

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: 0°/0°/0°/0°/0°, 0°/45°/0°/45°/0° and 0°/90°/0°/90°/0°. 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 used worldwide 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.

The present research work E-glass/epoxy composite materials are fabricated at different laminate orientation and mechanical testing were performed to found out the influence of glass reinforcement at different orientations on the tensile strength of fabricated composite materials. 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/cm² 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.



Fig.1: Tensile test specimen

III. RESULTS AND DISCUSSION

The Glass fiber epoxy composite at different laminate code i.e. $0^{\circ}/0^{\circ}/0^{\circ}/0^{\circ}/0^{\circ}$, $0^{\circ}/90^{\circ}/0^{\circ}/90^{\circ}/0^{\circ}$ and $0^{\circ}/45^{\circ}/0^{\circ}/-45^{\circ}/0^{\circ}$ 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 $0^{\circ}/0^{\circ}/0^{\circ}/0^{\circ}/0^{\circ}$ 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 $0^{\circ}/90^{\circ}/0^{\circ}/90^{\circ}/0^{\circ}$ on the application of tensile pull the fiber in the direction of 0° provide tensile strength but fiber in direction of 90° does not give any strength in the direction of 0° and in case of laminate code $0^{\circ}/45^{\circ}/0^{\circ}/-45^{\circ}/0^{\circ}$, fibers in direction of 45° and -45° 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)
$0^{\circ}/0^{\circ}/0^{\circ}/0^{\circ}/0^{\circ}$	388	436	412
$0^{\circ}/45^{\circ}/0^{\circ}/-45^{\circ}/0^{\circ}$	298	260	279
$0^{\circ}/90^{\circ}/0^{\circ}/90^{\circ}/0^{\circ}$	213	217	215

Tensile Stress vs. Strain graphs of glass fiber epoxy composite at $0^{\circ}/0^{\circ}/0^{\circ}/0^{\circ}/0^{\circ}$, $0^{\circ}/90^{\circ}/0^{\circ}/90^{\circ}/0^{\circ}$ and $0^{\circ}/45^{\circ}/0^{\circ}/-45^{\circ}/0^{\circ}$ are given in the Figure 2.

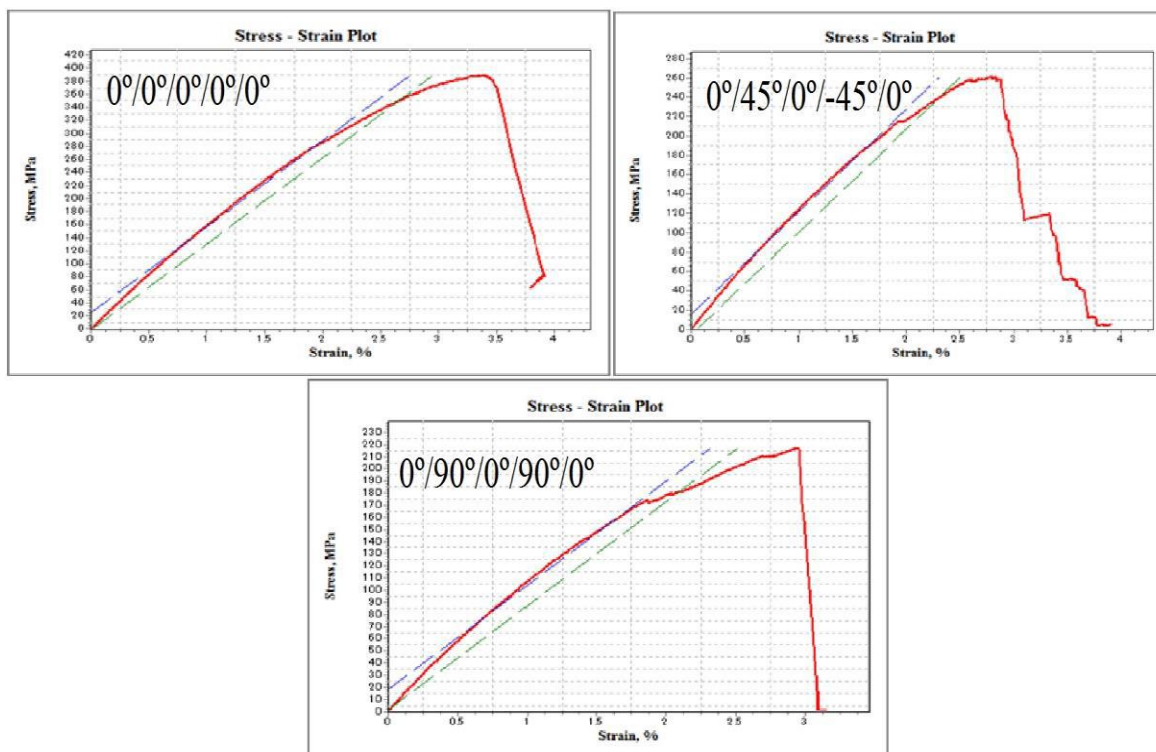


Fig.2: Tensile Stress vs. Strain graph of glass fiber epoxy composite at $0^{\circ}/0^{\circ}/0^{\circ}/0^{\circ}/0^{\circ}$, $0^{\circ}/45^{\circ}/0^{\circ}/-45^{\circ}/0^{\circ}$ and $0^{\circ}/90^{\circ}/0^{\circ}/90^{\circ}/0^{\circ}$

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)
0°/0°/0°/0°/0°	402
0°/45°/0°/-45°/0°	265
0°/90°/0°/90°/0°	204

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

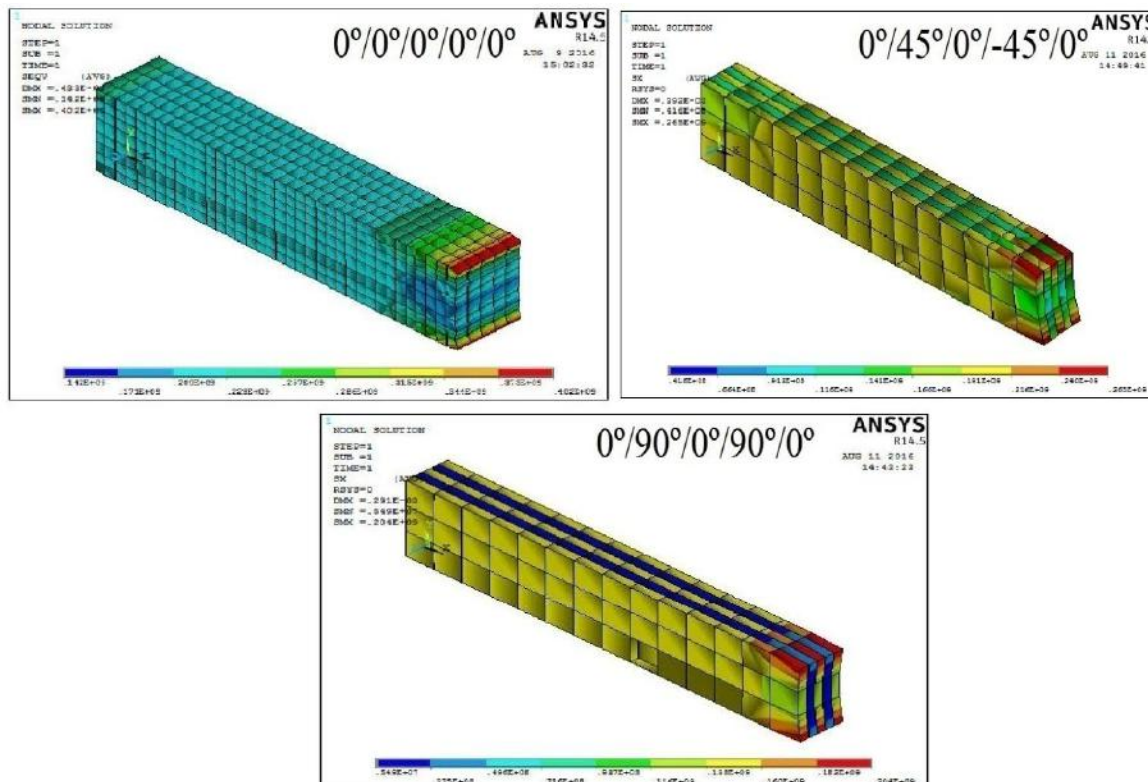


Fig.3: Variation of tensile strength of glass fiber epoxy composite at different laminate codes

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 0°/0°/0°/0°/0° provides 47.6% and 91.6% more tensile strength than glass epoxy glass-epoxy composite of laminate code at 0°/45°/0°/-45°/0° and 0°/90°/0°/90°/0° respectively. The glass-epoxy composite of laminate code at 0°/45°/0°/-45°/0° provides 29.7% more tensile strength than glass-epoxy composite of laminate code at 0°/90°/0°/90°/0°.
- ii). It has been concluded that all laminates in single orientation or laminate code at 0°/0°/0°/0°/0° provides highest tensile strength by laminate at 0°/45°/0°/-45°/0° and laminate at 0°/90°/0°/90°/0°.

- 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.

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