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Mechanical Characterization of Synthetic and Bio Fiber Reinforced Polyester Composites

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Abstract: The composite manufacturing has been a wide area of research and it is the preferred choice due to its superior properties like low density, stiffness, light weight and possesses better mechanical properties. This has found its wide range applications in aerospace, automotive, marine and sporting industries. There has been continuous lookout for synthesizing composites without compromising on the mechanical and physical properties. In this research, fiber reinforced composites were prepared using synthetic and bio fiber with polyester as reinforcement. The composites were synthesized at 60:40 fiber-resin weight percentages. The prepared composites were tested to study the mechanical properties of the composite such as tensile strength, flexural strength and interlaminar shear strength [ILSS].

Keywords: Synthetic fibre, Bio fibre, Polyester, Interlaminar shear strength [ILSS]

I INTRODUCTION

Composites are engineering materials made up of two or more constituents to form a single bulk mass. There are number of options for matrix and reinforcing materials and they can be mixed in different combinations, ratios, and directions to obtain a composite material with desired properties. FRP's are most frequently used in aircraft and structural and automotive application hence, damage tolerance and damage resistance are more important feature under impact loading. In order to produce an optimized design, it is essential to evaluate finished material for its properties like, tensile strength, flexural strength, impact resistance and interlaminar shear strength (ILSS).

II SELECTION OF MATERIALS

A. GLASS FIBRE

The transportation, aerospace and defence segments occupy the topmost positions in the glass fibre reinforced plastic composites market with 49% share by value in 2013. The light weight, strength, and corrosion resistant properties of glass fibre drive its growth in transportation, construction & infrastructure, electrical & electronics, consumer goods, marine, aerospace & defence, and wind energy segments. The factors responsible for the growing demand of glass fibre industry are the recovery in the global economy and improving prospects in various end-use markets. Since glass fibre composites are reliable, versatile, light weight, and cost-effective, the demand of GFRP Composites is higher. The enormous potential in the Asian countries, particularly China and India, is likely to foster further growth of the glass fibre market [1].

B. JUTE FIBRE

Natural fibre has attracted worldwide attention as potential reinforcement for composites because of their easy availability, easy process ability, Low Density, Light weight, Non abrasively, and lower cost and above all eco-friendly characteristics. In the present work, jute fibre was used as the reinforcing material since it is produced in large scale in Indian Sub-continent, especially Bangladesh and has a minimal effect on the environment because of their biodegradable properties. Jute is the cheapest lignocelluloses long vegetable best fibre and abundantly available in Bangladesh. It is traditionally used for making hessian clothes, ropes, gunny and shopping bags, floor mats etc. One of the major drawbacks of using Jute fibre as reinforcing material is its hydrophilic nature, responsible for moisture absorption and consequent deformation of the product. Several researchers have conducted chemical treatment of jute fibre to improve its hydrophilic nature and the mechanical properties [2].

C. POLYESTER RESIN

All India Plastics Manufacturer's Association (AIPMA), the domestic polymer consumption showed a healthy growth at 10%-12% CAGR over the past decade. "Unsaturated polyester resin market by product segments for pipes and tanks, electrical, building and construction, transport, marine, artificial stones and other end-user segments. The increase of building and construction industry in China and India is expected to be one of the factor driving the demand for unsaturated polyester resin over the next few years.Increasing the application scope of unsaturated polyester resin in the fiberglass market coupled with growing demand for unsaturated polyester is expected to open opportunities for growth of the market over the next few years.

III FABRICATION AND EXPERIMENTAL WORK

To conduct experimental work test specimens are prepared with 60% volume fraction of glass and jute fibre reinforced with ployester resin using hand layup technique.

A. HAND LAY-UP PROCESS

Hand layup technique was used for fabrication of woven fiber mat (E-glass, Jute) reinforced polyester laminate. The schematic form of hand layup technique is as shown in Fig.1. Mould was cleaned using acetone, allowed to dry and a thin layer of releasing agent (Polyvinyl acetylene) was applied on the mould because it is easier to remove the laminate after cured. At the same time woven fabric was cut to the required size (300×300 mm^2). Polyester resin was prepared by mixing accelerator (Cobalt) and catalyst (Methyl Ethyl Ketone Peroxide (MEKP) of 2% each. Once a layer of resin was applied on the mould using bristle brush, woven roving (0.45mm) placed on it and it was continues until all layers. The layers are consolidated and air bubbles are removed by squeezing using the hand roller. Finally top of the mould was closed and allowed to cure for 24 hours. After laminate preparation test specimens are cut into required dimensions as per ASTM standards.

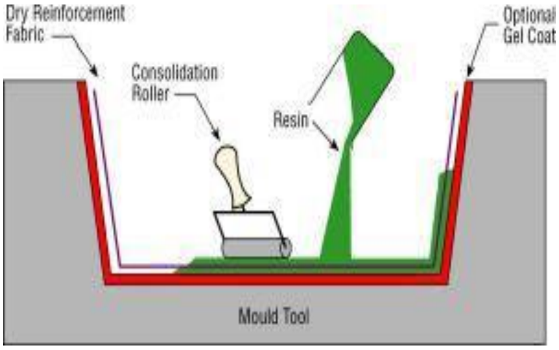

Fig. 1 Hand Lay-up Technique

B. TENSILE TEST

The tensile properties of the bidirectional composite specimens are determined by a series of tensile test in accordance with the ASTM D3039 test standard. A tensile test is done by mounting the specimen in the universal testing machine (UTM) and tension was continuously applied until fracture. Tensile force was recorded as a function of increase in gauge length. The longitudinal tensile strengths and young’s modulus are determined without strain gauge bonded.
The prepared test samples are shown in Fig. 2.

Fig. 2 Tensile Test Specimens

C. FLEXURAL TEST

The flexural coupons are preferred as per the ASTM D790.The shape of the specimens were rectangular having different dimension according to thickness. The depth to span ratio maintained to 1:16. Flexural test is performed on kalpak universal testing machine of 10 tonne capacity. Flexural test conducted using three point bend fixture and the cross head speed was set to 1.3mm/min. Force and deflection history are obtained by computer controlled UTM.. The geometry and dimension of the specimen is shown in fig.3.

Fig. 3 Flexural Test Specimens

D. INTERLAMINAR SHEAR STRENGTH TEST

The interlaminar shear strength test is performed according to ASTM D3846 to measure the interlaminar shear strength of composites. ILSS test is conducted using universal testing machine of 10 ton capacity. This test provides the shear strength between the laminas of the composite material. The test was conducted in compression mode and specimen is placed between the fixtures to restrict the buckling.

Fig. 4 ILSS Test Specimens

IV RESULTS AND DISCUSSIONS

A. TENSILE PROPERTIES

Woven glass and jute fiber reinforced polyester matrix specimens were tested according to test procedure described in the section (3.2). Ultimate tensile strength (UTS), modulus of elasticity (E) and tensile fracture energy is determined from the test and tabulated in table.1. The load carried by 6 mm thick glass/polyester composite shown maximum than 2 mm thick specimens, but tensile strength for both specimen thicknesses is applicably same. Jute/polyester also follows the same in first condition but comparing the tensile strength 2 mm thick, 11.18% greater. The strain was found to be more in 6 mm thick specimens of both materials.

Table 1: Modulus of Elasticity and UTS of specimens

Material	t in (mm)	E (GPa)	UTS(N/mm^2)
GFRP	2	25.66	381.64
GFRP	6	24.37	381.81
JFRP	2	6.25	51.79
JFRP	6	4.16	46.58

B. FLEXURAL PROPERTIES

Under the flexural loading condition top layer under compression and bottom layer under tension, failure begins at the tension side of the specimen. Failure occurs due to matrix cracking, fiber breakage and delamination at the compression side. The flexural strength and strain has been calculated and results are tabulated in Table 2. The maximum load and deflection is obtained by load history graph obtained during the experiment.

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Table 2: Flexural Strain and Flexural Strength of specimens

Material	Thickness (mm)	Flexural strain in %	Flexural Strength (MPa)
GFRP	2	2.43	648.30
GFRP	6	2.27	613.56
JFRP	2	2.36	131.89
JFRP	6	3.09	121.45

C. INTERLAMINAR SHEAR STRENGTH PROPERTIES

The shear properties of bidirectional woven fabric material were tested for ILSS. To determine ILSS of composite specimens were tested according to the ASTM D3846-02. ILSS of glass/polyester is 14 % greater than jute/polyester for same thickness. The debonding between the layers is due to mode II shear loading. The specimens were failed between the two mid layers. The compressive load carried by the GFRP (4207 N) composite and JFRP (3859 N) composite is almost equal. From this it was come to known that, ILSS is depends on matrix material rather than fiber.

Table 3: Maximum Load and Interlaminar shear Strength of specimens

Material	Thickness (mm)	Max. Load(N)	ILS Strength (MPa)
GFRP	6	4207	38.66
JFRP	6	3859	33.70

V CONCLUSION

The experimental results leads to the conclusion that synthetic fibre (E-glass) reinforced polyester composites (GFRP) are better than jute reinforced polyester composites. But JFRP can also be used as replacement for GFRP composites when strength required is low, because JFRP composites are biodegradable in nature, comparatively cheaper and produce good results. Interlaminar strength of both GFRP and JFRP are almost same.

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BIOGRAPHIES

Thyagaraj N R, Graduated in BE (Mechanical Engineering) and M.Tech from SJCIT, Chickkballapur. I have 8 years of teaching experience and also in research field from past 3years. The area research work is fibre reinforced composites.

Dr. N Chickkanna Graduated in BE (Mechanical Engineering) from SIT Tumkur, completed ME and PhD from UVCE Bangalore and served in different engineering colleges in various capacities and have proven record of accomplishment of valuable service in teaching and research.