Agro-Woven Panels: Transforming Textile & Agricultural Waste into Affordable Housing Solutions

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***Abstract*—The textile and agricultural industries are among the largest contributors to global pollution, generating significant waste and emissions. Rapid urbanization, increasing construction costs, and the accumulation of agricultural and textile waste present significant environmental and socio-economic challenges. This project proposes the development of Agro-Woven Panels as an innovative and sustainable solution for affordable housing applications. The panels are manufactured using wheat husk and sugarcane bagasse as primary agricultural waste materials, reinforced with textile thread and bonded using a low-cost adhesive.**

***Index Terms*—Environment, Innovation, Socio-economy, Sustainable Solution.**

I. INTRODUCTION

With the enormous population growth in the last few decades, there is a demand for infrastructure development and rapid urbanization that result in the depletion of natural resources, emission of greenhouse gases, and subsequently, exacerbation of the climate crisis. Moreover, waste materials generated by different industries such as the textile industry, Agricultural Sector etc, end up by burning or dumping them in landfills further posing serious health hazards. Besides, skyrocketing prices of housing and limited income of major population groups have resulted in the housing crisis. Therefore, it is imperative to find low-cost, environment friendly and sustainable solutions to mitigate aforementioned problems.

II. OJECTIVE OF THE STUDY

The primary objective is to develop a cost-effective, high-performance building material by upcycling agricultural and textile waste, mitigating environmental pollution while addressing the global demand for affordable housing. Key goals include optimizing the mechanical, thermal, and acoustic properties of these sustainable panels for use in low-cost, modular construction.

III. PROBLEM STATEMENT

Over 92 million tonnes of textile waste are generated globally each year, projected to reach 134 million tonnes by 2030 which will be goes to landfill every Second.

Approximately 150 million metric tons of wheat husk are generated each year. Which is burned in open air.

Approximately 180 to 280 million metric tons of sugarcane bagasse waste are generated globally each year it also creates air pollution

These study focuses on environmental & health risk Which gives solution on disposal of above waste caused by cancer & respiratory problem.

Global construction costs have surged by approximately 40% over the last five years.

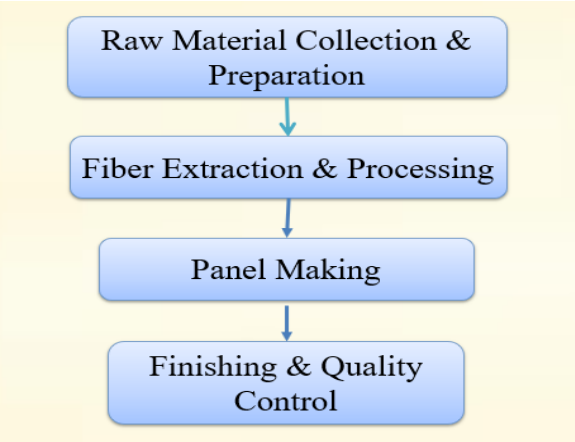
IV. METHODOLOGY AND PROCESS FOR IMPLEMENTATION

Agro-woven panels represent a dual-circular solution by upcycling two of the world's largest waste streams textile and agriculture into high-performance building materials. these panels are gaining traction for their ability to provide sustainable, rapid, and low-cost housing.

Uniqueness of Agro-Woven Panels

- Dual-Waste Integration

- Bio-Composite Composition
- Customizable Micro-Climates
- Cost Efficiency
- Superior Insulation
- Carbon Reduction
- Waste Diversion
- Used for Acoustic Purpose



1. Raw Material Collection & Preparation

The first stage involves collecting and cleaning specific waste streams to ensure a high-quality bond in the final panel.

Agricultural Residues:

Natural fibers such as rice husk, wheat husk & sugarcane bagasse are collected. & dry it under sunlight.

Textile Waste:

Post-industrial waste like threads of different textile material is collected.

2. Fiber Extraction & Processing

Depending on the source material Depending on the source material different extraction techniques are employed to isolate the structural fibers from the surrounding matrix

Mechanical Decortication: This is the primary method for large-stemmed waste like sugarcane, wheat husk. It involves crushing or scraping the outer layers using blades.

3. Panel Making

This is the core manufacturing step where the "waste" becomes a solid "panel."

- Binder Integration:

A binder (matrix) is added to the fiber mix. Fibers (e.g., 40% textile waste microfibers & 60% Agro waste fibers) are mixed with binders.

- Compression Molding:

The fiber-binder mat is placed into a mold and subjected to high heat and pressure (e.g., 140–170°C at 3–5.5 MPa). The heat melts the thermoplastic binder, which flows around the fibers; upon cooling, it solidifies into a rigid panel.

4. Finishing & Quality Control

Natural fiber panels are inherently hydrophilic (water-absorbing) and flammable, requiring specialized surface treatments to ensure longevity in housing.

Waterproofing & Moisture Resistance: Penetrating Sealants: Reactive organ silane solutions like ZydexZycosil+can penetrate up to 2mm into the substrate, sealing nano-pores to prevent water ingress and fungal growth without blistering.

Fire Retardancy:

Intumescent Coatings: These coatings (often based on ammonium polyphosphate or melamine) swell when exposed to heat, providing a protective char layer that insulates the core fibers from fire.

Termite & Microbial Protection: Chemical treatments such as alkali (mercerization) or saline treatment remove impurities like wax and lignin that attract pests, while also improving the bond between the fiber and the finish.

V. RESULT &DISCUSSION

The results and discussion of agro-woven panels focus on their performance as sustainable, cost-effective alternatives to synthetic materials in construction, agriculture, and automotive applications. Key findings from recent research highlight their mechanical, thermal, and physical properties.

1. Mechanical Performance

Research indicates that weave architecture and fiber content significantly influence the strength of agro-woven panels.

Mechanical Testing:

Universal Testing Machines (UTM) measure tensile strength (typically 11–40 MPa) and flexural modulus to ensure they can withstand structural loads.

2. Thermal and Acoustic Properties

Thermal & Acoustic Analysis: Panels are tested for thermal conductivity (insulation) and noise reduction coefficients (soundproofing).

Thermal Insulation: Panels made from sugarcane bagasse or flax shives show thermal conductivities ranging from 0.05 to 0.1166W/mK, which is lower than many conventional wood-based fiber boards.

Energy Savings: Simulations show that retrofitting buildings with these panels can achieve annual energy

savings of 5.04% to 5.07%, outperforming standard retrofitting models

Acoustic Absorption: Panels developed with a foaming agent can see an increase in sound absorption coefficients by 100% to 200%, making them effective for urban noise mitigation.

3. Physical and Environmental Discussion

The discussion around these panels often centers on their durability and environmental footprint.

Water Absorption: A major drawback identified is high water absorption (up to 18–20%) due to the amorphous nature of natural fibers like baggase, Wheat husk, which can limit theirdurability in humid environments.

Sustainability: Life Cycle Assessments (LCA) confirm that agro-fiber-based chains have a significantly lower carbon footprint and global warming potential than fossil-based synthetic reinforcements.

4. Diverse Applications

Discussion in the literature suggests these panels are versatile for both structural and non-structural uses:

Construction: Low-cost housing partitions and wall cladding.

Consumer Goods: Furniture like cupboard, Tables etc.

Acoustic Room: For making sound proof room.

VI. CONCLUSION

The Need: Global housing shortages and the environmental toll of traditional construction responsible for nearly 38% of global CO2 emissions demand sustainable alternatives. These panels address the dual crisis of waste disposal (reducing crop burning and land filling) and the scarcity of affordable building materials.

Effectiveness & Feasibility: Research indicates that panels reinforced with fibers like textile thread & bagasse offer superior thermal insulation and acoustic properties, enhancing indoor comfort while being significantly lighter than traditional concrete blocks.

Unique Selling Proposition (USP): Their primary USP lies in the "Waste-to-Wealth" circular model they provide 50% cost reduction in wall construction compared to conventional materials while offering inherent sound insulation and thermal efficiency

Commercial Viability: Beyond construction savings, these panels create local employment and additional income streams for farmers. Scalability is bolstered by the emergence of "agro-waste calendars" to manage seasonal supply gaps.

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