

Research, Analysis, and Development of Composite Material using Bamboo Fiber and Epoxy Resin

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Abstract

This study focuses on the research, analysis, and development of a composite material using bamboo fiber and epoxy resin as a sustainable alternative to glass-based composites. Bamboo fiber, a natural, renewable, and biodegradable material, was reinforced with epoxy resin, known for its excellent adhesion, mechanical strength, and chemical resistance. The composite fabrication process involves mixing of epoxy resin with bamboo fiber. This research highlights the potential of natural fiber composites in reducing environmental impact and promoting sustainable material development in various applications, including construction and manufacturing industries.

Keywords: Bamboo Fibre, Epoxy Resin, Composite, Glass Strength

Introduction

Composite materials consist of two or more different materials that form regions large enough to be regarded as continua and which are usually firmly bonded together at the interface (Cummings, 1983). The binder for a particulate aggregate simply serves to retain the composite mass in a solid form, but the matrix in a fibre composite performs a variety of other functions which must be appreciated if we are to understand the true composite action which determines the mechanical behaviour of a reinforced material (Harris, n.d.). In the study epoxy is the matrix material. Epoxy has a glassy appearance with advantages like good adhesion, good mechanical, good electrical insulation, good chemical resistance etc.

These epoxy resins offer outstanding electrical insulation properties, effectively shielding electrical components from potential issues like short circuits, dust ingress, and moisture exposure. As sealants, epoxy resins (compounds) remain popular among polymeric materials in terms of application. To date, due to the thermodynamic and reactive compatibility of epoxy oligomers, a huge number of compounds have been synthesized, and various hardeners have been successfully used to turn thermoplastic resins into infusible ones (Dallaev et al., 2023).

The natural fibre used in the present study is short bamboo fibre. Bamboo is a naturally grown renewable material that will decompose if discarded after end-of-life, and it offers excellent environmental performance based on the Life Cycle Assessment. The use of bamboo in construction is in line with the concept of sustainable development (Chen et al., 2022). In this article, bamboo fibre is combined with epoxy resin thereby a composite which can be used as an alternate for glass was developed, and the outcomes have been analyzed.

Methodology

Materials Used

Bamboo Fibre

Natural fibres are fast-growing, sustainable, biodegradable, and free from chemicals and toxicity. These qualities make them an environmentally friendly alternative to synthetic materials. One popular use of natural fibres is in packaging made from bamboo, which has gained popularity as a replacement for plastic due to its eco-friendly properties..

Epoxy Resin

Resin is produced from organic compounds, primarily consisting of carbon and oxygen atoms. It is free from BPA, making it safe for use in food serving applications. Additionally, resin has a low odour and is user-friendly during application. Known for its high mechanical properties, it offers durability and strength. Furthermore, resin is safe to use and provides UV protection, ensuring longevity and reliability in various applications.

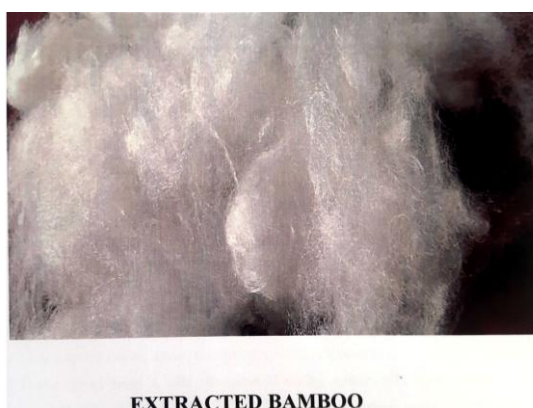
Hardener

A hardener is a curing agent used for epoxy fiberglass, acting as a catalyst that triggers the hardening process when mixed with resin. It plays a crucial role in solidifying the adhesive, ensuring that it becomes strong and durable once applied.

Process

Raw Bamboo

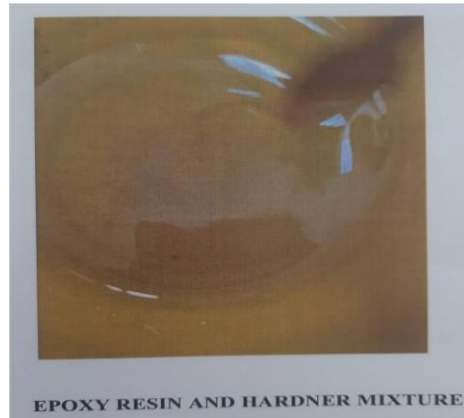
- Raw and 100% bamboo fibre is taken and the weight of which should be 50% of resin weight



Epoxy Resin and Hardener

- A suitable container was taken.
- The resin and hardener were combined at the recommended mix ratio.

- The mixture was stirred for 3-4 minutes while scraping the sides and bottom of the container until no streaks or striations were formed.
- It was then left to sit for 1-2 minutes to allow air bubbles to rise to the surface before being used immediately.



Metal Frame

- Three frames with sizes 30×30 sq cm, 2.5×12.5 cm, and 2.5×25 cm, each with a 5mm density for thermal, flammability, and thermal tests, were taken.

Final Process

- Resin and hardener were taken in a 2:1 ratio.
- The liquid was mixed for 3 minutes at room temperature.
- Then, 50% of bure bamboo fiber was added to the mixture.
- The mixing process was continued until it changed to a semi-solid state.
- The mixture was poured into the mold in the required shape.
- A setting time of 24 hours was given.
- After 24 hours, it was removed from the mold to form the composite.

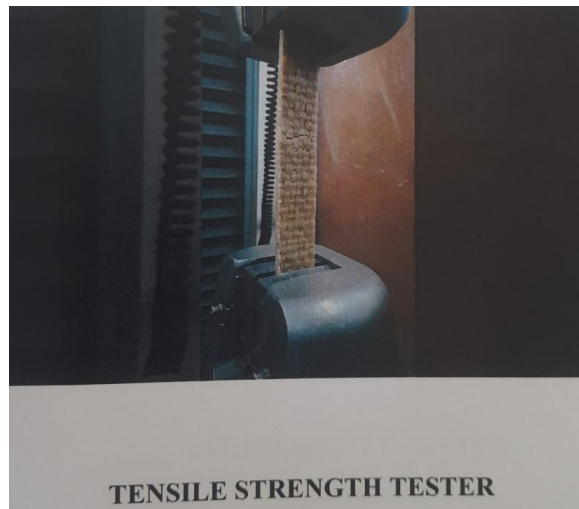


Tensile Test

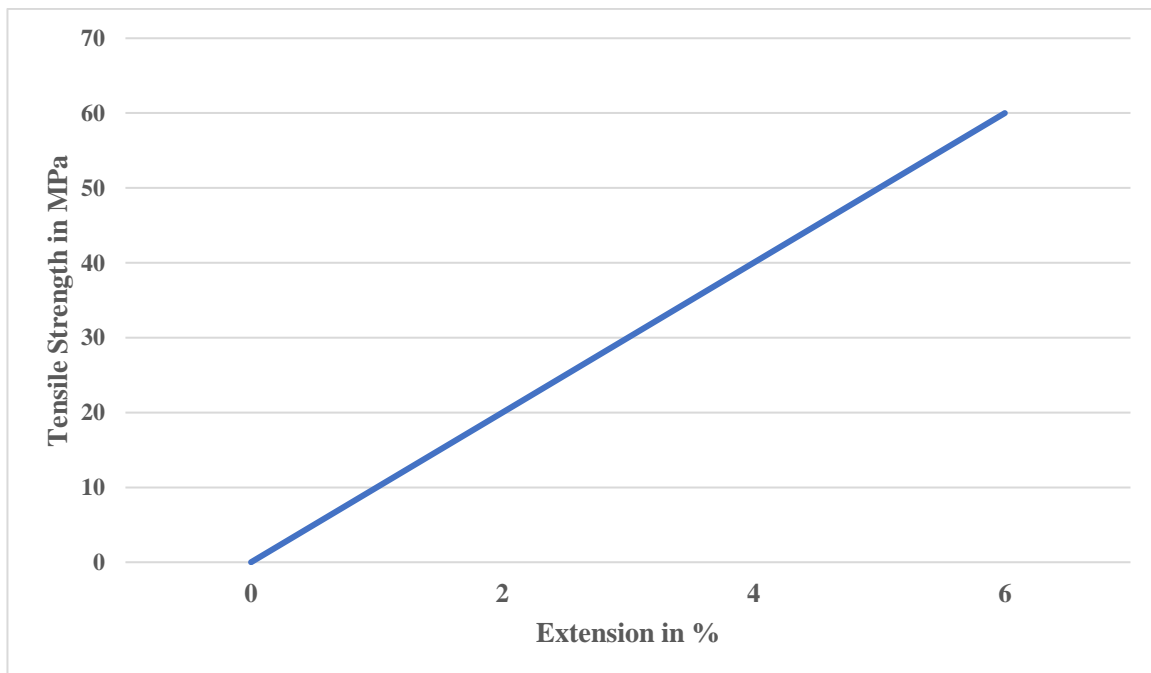
Tensile testing is also known tension testing. It is a fundamental materials science and engineering test in which a sample is subjected to a controlled tension until failure.

Test Procedure

The material developed is injected into the five dumbbells and the specimen is loaded into the tensile grips. Extensometer is attached to the sample. The test is begun by switching on the machine so that the tensile grips are separated at a constant rate of speed. The machine is stopped after the sample breaks.



Series Graph:



Test Results

S No	Specimen ID	S MPa	ℰ at failure %
1	Composite	40.2	5.2

In this test method, the strength of the composite was evaluated, with the upper jaw operating at a speed of 0.2 mm/min. The required tensile strength threshold was set at 30%, with a maximum limit of 60%. The test results indicated a tensile strength of 40.2%, accompanied by an elongation value of 5.2%, which exceeds the required benchmark. Based on these findings, this composite demonstrates superior performance and can be considered a viable alternative to glass.

Summary and Conclusion

The high cost of synthetic fibres such as Glass, Carbon, Kevlar etc, results in high cost of production and products derived from these materials which has necessitated alternative means of materials development. The fabrication of the composite was carried out using epoxy resin as the matrix and the bamboo fibre as reinforcement. Test were carried out to determine the mechanical property. Which revealed that the tensile property increased with increasing content of fibre in composite materials.

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