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Article

Reed Fibers Revolutionize Epoxy Composite Strength

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Abstract: In recent years, natural fibers have gained significant attention from the global research community due to their advantageous properties over industrial fibers. This study investigates the impact of reed fiber reinforcement on the mechanical properties of epoxy composites. Despite extensive research on various natural fibers, there is a knowledge gap regarding the use of reed fibers in composite materials. This research aims to explore how reed fiber orientation affects the tensile and compressive strength of epoxy composites. Reed fibers, cut to 100 mm in length and 2 mm in width, were embedded in epoxy resin at orientations of 0°, 45°, and 90° using hand molding techniques. The samples were cured at 75°C and subjected to mechanical testing. Results indicated that fibers oriented at 0° provided the highest mechanical strength, while the 0°/90° configuration resulted in the lowest strength. This study highlights the potential of reed fibers to enhance the mechanical properties of epoxy composites, emphasizing the significance of fiber orientation in optimizing composite performance.

Keywords: Mechanical Properties, Polymers, Reinforcement Materials, Reed Fibers, Composite Strength.

1. Introduction

Composite materials have been used in aerospace engineering applications because of their lightweight nature, which plays a significant role in the construction of aircraft and spacecraft. The composite consists of fibers with high strength and stiffness, such as carbon fibers, glass fibers, and aramid fibers, embedded in a lightweight plastic, polymer, or resin, such as polyester and epoxy. The binding material between the fibers is added to transfer shear stresses between them and provide protection against external materials that may harm them. Composite materials are characterized by design flexibility, as it is easy for an engineer to design them by placing the fibers in the direction of the loads, which contributes to the optimal use of the material and significantly reduces the weight of the final product. Composite materials have been used in many engineering applications, especially those requiring high strength combined with lightweight. However, composite materials have a weakness from an engineering standpoint, as they have limited ability to withstand dynamic shock loads, which leads to the separation of the material into layers [1].

Composite material products are designed for a relatively long estimated lifespan, as the materials used are stable and non-degradable. However, this feature has recently become undesirable due to the difficulty of disposing of these products after their expected lifespan. They are disposed of in two ways: first, by placing them in special landfills, and second, by burning them in special incinerators to convert them into gases. The first method leads to the accumulation of permanent waste as they do not decompose,

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requiring large areas of land. The second method contributes to environmental pollution. Both methods cause significant environmental damage, in addition to the high cost of both methods. Composite materials are not recyclable due to their composition of two different materials. In contrast, metal products can be reused by melting them down. Recycling has become a duty in the present time for two reasons: first, to conserve natural resources for future generations, and second, to protect the environment by reducing the environmental damage resulting from burial or burning [2].

Based on the above, studies are seeking to produce composite materials capable of decomposing and dissolving in the soil after being buried, being beneficial to the soil, or being recyclable and reusable after the end of their estimated lifespan. These materials have been named "green composite materials" in reference to the nature we seek to keep green. The studies resulted from the increase in the strength of systems and laws that impose on manufacturers the production of environmentally friendly materials and products at all stages of their lifespan, even after their period of use has ended. Recycling, reuse, and environmentally friendly design have become important in the industrial world today.

Composite materials consist of two basic elements with different physical or chemical properties in the form of very small particles or fibers and the matrix, which is the adhesive substance. The fibers or small particles are mixed together to give the composites their strength and stiffness, while the matrix maintains the cohesion of the composite materials by holding the fibers together. The matrix is also responsible for imparting resistance to high temperatures and thermal fatigue, as well as imparting hardness and the most important property, corrosion resistance.

The properties of composite materials depend on the type and proportion of materials in the composite, as well as their geometric shape, distribution method, size, and direction. The manufacturing and shaping techniques of composite materials differ from those of metals (mining) as they are not essential elements but are composed of different elements, as we mentioned at the beginning. Therefore, they require advanced technology in their manufacturing and shaping techniques, which is known as molding. This is a high-cost manufacturing process that requires special skills to complete. Most commercial composite materials are produced from polymer (the matrix material), which is a chemical compound usually called resin, a gum-like solution. There are several types of polymers, including polyester, epoxy, polyimide, and others. The reinforcing material is usually fiber, but sometimes it is a mixture of ground metals mixed with it, known as composite metal powder.

Manufacturing materials, such as composite materials, dominate most components of current tools and vehicles, and have even entered the field of building components and civil engineering, such as bridge foundations and skyscrapers, due to their high resistance to corrosion, weathering, extreme hardness, heat, and fire resistance. The main function of fibers in composite materials is to bear most of the load applied to the composite material and provide rigidity. For this reason, the fiber material has high tensile strength and high elasticity modulus. The fibers used for reinforcement can be continuously distributed along the length of the composite material or discontinuously distributed in the direction or randomly. Examples of fibers include glass fibers, carbon fibers, and Kevlar fibers. Many researchers have addressed the topic, including [5]

[1] Studied the effect of reinforcing a polymer material with flaxseed fibers to create partially green polymeric composites. Flaxseed fibers were added at a volume fraction ranging from 0.116 to 0.305, and their effect on mechanical properties, including tensile strength and impact properties, was studied. The results showed that reinforcing the polymer with flaxseed fibers improved tensile strength by 77.1% and impact strength by 112.6%. The best impact strength was found to be 88.54 J/m. additionally, increasing the fiber content contributed to a reduction in the weight of the composite.[2] The study aims

to determine the mechanical properties, specifically tensile strength and impact resistance, of a polymer composite consisting of HDPE polymer reinforced with green coconut fibers. Test samples were prepared according to Taguchi's L9 orthogonal array concept, taking into account the variables of fiber size and length. The mechanical property results were analyzed using response surface methodology (RSM) for modeling the results. Analysis of variance (ANOVA) was used to verify the validity of the model. The results indicated that the advanced models are suitable for predicting the mechanical properties of green coconut fibers for reinforcing polymer material [3]

The research focused on studying the reinforcement of epoxy resin with bamboo fibers, which were added at different angles and in the form of layers (0/0/0/0), (0/+45°/-45°/0), and (0/90°/90°/0) for all cases. A total of 25% by volume of bamboo fibers were integrated. The produced composites were subjected to tensile tests, and the practical results were compared with theoretical values. After the tensile and fracture tests, it was found that the tensile strength at the angles (0/0/0/0) and (0/+45°/-45°/0) gave the highest values compared to the results for the angle (0/90°/90°/0) due to the direction of the angle towards the applied tensile force. The practical results of the tensile test for the composite heavily depend on the strength of the bamboo fibers.

[4]This research aims to study the effect of changing the reinforcement ratio of fibers on the thermal conductivity and mechanical properties of a polymer composite material composed of epoxy resin, type EP10, reinforced with bidirectional glass fibers (0-45° type S) with a surface density of 550 g/cm². Different reinforcement ratios of 20%, 40%, 60%, and 80% were used for the resin with these fibers. The study investigates the impact of this change on the thermal conductivity of the composite material, using Fourier's equation to calculate the change in the thermal conductivity coefficient (k). Different fiber ratios were used to reinforce the resin (20%, 40%, 60%) in mechanical test models to calculate the impact resistance, tensile strength, and flexural strength. The relationship between temperature, mechanical properties, reinforcement ratio, and thermal conductivity (k) is illustrated in the graphs.

2. Materials and Methods

The practical aspect of the study included the following:

Materials Used:

- Epoxy Resin (EPOXY (A)): Used as the base material for the composite. A specific type, EVR – 0140-ATK, was used. The resin was mixed with a hardener (B) in a ratio of 1:2, and the reaction occurred at room temperature.

- Reed Fibers: Collected, cleaned, and cut into fibers with a length of 100 mm and a width of 2 mm.

Preparation of Test Samples:

-Mold Preparation: Hand molding was used to prepare the test samples. The mold was sprayed with a polyvinyl alcohol solution to facilitate the separation of the samples from the mold.

-Resin Application: A quantity of resin was applied to the inner surface of the mold and spread evenly with a brush to ensure uniform distribution as shown in Figure 1.

-Fiber Placement: The first layer of fibers was placed in the mold in the 0° direction, followed by another layer of resin and bamboo fibers in the 0° direction. This process was repeated for the remaining layers to achieve the desired composite thickness of 10 mm.

-Curing: The samples were left to cure, then removed from the mold and placed in an oven at 75°C to complete the curing process.

Additional samples were prepared by embedding bamboo fibers in the resin at 0°, 45°, and 90° directions. These samples were also cured and tested.

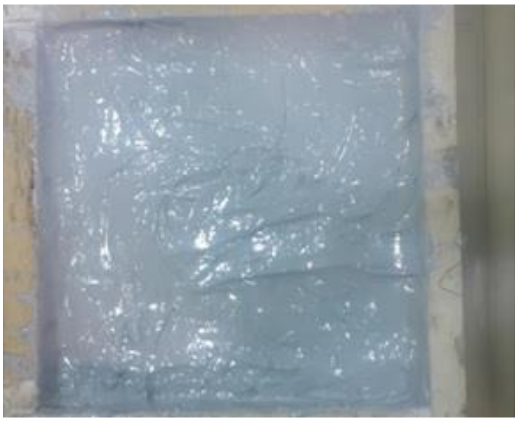

Figure 1. illustrates the composite material composed of epoxy resin reinforced with reed fibers

3. Results and Discussion

Tests samples preparation

Samples were manufactured as follows:

Tensile Test Samples

According to the ASTM D638-03 standard, the dimensions of the samples are shown in (Figure 2) prepared for tensile test after manufacturing.

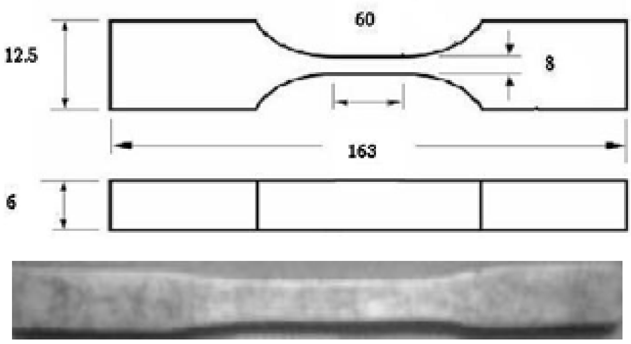

Figure 2. shows the dimentions of the tensile sample

Compression Test Samples:

The compression test samples were manufactured with dimensions of 163 x 12.5 x 6 mm according to the ASTM standard (Figure 3).

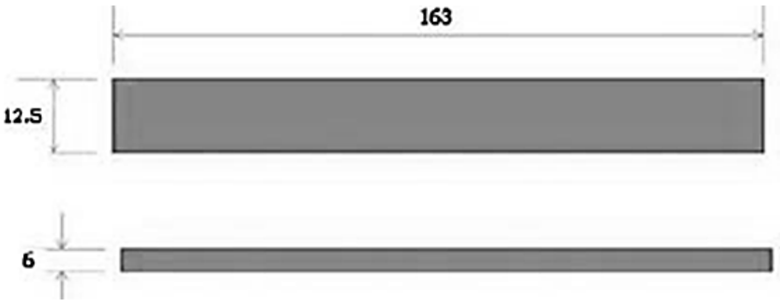

Figure 3. shows the compression sample

Classification of Test Samples:

After the completion of sample manufacturing, they were classified into groups as shown in Table 1.

Table 1. illustrates the classification of the samples.

The sample code	The direction of reed fibers
A	Without the addition of fibers
B	Adding fibers in the direction (0/0°)
C	adding fibers in the direction of 0/45°
D	Adding fibers in the direction 0/90°

Tensile Test:

A tensile test was conducted by applying a load of 500 kg at a loading rate of 1 mm/minute using the device shown in Figure 4. From the tensile test results, the properties of the welded joints were determined, including the ultimate tensile strength, yield stress, and elongation, by determining the deformation. The results are shown in Figure 5.

Figure 4. tensile test machine

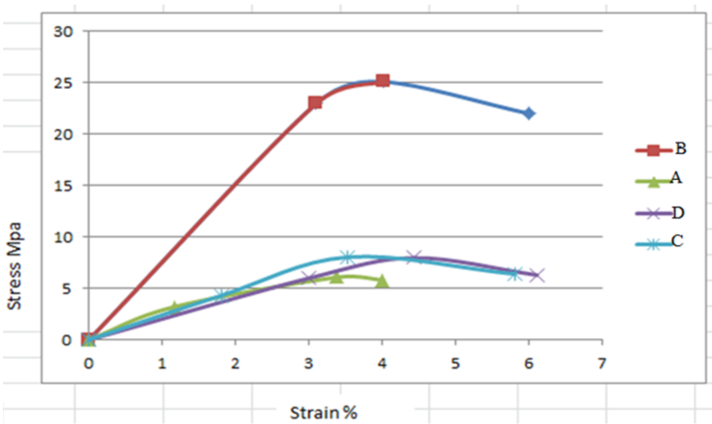

Figure 5. shows the results of the tensile test for all sample groups

Compression Test:

This test determines the material's ability to withstand a compressive load before it fractures. High values indicate strong bonding forces between the material's particles (usually measured in MPa). The compression test was conducted by applying a load of 500 kg at a loading rate of 1 mm/minute using the same device shown in Figure 4. The results are shown in Figure 6.

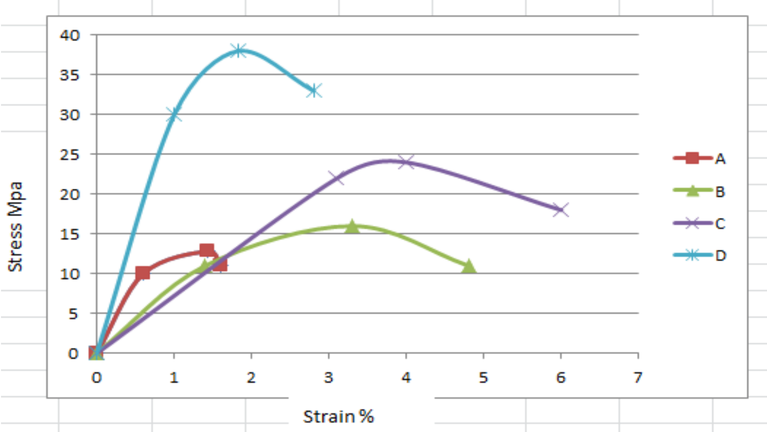

Figure 6. shows the results of the compression test for all sample groups

Resins are brittle materials with very low tensile strength, as seen in Figure 5A. However, adding fibers to these materials significantly improves their tensile strength because the fibers bear most of the applied load, increasing the composite material's tensile strength[8]. Fibers occupy a larger space within the resin, allowing for better distribution of the applied load. The direction of the fibers also has a clear effect on the composite material's properties. Adding fibers at different angles improved the tensile strength. For example, the 0/0 direction showed the highest value due to a more homogeneous load distribution, as did the 0/45 direction because of the effect of force coupling.

Reinforcing resin materials with fibers leads to an increase in the compression strength of the resulting composite. This is evident in Figure 6, which represents the compression test for epoxy resin reinforced with reed fibers. The compression strength increases sharply when reinforced with straw fibers due to the load distribution on the fibers and the efficiency of bonding between the base material and the reinforcing fibers, which increases the compression strength of the composite material. The composite material's resistance to compression increases with an increase in the proportion of added fibers for the same reasons mentioned above.

4. Conclusion

The mechanical properties of epoxy resin decrease due to its brittle nature, as with most resins. These mechanical properties improve when epoxy resin is reinforced with bidirectional fibers because the majority of the applied load is borne by the fibers. Mechanical properties improve with an increase in the proportion and orientation of the added fibers. The 0/0 direction yielded the best results, while the 0/90 direction yielded the lowest results due to force distribution.

REFERENCES

[1] K. Ramanaiah, A.V. Ratna Prasad, and K. Hema Chandra Reddy, "Effect of Fiber Loading on Mechanical Properties of Borassus Seed Shoot Fiber Reinforced Polyester Composites," *Journal of Materials and Environmental Science*, vol. 3, no. 3, pp. 374-378, 2012.

[2] Syed Altaf Hussain, "Mechanical Properties of Green Coconut Fiber Reinforced HDPE Polymer Composite," *International Journal of Engineering Science and Technology*, vol. 3, no. 11, pp. 7942-7952, Nov. 2011.

[3] M. R. Hossain, "Effect of Fiber Orientation on the Tensile Properties of Jute Epoxy Laminated Composite," *Journal of Scientific Research*, vol. 5, no. 1, pp. 43-54, 2013.

[4] Abbas A. Aljubori, Ali Ibraheem, and Sajid A. A., "Effect of Percentage of Fibers Reinforcement on Thermal and Mechanical Properties for Polymeric Composite Material," *The Iraqi Journal for Mechanical and Material Engineering*, Special Issue (A), pp. 70-82, 2017.

[5] Hitoshi Takagi and Antonio Norio Nakagaito, "Effect of Microstructure on Multifunctional Properties of Natural Fiber Composites," *Blucher Material Science Proceedings*, vol. 1, no. 1, Nov. 2014. [Online]. Available: www.proceedings.blucher.com.br/evento/mm-fgm2014

[6] M. N. Nahas, "The Latest Developments in the Field of Composite Materials Focus on Environmentally Friendly and Reusable Composites," *King Abdulaziz University Journal of Engineering Science*, vol. 1, pp. 77-102, 2005.

[7] Hitoshi Takagi and Yohei Ichihara, "Effect of Fiber Length on Mechanical Properties of Green Composite Using a Starch-Based Resin and Short Bamboo Fibers," *International Journal Series A Solid Mechanics and Material Engineering*, vol. 4, pp. 551-555, 2004.

[8] Yasser S. Mohamed and Ahmed Abdelbary, "Theoretical and Experimental Study on the Influence of Fiber Orientation on the Tensile Properties of Unidirectional Carbon Fiber/Epoxy Composite," *Alexandria Engineering Journal*, vol. 67, pp. 693-705, 2023.