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Mechanical Characterization of E-Glass Woven Fabric Composite: An Experimental Study

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ABSTRACT

Polymer-based composite materials are widely used in aerospace and automotive industries. The main aim of this project is the mechanical characterization of Glass Fiber Reinforced Plastic Laminates (GFRPs) with woven fabric composite. Experimental tests were conducted according to following ASTM standards: ASTM D3039 for tensile tests with specimen thickness of 2mm and 3mm, ASTM D3410 for compression tests. The average values of the following properties are determined by the statistical processing of the experimental data: Young's modulus E in tension, normal tensile stress at failure, normal compression stress at failure, normal compression strain at failure, normal tensile strain at failure.

KEY WORDS: Glass Fibre Reinforced Polymer, Tensile stress, Tensile strain, Compression stress and strain

1. INTRODUCTION

In recent years fiber reinforced composite materials are increasingly used for applications in the automotive field (inter design elements, board parts) or construction (panels).

Thus, it is important to know the performance of these types of materials regarding their strength and stiffness. This project deals with fabrication and determination of the mechanical characteristics such as strength, stiffness and impact behavior of E-Glass Woven Fabric Composite.

2. MATERIAL SELECTION AND MAKING SPECIMEN

Fiber-reinforced composite materials consist of a fibrous reinforcement with high strength and modulus, embedded in a matrix material, usually a type of polymer. The main types of commercially used fibers are glass, carbon, and aramid fibers. In general, these fibers carry the load and provide rigidity to the material, while the matrix mostly serves to keep the fibers in their desired location, thus providing structural integrity. The matrix is also responsible for the load transfer between the fibers and protects them against humidity or other environmental damage.

Reinforcement: The Material used as reinforcement is E-Glass woven roving mat with the areal density of 600 g/m2. E-glass (electrical) - lower alkali content and stronger than A glass (alkali). Good tensile and compressive strength and stiffness, good electrical properties and relatively low cost, but impact resistance relatively poor. It is the most common form of reinforcing fiber used in polymer matrix composite.

Woven Fabric Reinforcement: Woven fabrics are produced by the interlacing of warp (0°) fibers and weft (90°) fibers in a regular pattern or weave style. The fabric's integrity is maintained by the mechanical interlocking of the fibers. Drape (the ability of fabric to conform to a complex surface), surface smoothness and stability of fabric are controlled primarily by the weave style.

Epoxy Matrix: Epoxies out-perform most other resin types in terms of mechanical properties and resistance to environmental degradation. As a laminating resin, their increased adhesive properties and resistance to water degradation make these resins ideal. Epoxy (LY556) resin is used for laminating. They are easily and quickly cured at any temperature from 5°C to 150°C, depending on the choice of curing agent. Epoxies differ from polyester resins in that they are cured by a hardener rather than a catalyst. In this case, hardener (HY951) is used to cure the epoxy by an 'addition reaction' where both materials take place in the chemical reaction. Resin and hardener are mixed in the ratio of 10:1.

Making of Specimen: For making the specimen, the VARTM process was used. The E-glass woven roving mat was cut to the size of 300 x 300 mm. The number of layers of specimen we are placing will determine the thickness of the specimen. The setup was covered by a bag and sealed at the ends so that atmospheric air will not enter into it. One end of the bag was connected to resin pot to collect the excess resins from the bag. Resin pot was attached to pressure gauge to measure the pressure inside bag. The vacuum pump was connected to another end of the resin pot. Epoxy (LY556) resin with the hardener (HY951) was taken in a container with the ratio of 10:1.It is then connected to the vacuum bag. Because of the vacuum generated inside it, the resin was injected into the laminates through a spiral tube. An excess amount of resin was collected inside resin pot. Curing was done for nearly one day. After curing the composite plate was taken for cutting process. Specimens are used according to ASTM standards.

Static testing of specimen:

Tensile Test: Static tensile tests were done on various occasions in this study. In most cases, WDW-50 machine was used for the tests. This machine is equipped with hydraulic grips. The tests are done in accordance with the Standard test method for tensile properties of polymer matrix composite materials American Society for Testing and Materials

(ASTM) (D3039/D3039M-00). The static tensile tests were displacement controlled, and a test speed of 2 mm/min for the crosshead displacement was adopted.

The tensile test was carried out on two specimens one with 2mm thickness specimen and other with 3mm specimen. The dimensions for the tensile tests were (250mm x 25mm x 2mm) for one specimen and for another specimen (250mm x 25mm x 3mm). Glass fiber/epoxy composite end tabs (50mm x 25mm x 2 mm) were glued to all samples to protect them from grip damage.

Compression test: Static compression test was done using TUE-C-1000 machine. The test was carried out by the Standard test method for tensile properties of polymer matrix composite materials (ASTM-D3410).

For testing, woven fabric composite specimen (100 x 10 x 2) is taken with the E-Glass fiber/epoxy composite end tabs (45 x 10 x 10) were glued at the sample to protect them from the grip. Compressive load is acted along the fiber direction. The computer connected to the machine registered the displacement of the grips as well as the load on the sample. This allowed for the stress-strain curves to be constructed, and the compressive strength of the material.

3. EXPERIMENTAL RESULTS

Static Tensile Test: The experimental set up is shown in figure 1.The results of the static tensile test in 2mm thickness specimen (4 layers of WRM was used) is given in Table 1. The table shows the average values of series of experiments which was conducted. The stress-strain graph for the 2mm specimen is given in figure 2.

Figure.1. Experimental set up

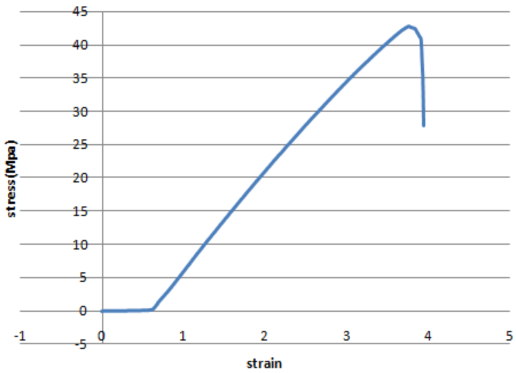

Figure.2. Stress-Strain relation curve for 2mm specimen

Table.1. Tensile test for 2 mm specimen

Thickness (mm)	Width (mm)	Area (mm^2)	Max.load (KN)	Tensile modulus (GPa)
2	25	50	4.278	10.6
Stress at max.load (MPa)	**Strain at max. load**	**Load at break (KN)**	**Stress at break (MPa)**	**Strain at break**
42.78	3.762	2.788	27.88	3.94

The results of the static tensile test for 3mm thickness specimen (6 layers of WRM was used) is given in Table 2.The table shows the average values of series of experiments which was conducted.

Table.2. Tensile test for 3 mm specimen

Thickness (mm)	Width (mm)	Area (mm^2)	Max.load (KN)	Tensile modulus (GPa)
3	25	75	7.186	13.5
Stress at max.load (MPa)	**Strain at max. load**	**Load at break (KN)**	**Stress at break (MPa)**	**Strain at break**
95.81	5.856	6.416	85.54	5.962

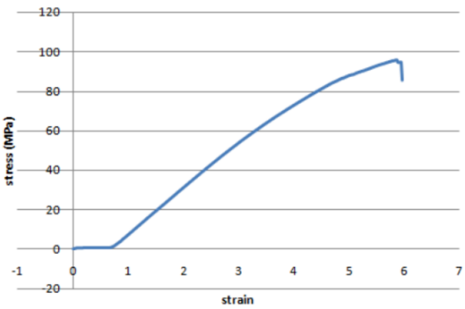

Figure.3. Stress-Strain relation curve for 3mm specimen

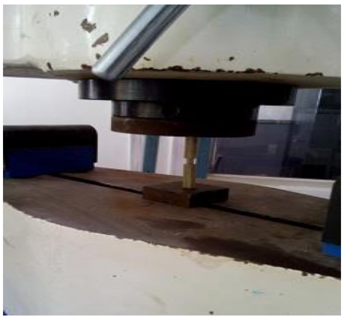

Figure.4. Compression test – set up

Static Compression Test: The experimental set up for the compression test is shown in figure 4. The results for static compression test in 2mm thickness specimen (4 layers of WRM was used) is given in Table 3.The table shows the average values of series of experiments which was conducted.

Table.3. Compression test (2mm)

Layers of WRM	Thickness (mm)	C.S. Area	Load at peak (KN)	Comp. strength (N/mm^2)
4	2	20	16.43	821.5

4. CONCLUSIONS

Tensile strength of WRM composite with different thickness was determined. From the above two cases, it is clear that increase in thickness has more impact on tensile strength. With 16% increase in thickness, it shows 33% increase in tensile strength. From the above case, it is clear that compression strength is much lower than tensile strength because, during compression, the load acts only on matrix not in reinforcements.

REFERENCES

Astrom BT, Manufacturing of polymer composites, Chapman and Hall, 1997, 194-234.

Findik F, Misirlioglu M, Soy U, The structural features of glass fiber reinforced polyester matrix composites, Sci Eng Compos Mater, 10 (4), 2002, 287-95.

Hassan MA, Naderi S, Bushrod AR, Low Velocity Impact Damage of woven fabric composites: Finite Element Stimulation and Experimental verification, J. Materials and Design, 53, 2014, 706-718.

Joseph B. Jordan, Clay J. Naito, Bazle Z. Haque, Progressive Damage modeling of plain weave E-glass/phenolic composites, J. Composites: Part B, 61, 2014, 315-323.

Mallick PK, Fiber-reinforced Composites: Materials, Manufacturing and Design, Third edition, CRC Press, Taylor and Francis Group, 2008.

Yasuhide Shindo, Akihiro Inamoto, Fumio Narita, Katsumi Horiguchi, Mode I fatigue delamination growth in GFRP woven laminates at low temperatures, J. Engineering Fracture Mechanics, 73, 2006, 2080-2090.