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Effect of Thickness on Flexural Properties of Epoxy based Glass Fiber Reinforced Laminate

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ABSTRACT

Many structures are often prone to bending loads, which can result in serious damage. Therefore, for structural integrity, structures must be efficient to resist bending. Flexural loading causes stresses in the composites, which vary through the thickness. These flexural stresses are the maximum at the outer surfaces and zero in the middle at the neutral axis. In pure bending, the composite failure initiates on either the tensile or compressive side depending upon whether the composite is stronger in compression or tension respectively. The stress in an individual ply depends upon the stiffness of that ply and its distance from the laminate's neutral axis. By including, one or more extra components having relatively better elastic properties in the laminate can help in improving the flexural properties of the composite.

This paper investigates the influence of thickness on flexural properties of glass fiber-epoxy laminated composite material. In the present study the composite laminate specimen is prepared using the vacuum baggage technique and the specimen is subjected to static 3 point bending and the investigation is carried out as per the ASTM D90 standards. Flexural properties evaluated are flexural strength and stiffness of the composites system appropriate conclusions was drawn.

Keywords: *Composite laminate, Flexural, E-glass, Three point bending, Stiffness, Strength*

I. INTRODUCTION

Since their introduction, glass fiber reinforced polymer composites have become an important class of composite materials owing to their high specific strength and specific stiffness. Glass fibers reinforced polymer matrix composites are being used extensively in automotive and aerospace structures due to their superior specific properties which translate into low fuel consumption, higher passenger capacity and decreased maintenance cost, for example. The first use of modern composite materials in the aircraft industry was about 30 years ago in military aircrafts and first use of modern composite materials in commercial aircrafts was by Airbus in 1983 [1]. The use of composite materials was limited only to secondary aerospace structures but with the development of knowledge about these materials, their use in primary aerospace structures has increased. Mostly, aerospace structures are based on thermosetting polymer matrices. However use of thermoplastics is increasing everyday due to the excellent properties they offer such as unlimited shelf life, storage without freezing, improved toughness, possibilities for recycling and above all the short cycle productivity. Banerji and Nirmal [2] reported an increase in flexural strength of unidirectional carbon fiber/ Poly(methyl methacrylate), composite laminates having polyethylene fibers plies at the lower face Li and Xian [3] showed that theincorporation of a moderate amount of carbon fibers into ultra-high-modulus polyethylene (UHMPE) fibers reinforced composites greatly improved the compressive strength, flexural modulus while the addition of a small amount of UHMPE fibers into a carbon fiber reinforced composite remarkably enhanced the ductility with only a small decrease in compressive strength. Rohchoon and Jang[4] studied the effect of stacking sequence on the flexural properties and flexural failure modes of aramid-UHMPE hybrid composites. The flexural strength depends upon the type of fibers at the compressive face and dispersion extent of the fibers. Matteson and Crane [5] reported increase in flexural strength by using unidirectional steel wire tapes in glass fiber composites and carbon fibers composites. They showed that the increase in flexural strength was due to a change in failure mode from compressive buckling to nearly ductile tensile failure. Bradley and Harris [6] used unidirectional high carbon steel wires to improve the impact properties of epoxy resin reinforced with unidirectional carbon fiber reinforced. By having steel wire on the compression side of the specimen, the energy of fracture was increased by 200% by elimination of compressive failure mode. Flexural strength was increased particularly when the wires were placed in the compression side of the specimen and also as the volume fraction of the wire was increased.

II. MATERIALS & EXPERIMENTATION

On the whole various composite specimen models will be fabricated as per standard procedure and tested. The fibers chosen were bi-woven glass fiber with density of 360 gsm. The laminate will be cut to the required size and bonded to the glass fiber cloth by using an adhesive made from a mixture of **LY556** resin & **HY 951** hardener in proportions of 100:10 by weight.

The surfaces will be thoroughly cleaned in order to ensure that they were free from oil, dirt. etc., before bonding at room temperature and pressure. The models will be allowed to cure for about 24 hours. Thicknesses of the Specimens was be maintained at 2 mm & 4 mm throughout the experiments for all the specimens prepared. Details of the composite specimens fabricated are as shown in Fig 1 below.

Figure 1: Fabrication of Fiber Glass Laminated Composite

The 3-point bending tests were performed in a servo controlled UTM machine (LLYODS, UK) according to the procedure outlined in ASTM D790. At least 3 specimens were tested for each thickness of laminate. The crosshead speed was maintained at 2mm/min. The tested specimens were examined using through visual inspection for failure of fibers and matrix. Densities of composite laminates were determined by the Archimedes principle to calculate the specific values (property/density) of flexural properties.

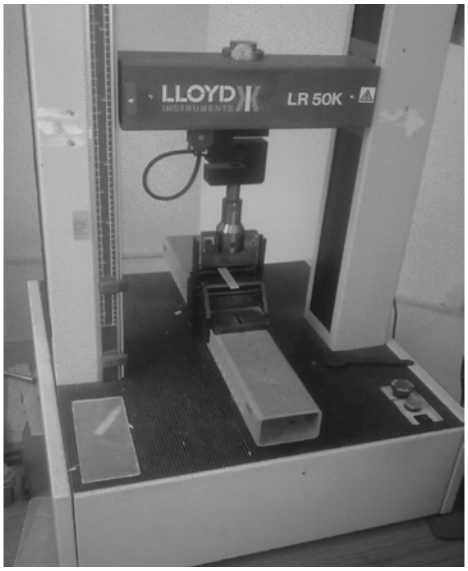

Fig – 2 Three point Bend Test

Fig – 3 Sample Specimen Damaged due to Bending

III. RESULTS AND DISCUSSIONS

Table – 1 Results of Flexural Test

Specimen Designation	Load, N			Deflection, mm			Max. Stress MPa			Max. Strain %			Stiffness N/mm
	T_1	T_2	Av.	T_1	T_2	Av	T_1	T_2	Av	T_1	T_2	Av	
S – 1(2mm)	427	509	468	4.56	5.66	5.11	180	210	195	10	10	10	91.5
S – 2 (3mm)	610.5	612	611	4.99	5.53	5.26	258	260	259	11	12	11.5	110.6

T_1- Trial 1; T_2- Trial 2

Glass fabrics reinforced with two different thicknesses were tested in 3-point bending and their flexural properties and failure mechanism were investigated. Typical flexural stress-strain curves for both laminates presented in figures 4 and 5 respectively. The graphs show linear behavior until the failure. The curves for both specimens show similar behavior on stress-strain curves.

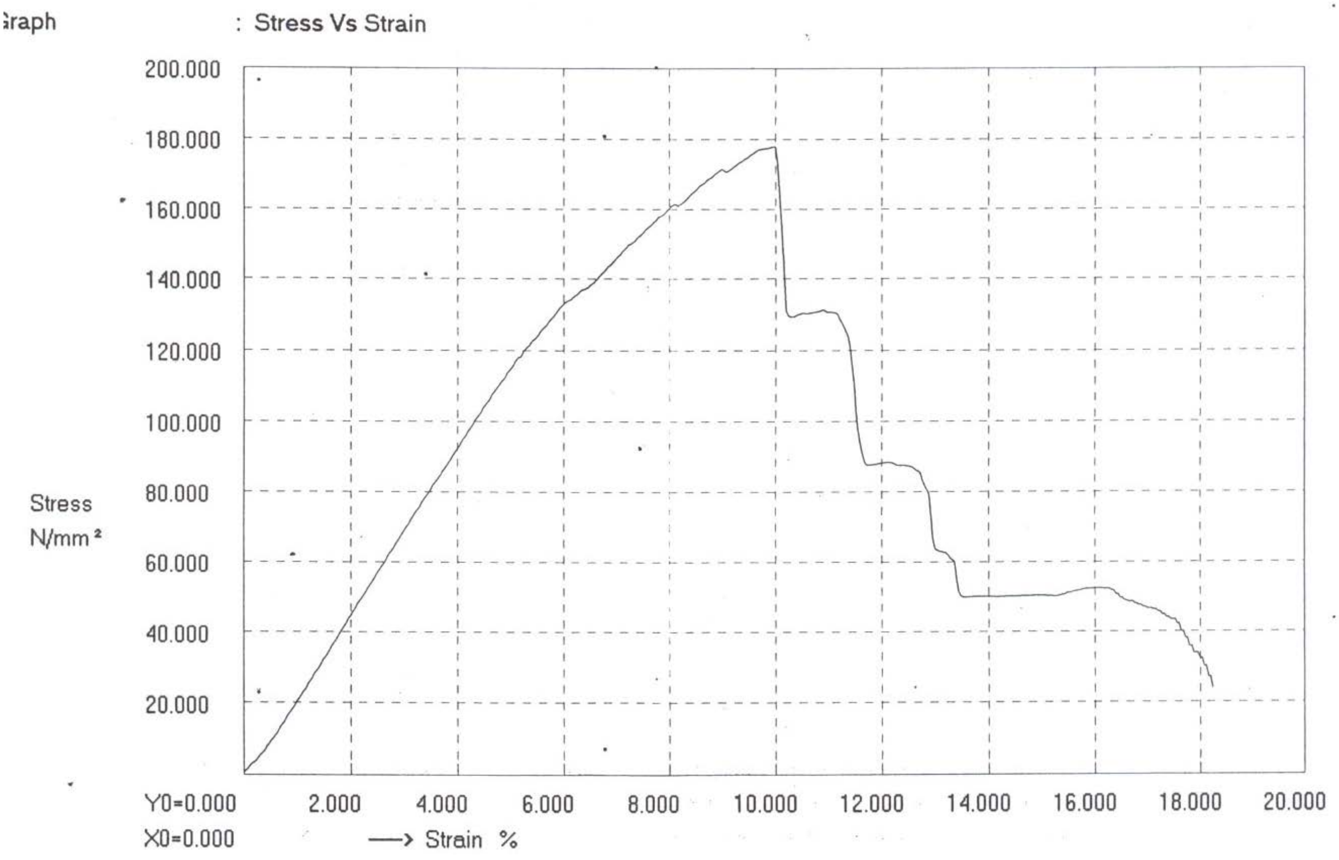

Fig – 4: Graph of Stress –Strain for Glass Laminate with 2mm Thickness

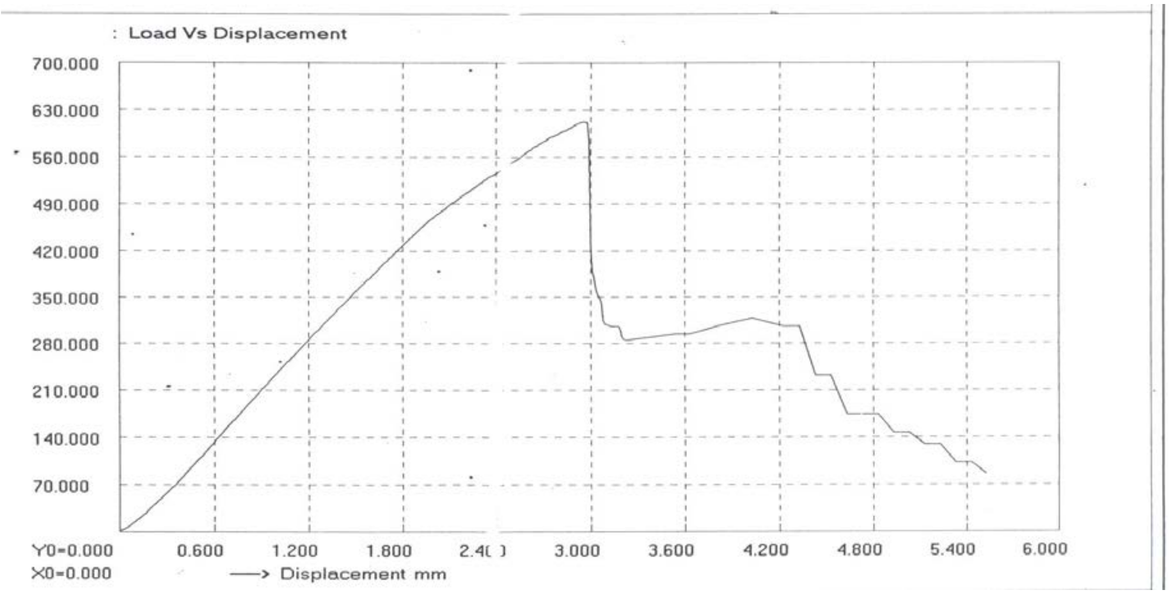

Fig – 5: Graph of Stress –Strain for Glass Laminate with 3mm Thickness

Table 1 provides the detailed results of flexural properties of glass laminates with 2mm and 3mm thickness. It can be observed that flexural properties increase 14% in case of 3mm thick specimen as compared to 2mm thick specimen. Consequently, there is increase in the deflection in case of 3mm thick specimen, this can be attributed to increase in the load causes more deflection. However, increase in stiffness can be achieved significantly in case of 3mm thick specimen with little sacrifice in the weight. By visual inspection, it can be observed in fig 4, the damage of glass fibers on the top layers subjected to compression and bottom layers subjected to tensile failure which is in accordance with the bending theory of beams.

IV. CONCLUSIONS

Flexural tests on epoxy glass laminates have been successfully conducted and results are recorded. To improve flexural properties of fiber composite laminate a slight increase in the thickness without sacrificing much on the weight can be recommended which significantly increases flexural properties. The results of this work, is recommended for designers of composites community for better improvement of strength and stiffness for FRP composites.

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