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Mechanical Property Evaluation of Banana Fibre Reinforced Composite

Smitha B S
Assistant Professor, Department of Automobile Engineering, New Horizon College of Engineering, Outer Ring Road, Marathalli, Bengaluru, Karnataka, India

ABSTRACT

Polymeric materials reinforced with synthetic fibres such as glass, carbon and aramid exhibit high stiffness and strength to weight ratio as compared to conventional materials like metals. The potential of using natural fibres as reinforcements in Polymer Matrix Composites (PMC) to replace conventional synthetic fibres in structural applications has been in focus in the recent times. Synthetic fibres are not biodegradable and the manufacturing of synthetic fibres releases harmful emissions to the atmosphere. In the present work PMC with banana fibres as reinforcement in epoxy resin as the matrix and mango fibres as additives has been studied. The specimens are fabricated using the hand lay- up process with different orientation to test the mechanical properties.
Keywords : Fibre reinforced composite, mechanical properties, banana fibre, biodegradable, hand layup

I. INTRODUCTION

Natural Fibre Composites:

Fibre Reinforced Composites (FRC) has an immense scope in various industries. Automobile industry is also dependent on FRC for many parts and body panel. The synthetic fibres like glass, aramid etc., are not biodegradable and also the production process is not environmental friendly process. Therefore many researchers have studied the possibility of using natural fibres like jute, kenaf, hemp etc. to replace the synthetic fibers. The natural fibres are easily available and cost effective. Also they have low density and satisfactory mechanical properties which make them an attractive ecological alternative to man-made fibers used for the manufacturing of composites.

- Natural fibers can be categorized as:
- Animal Fibre
- Mineral Fibre
- Plant Fibre

Plant fibers generally include examples like cotton, jute, flax, ramie, sisal and hemp etc, which are made up of cellulose and are mainly used in the manufacture of paper and cloth. This can be further categorizes as,

- Seed fiber: The fibers that are collected from the seed and seed case, e.g. cotton and kapok.
- Leaf fiber: The fibers that are collected from the leaves e.g. sisal and agave.
- Skin fiber: The fibers that are collected from the skin or the stem of their respective plant.

Plant fibers exhibit high tensile strength as compared to other fibers due to which these fibers are used for

applications such as durable yarn, fabric, packaging etc. Example: flax, jute, banana, hemp, and soybean.
Fruit fiber: The fibres that are collected from the fruit of the plant, e.g. coconut (coir) fiber.

Stalk fiber: The fibres that are actually collected from the stalks. Example: Straws of wheat, rice, barley, bamboo and grass. The natural fibers can be with thermosetting as well as thermoplastic matrices.
Thermosetting resins such as epoxy, polyester, polyurethane, phenolic, etc. are commonly used as a matrix material in natural fiber composites in which composites are required for higher performance applications.

They provide good stiffness and strength properties. New materials based on renewable resources are gaining importance because of the wide spread awareness about the emission of greenhouse effect caused by the gases such as CO2 into the atmosphere and global ill-effects of fossil energy resources.

Banana fibre:

Banana is available in most parts of India, and banana fibre availability is more. The banana fibre is obtained from the stem of a banana tree. After banana is taken from the tree the whole tree is of waste especially the stem. The chemical composition of banana fibre is cellulose, hemicellulose, and lignin. It is a highly strong fibre. It is a very light weight fibre. The hydrogen bonds and other chemical linkages provide necessary strength and stiffness to the fibres. The density of banana fibre is 1300 kg/m3, tensile strength is around 355 MPa, young's modulus is 33.8 GPa and elongation at break is 5.3%. It has a strong moisture absorption quality; it absorbs as well as release moisture very fast.

The stem of the banana tree is in the form of layers. The strength of the fibre varies according to the layer position, as the layers goes towards the centre the strength starts to decrease. Hence, the outer layer has more strength compared to the inner layer. The outer layers are dried for few weeks to take out the moisture present in the stem layers. The dried fibres are twisted for removal of more moisture as well as to reduce the size of the fibre. The thickness of the twisted fibre obtained will be around 1.8mm to 2.1 mm, this fibre is made into a yarn. The fibre yarn is then woven to make sheets. The banana sheets are used in this work because of all the above mentioned properties.

Fig. 1 Raw banana fibers

Mango fibre:

Mango is an abundantly available fruit in several parts of world. Mango fibre is also another natural fibre which has a better strength, environmental friendly, and also is bio-degradable. Mango fibre is extracted out of mango endocarp (mango seeds) after drying the seeds in sunlight for 2-3 days to remove the water content and then they are powered for use as filler. Mango seeds plays a major role for the material strength. The properties that mango seed imparts to composites are high strength to weight ratio, less weight, low cost. The major advantage is that it is a waste product. Once the mango is consumed the seeds are thrown to waste. These waste seeds can be used for manufacturing of composite materials. It can be used as particles or can be powdered and mixed with the binders. It can be used as filler in manufacturing natural fibre composites.

Fig 2.Powdered mango endocarp

Fabrication:

In the present work resin Araldite LY-556 and hardener Aradur LY- 951 are used as matrix materials. The readymade banana fiber sheets are used as resin and mango seed particles are used as filler/ additive material. The fabrication of the laminate was done using hand lay-up process.

Following are the specifications of the fabricated laminate:

- Process selection- Hand Lay-up Process
- Number of layers -3.
- Size of Laminates-300*300*4
- Length of fibers used-15mm.
- Orientation- Bi-Directional (0^o & 90^o)
- Resin: Hardener- 10:1
- Volume fraction= 50:50
- Weight of Resin used is 400 grams
- Therefore, the amount of hardener used =(1/10)*400 = 40gm
- Then mango seed is used as filler = 3%

Mold preparation: The base plate was cleaned with an abrasive paper. The surface is allowed to dry after cleaning it with a thinner solution. After drying, the surface was coated with silicon gel. The surface is now set for the mold layup.

The fibre is placed inside the mould and a sealant is placed over the fibre to create vacuum. This is to keep the fibre dry and not to make any contact with moisture. Water content should be as less as possible for the fiber to absorb the resin to the maximum. Maximum absorption of resin increases the strength of the composite fabricant. If the moisture is present in the fiber it will have a huge effect on the properties of final product.

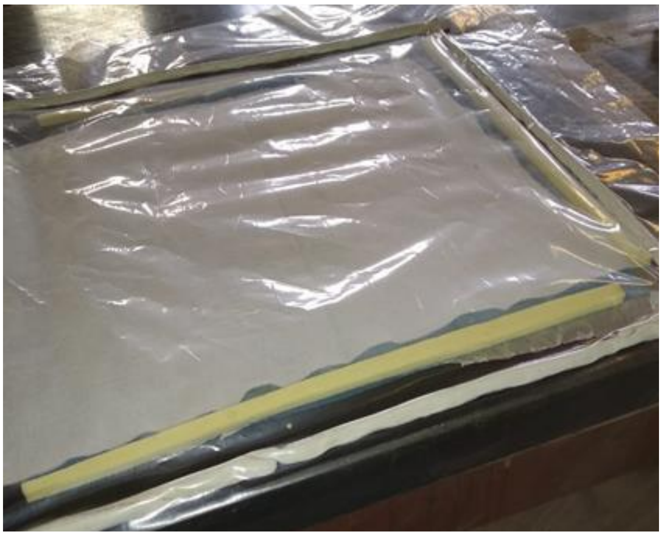


Fig 3. Vacuum bagging process

Based on the above calculations resin (araldite LY-556) and hardener (Aradur HY-951) is mixed in 10:1 proportion. And 3% of mango endocarp powder is mixed with resin and hardener. 400 grams of resin, 40 grams of hardener and 12 grams of mango endocarp is mixed together. The resin and hardener mixture should be carefully selected such that, the resin should not cure in the curing pot itself.

Once the fibre is wetted with resin mixture, the perforation sheet is placed on top of the banana fibre. After all these processes are done, vacuum bagging is done after 30 minutes by switching on the vacuum and made to run for 1 hour. The laminate is then heated in the oven for 1 hour at 100^0C for curing.

II. RESULTS AND DISCUSSION

Tensile test is carried out after cutting the specimens to the required dimension according to the ASTM standards. Tensile tests produce a stress-strain diagram, which is used to determine tensile modulus.

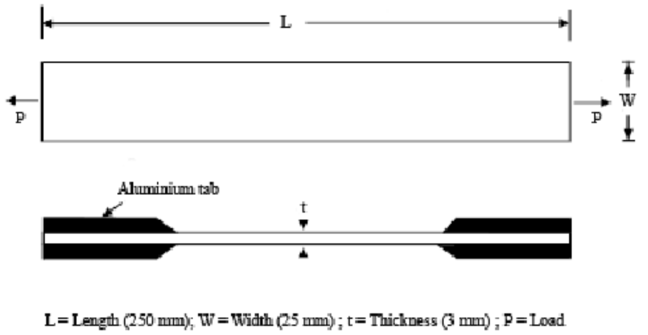


Fig 4. ASTM D3039 (Tensile test) specimen dimensions

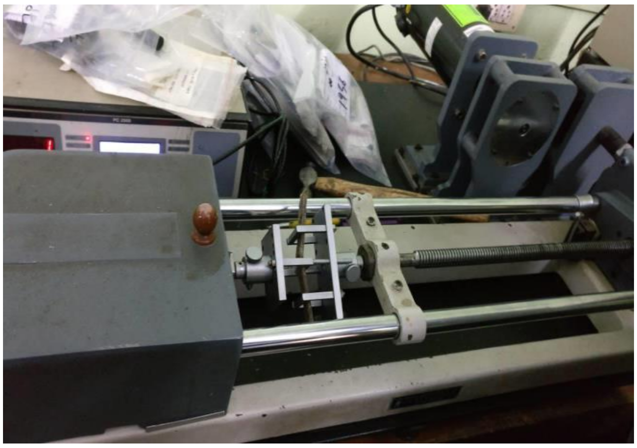


Fig 5. Tensile testing of the specimen

Displacement

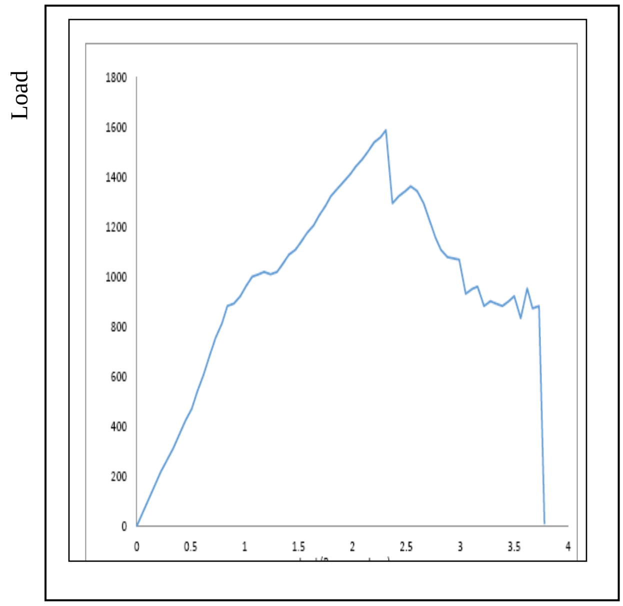
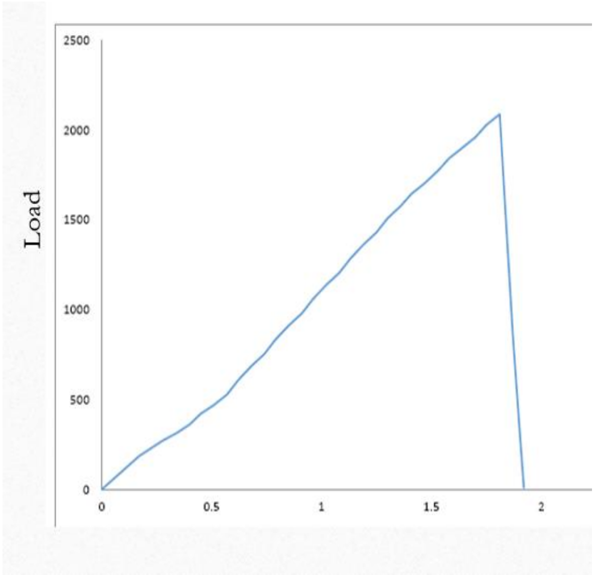


Fig 6. Tensile test graph for 0°/90°



Displacement

Fig 7. Tensile test graph for +45°/-45°

III. CONCLUSION

- The tensile test showed very good load bearing capacity for the 0/90 ° direction with a peak load 1600N.
- The peak load for +45°/-45° was around 2000N.
- The laminates showed good results in both the cases. Also, the strength of the fiber is higher in longitudinal direction than that of transverse.
- The results give scope for the application of these natural fibers in interior of automobiles.
- The addition of mango particles have given improved results in tensile strength compared to the results with only banana fibres.
- The work can be extended by increasing the number of layers and varying the percentage of fibres.

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