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Experimental study of bamboo using banana and linen fibre reinforced polymeric composites☆

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Summary The application of natural fibres such as bamboo, jute, banana, coir, linen and the like in Fibre Reinforced Polymeric (FRP) composites have become so vital due to their high effective stiffness and strength, availability, low cost, specific strength, better dimensional stability and mechanical properties, eco-friendly and biodegradable as compared with synthetic fibres. The interest in natural fibre reinforced polymeric composites is rapidly springing up in terms of research and industrial applications. The increased applications of these natural fibres in such composites are a proof to this claim. The paper deals with the detailed study of bamboo fibre, banana fibre and linen fibre cut into 2—4 mm of length with epoxy resin having random orientations. Various tests like Impact test (IZOD and CHARPY test), Fourier Transform Infra-Red (FTIR) test and Rockwell Hardness test were conducted on 10 specimens of bamboo epoxy resin composite, bamboo—banana epoxy resin composite and bamboo—linen epoxy resin composite. It is analysed and proved that bamboo—banana epoxy resin composite shows better results in Impact test with values of 4 Joules for Izod test and 5 Joules for Charpy test and in FTIR test, compatibility of fibres with polymers in bamboo—banana epoxy resin composite are the best while bamboo—linen epoxy resin composite shows better result in Rockwell hardness test with value of 40 RHN.

Introduction

Composite material is a material made from two or more materials with different physical and chemical properties but the individual components remain separate and distinct in final product. Fibre Reinforced Polymer is a composite material made of a polymer matrix imbedded with

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high strength fibres such as glass, basalt, aramid, etc. The polymers are usually vinyl ester, polyethylene, epoxy and polyester resins (Aniber Benin et al., 2015). The use of natural fibres as a substitute for synthetic fibres in composites has gained an escalating importance in the recent years due to environmental concerns and growing cost of synthetic materials (Rakshit Agarwal et al., 2015). The centre of study on natural fibres as substitute reinforcement in polymeric composites has created a vast attention of many researchers and scientists. The various advantages of natural fibres such as biodegradability, renewable, low cost, eco-friendly and comparable high mechanical properties make it more noticeable (Bino Prince Raja et al., 2015). Bamboo fibre, banana fibre and linen fibre are some of the natural fibres that have high profitable potential and are extensively cultivated. Bamboo fibre is a regenerated cellulose fibre made from the starchy pulp of bamboo plants processed from bamboo culms (Stanly Johns Retnam and Ramachandran, 2015). It is found to have outstanding properties like high specific strength, high tensile strength, very resilient, durable, low cost, recyclable, etc. Banana plant not only gives the appetising fruit but also provides banana fibre. It is a multiple celled lingo cellulosic fibre obtained from the pseudo stems of banana plant (Musa sepientum). The lumens are large in relation to the wall thickness, cross markings are rare and fibre tips either pointed or flat. Banana fibre is a natural fibre with high mechanical properties which can be blended easily with various other fibres or materials (Ramachandran et al., 2015). Linen is a long vegetable fibre which falls into the bast fibre category (fibre collected from bast, the phloem of the plant, sometimes called the skin) derived from the stems of flax plant, Linum usitatissimum. The fibres are mostly yellowish to grey and are 18–30 inches in length. Linen fibre is in great demand due to its high tensile strength, lustre, specific gravity, evenness and length. Natural fibre reinforced polymeric composites are found in countless products including aerospace, civil, automotive, marine and textile applications (Caprino et al., 2015). As a result, increasing attention has been devoted to research on Natural Fibre Polymeric Composites (NFPC).

Specimen preparation

In this work, the bamboo fibre, banana fibre and linen fibre are cut into 2–4 mm of length, mixed with epoxy resin and kept for duration of 11–12 h. Three samples are arranged named sample A, sample B and sample C. All the three samples are prepared by hand layup moulding process. Firstly, wax coating is provided on the surface of the forming tool so as to prevent the fibre reinforced polymer to stick (Pradeep et al., 2015). Then, the fibres and the epoxy resin; mixed thoroughly with a hardener is poured in the mould uniformly. For sample A, B and C, the combinations taken are in the ratio 90:10 (epoxy resin: bamboo fibre), 90:5:5 (epoxy resin: bamboo fibre: banana fibre), 90:5:5 (epoxy resin: bamboo fibre: linen fibre), respectively. Further, the addition of fibre layer is provided to get the necessary thickness of the fibre reinforced polymer. Table 1 shows the orientation; composition and volume of sample A, sample B and sample C.

Table 1 Compositions of sample A, sample B and sample C.

Sample	Orientation	Composition	Volume (%)
A	Random	Epoxy resin, Bamboo fibre (size-2–4 mm)	90/10
B	Random	Epoxy resin, Bamboo fibre (size-2–4 mm), Banana fibre (size-2–4 mm)	90/5/5
C	Random	Epoxy resin, Bamboo fibre (size-2–4 mm), Linen fibre (size-2–4 mm)	90/5/5

Impact test

Fiber Reinforced Polymeric (FRP) composites are prone to impact damage. Therefore, impact testing has been performed to study the effect of impact as a little impact can lead to catastrophic failure in various industrial applications where these composites are being used. Impact testing is used to determine Toughness (Tara Sen et al., 2013). Toughness is the ability of a substance to absorb energy without breaking. It is considered as one of the most significant mechanical property of thermoplastics because it relates to lifetime of materials, product safety and legal responsibility. Impact test consists of various tests out of which Izod and Charpy are the ones (Pothan et al., 2002). Izod test is used for determining the impact resistance of materials whereas Charpy test is a standardised high strain rate test which determines the amount of energy absorbed by a substance during fracture. Fig. 1a and b. shows bamboo epoxy resin composite before and after break, Fig. 1c and d shows bamboo–banana epoxy resin composite before and after break and Fig. 1e and f shows bamboo–linen epoxy resin composite before and after break for Izod test. Fig. 2a and b. shows bamboo epoxy resin composite before and after break, Fig. 2c and d shows bamboo–banana epoxy resin composite before and after break and Fig. 2e and f. shows bamboo–linen epoxy resin composite before and after break for Charpy test.

As per the above results (Table 2), bamboo–banana epoxy resin composite shows the highest value of 4 Joules and 5 Joules for Izod test and Charpy test, respectively, while bamboo epoxy resin composite shows the lowest value

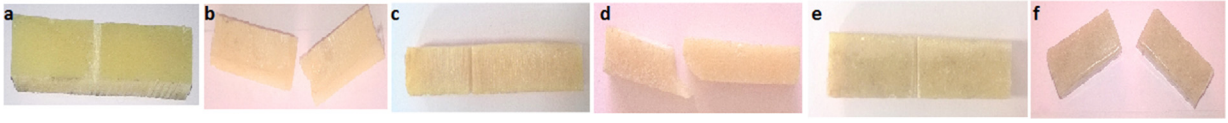

Figure 1 Specimen for IZOD Test.