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Preparation and Tensile Strength Evaluation of Synthetic Fibers Sandwiched with Foam Structures

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Abstract - *Glass fiber reinforced polymer plastics are widely employed in many commercial application pertaining to automotive industry due to advantages such as low weight, ease of processing, price and noise suppression. Composite materials play a vital role in many industrial applications. Researchers are working on fabrication of new composites materials worldwide to enhance the applicability of these materials. 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 and 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. Compared with respect to different thickness of composites, the composites of higher thickness shows greater mechanical properties compared to the thin ones. At higher load the tensile strength is appraisable and also with greater resistance is offered to the tensile load*.

***Key Words*: sandwich composites, core thickness, tensile modulus.**

1. INTRODUCTION

Light weight structures play a vital role present condition which aims to represent the versatile aspects of aerospace 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.

2. 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. Glass fibers are 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 [8].chopped strand Mat fibre used for the present study is as shown in figure.1

Fig.1: Chopped strand mat fiber glass

Glass fibers are 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. 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. 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.

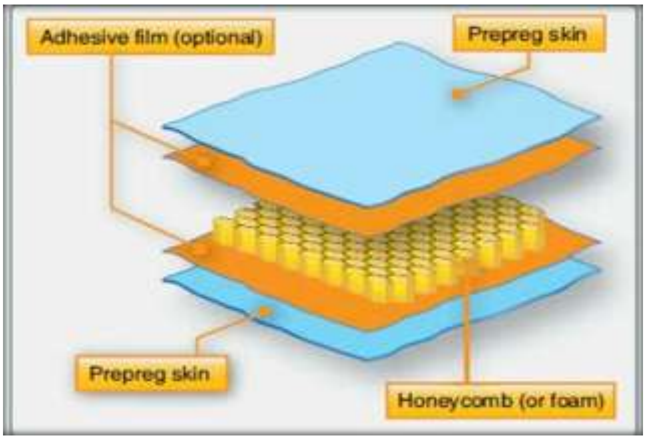

Fig.2: Sandwich structure

Polyurethane insulation is lightweight but strong, with a density ranging between 30 kg/m^3 and 100 kg/m^3 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/m^3.Even at low densities, polyurethane keeps excellent mechanical properties such as compressive stress, compressive strength and creep.

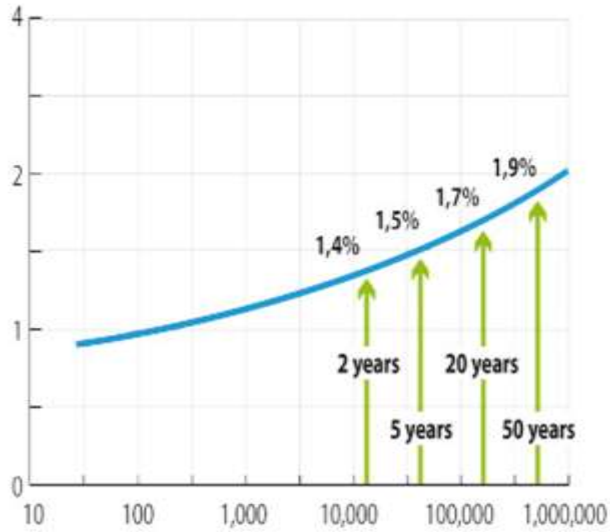

Fig.3: Deformation of Polyurethane foam with respect to time

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. Most epoxies are slower in curing, and more unforgiving in relation to proportions of resins and hardener than polyesters.

Fig.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.

3. 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.

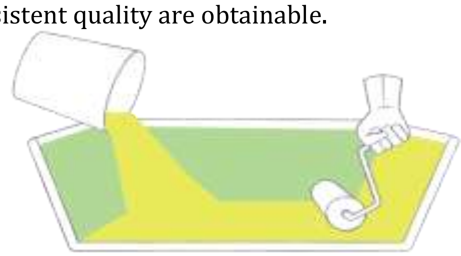

Fig.5 : Hand Lay-up Process

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.

Fig.6 : Prepared Sample thickness 11mm & 15mm

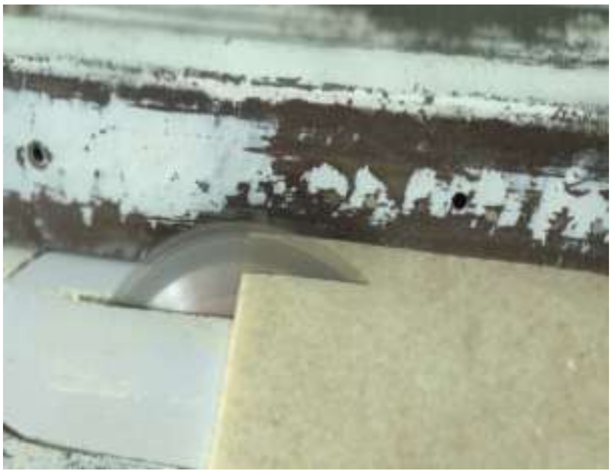

Fig.7 : Material has been cut into required Dimension

TENSILE TEST

The prime aspect of structural material is to assess the ultimate tensile strength by using digital testing machine. Testing of the sample is done according to ASTM standards. Testing of sample could be done in a controlled tension until failure. Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics. Uniaxial tensile testing is the most commonly used for obtaining the mechanical characteristics of isotropic materials. Some materials use biaxial tensile testing.

The most common testing machine used in tensile testing is the universal testing machine. This type of machine has two crossheads; one is adjusted for the length of the specimen and the other is driven to apply tension to the test specimen. There are two types: hydraulic powered and electromagnetically powered machines. The machine must have the proper capabilities for the test specimen being tested. There are four main parameters: force capacity, speed, precision and accuracy. Force capacity refers to the fact that the machine must be able to generate enough force to fracture the specimen. The machine must be able to apply the force quickly or slowly enough to properly mimic the actual application. Finally, the machine must be able to accurately and precisely measure the gauge length and forces applied; for instance, a large machine that is designed to measure long elongations may not work with a brittle material that experiences short elongations prior to fracturing. One material property that is widely used and recognized is the strength of a material. But what does the word strength can have many meanings, so let us take a closer look at what is meant by the strength of a material. We will look at a very easy experiment that provides lots of information about the strength or the mechanical behavior of a material, called the tensile test. The basic idea of a tensile test is to place a sample of a material between two fixtures called grips which clamp the material. The material has known dimensions, like length and cross-sectional area. We then begin to apply weight to the material gripped at one end while the other end is fixed. We keep increasing the weight (often called the load or force) while at the same time measuring the change in length of the sample.

Figure.8: Tensile Testing of Specimen

4. RESULTS AND DISCUSSIONS

Specimen according to ASTM D3039 Standard.

Table.2: Different parameters of Tensile test of 10mm thickness dimension specimen

Legends	Specimen number	F_{max} (in n)	Tensile strength Mpa	Strain@break (in%)	Thickness (in mm)
	1	12240	60.8	13.3	10
	2	15132	70.9	11.9	10

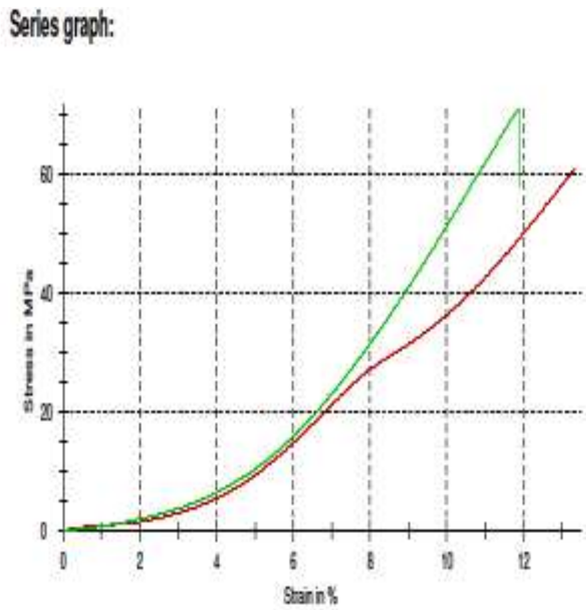

Figure.9 Graphical representation of Stress verses Strain of 10 mm Dimension specimen

Table.3: Force v/s Tensile strength for 11mm thick specimen

Specimen number	Force (in Newton)	Tensile Strength (in MPa)
1	12240	60.8
2	15132	70.9

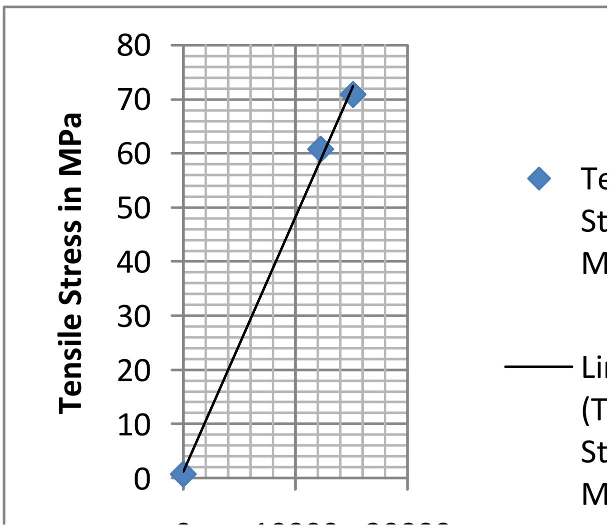

Figure.10 Graphical representation of Tensile strength verses Force

Experimental observations have been made to assess the tensile behavior of chopped strand mat sandwiched composite specimens. Table.2 and Table.3 show the recorded values upon testing of samples with thickness of 10 mm and 11 mm respectively. Figure.9 depicts the graphical representation of stress verses Strain which highlights the tensile experimental behavior of samples tested. It is observed that the tensile stress of the specimen is better compared to the load applied to the specimen on longitudinal axis. Figure.10 depicts the tensile strength of the composites against force applied. It is also clearly noticed that increase in thickness leads to increase in resistance to tensile loading of the samples experimented under room temperature conditions.

5. CONCLUSION

In this study, an experimental evaluation of tensile behavior of sandwiched composite prepared with CSM fiber glass and polyurethane foam with different thickness. The following main conclusions can be drawn from this study:

- Prepared sandwiched composite made of chopped glass fibre and polyurethane foam of different thickness has been done by simple hand lay-up technique.
- The modified thickness influence greatly on mechanical properties of sandwich composites to recommend them as light weight structures
- Compared with respect to different thickness of composites, the composites of higher thickness shows greater resistance to tensile loading.
- At higher load the tensile strength is appraisable and also with greater resistance is offered to the tensile load.

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