º/0º all the fibers are in same direction and when tensile pull is applied all fibers provide tensile strength thus need higher tensile pull to break the specimen. At laminate code 0º/90º/0º/90º/0º on the application of tensile pull the fiber in the direction of 0º provide tensile strength but fiber in direction of 90º does not give any strength in the direction of 0º and in case of laminate code 0º/45º/0º/-45º/0º, fibers in direction of 45º and -45º provide partial tensile strength.

Table.1: Experiment tensile strength value of the composite laminate

Glass/epoxy composite at different laminate code	Tensile Strength First sample (MPa)	Tensile Strength Second sample (MPa)	Average Tensile Strength (MPa)
0º/0º/0º/0º/0º	388	436	412
0º/45º/0º/-45º/0º	298	260	279
0º/90º/0º/90º/0º	213	217	215

Tensile Stress vs. Strain graphs of glass fiber epoxy composite at 0º/0º/0º/0º/0º, 0º/90º/0º/90º/0º and 0º/45º/0º/-45º/0º are given in the Figure 2.

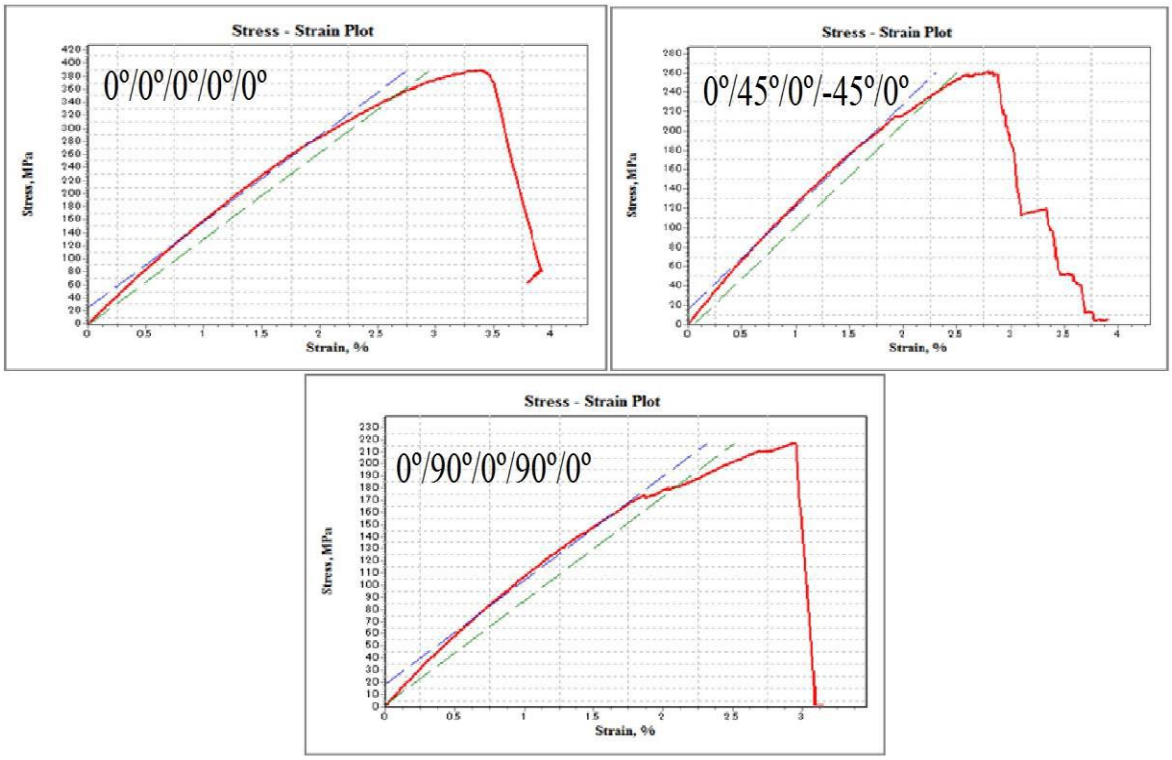

Fig.2: Tensile Stress vs. Strain graph of glass fiber epoxy composite at0º/0º/0º/0º/0º, 0º/45º/0º/-45º/0º and0º/90º/0º/90º/0º

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Numerical Analysis

A three –dimensional (3D) finite element model of glass fiber epoxy composite at different laminate code was developed in ANSYS to analyze the tensile strength. Numerical value of tensile strength at different laminate code are listed in Table 2.

Table.2: Numerical tensile strength, flexural strength and ILSS value of the composite laminate

Glass/epoxy composite at different laminate code	Tensile Strength (MPa)
0º/0º/0º/0º/0º	402
0º/45º/0º/-45º/0º	265
0º/90º/0º/90º/0º	204

Figure 3 show the variation of tensile strength of glass fiber epoxy composite at different laminate code.

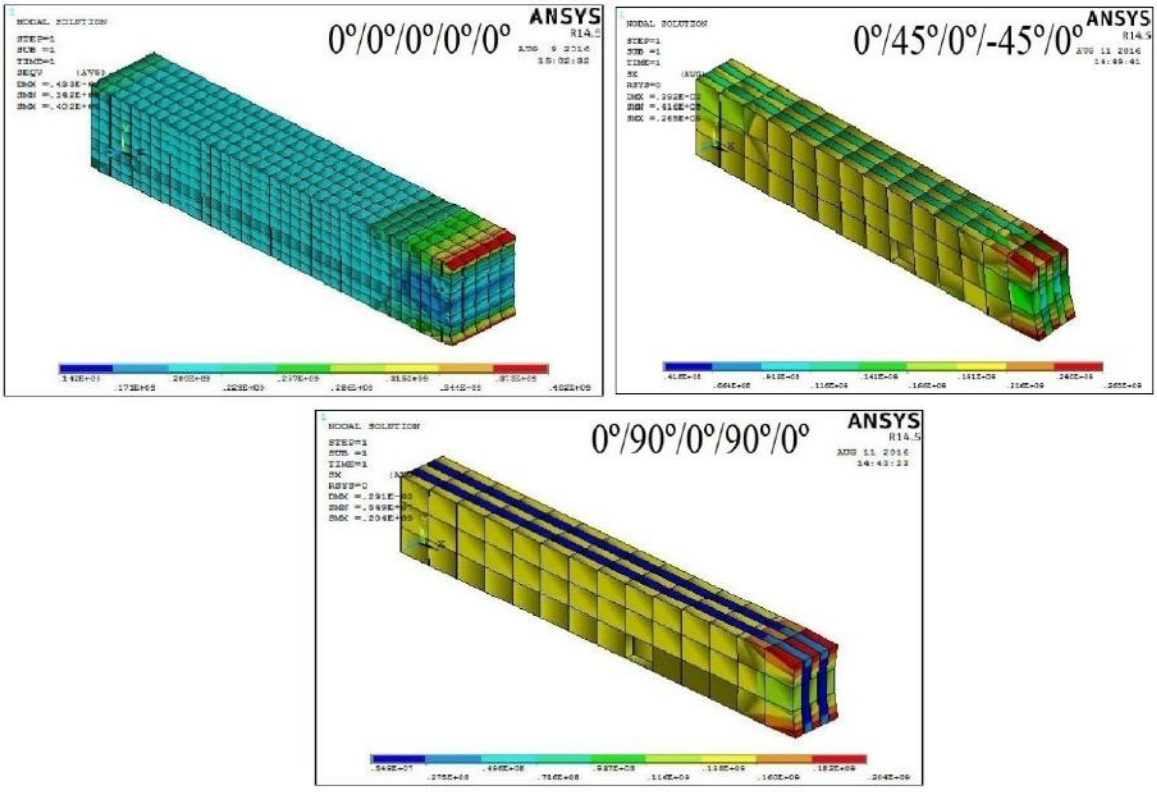

Fig.3: Variation of tensile strength of glass fiber epoxy composite at different laminate codes

IV. CONCLUSIONS

In this research work composite was fabricated at three different laminated codes and tested for their tensile strength. The following conclusions are drawn:

i). The glass-epoxy composite of laminate code at 0º/0º/0º/0º/0º provides 47.6% and 91.6% more tensile strength than glass epoxy glass-epoxy composite of laminate code at 0º/45º/0º/-45º/0º and 0º/90º/0º/90º/0º respectively. The glass-epoxy composite of laminate code at 0º/45º/0º/-45º/0º provides 29.7% more tensile strength than glass-epoxy composite of laminate code at 0º/90º/0º/90º/0º.

ii). It has been concluded that all laminates in single orientation or laminate code at 0º/0º/0º/0º/0º provides highest tensile strengthby laminate at 0º/45º/0º/-45º/0º and laminate at 0º/90º/0º/90º/0º.

iii). The results of FEM analysis (average error of 4.2%) in this research show a good agreement with the experiment results. Therefore it can be concluded that the FEM analysis can be taken as guidance for results when experimental modal analysis is carried out.

REFERENCES

[1] Hegde A, DarshanRS.Tensile properties of unidirectional glass/epoxy composites at different orientations of fibres.Int. Journal of Engineering Research and Applications. 2015; 5(3):150-153.

[2] Babu AK, Ali A. Finite Element Analysis of Glass/Epoxy CompositeLaminates with Different Types of Circular Cutouts.Indian journal of applied research. 2011; 3(6):198-201.

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[3] Yang B, Kozey V, Adanur S et al. Bending, compression, and shear behavior of woven glass fiber-epoxy composites. Composites Part B: Engineering. 2000; 31(8):715-721.

[4] Hamed AF,Hamdan MM, Sahari BBet al.Experimental characterization of filament wound glass/epoxy and carbon/epoxy composite materials. ARPN Journal of Engineering and Applied Sciences. 2008; 3(4):76-87.

[5] Adem E, Didwania M, Reddy GM et al. Experimental Analysis of E-Glass /Epoxy & E-Glass /polyester Composites for Auto Body Panel. American International Journal of Research in Science, Technology, Engineering & Mathematics. 2015; 10(4):377-383.

[6] Bakir B, and Hashem H. Effect of Fiber Orientation for Fiber Glass Reinforced Composite Material on Mechanical Properties. International Journal of Mining, Metallurgy and Mechanical Engineering. 2013; 1(5): 341-345.

[7] Manoharan R. and Jeevanantham AK. Stress and load displacement analysis of fiber reinforced composite laminates with a circular hole under compressive load. ARPN Journal of Engineering and Applied Sciences. 2011; 6(4):64-74.

[8] Mistry AA, Thanki SJ, Gandhi AH. Investigation of the Effect of Fiber Orientation on Mechanical Properties of Composite Laminate Using Numerical Analysis. International Journal of Advanced Mechanical Engineering. 2014; 4(5):501-508.

[9] Vengatesan T, Kavitha K, Mohanraj M, Rajamani GP. Study and analysis of drilling in GFRP composites using ANSYS 14.5. International journal of innovative research in technology. 2014; 1(7): 170-174.

[10] Patil AS, Khadabadi UB. ANSYS as a Tool to Perform FEA and Failure Analysis of Hybrid Laminated Composites. International Research Journal of Engineering and Technology. 2016; 3(6): 1235-1241.

[11] Tanwer AK. Mechanical Properties Testing of Uni-directional and Bi-directional Glass Fibre Reinforced Epoxy Based Composites. International Journal of Research in Advent Technology. 2014; 2(11): 34-39.

[12] Mathapati SS, Mathapati SS, Testing And Analysis of Mechanical Properties of E- Glass Fiber Reinforced Epoxy Polymer Composites. International Journal of Research and Innovations in Science and Technology. 2015; 2(1): 46-52.