

**How to Cite:**

Sachudhanandan, S., Patil, R., Kaviti, R. V. P., & Bharath, V. G. (2022). Tensile and flexural properties of ramie fiber and synthetic fiber reinforced with epoxy polymer composite. *International Journal of Health Sciences*, 6(S9), 3720–3727. Retrieved from <https://sciencescholar.us/journal/index.php/ijhs/article/view/13436>

## **Tensile and flexural properties of ramie fiber and synthetic fiber reinforced with epoxy polymer composite**

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**Abstract**--Polymer matrix composites have gaining traction as the more reliable and cost-effective alternative to monolithic materials. Polymer matrix composites are being used in a variety of situations, from the household to the industry. In this study, ramie fiber, glass fiber, and Kevlar fiber were used as reinforcing materials, while Epoxy resin was used as a matrix material. The composite material was made by hand layup with various combinations when tested according to ASTM standards. The results of this investigation reveal that the combination of 2 layers of ramie + 4 layers of glass + 6 layers of Kevlar fiber has greater mechanical qualities than the other.

**Keywords**---Composite, glass, fiber, Kevlar, Reinforcement.

**Introduction**

Natural fibers are commonly employed in reinforcement for polymeric composites because of their inexpensive cost, biodegradability, with lower weight, which can

lead to greater specific rigidity than glass fiber. Fiber manufacture consumes extremely little energy and emits very little CO<sub>2</sub> since there is no friction. Reinforcement fibers include silk, flax, ramie, sisal, jute, banana, bamboo, curaua, as well as the buriti [1]-[7].

In garments, synthetic fibers have mostly replaced ramie fabrics [2]. As a result, the purpose of this research is to look into the usage of ramie fiber as a composite reinforcement with in future in order to protect the country's fiber culture. In addition, the research concentrated on improving fiber-matrix interaction utilizing chemicals (processed using NaOH solution) with hand-lay-up composites in response to the pressing need to develop environmentally acceptable materials.

Hand lay-up is utilized in the automotive sector and has several advantages over traditional methods, including lower capital investment; lower void content, shorter cycle times, and greater process control those results with less waste [6]. Natural fibers have a number of disadvantages in Considerable hydrophilic nature, lack of homogeneity, with poor mechanical properties are all problems with polymeric composites. The non-polar properties of thermosetting resins, as well as the polar high hydrophilic qualities of lignocellulosic fibers, are serious negatives [7].

As a result, the fiber and matrix are separated by a weak interphase. Surface modification, isocyanate treatment, peroxide treatment, vinyl peel, bleach, acetylation, other coupling agent treatment are all options for promoting fiber-matrix interaction, but their cost and complexity might be prohibitive [8]. Curaua fibers were subjected to four distinct treatments by Spinacé et al. [9]: pristine curaua, curaua washed with water, curaua treated using sodium hypochlorite, and curaua treated to cold oxygen plasma. The crystallinity the superficial roughness of washed fibers increased even as moisture content decreased.

Cold oxygen plasma-treated fibers indicate a reduction in crystallinity, although sodium hypochlorite-treated fibers behave similarly. Without requiring chemical treatments, fibers can be washed with water to eliminate impurities and improve fiber-matrix interaction. Synthetic fibers (e.g., glass fiber) can be added to natural fiber composites to improve stiffness, strength, and water resistance. Among many other properties. Because natural reinforcement was recyclable and allows users custom mechanical qualities, the possibility of combining multiple kinds of reinforcement becomes intriguing. As both a result, an compromise has been reached between the parties. It is feasible to have a favorable environmental impact while also attaining excellent outcomes. [9]-[11] Jawaid and Khalil [11] cited a few recent polymer hybrid composites experiments.

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### **Materials**

Go green Product provided the ramie mat, and Marktech Bangalore provided the glass fiber and Kevlar fibers. Marktech Bangalore provided epoxy resin LY556 and hardener Hy 951.

### **Chemical Treatment**

The most extensively used technique for bleaching as well as cleaning the outer surface of ordinary fibers in order to obtain high-quality fibers is alkali treatment with sodium hydroxide (NaOH). Sodium hydroxide pellets with filtered water were used to make a 5% sodium hydroxide solution. According to a composites study, increasing that amount of sodium in such a solution causes the fibers' properties to be disrupted by a drop in bonding capability. At that moment, ramie fibers were immersed in water for 2 hours each. Previously, it had been washed away by flowing water. After that, this was dried for twenty hours in the sun.

### **Composite Preparation**

A 300 mm × 300 mm layup technique open mould is used to make the specimen by hand. To make composite removal easier, the mould is polished and just a mould releasing medium is put to the outside of the mould. By mass, LY-556 epoxy resin and HY-951 hardener were blended in a 10:1 ratio. The ramie fibers were manually inserted with in mould, aligned as necessary, and enough epoxy resin was added. Repeat process until you reach the desired thickness. A roller is used to complete rolling the fiber each time to remove unwanted air bubbles. After that, it will be kept as room temperature for 24 hours. Figure I depict the fabrication process.



Figure 1a Ramie Fiber

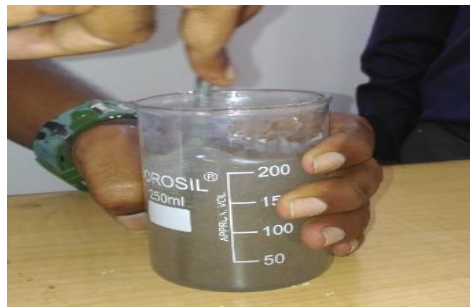


Figure 1b Mixing Of Resin

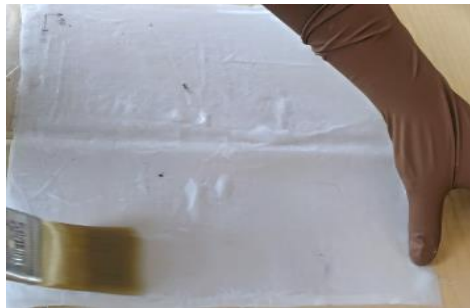


Figure 1c Applying Resin



Figure 1d. Applying roller



Figure 1f Ramie Composite

## Mechanical Characterization

### I. Tensile Test

The highest stress that even a material can endure before fractures are strained or dragged is known as maximum tensile strength, or simply tensile strength. The samples were nevertheless tensile tested in line to ASTM D 3039. The sample is 250mm X 25mm X 5mm in size. Figure II depicts a fixture used in tensile testing. The formula for calculating ultimate tensile strength is as follows: (1)

$$\text{Tensile strength} = \frac{\text{Extreme load}}{\text{Cross sectional area}} \quad \text{in MPa} \quad \text{-----}(1)$$

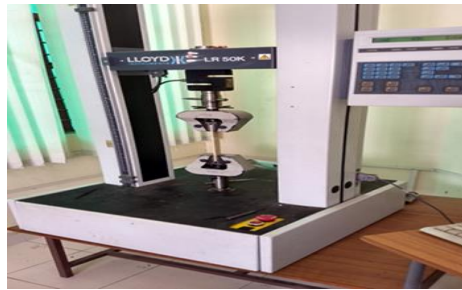


Figure II Tensile Test Fixture

### II. Flexural test

Flexural testing is often used to control overall mechanical properties of the composite composites due to the little effort required for the test samples, layout, and testing equipment. The flexural strength of materials was assessed using the ASTM – D790 three-point bending test. The samples have dimensions of 200 mm x 15 mm x 5 mm. Figure III depicts this experiment's flexural test setup. When utilizing equation 2, the composites' flexural strengths remained constant.

$$FS = \frac{3PL}{2BD^2} \quad \text{in MPa} \quad \text{-----} (2)$$

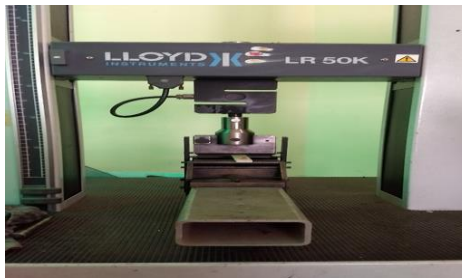


Figure III Flexural Test Fixture

## Result and Discussion

### I. Tensile strength result

The tensile strength results for various combinations of ramie and hybrid composite are shown in Table I. In this experiment, we take two materials and assess their tensile strength. When compared to other combinations, having 2 layers of ramie + 4-layer glass + 6-layer Kevlar fiber has the highest tensile strength.

Table 1 Tensile Strength Of Ramie And Hybrid Composite

Samples	Materials	Average UTS in Mpa
A	2 layers of ramie + 4-layer glass+ 6-layer Kevlar fiber	120
B	6-layer Ramie fiber + 6-layer Kevlar fiber.	98
C	6-layer Ramie fiber + 6-layer Glass fiber.	66
D	12 Layer ramie	34

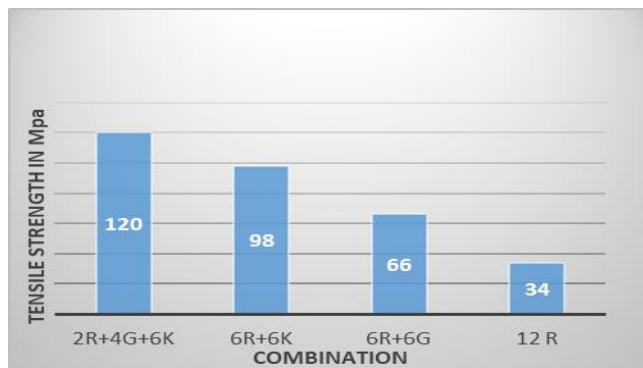


Figure IV Tensile Strength Of Ramie And Hybrid Composite

Figure IV shows result of tensile strength of ramie and hybrid composite. Tensile strength is maximum at sample A is 120 MPa and minimum at sample 34 MPa

### II. Flexural strength result

The flexural strength test results for various combinations of ramie and hybrid composite are shown in Table II. In this experiment, we take two materials and assess their tensile strength. In comparison to other combinations, having 2 layers of ramie + 4-layer glass + 6-layer Kevlar fiber has the highest flexural strength.

Table II Flexural Strength Of Ramie And Hybrid Composite

Samples	Materials	Avg FS in Mpa
A	2 layers of ramie + 4-layer glass+ 6 layers Kevlar fiber	168
B	6-layer Ramie fiber + 6-layer Kevlar fiber.	162
C	6-layer Ramie fiber + 6-layer Glass fiber	144
D	12 Layer ramie	106

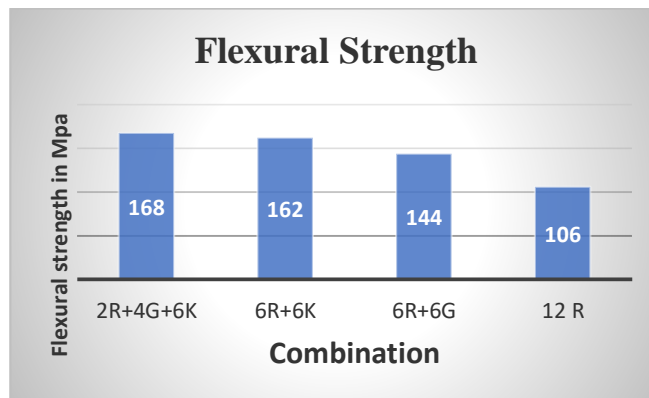


Figure V. Flexural strength of ramie and hybrid composite

Figure V shows result of flexural strength of ramie and hybrid composite. Tensile strength is maximum at sample A is 168 MPa and minimum at sample 106 MPa

### Conclusion

In the current study, four different types of combinations were achieved using ASTM standards for testing. The results of the investigative study on the effect of various combinations before to the treated ramie with hybrid composite reflect the following conclusion. In comparison to other combinations, tensile strength is maximum 120 MPa but also flexural strength is maximum 160 MPa at 2 layers of ramie + 4 layers of glass and 6 layers of Kevlar.

### Acknowledgment

I am grateful to the Brindavan College of engineering, department of mechanical engineering for their support in bringing the research work to completion.

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