Fabrication of Banana Fiber – Rice Husk Reinforced Composite for Partition Boards

W.K.P. Bhagya
Department of Materials Science & Engineering
University of Moratuwa
Katubedda, Sri Lanka
bhagyawkp.20@uom.lk

G.V.D.P Senevirathne
Department of Materials Science & Engineering
University of Moratuwa
Katubedda, Sri Lanka
senevirathnegvdp.20@uom.lk

S.V. Udayakumara
Department of Materials Science & Engineering
University of Moratuwa
Katubedda, Sri Lanka
udayakumara@uom.lk

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I. Introduction

The escalating environmental impact of synthetic polymer composites highlights the significance of the development of sustainable alternatives derived from renewable resources. Agricultural waste by products such as banana fibers and rice husk are abundant in many tropical and agricultural countries, including Sri Lanka. But they remain vastly underutilized, often contributing to environmental pollution [1]. These agro-wastes can be utilized as reinforcements in polymer composites aligns with circular economy principles by reducing waste and mitigating dependence on non-renewable materials [2].

Even though, the existing studies have investigated natural fiber composites, limited research has systematically evaluated the combined effects of banana fiber and rice husk reinforcement in epoxy matrices, exclusively focusing on optimizing volume ratios to achieve balanced mechanical and moisture resistance properties. Addressing this gap, the present study fabricates and characterizes banana fiber–rice husk epoxy reinforced composites across varying volume ratios, targeting applications in sustainable construction materials.

II. Literature Review

Banana fibers are cellulosic fibers characterized by high tensile strength, good stiffness, and biodegradability, making them ideal candidates as eco-friendly reinforcements in composites [3]. Moreover, they are well known for their impressive tensile strength, biodegradability, and renewability while proper matrix selection and fiber treatment reinforce moisture resistance[4], [5].

Rice husk, a silica-rich agro-waste byproduct of rice milling, facilitates low density and excellent thermal stability, increasing the durability of composite [6]. Therefore, incorporation of rice husk can improve mechanical properties and water resistance while well proportion is required to avoid potential brittleness.

Strong adhesion, mechanical robustness, and chemical resistance of epoxy resins facilitate efficient stress transfer in fiber-reinforced composites serving as effective matrices [7]. The combined effect of banana fibers and rice husk aims to amplify the mechanical advantages of both components while overcoming respective limitations, yielding composites with improved strength, moisture resistance, and environmental sustainability.

III. Materials & Methods

A. Materials

Locally sourced banana fibers were thoroughly cleaned and mechanically crushed to reduce fiber size before sieving through a $1000\ \mu m$ mesh to achieve a uniformity below $1000\ \mu m$. Rice husks were similarly ground and passed through a $710\ \mu m$ sieve for particle size control. Both reinforcements were dried at $60°C$ for $24\ hours$ to decrease moisture content prior to blending. As the matrix, *bisphenol A–epichlorohydrin epoxy resin* was selected along with $Epoxy\ Hardener\ PK$ 13, primarily based on its established compatibility and bonding capacity.

B. Method

1) Determination of optimum adhesive content

The optimum resin–hardener content was determined through preliminary mixing trials ensuring thorough wetting and matrix–fiber bonding while concerning on the prevention of excess matrix bleed-out. The epoxy matrix was prepared by mixing resin and hardener in a 2:1 ratio, while stirring slowly to avoid air bubble entrapment.

2) Composite fabrication

Five composite samples had maintained a total mould volume of 350 ml, consisting of an epoxy volume fraction of 30.25%. The remaining fraction was composed of banana fibers and rice husk in different volume ratios as $90:10, 80:20, 70:30$ & $60:40$, while maintaining a constant total reinforcement fraction. Pre-mixed epoxy system was integrated into the fiber and rice husk mixture manually permitting an uniform dispersion. That mixture was then transferred into a rectangular steel mold and hot pressed at $130°C$ under a pressure of 5.5 MPa for 30 $minutes$ to yield composite plates. All samples underwent post-curing at ambient temperature for 24 hours (manufacturer's product specifications) to complete ambient crosslinking.

3) Characterization of composite samples

Test specimens ($34mm \times 18mm \times 3mm$) for all characterizations were cut from the composite plates according to applicable standards. Tensile properties were

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evaluated using a universal tensile testing machine, following $ASTM\ D3039$ standards, to assess the mechanical integrity of each formulation. This test is crucial to understand the ultimate strength and suitability for structural and semi-structural usage of the designed composite. Water absorption was determined according to $ASTM\ D570$ standards by recording the weight increment of samples after $24\ hours$ of full immersion in distilled water, as a measure of environmental durability and resistance to water uptake. Thickness swelling was simultaneously measured by measuring the dimensional change in thickness after $24-hour$ immersion, also as per $ASTM\ D570$, to assess swelling behavior and dimensional stability under wet conditions.

All characterization techniques were conducted in triplicate to ensure accuracy and reliability, and the reported values represent the corresponding sample means.

IV. Results and Discussion

A. Water Absorption

Different water absorption results were obtained after 24 hours of immersion, depending on the banana fiber-to-rice husk volume ratios. Samples with volume ratios corresponding to approximate volume ratios of 90:10, 80:20, and 70:30 exhibited water uptakes of 23.1%, 22.74%, and 23.13%, respectively, which exceeded the standard range (ASTM D1037 / ISO 62) of 8–20%. In contrast, the sample with the highest rice husk content (volume ratio ~60:40) showed a markedly lower water absorption of 15.59%, falling within the acceptable range. This behavior indicates that increased rice husk content, due to its comparatively lower water affinity than banana fibers, reduces the water uptake of the composite, increasing moisture resistance.

B. Thickness Swelling

Thickness swelling showed a similar trend with different volume ratios, where the composite with the highest banana fiber volume ratio ($90:10$) exhibited the minimum swelling at 2.85%, while increasing rice husk content resulted in slightly increased swelling to a maximum of 6.09% at the $60:40$ volume ratio. Despite this increase, all samples displayed thickness swelling well below the upper recommended limit of ASTM D1037 standards depicting desirable dimensional stability. The comparatively higher swelling with rice husk content may be due to its porous structure absorbing more water volume, despite lower overall weight-based water absorption.

C. Tensile Strength

Tensile strength values demonstrated substantial mechanical integrity across all volume ratios, exceeding typical matrix resin strength benchmarks significantly ($targeting \geq 0.5\ MPa$). The highest tensile strength of approximately $19\ MPa$ was recorded at a $60:40$ banana fiber-to-rice husk volume ratio, followed by $17\ MPa$ at $70:30$ ratio. The comparatively lower strengths at $90:10$ ($14\ MPa$) and $80:20$ ($15\ MPa$) volume ratios propose an optimal mixing requires higher rice husk content, due to enhanced fiber–matrix interaction or better stress transfer. Overall, based on the combination of mechanical strength and

TABLE I. CHARACTERIZATION TEST RESULTS

Test	Banana Fiber: Rice Husk			
	90:10	*80:20*	*70:30*	*60:40*
Water Absorption (%)	23.13	23.1	22.74	15.59
Thickness Swelling (%)	2.85	4.67	5.13	6.09
Tensile Strength (MPa)	14	15	17	19

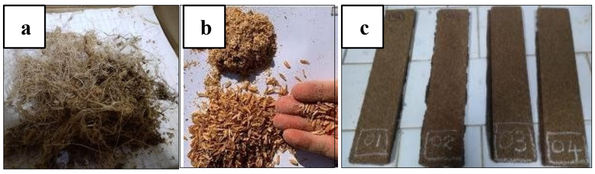

Fig. 1. (a) Banana Fibers (b) Rice Husk (c) Hot Pressed Composite Samples Using a Stainless-Steel Mould ($25cm \times 7cm \times 0.85cm$)

moisture resistance the composite with the 60:40 banana fiber-to-rice husk volume ratio was chosen as the optimum ratio for the utilization of partition boards.

V. Conclusion

The banana fiber–rice husk epoxy composite developed in this study demonstrated a promising balance of mechanical integrity and moisture resistance, particularly at the 60:40 volume ratio. Comprehensive characterization confirmed its suitability for non-load-bearing applications such as partition boards, where durability, dimensional stability, and sustainability are critical. By utilizing abundant agricultural wastes from Sri Lanka, the composite provides an eco-friendly alternative to conventional materials while promoting sustainable construction practices. Further optimization and long-term durability assessments are recommended to advance its commercialization potential in the partition board market.

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