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STUDIES ON TENSILE PROPERTIES OF JUTE – E GLASS EPOXY HYBRID COMPOSITE

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Abstract: Over the last twenty to thirty years composite materials has been used in engineering field. Composite materials possess high strength and high strength to weight ratio, and due to these facts composite materials are becoming popular among researchers and scientists. The major proportion of engineering materials consists of composite materials. Composite materials are used in vast applications ranging from day-to-day household articles to highly sophisticated applications.

In this present investigation hybrid composites of Epoxy/Nano clay/Glass fiber are prepared by Hand-layup technique. The glass fiber used in this present investigation is E-glass fiber bi-directional: 45° orientation). The composite samples are made in the form of a plate. The wt% of nanoclay added in the preparation of sample was varied, ranging from 1wt% to 5wt%. The fabricated composite materials were cut into corresponding profiles as per standards for tensile testing.

Keywords: Jute, Hemp, E-Glass and Tensile

I. INTRODUCTION

A composite material generally consists of relatively strong fibers in a tough resin resin matrix.Wood and bone are the examples of natural composite materials. Cellulose fibers are found in wood in lignin matrix while bone contains hydroxyapatite particles in a collagen matrix. Composite material has the main advantage of formability into more complex shapes than their metallic counterparts. Use of composite material reduces the number of parts making up a given component and also reduces the need for fasteners and joints which may otherwise weaken the component.

There is a significant growth in the use of bio composites in the automotive and decking markets over the past one decade. Sustainability, green chemistry and industrial ecology are driving the automotive industry to seek alternative, Eco-friendly materials for automotive applications. Materials from renewable sources are sought to replace not only the reinforcement element but also the matrix plane of composite materials, to overcome the sustainability issues associated with using synthetic materials in composites.

The use of natural fibers with polymers based on renewable resources resolve many environmental related issues. The natural fibers such as flax, jute, hemp and sisal have received considerable attention as an environmentally friendly alternative for the use of glass and synthetic fibers in composites materials. The amount of energy needed and also the cost of production will be lesser than that of glass fibers.

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II. EXPERIMENTATION

2.1 Material Selection

The raw materials used in present research work are:

1. Jute/Hemp fibre (+or -90* orientation)
2. E Glass fibre (+or- 90*orientation)
3. Epoxy Resin (0.5 grade)
4. Hardener (951grade)
5. Bentonite nano clay (200 mesh size)

2.1.1 Hemp fiber: Hemp or industrial hemp typically found in the northern hemisphere, is a variety of the Cannabis sativa plant species that is grown specifically for the industrial uses of its derived products. It is one of the fastest growing plants and was one of the first plants to be spun into usable fiber 10,000 years ago. It can be refined into a variety of commercial items including paper, textiles, clothing, biodegradable plastics, paint, insulation, biofuel, food, and animal feed.

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Fig 1: Hemp field

A mixture of fiber glass, hemp fiber, kenaf, and flax has been used since 2002 to make composite panels for automobiles. The choice of which best fiber to use is primarily based on cost and availability. Various car makers are beginning to use hemp in their cars, including Audi, BMW, Ford, GM, Chrysler, Honda, Iveco, Lotus, Mercedes, Mitsubishi, Porsche Saturn, Volkswagen and Volvo. For example, the Lotus Eco Elise and the Mercedes C-Class both contain hemp (up to 20 kg in each car in the case of the latter).

Fig 2: Hemp stems showing fibers

2.1.2 Epoxy Resin: The large family of epoxy resins contains some of the highest performance resins available at this time. The generic term epoxy resin describes a class of thermosetting resins prepared by the ring-opening polymerization of compounds containing an average of more than one epoxy group per molecule.

2.1.3 E-Glass fiber: E glass fiber reinforced epoxy composites without filler (Resin and Fiber): The mechanical properties of the E-glass fiber reinforced epoxy composites without filler with different fiber loading/test under this investigation are presented as follows, glass fibers are most commonly used fibers. Physical properties of glass fiber are listed in table.

TABLE I PHYSICAL PROPERTIES OF GLASS FIBER

Properties	**Glass fiber**
GSM	360gm
ORIENTATION	Plane woven fabric
UTS	40Gpa
MODULUS	1.0Gpa
DENSITY	1.9g/cc

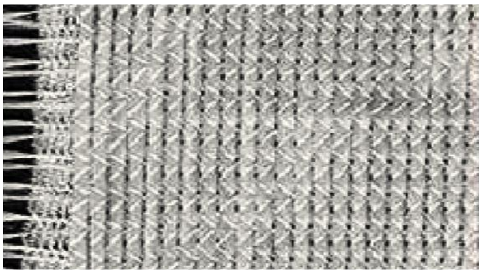

Fig 3: Glass Fiber

2.1.4 Jute fibers: Jute fibers are very suitable replacements for a variety of fossil-based materials. In this study, 19 fossil-based applications are compared to their JUTE-based alternatives regarding the environmental impacts on climate change and primary energy use. The products are compared based on their functionality and based on a unit of area.
Both approaches are crucial for the comparison and improvement of products. Not only the use of fossil fuels but also the use of land will become a limiting factor in the future. The use of JUTE fibers requires land for the cultivation of JUTE. However, land is not limitlessly available, instead demand for it is growing and land use efficiency will be an increasingly important factor as competition rises for food, feed energy, materials, urban areas and protected natural zones.

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The Jute used in this study was produced in the Hubei province of China. Table and Figure shows the chemical composition and bundle of the Jute fibers, respectively. This composition plays an important role in influencing the characteristic of the fibers. Hence, the composition may affect the properties of the composites. The fibers were washed with water to remove dust and ash. Then, the JUTE fibers were sterilized in boiling distilled water in an oven maintained at 100 ℃ for 1 h. After these processes, the fibers were rinsed in tap water and then dried in an oven at 70 ℃ for 12 h. The total length of the fibers was about 2,500 mm and they were cut into short fibers, 510 mm in length, by scissors.

Fig 4**:** Jute fiber

For the extraction of Jute fibers the field-retted and dried Jute straw is separated in a fibre decortications plant into fibers and shives. The fibers are treated depending on the intended application. The extraction of long fibers mostly used for the manufacture of textiles requires more care and is time-consuming. Jute is the second most important vegetable fibre after cotton; not only for cultivation, but also for various uses. Jute is used chiefly to make cloth for wrapping bales of raw cotton, and to make sacks and coarse cloth.

2.1.5 Nano clay: Bentonite nano clay is used as a filler material in order to increase the bonding strength between the glass and fiber reinforcement in order to enhance the mechanical properties.

2.2 Fabrication Methods

The fabrications of composite slabs are carried out by conventional hand layup technique. The bi-directional Jute fibre and the E-glass fibers are used as reinforcement and epoxy is taken as matrix material. E-glass fibers are obtained from Saint Gobian Ltd. The epoxy resin and the corresponding hardener are supplied by Ciba Geigy India Limited. The low temperature curing epoxy resin and hardener are mixed in a ratio of 10:1 by weight percentage.

Fig 5: Bidirectional Jute fiber

Composites of different compositions with three different fiber loading (30wt%, 50wt% and 70wt%) and three different fiber orientations(90^0) are made. Figures show bi- directional Jute fiber and glass fiber respectively. Similarly, Figure shows Jute/glass fiber reinforced epoxy hybrid composite. The detailed composition and designation of the composites are presented in Table. The cast of each composite is cured under a load of about 50kg for 24hours. Finally, the specimens of suitable dimension are cut with the help of hack saw for characterization and testing.

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Fig 6: Glass fiber

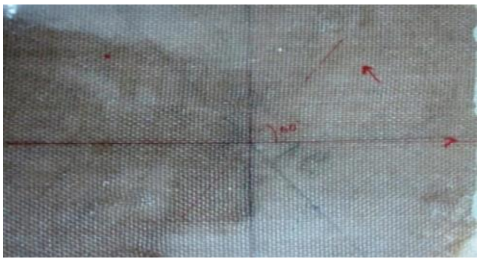

Fig 7: Bidirectional Jute/Hemp Glass fibre reinforced hybrid composites

The designation of the composites is shown in the below table.

TABLE II DESIGNATION OF COMPOSITES

Composites	Stacking Sequence	Compositions
C1	GJJJJG	Glass (30%) +Jute(70%)
C2	GJGJGJG	Glass(50%)+Jute(50%)
C3	GGJGGJGG	Glass(70%)+Jute(30%)

2.3 Hand Lay-up Technique

Hand lay-up is a simple method for composite production shown in figure. The laminates can be as simple as a flat sheet or have infinite curves and edges. For some shapes, laminates must be joined in sections so they can be taken apart for part removal after curing. Before lay-up, the laminates are prepared with a release agent to ensure that the part will not adhere to the laminate Reinforcement fibers can be cut and laid in the mould. It is up to the designer to organize the type, amount and direction of the fibers being used. Resin must then be catalyzed and added to the fibers. A brush, roller or squeegee can be used to impregnate the fibers with the resin.

The lay-up technician is responsible for controlling the amount of resin and the quality of saturation. Resins are impregnated by hand into fibers, which are in the form of woven, knitted, stitched or bonded fabrics. The fiber is positioned in or on the mould by hand. If the mould is a complex shape small pieces of mat are cut to fit and then more layers applied to achieve the required thickness. The liquid resin is poured over the fiber and rolled to ensure complete wetting of the fiber and removal of air bubbles. In general, the whole assembly was kept in a vacuum bagging of 300 MPa and allowed the resin to cure at room temperature with the use of an accelerator and a catalyst for a day. If a hot cure is used then there is no need to use an accelerator. Post curing of cold cured laminates is recommended (1 hours at 100°C or 16 hours at 40°C depending on resin manufacturer's instructions).

Prior to application of the fiber and resin, woven jute, hemp and kevlar fabric was placed on a Teflon sheet over which the epoxy resin mixed with hardener in the ratio 100:10 by weight. To ensure uniform thickness of the samples, a 3mm spacer was used. The laminate is prepared with either polyvinyl alcohol or non-silicon wax to aid release of the component. Release of the component is achieved by either tapping wedges between laminate and component or by the use of compressed air to gently force the pieces apart.

2.4 Preparation of Composite Test Samples

A mould of size 200 mm×200 mm× 3 mm was prepared using mild steel plates. Interior surfaces of the moulds were finely polished and chrome plated. All the surfaces of the moulds were layered with Teflon sheet. The part coming in contact with surface of the composite to be cast, were smeared with a uniform layer of silicone releasing agent in order to facilitate the release of the composite slab. The bi-directional carbon fabric (diameter 6–8 µm) 71 reinforced with the LY556 Epoxy resin matrix materials, added with HY951 room temperature curing hardener and diluents DY021 (all supplied by Hindustan Ciba Giegy) have been considered for panel fabrication. Ten layers of fabric were used to obtain

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about 3 mm thick laminates. Particulate-filled carbon fabric-reinforced epoxy composite was prepared by hand lay-up procedure, followed by compression moulding. The filler material used is SiC powder of size 5–10 μm. The SiC filler was treated with 2% organo-reactive silane coupling agent.

TABLE III ASTM STANDARD FOR DIFFERENT TESTS

Test	ASTM standards
Tensile	ASTM-D3039
Flexural	ASTM-D790

2.5 Experimental Set-Up

2.5.1 Tensile Test :

The tensile test generally performed on flat specimen. Tensile test of composite sample is carried out in ASTMD3039-76 test standard. In tensile test, a uniaxial load was applied through both the ends. The tensile test specimen of bidirectional Jute/glass fibre reinforced epoxy hybrid composites is shown in Figures. Figures show the experimental set up and loading arrangement of specimen for tensile test.

Fig 8: Tensile test specimen of Jute/Hemp/glass fiber reinforced epoxy composites(photography)

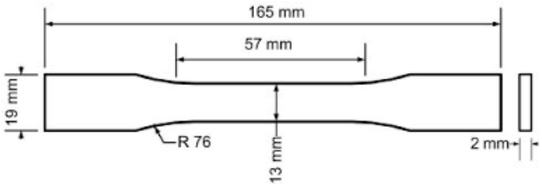

Fig 9: Tensile test specimen of Jute/Hemp/glass fiber reinforced epoxy composites(diagram)

Fig 10: Experimental set up of specimen for tensile strength test

Fig 11: Loading arrangement of specimen for tensile strength test

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2.5.1 Flexural and Inter-laminar shear Test

Flexural test is to determine the capability of a material to withstand the bending before reaching the breaking point. This test is done on a three-point bend test using Instron1195.

Fig 12: Experimental setup of the specimens for flexural test

Inter-laminar Shear test is also performed on the same equipment. A span of 40mm was taken and cross head speed was maintained at 2mm/min. Figures shows the experimental set up and loading arrangement of the specimens for flexural test respectively.

Fig 13: Loading arrangement of the specimens for flexural test

III. RESULT AND DISCUSSION

3.1 Effect of Fiber Loading and Orientation on Tensile Properties of Composites

The influence of fiber loading and fiber orientation on the tensile strength and tensile modulus of the composites is shown in Tables. It is evident from the Tables the tensile strength of the composites decreases with increase in fiber loading and orientation. This is because of poor adhesion between fiber and matrix. The maximum tensile strength is observed for composite with 30wt% fiber loading and + or - 90° fiber orientations. Similar trend of maximum tensile strength at 30wt% fiber loading and 15° fiber orientation is observed by previous researchers & fellowships.

3.2 Tensile Test

The material is cut into specimens with dimensions 120mm x 13mm x 3mm and a notch was made at the centre of the specimen at 45 degrees angle for tensile testing as per ASTMD638-10 specifications. The tensile strength of the specimen is determined using UTM tensile tester. The samples were tested at a cross head speed of 2 mm/min, using an electronic tensometer, (UTM) supplied by M/s Mikrotech, Pune. India.

The tensile test determines the overall strength of the given object. In a tensile test, the object fitted between two grippers at either end then slowly pulled apart until it breaks. A tensile provides vital information related to a product's durability including yield point, tensile strength and proof stress. Tables show the tensile testing values of glass and Jute/hemp fibers with bentonite nano clay reinforced epoxy matrix composites respectively.

Fibers are of two types, namely natural fibers and synthetic fibers. Natural fibers such as bamboo, sisal, Jute etc are used as reinforcement and either thermoset or a thermoplastic are used as matrix. Synthetic fibers are polysters, aramide, nylon etc. The fibers may be continuous (long) or discontinuous (short).

The matrix must have a mechanical strength commensurate with that of the reinforcement i.e., both should be compatible. Thus, if a high strength fiber is used as the reinforcement, there is no point using a low strength matrix, which will not transmit stresses efficiently to the reinforcement. The matrix must stand up to the service conditions, viz., temperature, humidity, exposure to ultra-violet environment, exposure to chemical atmosphere, abrasion by dust particles, etc. It should not be toxic and should have a high flash point.

Tensile test among the many mechanical properties of plastic as well as composite materials, tensile properties are probably the most frequently considered, evaluated, and used throughout the industry. These properties are an important

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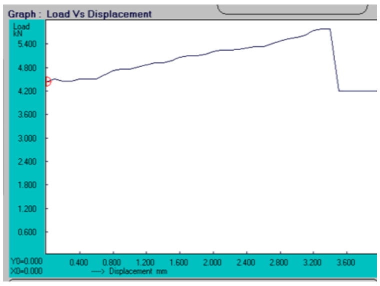
indicator of the material's behavior under loading in tension. Tensile testing provides these useful data: tensile yield strength, tensile strength at break (ultimate tensile strength), tensile modulus (Young's modulus), and elongation at yield and break.

The tensile strength (σ) is given by $\sigma = F/(b*h)$
where F: load b: width of the sample h: thickness of the sample
Strain or elongation is defined as: $E = (\Delta L/L)$
where Δl: is the extension L: the initial gauge length

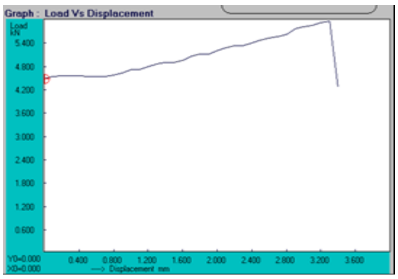
The Young's modulus in tension (Et) is the slope of the stress vs. strain curve evaluated at small strains, where the response is linear. Dog-bone shaped specimens with the dimensions of 160 × 10 × 4 mm were used for testing the tensile behaviour of polypropylene composites, injection molded. However, for study epoxy composites, transverse plates with the dimension of 250 × 25 × 2 mm were used. Using the Universal testing machine Zwick 1456, the tensile test was performed according to ISO 527-2.
The use of modeling is reported in some literature in order to predict the mechanical properties of the composites. In our work, models are used to compare the experimental data of the Jute/polypropylene composites with the possible performance expected by these models. An effective use of fiber strength is dependent on both the interfacial adhesion properties and the critical fiber length. The micro-mechanical evaluation was done by using single fiber pull-out test. It is well known that fiber length plays an important role in the mechanical performance of fiber reinforced composites
Properties of the composites with different fiber percentages, 20 gms bentonite nano clay, epoxy at tensile test:
Properties of the composites with different fiber percentages, 20 gms bentonite nano clay, epoxy at tensile test:

TABLE IV PROPERTIES OF COMPOSITES WITH DIFFERENT FIBER PERCENTAGES, 20 GRAMS BENTONITE NANO CLAY, EPOXY AT TENSILE TEST (JUTE AND GLASS FIBER)

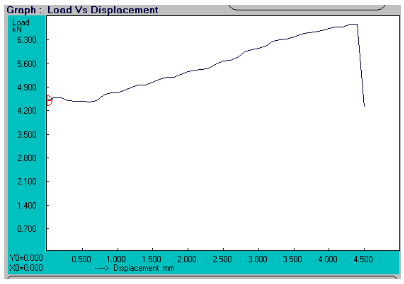
Composition	**Break Load**	**Displacement mm**	**Max Displacement (F max) mm**	**Ultimate stress, KN/sq-mm**	**Elongation, %**	**Yield stress, KN/sq-mm**	**Peak load, KN**
70%J-30%G	4.28	3.3	3.4	0.119	4.25	0.152	5.96
50%J-50%G	4.32	4.3	4.5	0.225	5.625	0.113	6.76
30%J-70%G	4.2	3.3	4.0	0.193	5.0	0.150	5.78



70% Jute and 30% Glass Fiber



50% Jute and 50% Glass Fiber



30% Jute and 70% Glass Fiber

TABLE V PROPERTIES OF COMPOSITES WITH DIFFERENT FIBER PERCENTAGES, 20 GRAMS BENTONITE NANO CLAY, EPOXY AT TENSILE TEST (HEMP AND GLASS FIBER)

Composition	**Break Load**	**Displacement mm**	**Max Displacement (F max) mm**	**Ultimate stress, KN/sq-mm**	**Elongation, %**	**Yield stress, KN/sq-mm**	**Peak load, KN**
70%H-30%G	4.32	2.5	2.6	0.189	3.25	0.150	5.68
50%H-50%G	4.26	3.9	4.3	0.206	5.375	0.204	6.180
30%H-70%G	4.42	4.5	5.5	0.267	6.875	0.150	8.020

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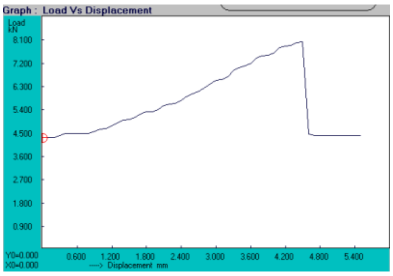
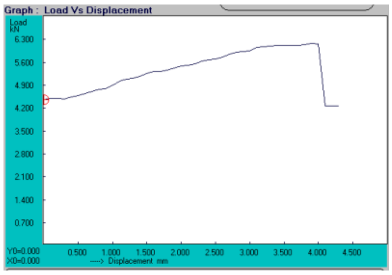
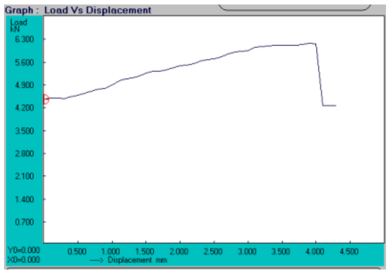


70% Hemp and 30% Glass Fiber



50% Hemp and 50% Glass Fiber



30% Hemp and 70% Glass Fiber

IV. CONCLUSION

Effect of Fiber Loading and Orientation on Tensile Properties of Composites
Tables shows the tensile testing values of glass/jute/hemp fibres with constant 20gm Bentonite nanoclay reinforced epoxy matrix composites respectively. Graphs 1-6 shows the variation of load v/s displacement plots of tensile test for different composite compositions.
From the Tables and Graphs 1-6 it is observed that equal proportion of glass and jute fibres gives better results, this is due to addition of nanoclay & increase or decrease in weight percentage of fiber results in lower or higher impregnation of matrix materials and there are chances of presence of voids and poor wetting of fibres. Thus at higher or lower wt % the displacement is lower or higher respectively.

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