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Fabrication & Material Characterization of Natural Fibre Reinforced Composite for Helmet Application

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Abstract: Bio composite materials which have attracted the attention of researchers due to their low density with high specific mechanical strengths i.e. strength to weight ratio, availability, renewability, degradable and being environmental-friendly. This has found its wide range applications in aerospace, automotive, marine and sporting industries. The present work attempts to find an alternative to the current existing use of helmet materials in order to obtain better mechanical properties & to optimize the costs in manufacturing the mould of a helmet. In this project, fibre reinforced composites were prepared using epoxy as resin and flax as reinforcement with the addition of a hardener Araldite (HY951). The composites were synthesized at 1:5 fibre-resin weight ratios. The prepared composites were tested to study the mechanical properties of the composite such as tensile strength, flexural strength and impact strength. The results were compared to those obtained from glass fibre reinforced epoxy composites.

Keywords: Natural fibre, Flax fibre, Epoxy, Araldite.

I INTRODUCTION

According to the 2015 data from savelifefoundation.org, a two-wheeler rider is the most at risk of being killed in a road accident. The number of people killed in crashes involving two-wheelers was 36,803 in 1, 44,391 incidents. 31.5 per cent of the people killed in road accidents were on two-wheelers, which is more than in any other mode of transport. One of the main reasons of these accidents is due to the lack of good quality helmets at cheaper rates. Another reason is that motorcyclists refuse to wear helmets due to its lack of comfort due to its weight. 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, and impact resistance.

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. FLAX 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, flax fibre was used as the reinforcing material since it has a minimal effect on the environment because of their biodegradable properties. Flax fibres are taken from the stem of the plant, and are two to three times as strong as those of cotton. Additionally, flax fibres are naturally smooth and straight. The use of flax fibres dates back tens of thousands of years and linen, a refined textile made from flax fibres was worn widely by Sumerian priests more than 4,000 years ago. Industrial-scale flax fibre processing existed in antiquity.

C. EPOXY RESIN

Epoxy is a thermosetting matrix resin and among the most commonly used resin systems in the composites industry. It's frequently used with continuous carbon fibre in aerospace, race car, marine and other high-performance applications. Epoxies are best known for their excellent adhesion, chemical and heat resistance, mechanical properties, and outstanding electrical insulating properties. The chemical resistance of epoxies is excellent against basic solutions (best choice for brine tanks).

Epoxies are more expensive than polyesters, and cure times are longer, but their extended range of properties can make them the cost/performance choice for critical applications. The epoxy resins are formed by a reaction of an epoxide (like epichlorohydrin) with a hardener or polyamine (like triethylenetetramine) that has tremendous cross-linking to create a very tough and yet stiff polymer. The viscosity of epoxies is another step higher than polyesters or vinyl esters. Most epoxies start in the range of 900 centipoise. Attributes of epoxy resins include extremely low shrinkage, good dimensional stability, high temperature resistance, good fatigue and adherence to reinforcements. It adheres well to all reinforcements.

III FABRICATION AND EXPERIMENTAL WORK

To conduct the experiment three types of work test specimens are prepared. All specimens have 16% weight percentage of flax fibre reinforced with 76% weight percentage of epoxy resin including 8% of Araldite hardener. The first type has flax fibres chopped to 2.54cm each. The second type has flax fibres of length 30cm each. The third type has flax fibres of length 30cm each sandwiched between to sheets of glass fibre. The laminates are made by hand lay-up process.

A. HAND LAY-UP PROCESS

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.

Epoxy resin was prepared by mixing hardener (Araldite). Once a layer of resin was applied on the mould using bristle brush, Flax fibres were placed on it and the process was repeated for all three types of specimens. 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 the laminates are prepared, test specimens are cut into required dimensions as per ASTM standards.

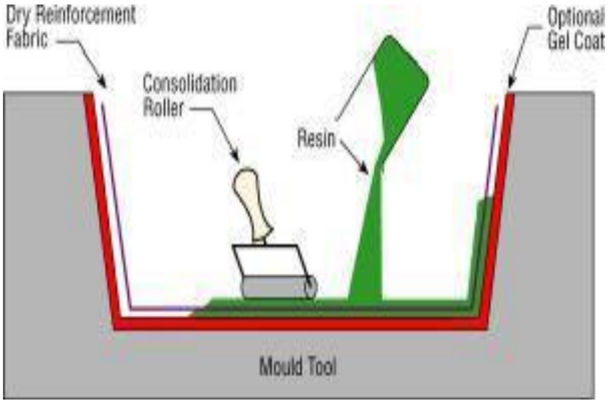

Fig.1. Hand Lay-up Technique

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.

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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. IMPACT TEST

Impact tests are designed to measure the resistance to failure of a material to a suddenly applied force. The test measures the impact energy, or the energy absorbed prior to fracture. In this project, we carry out the Charpy test.

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While most commonly used on metals, it is also used on polymers, ceramics and composites. The Charpy test is most commonly used to evaluate the relative toughness or impact toughness of materials and as such is often used in quality control applications where it is a fast and economical test. Charpy test specimens normally measure 55x10x10mm and have a notch machined across one of the larger faces. The V-shaped notch is 2mm deep, with 45° angle and 0.25mm radius along the base.

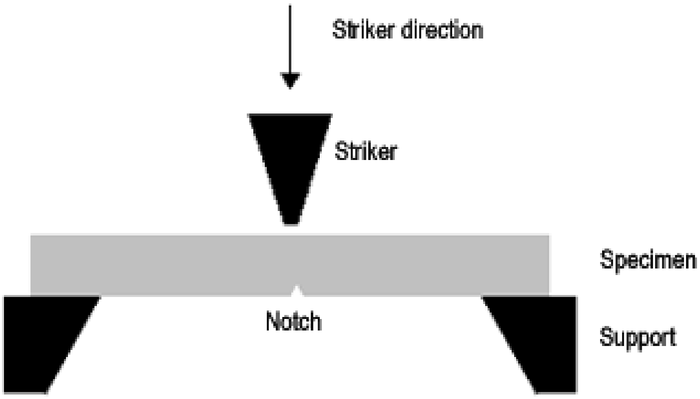

Fig.4. Schematic of the Charpy impact test

IV RESULTS AND DISCUSSIONS

A. TENSILE PROPERTIES

The 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 140 mm^2 cross section glass-flax/epoxy composite showed maximum than the other two specimens, but tensile strength for both specimen thicknesses is applicably same.

From the readings obtained it is seen that flax-glass fibre composites have highest ultimate tensile strength among all other specimens. The readings are tabulated below.

Table 1: Modulus of Elasticity and UTS of specimens

Material	CS Area (mm^2)	E (MPa)	UTS(MPa)
FG2	140	13672.32	149.31
FL1	120	3986.50	26.65
FC1	100	3709.74	9.35

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.

Table 2: Flexural Moduli and Flexural Strength of specimens

Material	CS Area(mm^2)	Flexural Moduli (GPa)	Flexural Strength (MPa)
FC1	120	4505.79	25.08
FL2	120	2134.84	62.28
FG1	140	1966.84	37.61

C. IMPACT PROPERTIES

Impact tests were carried out as stated above. It was found that flax and glass fibre composites could absorb more energy before fracture. Also energy absorbed by long flax fibres are more than that of chopped flax fibres. The values of energy absorbed by each specimen are tabulated below.

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Table 3: Maximum Load and Interlaminar shear Strength of specimens

Material	Thickness (mm)	Energy Absorbed(J)	Impact Strength (J/mm^2)
FC4	10.9	2	0.0327
FL3	10.3	6	0.0939
FG4	11.7	10	0.111

V CONCLUSION

The experimental results lead to the conclusion that flax-glass fibre reinforced epoxy composites are better than flax reinforced epoxy composites. But flax can also be used as replacement for flax-glass fibre composites when strength required is low, because flax composites are biodegradable in nature, comparatively cheaper and produce good results.

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