International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 09 | Sept - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

# To Evaluate Mechanical Properties of Epoxy Resin Based E-Glass / Kenaf / Husk Hybride Composite

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**Abstract**

The mechanical behavior of epoxy resin composites reinforced with combination of E-glass, kenaf and coconut husk fibers, which is a hybrid fiber, is investigated in the present study. The aim was to establish the effect of fiber length and proportion variation on tensile, flexural and impact properties. A hand lay-up process was adopted to create the composites, whereby, the epoxy resin was used as the matrix, and the fibers were added in predetermined proportions. Before being fabricated, coconut husk fibers had been treated with alkali to make them stick. Tensile, bending and impact resistance tests were done based on ASTM standardized specimens to established that hybridization is an effective solution to counteract high stiffness of E-glass fibers with toughness and ability of natural fibers to absorb the energy composites with longer kenaf and husk fibers proved to be better in terms of tensile and flexural strength, whereas coir played a significant role in impact resistance. In order to obtain optimal fiber blends, the tensile strength, flexural strength and impact strength. The results prove the fact that epoxy resin-based hybrid composites are capable of producing high mechanical performance at light weight and sustainable manufacturing. These materials are of great automotive, construction and structural potential with a viable alternative to fully synthetic composites that is environmentally responsible.

## I.Introduction

The ability of composite materials to integrate the specific properties of two or more materials into a unified and multi-functional system has rendered composite materials indispensable in the contemporary engineering field [1,2]. The polymer matrix composites (PMCs) are the ones that have attained the most industrial recognition because of their processability, lightness and desirable strength-to-weight ratio [3]. The epoxy resins especially have found extensive applications as polymeric matrices due to their good adhesion, chemical resistance and mechanical stability [4].

During the last several years, natural fiber reinforced composites have gained more attention. Agricultural wastes like kenaf, coconut husk offer a potential substitute to traditional reinforcement since it is cheap, available, renewable and biodegradable [5-7]. Nevertheless, they cannot be used independently in the high-performance applications because of their relatively low tensile strength and flexural strength in the case of synthetic fibers [8]. Conversely, E-glass fibers are stronger, stiffer and resist thermal changes, yet they are non-biodegradable and require a lot of energy during their manufacturing making them an environmental problem [9]. The above limitations have necessitated the development of the concept of hybrid composites as a long term way forward. Hybridization is the synthesis of synthetic fibres and natural fibres into a common matrix so that their advantages can be exploited and their shortcomings avoided [10,11]. An example is the fact that E-glass fibers boost the strength-carrying capacity, and natural fibers add toughness, lower density, and energy absorption. A number of studies have shown that hybrid composites perform better in tensile, flexural and impact than single-fiber systems [12 -14]. Moreover, the use of natural fibres facilitates the worldwide sustainability trends in terms of decreasing the use of reinforcing materials that are entirely synthetic fibers [15].

The most promising of the natural fibers is kenaf fiber has the high content of cellulose contributes to rigidity, and the favorable aspect ratio facilitates the transfer of stress [16]. Likewise, coconut husk fiber (coir), available in large amounts of lignin, is a good source of strength and excellent shock-absorbing properties [17]. These natural fibers together with glass fibers enhance the absorption of energy during impact loading and prevents crack propagation [18]. Nevertheless, there are still some issues: natural fibers are hydrophilic and can easily absorb water, thus interfering with dimensional stability. These disadvantages are usually addressed by using chemical modifications such as alkali and silane treatment that enhance adhesion at the interface with the matrix [19,20]. Moreover, it is important to maximize the volume fraction, orientation and length of fiber to attain consistency and reproducibility in composite behavior [21]. The aim of the current research is to improve the mechanical performance of E-glass, kenaf and coconut husk fibers reinforced epoxy resin composites. The work will systematically change the length of fiber and weight percentage to determine their effect on tensile, flexural and impact properties. The general goal is to find hybrid formulations that will provide the best balance between environmental sustainability and mechanical performance. Such results are likely to have direct implication on the development of lightweight automotive parts, structural panels and other engineering applications whereby the strength, durability and eco-responsibility are of the utmost consideration [22-24].

## II.METHODOLOGY

### Materials:

The material used was low-temperature curing epoxy resin (LY 556) mixed with hardener (HY 951) with weight ratio of 10:1. E-glass fibers were ordered in chopped strand, and kenaf fibers were local. The agricultural waste was processed into coconut husk fibers which underwent an alkali treatment (5 percent NaOH solution 24 hours) to remove the hemicellulose, wax and lignin components to enhance the surface roughness and inter-faces bonding.

### Material Preparation:

The approach that was used to produce hybrid composites was a manual hand lay-up technique. The drying process of pre-treated fibers was done at 80 o C during 12 hours to remove any remaining moisture. The mixture of epoxy resin and hardener was made and mixed with the fibers in pre-planned proportions of weight. To readily demold the molds, a releasing agent was applied to the molds. The fiber-resin composite was cast to rectangular molds with evenly spacing, and the mixture was pressed at 20 kg load during 24 hours. Specimens were air-cured further after demolding (24 hours).

### Relationship between fiber volume and weight ratio

To find the fiber weight ratio, you can use the fiber/resin volume ratio. Here's how:

We have $V_f = 1 - V_r - V_{voids}$ and $V_f = 1 - V_r$.

Where $V_f$ is the volume of the fiber

$V_r$= the amount of resin in the matrix that determines the fiber volume ratio

And we have $V_r = 1/1+(V_f/V_r)$

From the equation above, we can find the $V_f/V_r$, which tells us the weight ratio of fiber to resin.

$V_t/V_r = (W_f/W_r)\ (P_r/P_f)$ The resin weighs less than the composite material and fiber.

$W_{matrix} = W_{composites} - W_{fibers}$

You may find Wmatrix and Wfibers by plugging in the values you found into the equation above.

As per ASTM D-638 says that tensile specimens need varied amounts of weight depending on the type of fiber and resin and the volume proportion.

The weight of fiber is equal to $\rho_f \times V_f \times \Delta f$

weight of resin = $\rho_m \times V_r \times \Delta m$

**The density of various materials**:

The density of glass fiber = 2.62 g/cm3.

The density of coconut husk = 1.2 g/cm3.

Fiber weighs 269.68 grams.

The resin weighs 187.68 grams.

| Composites | Compositions |
|---|---|
| S1 | Epoxy (75wt%) + glass fiber (20wt%) +coconut Husk (fiber length 10mm) (5wt%) |
| S2 | Epoxy resin (75wt%) + glass fiber (20wt%) + coconut husk (fiber length 10mm) (5wt%) |
| S3 | Epoxy (75wt%) + glass fiber (20wt%) + coconut husk (fiber length 15mm) (5wt%) |
| S4 | Epoxy (75wt%) + glass fiber (20wt%) +coconut husk (fiber length 15mm) (5wt%) |

**Table 1:Preparation of composites**

## Testing methods:

**Tensile Test (ASTM D-638):** Dog-bone specimen was subjected to Universal Testing Machine (UTE-60). Constant rate loading up to fracture was applied and tensile strength calculated as the maximum load/area.

**Figure 2: Before tensile test**

**Figure 1: After tensile test**

**Figure 3: Before flexural test**

**Figure 4: After flexural test**

**Flexural Test (ASTM D-790):** The test was a three-point bending set-up. The specimens were held at one end and some load was put at the center until failure.

**Impact Test (ASTM D-256):** Izod impact test was conducted using notched specimen. The signal of energy taken before the fracture was directly registered on the pendulum scale which represents the impact resistance.

**Figure 5: Before impact test**

**Figure 6: After impact test**

## III.Results and Discussion:

| Composites | Tensile strength | Flexural strength | Impact strength |
|---|---|---|---|
| S1 | 65 | 40.3 | 5.4 |
| S2 | 74 | 43.7 | 6.2 |
| S3 | 78 | 45.5 | 6.5 |
| S4 | 87 | 56.1 | 7.3 |

**Table 2: Observation of hybrid composite materials**

**Tensile Strength:**

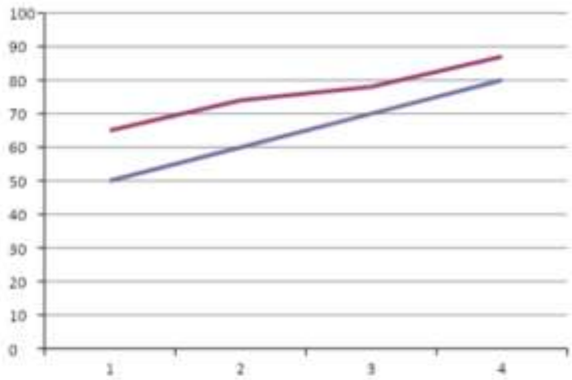


**Figure 7: The Effect of Fiber Loading and Length on the Tensile Strength of Composites**

There was a gradual rise in tensile strength as a result of fiber length and optimal fiber loading. The tensile strength of sample S4 was maximum (87 MPa), which implies longer husk fibers were transferred to effective loads. This improvement is due to better fiber- matrix interfacial bonding especially following alkali treatment.

**Flexural Strength:**

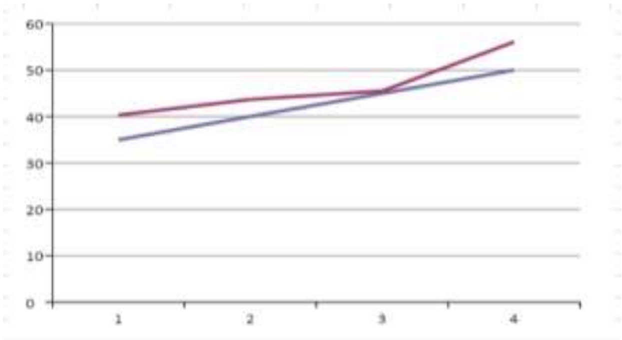


**Figure 8: How the amount and length of fibers affect the flexural strength of composites**

obtained with flexural strength, which rose to 56.1 Mpa in S4 after starting at 40.3 Mpa in S1. Bending loads were resisted by the addition of longer husk and kenaf fibers. The rigidity of the glass fibers with the plastics of natural fibers was a synergistic boost.

**Impact Strength:**

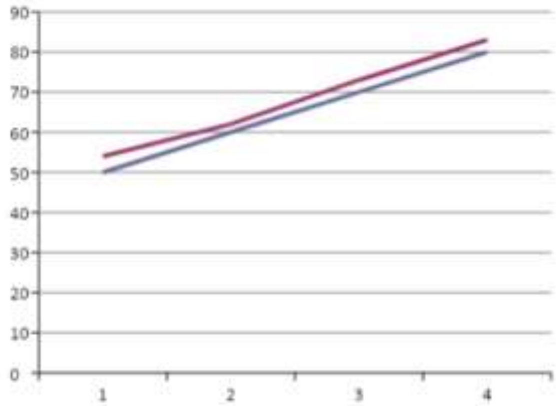


**Figure 9: Effect of Fiber Loading and Length on the Impact Strength of Composites**

Coir fibers proved to be very helpful in the impact resistance. S4 produced the greatest impact strength of 7.3 MPa. Lignin content released in the coconut husk fibers was so high that it allowed to absorb energy efficiently, and the composites became less vulnerable to abrupt loading.

## IV.Conclusion:

In this paper the experimental study proved that hybridization is better in tensile, flexural, and impact properties than single-fiber composite. We have observed that the mechanical performance with the sample whose husk fibers were longer (S4): tensile strength of 87 Mpa, flexural strength of 56.1 Mpa and impact strength 7.3 Mpa. The results also emphasize the role of the length of the fibers, treatment, and weight ratio to establish the strength and stiffness of hybrid composite materials. The mechanical reliability coupled with the lightweight and environmental sustainability of tough natural fibers combined with stiff synthetic fibers was made possible by the synergy of the two to create synthetic and natural fiber composites.

More research in the future should be aimed at optimizing the fiber orientation, discussing new fillers, including nano-silica or rice husk ash, and evaluating durability of the materials in the long-term under cyclic loads and environmental effects. These enhancements might open the door to mass utilization of these hybrid composites in the automotive sector, aerospace sector, and also civil engineering to offer an alternative green material to fully synthetic material.

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