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Study on the Mechanical Behaviour of Bamboo Fiber Based Polymer Composites

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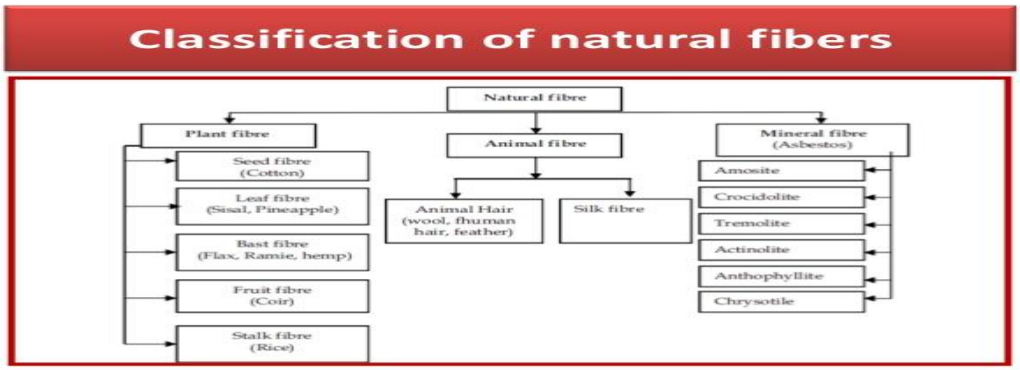
Abstract:
Natural fiber reinforced polymer composite has a huge affinity to replace the composite made up of synthetic fiber. This is primarily because of the advantages like light weight, non-toxic, non-abrasive, easy availability, low cost, and biodegradable properties. The synthetic fibers have higher end of mechanical properties like tensile strength and tensile modulus however the specific mechanical properties like specific tensile modulus and other specific properties (properties/specific gravity) of natural fiber gives a satisfying result for composites as compared to synthetic fiber based composites. The objective of the present study is to investigate the mechanical behaviour of short bamboo fiber reinforced epoxy based composites. Bamboo fibers with different length and contents are reinforced in epoxy resin to fabricate composite materials. The effect of fiber length and content on the mechanical behaviour of composites is studied.

Keywords: Bamboo, Synthetic Fiber, Synthetic Fiber, Matrix

1. INTRODUCTION

Composite material can be defined as the material which is composed of two or more distinct material with different properties to form a new material with a property that is entirely different from the individual constituents. The primary phase of a composite material is called a matrix having a continuous character. In other words, matrix is a material which acts as a binder and holds the fibers in the desired position thereby transferring the external load to reinforcement. These matrixes are considered to be less hard and more ductile. The composite material consists of a matrix along with a fiber with some filler material. The reinforced material can be either synthetic or natural fibers. In the demand of increasing environmental security, several natural fibers reinforced polymer composites (NFPCs) are brought into the competitive market. NFPCs provide a wide range of advantages over synthetic fiber based composites. These advantages include high strength to weight ratio, high strength at elevated temperatures, high creep resistances and high toughness . These advantages can also be in the form of their light weight, high durability and design flexibility. In NFPCs, the used matrices are either thermoset or thermoplastic. Polyester, Epoxy and phenolic resin are the commonly used thermoset matrix whereas polypropylenes, polyethylene and elastomers occupy the large scale position in thermoplastic matrix.According to the type of matrix material, composites can be grouped into the following categories:- a) Polymer Matrix Composites (PMC) b) Metal Matrix Composites (MMC) c) Ceramic Matrix Composites (CMC) The selection of any of the above composite material depends upon the type of application. The most commonly used composites are polymer matrix composite. This is primarily because of their light weight and specific properties compared to ceramics and metals. Besides, the polymer matrix composites can be processed at low temperature and pressure.In the present study, epoxy is as the matrix material. Generally, epoxy has a glassy appearance with classic advantages like good adhesion to other materials, good mechanical properties, good electrical insulating properties, good environmental and chemical resistances. The epoxy when treated with natural fiber to synthesize a fiber reinforced polymer composite, there is an interface formed between the matrix and the fiber. The adhesion between the fibers and the matrix around this interface decides the properties of the composites based on which its further application is decided. There are numerous fibers provided by nature to the human mankind. Based on the source of origin, this natural fiber can be classified into three categories such as animal fiber, vegetable fiber and mineral fibers.



2. BAMBOO FIBER

Bamboos are the largest members of the grass family. It is a long fleshy plant which technically comes under grass family but the appearance is never like grass. It is soft towards the centre and hard towards its periphery. Bamboo is mostly grown in tropical countries and is naturally occurring composites. Bamboos are largely used for the purpose like housing forestry, agro-forestry, agricultural activities, utensils and weapons. It is mainly planted in Asian countries and constitutes about 65% of the total bamboo resources found in the world . India and China is the leading nation in production of bamboo. Globally, the area occupied by bamboo is expected to be 36 million hectares or an average of 3.2 percent of the total forest area if bamboo outside forest area is included. Out of these 36 million hectares, 24 million hectares of bamboo forest, constituting about 4.4 percent of the total forest area are occupied in Asia itself. Bamboo shows the mechanical properties which are analogous to that of wood. Bamboo shows better mechanical properties as compared to fibers such as sisal, banana, vakka etc. Bamboo can be used in a different form to synthesize a composite product. These can be either in a form of a long strip, whole bamboo, sections, and short bamboo fibers. The selection of their fiber kind depends upon the property to be imparted in the composite. Longer bamboo strips are used in making structural composite that is used in automobile roofings, shorter bamboo fibers are used in making of medium density fibreboard, ply bamboo are made up of bamboo vaneer and medium sized bamboo flake can be used for making of bamboo flake board . Studies are going on to determine the feasibility of using bamboo for reinforcing concrete with flat symmetric structure decisions and smooth surface from a combination of bamboo, bamboo strips and wood veneer particles that play an important role as new material and is used for concrete formwork . Although bamboo finds its wide application in various fields but their use in polymer matrix composites are very rare.

Table.1. Various Properties of Bamboo Fiber are given in table

S.NO	Properties	Values
1	Tensile Strength	125-215
2	Young modulus	10-15
3	Elongation	Approximate 3%
4	Density	0.5-1.2%

3. PREPARATION OF COMPOSITES

The materials that are used in the present concern of study are:

1. Epoxy Resin
2. Short Bamboo Fiber
3. Hardener

Dry bamboo fibers were bought from the local market, in the form of long strip with an average width of about 10mm. The fibers were then further left to be died for a week. Epoxy Resin and the hardener (HY 951) were supplied by Ciba Geigy India Ltd. A wooden mould having a dimension of 200 × 200 × 40 mm3 was used for composite fabrication. Composites with three different wt.% (15wt.%, , 25wt.% and 35wt.% of fiber with length o10mm was taken for the composite fabrication. The weighed epoxy and hardener is first manually stirred with a glass rod followed with an addition of weighed fiber. The fiber and epoxy resin is thoroughly stirred to make sure there is no air bubble trapped in the mixture. The mixture was then poured on a relieving sheet which was already placed in a mould. The mixture was uniformly distributed over the inner surface of the mould and then closed by another relieving sheet on its top. The mould was then closed and a constant dead load of 50 kg was put on the mould for the purpose of curing to enhance the mixture to take the desired shape of mould. The load was left for 24 hours and then released. The composite thus obtained was further allowed to be cured in air for another 24 hours.

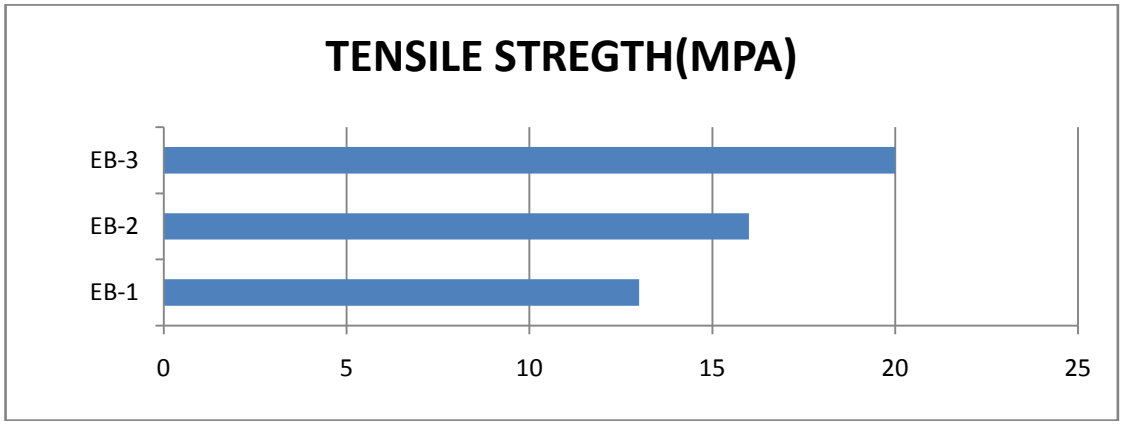
Table.2. Composition and Designation of Fiber Reinforced Composites

S.NO	COMPOSITE	COMPOSITION
1	EB-1	Epoxy(85wt%)+Short bamboo fiber of length 10mm (15wt%)
2	EB-2	Epoxy(75wt%)+Short bamboo fiber of length 10mm (25wt%)
3	EB-3	Epoxy(65wt%)+Short bamboo fiber of length 10mm (35wt%)

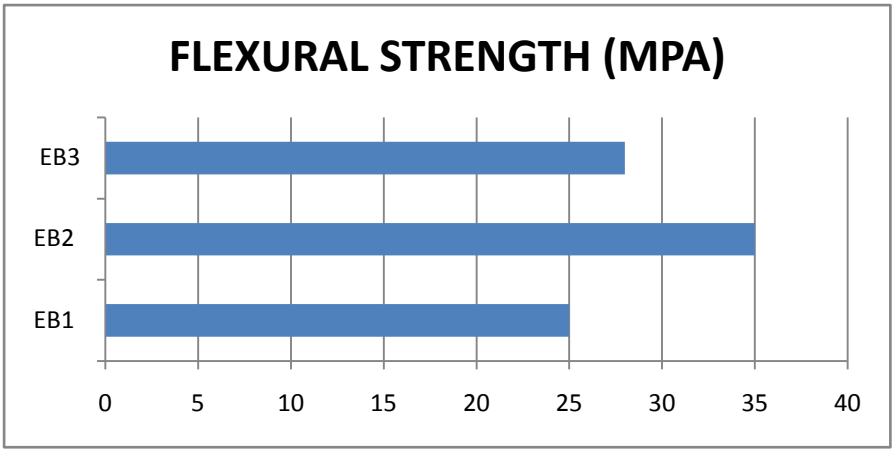
4. MECHANICAL PROPERTIES OF COMPOSITES

Mechanical properties of bamboo reinforced epoxy based composites such as tensile strength, flexural strength, impact strength and hardness number with their varying composition are tabulated below.

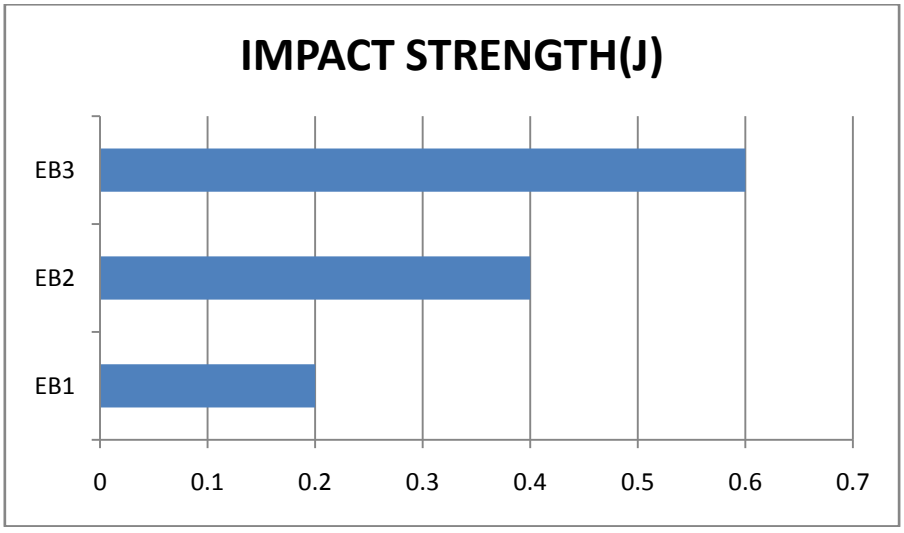
4.1 TENSILE STRENGTH- Tensile strength of a material is defined as the resistance offered by the material to get broken under tension. Tensile strength in this case varies with varying composition and it is found that the strength goes on increasing with increasing percentage of fiber in the composite of fiber.



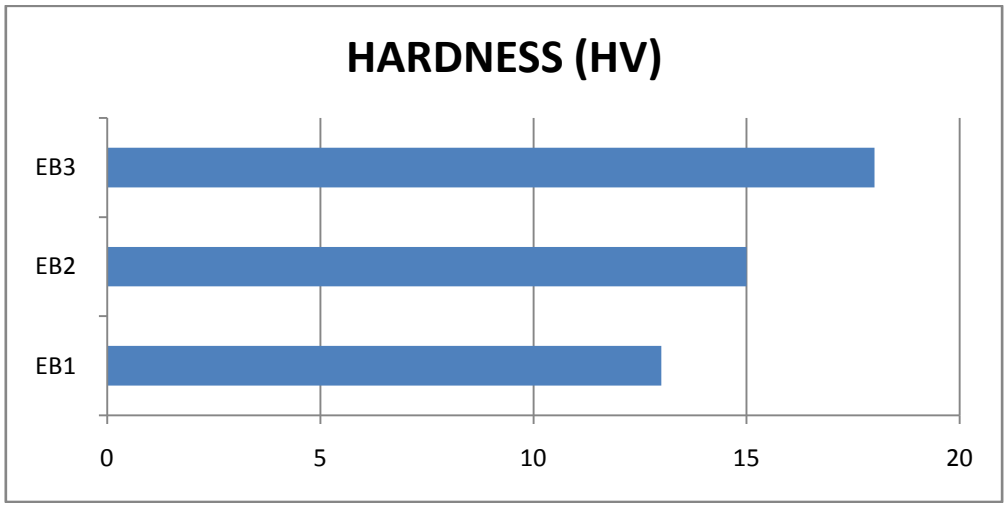
4.2 FLEXURAL STRENGTH - Flexural strength is defined as the ability of a composite by virtue of which it opposes the deformation likely to be imparted to it under the application of load.



4.3 IMPACT STRENGTH- Impact strength refers to a shock absorbing capacity of composite material. This is entirely related to a toughness of the composite material.



4.4 HARDNESS- Surface hardness of composite material is sometime a matter of concern when the composite material so produced is encountered for space application. For a given work, the composite material was subjected to Vicker's Hardness test and the following observations were made are given below.



5 CONCLUSION

The successful fabrication of a new class of epoxy based composites reinforced with short bamboo fiber and alumina particulates have been done. From the analysis It has been explored that the mechanical properties of the composites such as tensile strength, flexural strength, impact strength and hardness are highly influenced by the size of the fibers used. The present investigation reveales that 35wt% fiber loading shows superior hardness, tensile strength and impact strength.

Whereas, for flexural strength show better in 25wt% of fiber loading.

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