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Impact of Modified Thickness on Flexural Modulus of PU-Foam /CSM Glass Fabric Sandwich Panels

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ABSTRACT

Sandwich panels serve the most desirable industrial aspects by being lightweight with adequate strength offering structural benefits to replace heavy components. Researchers are working on fabrication of new composites materials worldwide to enhance the applicability of these materials. Glass fiber reinforced polymer composites is widely used many industrial application particularly in the automotive industry due to advantages such as low weight, ease of processing, price and noise suppression. Sandwiched structure forms a new option for automotive industry. A sandwiched structure is a special type of sandwiched–structure composite that is fabricated by attaching two thin but stiff skins to a light weight but thick core. The core material is normally low strength material, but its higher thickness provide the sandwiched structure composite with high bending stiffness with low overall density. Keeping this in mind our present study concern about the preparation of sandwich composites by using glass fibre as skin and polyurethane foam as a core material and sample was prepared by hand layup method for two different thickness of the core, which influence greatly on the mechanical properties of material. Testing of samples according to ASTM standard was done, phenomenal observations are accurately noted, and results are tabulated. The qualitative comparison has been made to samples of different thickness to recommend the applicability of sample. It was observed that remarkable changes have been recorded as thickness of the sandwich affects greatly on resistance to bending, which is because of core material sustain greater value of load with its increased load bearing area. The experimental results has been recorded for all the loading conditions and qualitative comparison has been made to assess the effect of modified thickness on bending modulus of sandwich panels was properly enumerated for the corresponding thickness of the samples

Keywords : Light Weight Structures, Sandwich Composites, Effect of Thickness, Flexural Rigidity.

I. INTRODUCTION

Light weight structures are profound materials to considers for numerous applications in many industry for their high specific stiffness. However, the cost of traditional composite materials is also considerable. Random chopped fiber-reinforced composites (RFCs) have emerged as promising alternative materials for lightweight structures due to their low cost and mass production capabilities [1]. Their potential application in, for example, automotive industry has been documented. In order to expand their use, accurate material characterization is required. The main difficulty in fully exploring model their geometry at the micro-level for high fiber volume ratios (35-40%). This difficulty becomes even more obvious at high aspect ratio fibers [2]. Glass-fiber reinforced composites (or glass- fiber reinforced plastics, GFRP) have seen limited use in the building and construction industry for decades. Because of the need to repair and retrofit rapidly deteriorating infrastructure in recent years, the potential for using fiber – reinforced composites for a wider range of applications is now being realized[3]. Mechanical properties of fiber-reinforced composites are depending on the properties of the constituent materials (type, quantity, fiber distribution and orientation, void content). Beside those properties, the nature of the interfacial bonds and the mechanism of load transfer at the interphone also play an important role[4].The reports studies on short fiber reinforced composites by different investigators are found to have focused mostly on the strength properties of the composites. They have described the influence of fiber shape in short glass fiber composites [5]. They have studied the flexural properties of misaligned short fibers reinforced polymers by taking into account the effects fiber length and fiber orientation. Recently, efforts to reduce the weight of automobiles by the increased use of plastics and their composites, have led to a growing penetration of short-fiber reinforced injection molding thermoplastics into fatigue-sensitive applications [6]. In general, short-fiber/polymer matrix composites are much less resistant to fatigue damage than the corresponding continuous fiber reinforced polyester (GRP) is widely used in pressure vessel and pipe line system for chemical industry [7].Keeping this historical evidence in mind the present study highlights the preparation of chopped strand mat glass fabrics sandwiched with polyurethane foam by varying the thickness and the mechanical tests have been done upon preparing the samples according to testing conditions. Comparative results resemble the influence of core thickness on mechanical properties of light weight materials.

II. MATERIALS & METHODOLOGY

2.1 THE RAW MATRERIALS USED

- S glass fiber(chopped strand mat)
- Epoxy Resin
- Hardener
- Polyurethane Foam (PU Foam)

2.1.1 Glass fibre

Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites[8]. Glass fibersare therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic [9].chopped strand Mat fibre used for the present study is as shown in figure 1.

Figure 1. Chopped strand mat fiber glass

Glass fibersare used successfully for reinforcing material for rubbers has been studied. High initial aspect ratio can be obtained with glass fibers, but brittleness causes breakage of fibers during processing. The mechanical properties of types of different glass fibres are shown in table 1.

Table 1. Comparison of S- Glass and E- Glass

Fiber type	UTS (MPa)	Density (g/cm^3)	Thermal expansion (μm/m·°C)	Softening T (°C)
E-glass	3445	2.58	5	846
S-glass	4890	2.46	2.9	1056

2.1.2 Polyurethane foam

Polyurethane (PUR and PU) is a polymer composed of organic units joined by carbonate (urethane) links[10]. While most polyurethanes are thermosetting polymers that do not melt when heated, thermoplastic polyurethanes are also available. Polyurethane polymers are traditionally and most commonly formed by reacting a di- or poly-isocyanate with a polyol[11]. Both the isocyanates and polyols used to make polyurethanes contain, on average, two or more functional groups per molecule Polyurethanes are produced by mixing two or more liquid streams.

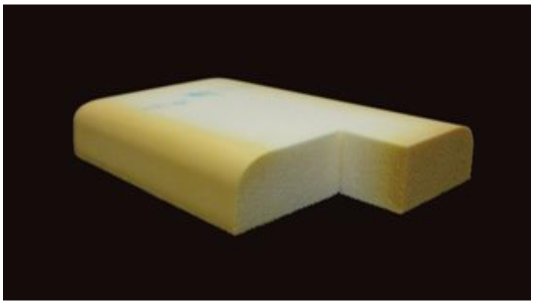

Figure 2. Polyurethane foam

Polyurethane insulation is lightweight but strong, with a density ranging between 30 kg/m³ and 100 kg/m³ depending on the application. For special applications that are subject to extreme mechanical loads, the density of the PUR/PIR rigid foam can be increased to 700 kg/m³.Even at low densities, polyurethane keeps excellent mechanical properties such as compressive stress, compressive strength and creep.

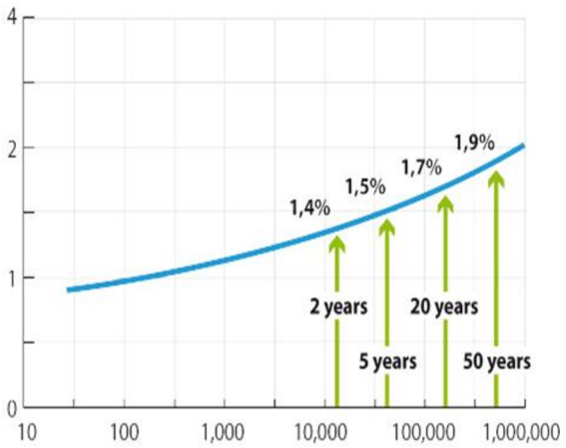

Figure 3. Deformation of Polyurethane foam with respect to time

2.1.3 Epoxy

Epoxy resins are thermosetting resins, which cure by internally generated heat. Epoxy systems consist of two parts, resin and hardener. When mixed together, the resin and hardener. When mixed together, the resin and hardener activate, causing a chemical reaction, which cures (hardens) the material. Epoxy resins generally have greater bonding and physical strength than do polyester resins[12]. Most epoxies are slower in curing, and more unforgiving in relation to proportions of resins and hardener than polyesters.

Figure 4. General purpose Epoxy

Resin systems are relatively low in viscosity and contain low- loss filler for improved physical characteristics. Castings, which are shrink free, void free and low in thermal expansion, are easily prepared. The electrical characteristics are not scarified.

III. EXPERIMENTAL METHODS

Hand layup Method

Hand lay-up is an open molding method suitable for making a wide variety of composites products from very small to very large. Production volume per mold is low; however, it is feasible to produce substantial production quantities using multiple molds. Hand lay-up is the simplest composites molding method, offering low cost tooling, simple processing, and a wide range of part sizes. Design changes are readily made. There is a minimum investment in equipment. With skilled operators, good production rates and consistent quality are obtainable.

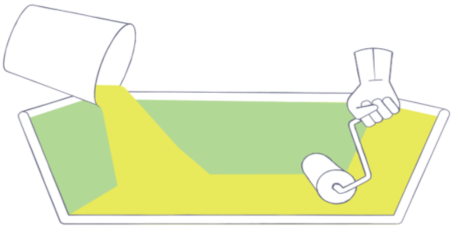

Figure 5. Hand Lay-up Process

STEPS INVOLVED IN MAKING THE MATERIAL

PU Foam and fiber glass is cut into 200*200 mm dimension. Two pieces of PU Foam is cut into required dimension. Six sheets of Fiber Glass are cut for one sample and ten for another as per required dimension (200*200). First the foam layer (3mm) is securely placed in the mould and layer of resin is coated over it. Care should be taken that the layer should not have excess amount of resin since it contributes to wastage. Then the first layer of fiber mat is placed properly over the foam and then again a coating of resin is applied over it. After each layer formation, mixture is applied on the layer of mat and then allowed to bond with each other .The coating of resin is done with the help of special brush which is strictly used for fiber purpose. After the final layer is coated with the resin the mixture is spread evenly by using hand rolls. After the material has been formed, it is kept for drying and applying suitable quantity of load on it. Two sets of specimens have been prepared having thickness of 11mm & 15mm.

Figure 6 . Prepared Sample thickness 11mm & 15mm

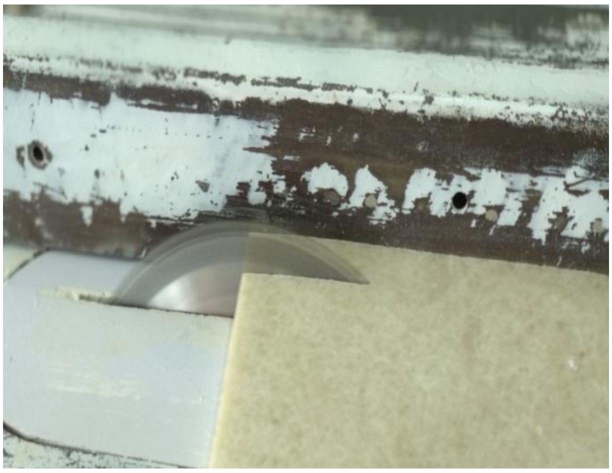

Figure 7 . Material has been cut into required Dimension

FLEXURAL TEST

Flexural testing is used to determine the flex or bending properties of a material. Sometimes referred to as a transverse beam test, it involves placing a sample between two points or supports and initiating a load using a third point or with two points which are respectively called 3- Point bend and 4-point bending test. Maximum stress and strain are calculated on the incremental load applied. Typical materials tested are plastics, composites, metals, ceramics and wood. Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular

Table2. Flexural Test results of 11mm& 15 mm thickness of the samples respectively

Legends	Specimen	Flex modulus Mpa	Flex Strength Mpa	Thickness mm	Width mm	Length mm
(red)	1	514	7.66	11	15	180
(green)	2	518	8.17	11	15	180

(i). Sample with 11mm Thickness

Legends	Specimen	Flex modulus Mpa	Flex Strength Mpa	Thickness mm	Width mm	Length mm
	1	321	13.2	15	15	180
	2	404	12.5	15	15	180

(ii).Sample with 15mm thickness

cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of yield. It is measured in terms of stress, here given the symbol sigma. When an object formed of a single material, like a wooden beam or a steel rod, is bent (Figure 5.2), it experiences a range of stresses across its depth (Figure 5.1). At the edge of the object on the inside of the bend (concave face) the stress will be at its maximum compressive stress value. At the outside of the bend (convex face) the stress will be at its maximum tensile value. These inner and outer edges of the beam or rod are known as the 'extreme fibers'. Most materials generally fail under tensile stress before they fail under compressive stress, so the maximum tensile stress value that can be sustained before the beam or rod fails is its flexural strength. In mechanics, the flexural modulus or bending modulus is an intensive property that is computed as the ratio of stress to strain in flexural deformation, or the tendency for a material to resist bending. It is determined from the slope of a stress-strain curve produced by a flexural test [ASTM D790] and uses units of force per area.

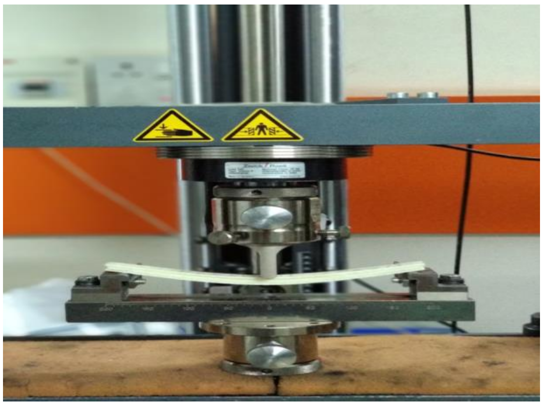

Figure 8. Flexural Test Machine

IV. RESULTS AND DISCUSSIONS

The test was conducted using Flexural testing machine. The test specimen was prepared according to ASTM D790 standard.

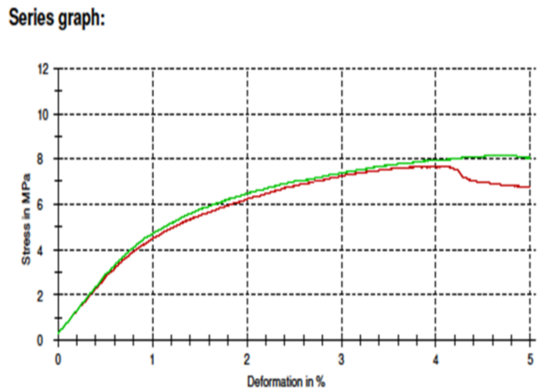

Figure 9. Graphical representation of Stress verses Deformation of 11mm thickness dimension specimen

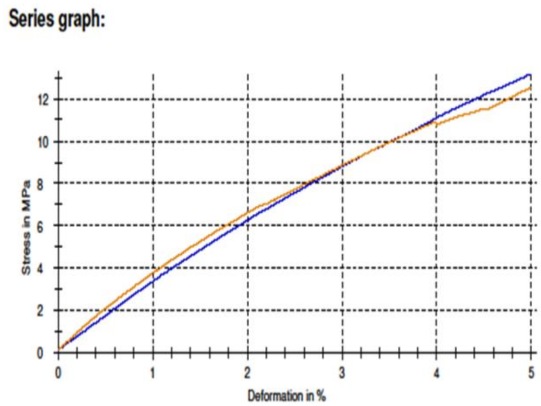

Figure 10. Graphical representation of Stress verses Deformation of 15mm dimension specimen

3-point bending test has been conducted for the prepared sandwich composites of two different thickness which intrpretes the quantitative data recorded when the bending load is applied which is as shown in table.2. Graphical representation of stress aginest deformation for two different thcikness of the samples are shown in figure.9 and 10 respectively which gives out the constructive information where resistance of the core moulded by the polyurethene foam with significant portion of glass fibre and epoxy laminates showcase the greater susciptablity to bending load.

Thickness of the sample

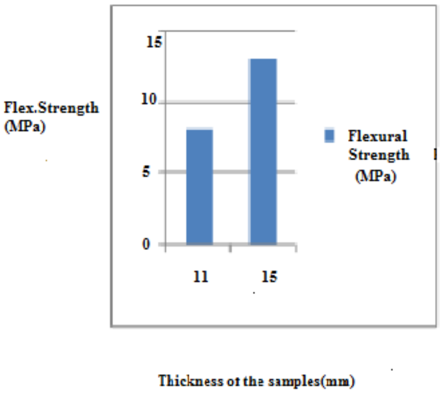

Figure 11. Comparison of flexural strength of two different thicknesses of the specimen.

3-point bending test has been done by using digital UTM for the samples prepared with different thickness to asses the influnece of thickness on the bending strength. It was more obevous that increase in core thickness will pottentially rise the strength of the composites where deflection of samples aginest loading is noted negligibly and it was concluded that that there is 61.56% increase in the flexural strength with the increase in the thickness of the sandwich composites.

V. CONCLUSION

In this study, an experimental investigation has been conducted to evaluate the 3-point bending properties of sandwiched composite of Fiberglass and polyurethane with different thickness. The following main conclusions can be drawn from this study:

- The successful fabrication of sandwiched composite of Fiber glass and polyurethane foam of different thickness has been done by simple hand lay-up technique.
- The present work modifies the mechanical properties of composites as the sandwiched composite performs comparatively better than other type of composites.
- Compared with respect to different thickness of composites, the composites of higher thickness shows greater mechanical properties compared to the thin ones.
- The flexural test results shows that about 61.56% increase bending strength of the samples which shows promising values for the increased thickness.

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