Design and Manufacturing of Ecofriendly Panels Using Rice Husk, Coconut Coir and Saw Dust

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Abstract
This study focuses on the design and manufacturing of eco-friendly composite panels using rice husk, coconut coir, and sawdust. The project begins with careful material selection to ensure the panels' mechanical strength, thermal insulation, and environmental sustainability. Locally sourced materials, including rice husk, coconut coir, and sawdust, are processed by cleaning, drying, and grinding to optimize their properties for the final product. The panels are formed by blending these materials with eco-friendly binders, such as polyester resin, and applying heat and pressure to enhance bonding and dimensional stability. A precisely constructed wooden mold is used to maintain uniform panel dimensions, and the panels are then trimmed and finished to meet aesthetic and functional requirements. Rigorous quality assessment is conducted to evaluate the panels' physical properties, including density, moisture resistance and thermal insulation. The use of agricultural and industrial waste in this process not only reduces environmental impact but also provides a sustainable alternative to traditional building materials, demonstrating the potential for eco-friendly panels in various applications.

Keywords: Eco-friendly panels, rice husk, coconut coir, sawdust, sustainability, composite materials, quality assessment.

1. INTRODUCTION

The increasing demand for sustainable materials in the construction and manufacturing industries has led to a growing interest in alternative, eco-friendly options to traditional materials. Conventional building materials such as cement, steel, and wood have significant environmental impacts, contributing to resource depletion, high energy consumption, and pollution. Agricultural by-products, such as rice husk, coconut coir, and sawdust, offer a promising solution to these challenges. These materials are abundant, renewable, and often considered waste, making them ideal candidates for developing sustainable composite materials. Rice husk, a by-product of rice milling, is lightweight and rich in silica, making it an excellent material for reinforcing composites. Coconut coir, derived from the husk of coconuts, is durable, moisture-resistant, and naturally resistant to fungi and pests, adding resilience to composite panels. Sawdust, a by-product of woodworking, is inexpensive and readily available, providing density and improving the processability of the panels. The utilization of these agricultural residues not only helps reduce waste but also mitigates the need for non-renewable resources, offering a sustainable and cost-effective alternative for building materials. This study explores the feasibility of creating composite panels from rice husk, coconut coir, and sawdust, with a focus on their mechanical properties, durability, and potential applications in construction, furniture, and insulation. By investigating the combination of these materials, this research aims to contribute to the development of eco-friendly panels that can replace conventional materials, reducing the environmental impact of the construction industry and promoting a circular economy.

2. METHODOLOGY

The project on designing and manufacturing eco-friendly panels using rice husk, coconut coir, and sawdust focuses on creating sustainable construction materials by repurposing agricultural by-products. These materials, chosen for their natural strength, flexibility, and insulation properties, contribute to reducing waste while supporting eco-friendly construction practices. By following a structured methodology, including steps like raw material processing, mixing, and quality testing, the project aims to produce high-quality, environmentally friendly panels suitable for a range of applications. The following sections outline each stage of the process in detail, from initial material selection to final packaging and storage.

2.1 Material Selection :

Raw materials - rice husk, coconut coir, sawdust, polyester resin, catalyst, and accelerator were selected for their mechanical strength, thermal insulation, cost-effectiveness, and sustainability.

2.2 Material Collection and Preparation of Mould :

Material Collection: Rice husk from Pathiripala rice mills, coconut coir from household sources, and sawdust from Ambalapara sawmills were chosen to support local industries and minimize environmental impact.

Mould Preparation: A 21cm × 21cm wooden mold was constructed for uniform panel production. It was designed for strength, precision, and ease of panel removal.

2.3 Raw Material Processing :

Raw materials were cleaned to remove impurities, dried to reduce moisture content, and ground into uniform particle sizes for consistent mixing and durability.

2.4 Mixing and Blending :

The processed materials were mixed with eco-friendly polyester resin. The mixture was adjusted to balance properties like strength, water resistance, and durability. Mix proportions varied among panels:

Table 1: Mix proportion of panel

Material	Panel 1	Panel 2	Panel 3
Rice husk	80%	60%	60
Coconut coir	60%	80%	60%
Saw dust	60%	60%	80%

2.5 Panel Forming Process :

Materials were placed in molds, compressed under pressure, and heat-pressed for curing. This ensured strong bonding, uniform density, and dimensional stability.

2.6 Trimming & Finishing :

Excess material was trimmed, and surfaces were smoothed to meet required aesthetic and dimensional standards for construction and interior applications.

2.7 Quality Assessment :

Panels underwent physical, mechanical, and thermal tests to evaluate durability, strength, and insulation properties. These tests ensured compliance with performance and safety standards.

3. TESTING AND ANALYSIS

3.1 Water Absorption Test :

The test was conducted as per ASTM standard D1037-12. sample having size 210x210x10mm were taken from each board and weighed. Then it is soaked in water for 24 hours. There after they were removed from water, cleaned and reweighed. The weight gain in percentage of the samples were calculated by using the following equation.

Water Absorption % = ((W2-W1)/W1) X100

where, W1- Dry weight of the specimen

W2- Weight of specimen after immersion

Result of water absorption test :

Table 2: Water Absorption Percentage Of Different Panels

Panel Type	Initial Weight (g)	Final Weight (g)	Water Absorption (%)
Panel 1	412	435.896	5.8%
Panel 2	413.5	438.682	6.09%
Panel 3	412	435.484	5.7%

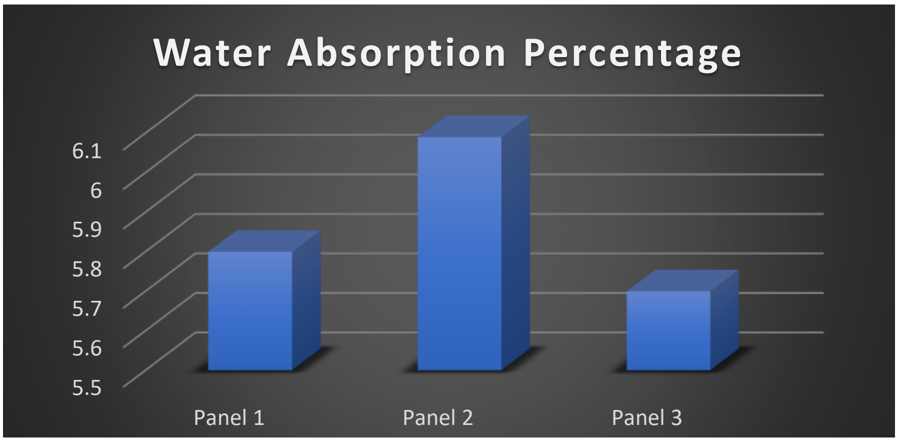

Chart 1:Water Absorption Percentage

Results indicate that all the panels exhibit similar water absorption behavior, with only slight differences between them. This suggests that the panels are absorbing moisture to a moderate extent.

3.2 Thickness swelling Test:

The test was performed in accordance with ASTM standard D1037-12. Sample having dimension 210x210x10mm were taken from each board and their thickness is noted. Then it is soaked in water for 24 hours. Thereafter they were removed from water, cleaned and thickness after immersion in water is taken. The percentage thickness swelling was calculated from the equation,

Thickness Swelling = ((T2-T1)/T1)/ X 100

where, T1- Thickness of sample before immersion in water

T2- Thickness of sample after immersion in water

Result of thickness swelling test :

Table 3: Thickness swelling percentage of different panels

Panel Type	Thickness swelling (%)
Panel 1	1.9
Panel 2	2
Panel 3	1.33

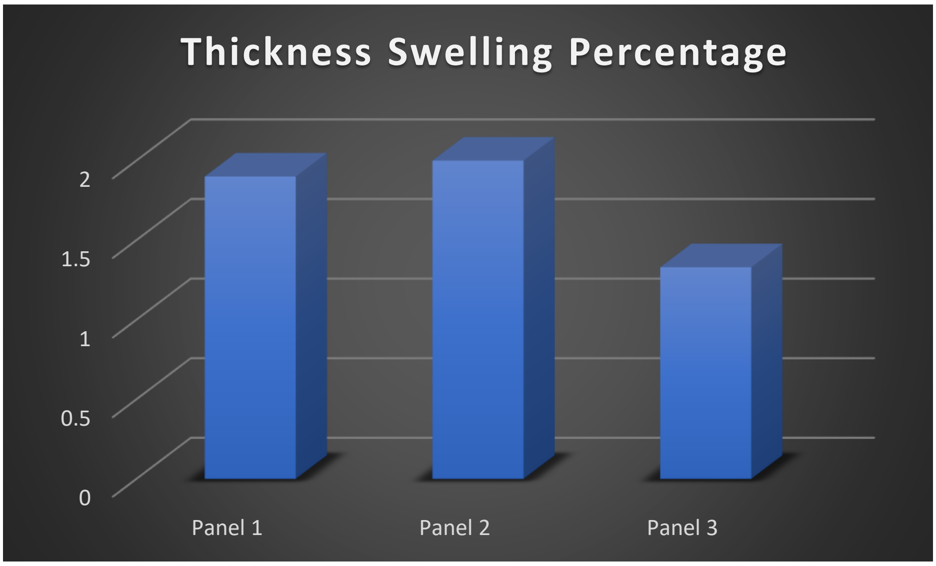

Chart 2:Thickness Swelling Percentage

The thickness swelling of the panels shows slight variation, with Panel 2 experiencing the highest swelling, followed by Panel 1 and Panel 3. This indicates that while all the panels undergo some degree of thickness expansion, Panel 2 shows the most significant increase. Overall, the swelling is relatively low across all panels, suggesting that they maintain a good structural integrity despite moisture exposure.

3.3 Cost Analysis :

A cost analysis of a composite panel made from rice husk, coconut coir, sawdust, polyester resin, catalyst, and accelerator provides insights into its economic feasibility. The panel under consideration consists of **60 grams of rice husk, 60 grams of coconut coir, 80 grams of sawdust, 200 grams of polyester resin, and 2 grams each of catalyst and accelerator.** The primary cost contributor is polyester resin, which serves as the binding material due to its strong mechanical properties and chemical resistance. In Kerala, polyester resin is priced at approximately ₹200 per kilogram, leading to a calculated cost of ₹20 for the 200 grams used. Catalyst and accelerator, essential for initiating and controlling the curing process, are priced at ₹130 per kilogram, adding approximately ₹2.6 for the 4 grams used in the panel.The natural fillers rice husk, coconut coir, and sawdust are agricultural by-products available at a relatively low cost. With an average price of ₹5 per kilogram, the total cost for the 200 grams of natural fillers amounts to approximately ₹1. These low-cost natural fillers help reduce the overall production cost while maintaining good mechanical and insulating properties. The overall cost structure reflects a balance between material performance and affordability. The low cost of natural fillers combined with the stable pricing of polyester resin and additives makes the composite panel a cost-effective and sustainable alternative to conventional materials. This analysis highlights the potential for scaling production while maintaining economic and environmental benefits.

Table 4: Material Quantities

Materials	Quantity
Rice Husk	60g
Coconut coir	60g
Saw dust	80g
Polyester resin	200g
catalyst	2g
accelerator	2g

Table 5: Cost of Materials

Materials	Cost/unit (in Rs)	Quantity of Material Used	Cost (in Rs)
Rice Husk	6 Rs/ kg	60g	Rs. 0.36
Coconut coir	40 Rs/ Kg	60g	Rs. 2.4
Saw dust	20 Rs/ Kg	80g	Rs. 1.6
Polyester resin	100 Rs/ Kg	200g	Rs. 20
catalyst	50 Rs/ Kg	2g	Rs. 1.6
accelerator	80 Rs/ Kg	2g	Rs. 1

Table 6: Total Panel Cost

Materials	Quantity/panel used	Cost
Rice Husk	80g	Rs. 0.48
Coconut coir	60g	Rs. 2.4
Saw dust	60g	Rs. 1.2
Polyester resin	200g	Rs. 20
catalyst	2g	Rs. 1.6
accelerator	2g	Rs. 1
Total Cost =		26.96 = Rs.30/Panel

Table 7: Cost Comparison

Panel using Rice husk Coconut coir and Saw dust	Standard laminate panels
Cost = Rs. 30/ Panel	Cost = 60 Rs-350Rs /Panel

3.4 Carbon Foot Print:

A carbon footprint is the total amount of greenhouse gases (like carbon dioxide and methane) released into the atmosphere due to human activities, such as driving cars, using electricity, and producing goods. It measures the impact of these activities on climate change, usually in terms of CO_2 equivalent (CO_2e). Reducing your carbon footprint can help fight global warming by using less energy, cutting waste, and choosing sustainable options.

CFproduct= ∑ (M×E)
M = Mass or quantity of material or energy used
E = Emission factor (CO_2 equivalent per unit of material or energy

Table 8: Carbon foot print of different panels

Panel type	Carbon foot print
Panel 1	1.1326 kg CO_2e
Panel 2	1.135 kg CO_2e
Panel 3	1.1324 kg CO_2e

3.5 Thermal conductivity :

A thermal conductivity test was conducted on a composite panel made from rice husk, coconut coir, and sawdust, with polyester resin serving as the binder, using ANSYS software. The primary objective of the simulation was to evaluate the panel's ability to resist heat transfer and assess its potential as an insulating material for construction and industrial applications. In the ANSYS analysis, the panel was subjected to a controlled heat flux, with one side of the panel maintained at a constant temperature of **100°C**. The resulting temperature distribution, heat flow, and thermal gradient across the panel were carefully monitored to understand the material's thermal behavior. The results demonstrated that the panel exhibited low thermal conductivity, indicating that the combination of natural fibers and polyester resin effectively minimizes heat transfer by creating air pockets and reducing direct heat conduction. The low thermal conductivity can be attributed to the insulating properties of the natural fibers and the uniform dispersion of the polyester resin, which enhances the panel’s thermal resistance. The simulation also revealed that factors such as fiber orientation, particle size, and the degree of resin saturation play a significant role in the panel's overall thermal performance. The detailed analysis provided valuable insights into how the composite structure responds to thermal stress, confirming that the panel has strong insulating properties and making it a promising eco-friendly material for improving energy efficiency in construction and other high-temperature environments.

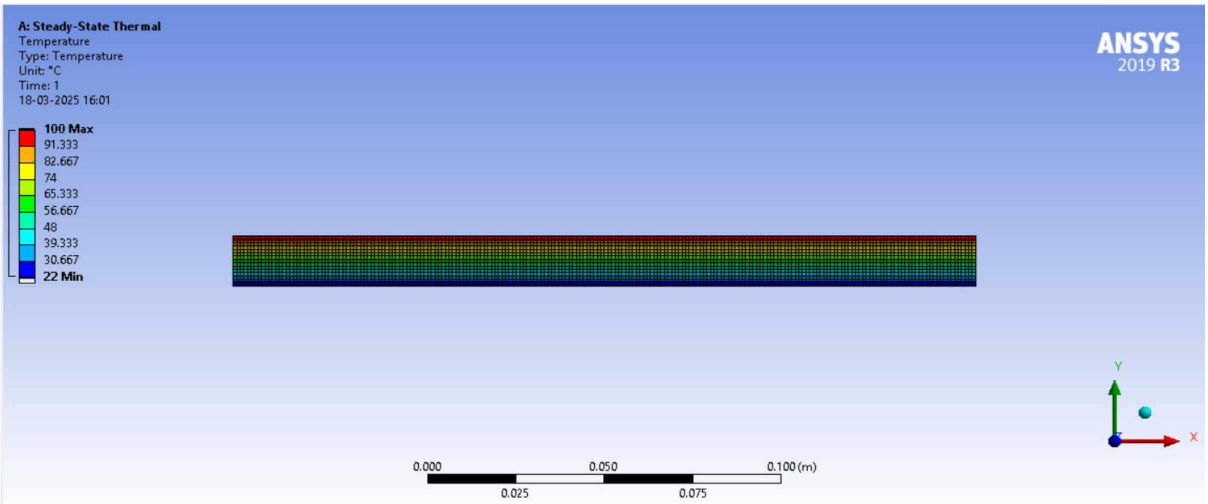

Fig 1: Thermal analysis of panel 1 at 100 ºc

Max temperature applied = 100ºc
Min temperature obtained = 22ºc

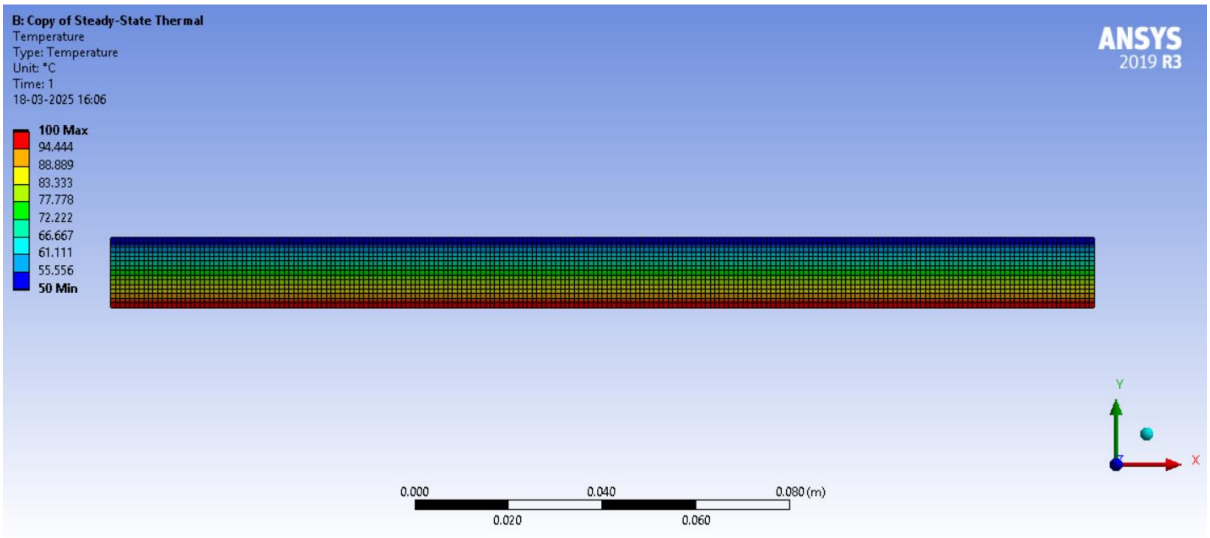

Fig 2: Thermal analysis of panel 2 at 100ºc

Max temperature applied = 100ºc
Min temperature obtained = 50ºc

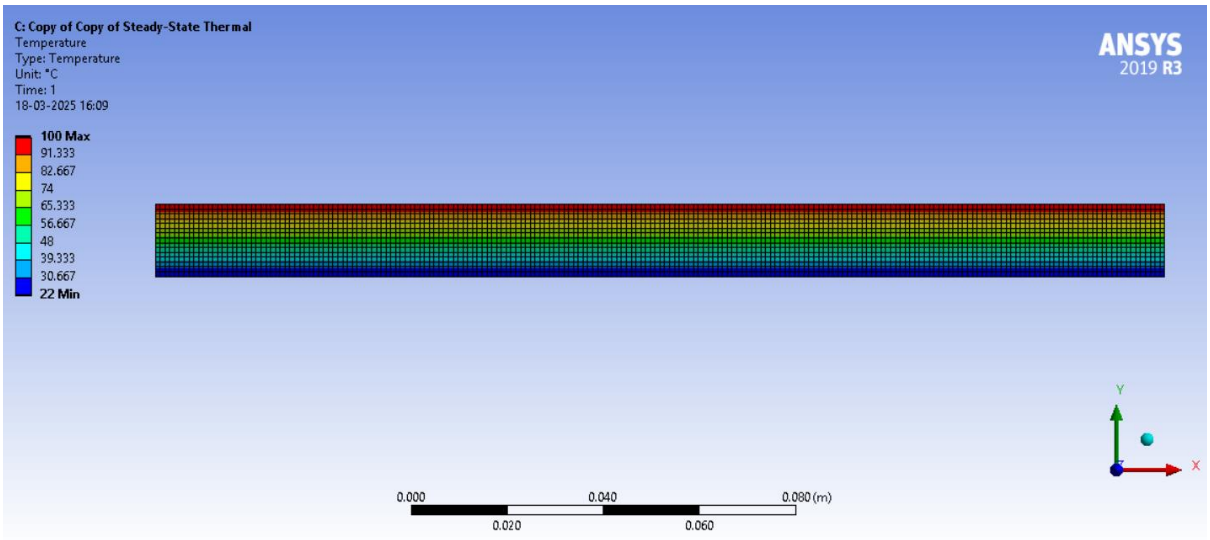

Fig 3: Thermal analysis of panel 3 at 100ºc

Max temperature applied = 100ºc
Min temperature obtained = 22ºc
The thermal conductivity test results for the composite panels made from rice husk, coconut coir, sawdust, and polyester resin show that the panels exhibit excellent insulating properties. The simulation revealed that the panels effectively minimize heat transfer, with Panel 1 and Panel 3 achieving a minimum temperature of 22°C and Panel 2 reaching 50°C, despite being exposed to a maximum temperature of 100°C. These results highlight the panels' ability to resist heat flow, confirming their suitability as energy-efficient materials for construction and industrial applications.

4. CONCLUSION

The test results of the eco-friendly composite panels, made from rice husk, coconut coir, and sawdust, demonstrate promising performance across various parameters. The water absorption test showed moderate moisture uptake, with Panel 1, Panel 2, and Panel 3 exhibiting absorption percentages of 5.8%, 6.09%, and 5.7%, respectively, indicating that the panels maintain good structural stability even when exposed to water. In the thickness swelling test, the panels showed minimal expansion, with values of 1.9%, 2%, and 1.33%, which suggests that the panels retain their form and integrity after moisture exposure. The cost analysis revealed that the production cost per panel is ₹30, offering a highly cost-effective solution compared to standard laminate panels, which typically range from ₹60 to ₹350 per panel. Additionally, the panels have a low carbon footprint, with values of 1.1326 kg CO_2e, 1.135 kg CO_2e, and 1.1324 kg CO_2e for Panels 1, 2, and 3, respectively, underscoring their sustainability. Thermal conductivity tests confirmed the panels' excellent insulating properties, with minimum temperatures of 22°C for Panel 1 and Panel 3, and 50°C for Panel 2 when subjected to 100°C heat. This indicates that the panels are effective at reducing heat transfer and can be used in energy-efficient applications. Overall, these results demonstrate that the panels are a sustainable, affordable, and high-performance alternative to conventional building materials, with significant potential for use in various construction and industrial applications.

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