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Analytical Study on the Physical and Mechanical Properties of the Bamboo Fibre Reinforced Epoxy Composites

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Abstract:
The attention of the investigators on natural fibre reinforced composites grows fast both in terms of their industrial applications and fundamental research. Their availability, renewability, low density and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and other man-made fibres used for the manufacturing of composites. The utilization of bamboo fibres as reinforcement in composite materials has increased tremendously in recent years as a response to the increasing demand for developing biodegradable, sustainable, and recyclable materials. **Dendrocalamus strictus,** the botanical name of bamboo used for the purpose, makes this effort a socially relevant project, as this species is richly available throughout India. Though the present research is focused mainly on the bamboo fibre reinforced composites, their relative evaluation can only be made on comparing them with a similar set of composites with some conventional synthetic fiber. The measured values of the physical and mechanical properties, like, Density and Void Fraction, Micro-hardness , Tensile Properties, etc. of the bamboo fiber reinforced epoxy composites filled with different particulate fillers are compared with those of a similar set of glass fibre reinforced composites filled with same particulate fillers.

Key words: Dendrocalamus strictus, Thermoplastic, Thermoset matrices, epoxy composites, tensile strength, modulus, break load, flexural strength and impact strength.

I. INTRODUCTION

Researchers on natural fibre reinforced composites , pay much of their attention in terms of their industrial applications[1]. A **fibre-reinforced composite** (FRC) is a **composite** building material that consists of three components: (i) the fibers as the discontinuous or dispersed phase, (ii) the matrix as the continuous phase, and (iii) the fine interphase region, also known as the interface. **Fiber-reinforced plastic** (**FRP**) is a composite material made of a polymer matrix reinforced with fibres. Bamboo fibre materials have attracted broad attention as reinforcement polymer composites due to their environmental sustainability, mechanical properties, and recyclability, and they can be compared with glass fibres. This review classifies and describes the various procedures that have been developed to extract fibres from raw bamboo culm. The three main types of procedures: mechanical, chemical and combined mechanical and chemical extraction, composite preparation from extracted bamboo fibres and various thermal analysis methods are also classified and analysed.

Scope of this Study

The aim of this investigation is to characterize the mechanical, structural and microstructural properties of local and waste materials as composites in terms of flexibility, ductility and energy absorption to improve water resistance. Efforts have contributed to describe the various procedures adopted to extract fibres from bamboo culm[2]. Plant fibers are renewable with good mechanical properties, which justify their use as reinforcement for polymers[3]. Since the materials chosen in this research work are locally available materials, a detailed characterisation through various testing and analytical methods are essential. Linear regression analyses have been carried out for mechanical strength properties . The development of bamboo fibre-reinforced composites and interfacial adhesion fabrication techniques must consider the type of matrix, the microstructure of bamboo and fibre extraction methods.

Advantages of bamboo Fibres

Many parameters affect the mechanical properties and composite characteristics of bamboo fibres and bamboo composites, including fibre extraction methods, fibre length, fibre size, resin application, temperature, moisture content and composite preparation techniques. High strength, healthcare, Anti-bacteria, Moisture management and Soft hand feel are in favour of the bamboo.

Fabrication of composites

Dendrocalamus strictus species occupies about 53 per cent of total bamboo area in India. This is one of the predominant species of bamboo in Uttar Pradesh, Madhya Pradesh, Orissa and Western Ghats in India. In general, bamboo is available everywhere around the world and is an abundant natural resource.[4] Cross plied bamboo and E-glass fibres are reinforced separately in epoxy resin to prepare the fiber reinforced composites in which no particulate filler is used. The other composite samples with four different particulate fillers of varied amount but with fixed fiber loading are fabricated. The fabrication of the composite slabs is done by conventional hand-lay-up technique followed by light compression moulding technique. The fillers are mixed thoroughly in the epoxy resin before the respective fiber mats are reinforced into the matrix body. Plant fibers are renewable with good mechanical properties, which justify their use as reinforcement for polymers. Different particulate fillers , red mud[5], copper slag, alumina and SiC were used for the purpose.

Mechanical Characterization

The theoretical density of composite materials in terms of weight fractions of different constituents can easily be obtained from equation given by Agarwal and Broutman. Micro-hardness Micro-hardness measurement is done using a Leitz micro-hardness tester. A diamond indenter, in the form of a right pyramid with a square base and an angle 136° between opposite faces, is forced into the material under a load F. The two diagonals X and Y of the indentation left on the surface of the material after removal of the load are measured and their arithmetic mean L is calculated. The tensile test is generally performed on flat specimens. The flexural strength of a composite is the maximum tensile stress that it can withstand during bending before reaching the breaking point. The three point bend test is conducted on all the composite samples in the universal testing machine Instron 1195. Low velocity instrumented impact tests are carried out on the composite specimens. The tests are done as per ASTM D 256 using an impact tester..

Table.1. Determined (measured)and expected (theoretical) densities with void fractions

S.No.	Composition	Observed Density(g/cc)	Theoretical Density(g/cc)	Volume fraction of voids (%)
1	Bamboo-epoxy with 0 wt% filler	1.22	1.25	0.96
2	Bamboo-epoxy with 10wt% filler Red mud	1.40	1.48	4.57
3	Bamboo-epoxy with 10 wt% copper slag	1.35	1.45	6.75
4	Bamboo-epoxy with 10 wt% alumina	1.35	1.45	5.14
5	Bamboo-epoxy with 10 wt% SiC	1.30	1.36	4.28

The impact strength of a material is its capacity to absorb and dissipate energies under impact or shock loading. The measured impact energy values of the various particulate filled composites under this investigation found that the bamboo-epoxy composites increase gradually with the filler content increasing from 0 wt% to 20 wt% for all the fillers except SiC.

II. RESULTS AND DISCUSSION

It is found from this investigation that the bamboo-epoxy composites have lower impact strength than their glass fiber counterparts irrespective of the filler type. However, bamboo fiber composites demonstrate better impact properties than composites reinforced with other natural fibers such as jute and kenaf[6] . Hence, for high performance applications, it is important to find ways to improve various strength properties of composites with bamboo fiber reinforcement. Among all the composites under this investigation, the maximum hardness value is recorded for bamboo-epoxy composite filled with 20 wt% alumina. The tensile strengths of these composites decrease invariably with increase in filler content irrespective of the type of filler. As far as the flexural strength is concerned, bambooepoxy composites are found not as good as the glass-epoxy composites either with or without particulate fillers. The inter-laminar shear strengths of bamboo-epoxy composites with different particulate fillers are comparable to those of glass-epoxy composites. Bamboo fiber composites demonstrate better impact properties than composites reinforced with other natural fibers such as jute and kenaf.

III. REFERENCES

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