Natural Fiber Board for Partition Wall Panel: A Sustainable Solution

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Abstract - The increasing demand for sustainable and lightweight construction materials has led to the exploration of natural fiber-reinforced composites as alternatives to conventional wall panels. This study focuses on the development of partition wall panels using pineapple leaf fiber (PALF), aiming to reduce wood consumption, landfill waste, and carbon emissions. The panels were produced using pineapple fiber, PV foam as the core material, and epoxy as a binder. To evaluate their feasibility, mechanical tests were conducted, including compressive strength, split tensile strength, and impact resistance. The results demonstrated that the pineapple fiber panels exhibit compressive strength (3.033–3.23 N/mm²) and impact resistance (2.1 J/mm²) comparable to Medium Density Fiber board (MDF). These findings indicate that pineapple fiber-based partition walls provide a viable, eco-friendly alternative to traditional materials, offering potential advantages in sustainability, durability, and lightweight construction.

Key Words: Pineapple Fiber board, Epoxy Resin, Medium Density Fiber Board, Compressive Strength, Split Tensile Strength, Impact Resistance

1.INTRODUCTION

Wall panel boards are widely used in construction for interior walls, ceilings, and partition systems due to their ease of installation and structural efficiency. Traditionally, these panels are made from wood, concrete, gypsum, and fiberglass. However, many of these materials pose environmental concerns, such as high energy consumption in production, non-biodegradability, and excessive reliance on natural resources. Additionally, some panels exhibit high water absorption, poor impact resistance, and significant weight, limiting their durability and performance in practical applications. To address these issues, this study explores the use of pineapple leaf fiber (PALF) as a sustainable alternative for partition wall panels. Pineapple fiber, derived from agricultural waste, is known for its high tensile strength, lightweight nature, and biodegradability, making it a promising material for eco-friendly construction. The panels in this study are composed of pineapple fiber, PV foam as the core material, and epoxy resin as a binder, ensuring structural integrity while reducing environmental impact.

This research evaluates the mechanical properties of the pineapple fiber panels through compressive strength, split tensile strength, and impact resistance tests, comparing the results with standard Medium Density Fiberboard (MDF). By demonstrating competitive strength, lightweight construction, and sustainability, this study aims to promote the use of pineapple fiber-based panels as a viable alternative to conventional partition walls, contributing to green building solutions and waste reduction.

2. RELATED WORKS

The use of natural fibers in composite materials has gained significant attention due to their sustainability, lightweight nature, cost-effectiveness, and mechanical properties. Natural fibers such as hemp, jute, coir, sisal, and pineapple leaf fiber (PALF) have been extensively studied for applications in construction, automotive, furniture, and packaging industries. Researchers have explored their potential as reinforcements in cement, gypsum, polymer composites, and fiberboards, aiming to develop eco-friendly alternatives to conventional building materials.

A study by Saha et al. (2021) investigated the mechanical, thermal, and biodegradation characteristics of pineapple leaf fiber-reinforced polymer composites, demonstrating high tensile strength and durability, making them suitable for structural applications. Similarly, Walia et al. (2021) analyzed natural fiber-reinforced epoxy composites, highlighting their moisture resistance and mechanical strength, which are essential for construction applications.

In another study, Tangjuank (2011) evaluated the thermal insulation and physical properties of particleboards made from pineapple leaves, indicating promising thermal resistance and structural integrity. Research by Guzman et al. (2021) focused on the development of wall panel boards using coconut and pineapple fibers, emphasizing their strength, durability, and moisture resistance, making them a viable alternative to MDF. Additionally, Sharma et al. (2023) discussed advancements in sustainable composite materials, reinforcing the potential of pineapple fiber-based materials in green construction.

Moreover, studies have highlighted pineapple fiber's high cellulosic content, contributing to excellent tensile and flexural strength. However, challenges such as moisture absorption and dimensional stability necessitate chemical treatments to enhance performance. Research has also compared pineapple fiber composites with other natural fiber-based boards, showcasing competitive mechanical properties and environmental benefits.

Given the promising characteristics of pineapple fiber, this study aims to evaluate its performance in partition wall panels, comparing it with Medium Density Fiberboard (MDF) through compressive strength, impact resistance, and split tensile strength tests. By demonstrating its structural efficiency and sustainability, this research contributes to the development of eco-friendly and lightweight construction materials.

3. METHODS

A. Preparation of Materials

North-east region of India has a vast potential to produce pineapple crop on a large scale. The extraction of pineapple leaf fibre for commercial purposes is creating a market for entrepreneurs and peasant farmers. Pineapple leaf fibre in nowadays are waste products of pineapple cultivation. A special purpose machine having metal knife scrapper roller and serrated roller used to scrap out the waxy layer and at the same time with retting process the pineapple leaf fibre being extracted. The new machine used for scrapping the pineapple leaf has the following modifications, such as the machine. The scratched leaves are being tied and immersed in a retting tank. Urea or diammonium phosphate added for quick retting. At the end of retting leaves are taken out and washed mechanically by pond water. By implying ceramic plate over the pineapple leaf with pressure and fast movement of it, will give the fibre beneath the leaf. after that pineapple fibre is weaving in weaving machine

B. Process of Making Pineapple Fiber Partition Wall Board

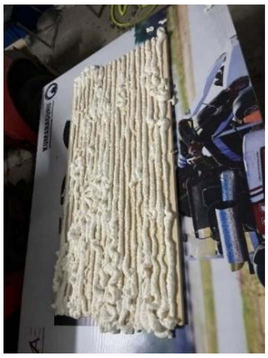

Fig-1: Polyurethane (PU) foam

Figure 1 shows PU Foam Polyurethane (PU) foam is selected for its soundproofing properties. The foam is cleaned to remove dust, ensuring strong adhesion. PU Foam Application: A layer of PU foam is sprayed over the base, filling gaps and enhancing acoustic insulation.

Curing: The foam is left to cure for 24 hours before proceeding to the next step. 1 kg of epoxy resin is mixed with 40 g of hardener for proper curing. Pineapple leaf fiber sheets are cut to fit the foam surface.

Fig-2: Resin with Pineapple fiber

Figure 2 shows that PALF is placed on both the top and bottom of the foam. The prepared epoxy resin mixture is evenly brushed over the PALF, ensuring strong bonding. The composite is left to cure for 4 days in a dry, ventilated area. This ensures the epoxy fully hardens and forms a durable structure. After curing, the board is trimmed to the desired dimensions. Surface finishing techniques like sanding or additional coatings can be applied for smoothness and durability. The final board undergoes soundproofing and mechanical tests to evaluate its performance.

C. Testing and Evaluation

a. To determine compressive strength test parallel to the load, Equation 1 was applied following the method.

$f_C = \frac{P}{A}$ (1) P is the maximum applied load , A is the cross-sectional area of the specimen.

Fig-3: Compressive Strength Test Parallel to the load

Figure 3 shows the Compressive strength test parallel to the load. Start the test by gradually applying the compressive load to the specimen. The UTM should apply the load steadily and uniformly, in accordance with the test standard.

Record the applied load at various stages, especially noting the maximum load just before failure

b. To determine compressive strength test perpendicular to the load, Equation 2 was applied following the method

$$f_C = \frac{P}{A} \quad (2)$$

P is the maximum applied load , A is the cross-sectional area of the specimen

Fig-4: Compressive Strength Test Perpendicular to the load

Figure 4 shows the Compressive strength test perpendicular to the load. Start the test by gradually applying the compressive load to the specimen. The UTM should apply the load steadily and uniformly, in accordance with the test standard.

Record the applied load at various stages, especially noting the maximum load just before failure

c. To determine split tensile strength test to the load, Equation 3 was applied following the method

$$f_t = \frac{2P}{\pi LD} \quad (3)$$

where:

P is the Maximum load at failure L is the length of the concrete cylinder, D is the Diameter of the concrete cylinder

Fig-5: Split Tensile Strength Test

Figure 5 shows split tensile strength test .Gradually apply the load along the diameter of the specimen using the UTM. The load should be applied at a uniform rate The load will induce tensile stresses in the concrete along the plane of the cylinder's diameter, causing it to crack along the length Record the maximum load at which failure occurs. This is the load corresponding to the tensile strength. After failure, carefully remove the specimen from the machine. The specimen will typically fail along a vertical plane running through its diameter.

d. To determine split tensile strength test to the load, Equation 4 was applied for the following method

$$\text{Izode impact stress} = \frac{\text{Izode impact test}}{\text{Area of cs below the notch}} \quad (4)$$

Fig-6: Izode impact Stress Test

Figure 6 shows that Charpy impact test machine, a pendulum hammer is lifted to a specific height before the test. This height corresponds to the potential energy the hammer will have when it strikes the specimen.The hammer is released, and it swings down to strike the specimen in the center of the notch. The machine measures how much energy is absorbed by the specimen during the fracture. This energy is usually measured in Joules (J).After the test, inspect the specimen for the fracture pattern. The break should occur at the notch, and the fracture type (brittle, ductile, or mixed) should be noted.

4. RESULTS AND DISCUSSION

A. Compressive strength test parallel to the load

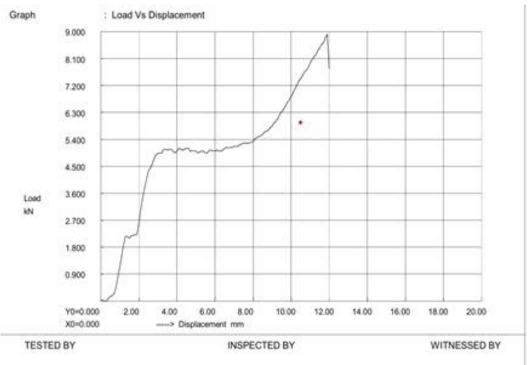

Fig-7: Graph for Compressive Strength Test Parallel to the load

Figure 7 shows that compressive strength test parallel to the load graph X-axis (Displacement in mm): Shows how much the material deforms under compression. Y-axis (Load in kN): Indicates the applied force.

Graph Characteristics:

Initially, there is a steep rise, indicating elastic deformation (material resisting compression).A small plateau follows, suggesting internal structural adjustments (e.g., fiber realignment or minor cracks forming).A gradual increase in load follows until peak strength (~8.1 kN) is reached. Sudden drop after peak indicates failure or crushing of the material

Table -1: Compressive strength test parallel to the load

S.NO	Material	Compressive Strength (N/mm²)
1	Pineapple Fiber Board	3.033
2	Medium Density Fiberboard (MDF)	2 - 5

The table 1 compares the compressive strength of pineapple fiber board and medium-density fiberboard (MDF):

Pineapple Fiber Board has a compressive strength of 3.033 N/mm², demonstrating its potential as a structural material. MDF has a wider range of compressive strength (2 - 5 N/mm²), depending on factors like density, resin content, and manufacturing process.

The results indicate that pineapple fiber board falls within the compressive strength range of MDF, making it a viable alternative for partition walls while being more sustainable and eco-friendly.

B. Compressive strength test perpendicular to the load

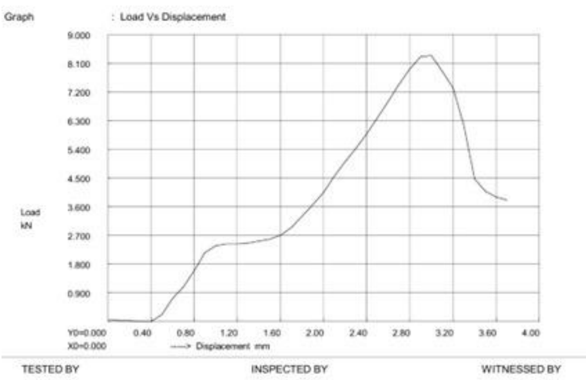

Fig-8: Graph for Compressive Strength Test Perpendicular to the load

Figure 8 shows that compressive strength perpendicular to the load X-axis (Displacement in mm): Measures the deformation of the material under compression. Y-axis (Load in kN): Represents the applied force.

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Graph Description: Initial Rise: The material starts resisting compression, leading to an increase in load. Small Plateau (~0.8 mm displacement): Indicates internal structural adjustments before further compression. Peak Load (~8.1 kN at ~2.8 mm displacement): Represents the maximum compressive strength before failure. Sudden Drop After Peak: Signifies material failure or crushing, showing the material's ultimate load capacity.

Table -2:Compressive strength test perpendicular to the load

S.NO	Material	Compressive Strength (N/mm^2)
1	Pineapple Fiber Board	3.23
2	Medium Density Fiberboard (MDF)	2 - 10

This table 2 compares the compressive strength (perpendicular to the load) of pineapple fiber board and medium-density fiberboard (MDF):

Pineapple Fiber Board has a compressive strength of 3.23 N/mm^2, showing good structural resistance. MDF has a broader standard range (2 - 10 N/mm^2), varying based on density, adhesive content, and manufacturing process. Since pineapple fiber board falls within the MDF range, it proves to be a sustainable alternative for partition walls while utilizing agricultural waste and reducing carbon footprint.

C. Split Tensile test for the load

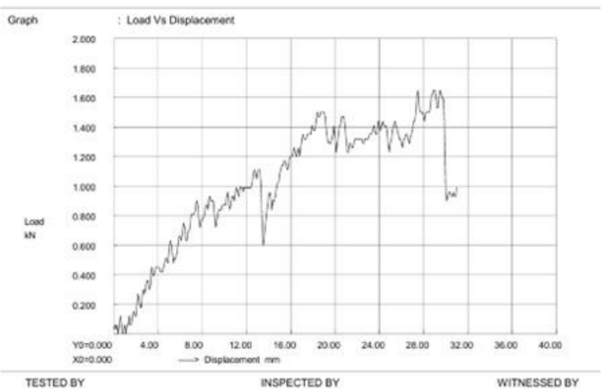

Fig-9: Graph for Split Tensile Test

Figure 9 shows that Split Tensile Stength load Graph X-axis (Displacement in mm): Shows the material's deformation under tensile stress. Y-axis (Load in kN): Represents the applied tensile force.

Graph Characteristics: Gradual Increase: The load increases steadily, indicating elastic deformation. Multiple Fluctuations: The irregular fluctuations suggest internal fiber realignment or micro-cracking during the test. Peak Load (~1.8 kN at ~30 mm) displacement): This represents the maximum tensile strength before failure. Sudden Drop After Peak: Indicates material failure, where the tensile force exceeded the board's structural capacity.

Table -3: Split Tensile Strength Test

S.NO	Material	Split Tensile Strength (N/mm^2)
1	Pineapple Fiber Board	0.56
2	Medium Density Fiberboard (MDF)	0.5 – 1.5

This table 3 compares the split tensile strength of pineapple fiber board and medium-density fiberboard (MDF): Pineapple Fiber Board has a split tensile strength of 0.56 N/mm^2, indicating good resistance to tensile forces.MDF has a standard range of 0.5 - 1.5 N/mm^2, varying based on density and fiber bonding. Since pineapple fiber board falls within the MDF range, it proves to be a potential sustainable alternative for partition walls, offering both structural reliability and eco-friendliness.

D. *Izode Impact testing*

Table -4:Izode impact Test

S.NO	Material	Impact Strength (J/mm^2)
1	Pineapple Fiber Board	2.1
2	Medium Density Fiberboard (MDF)	1.5-3.5

This Table 4 compares the impact strength of pineapple fiber board and medium-density fiberboard (MDF):

Pineapple Fiber Board has an impact strength of 2.1 J/mm², showing good resistance to sudden impacts. MDF has a standard range of 1.5 - 3.5 J/mm², depending on its density and resin content. Since pineapple fiber board falls within the MDF range, it proves to be a durable and sustainable alternative for partition walls.

5.CONCLUSION

The fabrication of a pineapple fiber partition wall panel was successfully demonstrated, proving its potential as a sustainable and eco-friendly alternative to conventional partition wall materials like Medium Density Fiberboard (MDF). The results from various mechanical tests validate its structural integrity and durability:

Compressive Strength (Both Parallel and Perpendicular to Load) Falls within the standard range of MDF, proving sufficient load-bearing capacity.

Split Tensile Strength Comparable to MDF, ensuring resistance to cracking and tensile forces.

Impact Strength Meets the impact resistance range of MDF, making it suitable for durable and shock-resistant applications.

Additionally, utilizing pineapple leaf fiber (PALF) and polyurethane (PU) foam in the wall panel manufacturing process reduces landfill waste, mitigates greenhouse gas emissions, and promotes sustainability by repurposing agricultural by-products.

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