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Eco-Friendly Noise Reduction System Using Coir and Jute Fibres

Dr.Balaji.V
Professor and Head, Department of Mechanical Engineering,
Sri Sairam College of Engineering, Bengaluru, India
https://orcid.org/0000-0002-9839-9560
hod.mech@sairamce.edu.in
Savarinathan K, Sanjana S, Roshan(A) Sabarish M,
Department of Mechanical Engineering,
Sri Sairam College of Engineering, Bengaluru, India

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Abstract : Industrial noise pollution poses significant risks to human health, workplace efficiency, and environmental sustainability. Conventional soundproofing materials like polyurethane foams and fiberglass, although effective, are environmentally harmful and pose health risks due to their non-biodegradable and chemically reactive properties. This study aims to develop an ecofriendly noise reduction solution utilizing natural fibres coir (from coconut husks) and jute that are sustainable, biodegradable, and economical. Acoustic panels were fabricated by blending coir and jute fibres with a natural binder composed of starch and tannin. Their acoustic properties were evaluated through sound level measurements and impedance tube testing. Findings revealed that a 70:30 ratio of jute to coir delivered optimal sound absorption, achieving a Noise Reduction Coefficient (NRC) of 0.62 at 100 mm thickness. This research offers a sustainable, cost-effective alternative to traditional industrial noise control materials.
Keywords: Acoustic panels, coir fibre, jute fibre, sound absorption, eco-friendly materials, noise pollution, sustainability.

1. INTRODUCTION

Noise pollution in industrial settings is a pressing occupational health issue, as prolonged exposure to noise levels above 85 dB can lead to hearing impairment, fatigue, and reduced productivity. Traditional sound-absorbing materials such as polyurethane foams and fiberglass, although efficient, rely on non-renewable resources and generate environmental pollution upon disposal. This underscores the need for environmentally sustainable noise mitigation materials. Natural fibres like coir and jute are abundant in India and possess excellent sound absorption characteristics due to their porous, fibrous structures. Coir, derived from coconut husks, offers high resilience, while jute, sourced from the jute plant stem, has a finer texture that enhances absorption in mid-frequency ranges. Combining these fibres can produce hybrid panels with broad-spectrum noise absorption, mechanical robustness, and environmental friendliness. The main objective of this study is to develop and evaluate acoustic panels using coir and jute fibres bonded with a natural starch–tannin adhesive, assessing their sound absorption capabilities relative to conventional materials.

2. LITERATURE REVIEW

Previous studies have explored natural fibres for acoustic applications. Coir fibre panels exhibit strong absorption above 1000 Hz owing to their hollow and rough structures. Jute fibre composites are more effective in the mid-frequency range (500–1500 Hz) due to their finer texture and larger surface area. Hybrid panels combining multiple natural fibres have shown enhanced overall absorption by leveraging the distinct properties of each fibre. However, many earlier works use synthetic binders such as epoxy or phenolic resins, which compromise biodegradability. Recent advances focus on bio-based adhesives like starch, tannin, or lignin to maintain eco-friendliness. Starch adhesives provide good bonding and thermal stability, while tannin improves water resistance and rigidity. This study employs a starch–tannin binder aiming to preserve biodegradability in natural fibre acoustic panels.

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3. METHODOLOGY

3.1 Materials

- Coir fibre: Cleaned and dried coconut husk fibre (30–40 mm length).
- Jute fibre: Natural jute fibre (25–30 mm length).
- Binder: Starch (15 wt %) with tannin (3 wt%) for strong, biodegradable bonding.
- Panel dimensions: 600 mm × 600 mm, thicknesses of 50 mm and 100 mm.
- Target density: 180 kg/m³.

3.2 Fabrication Process

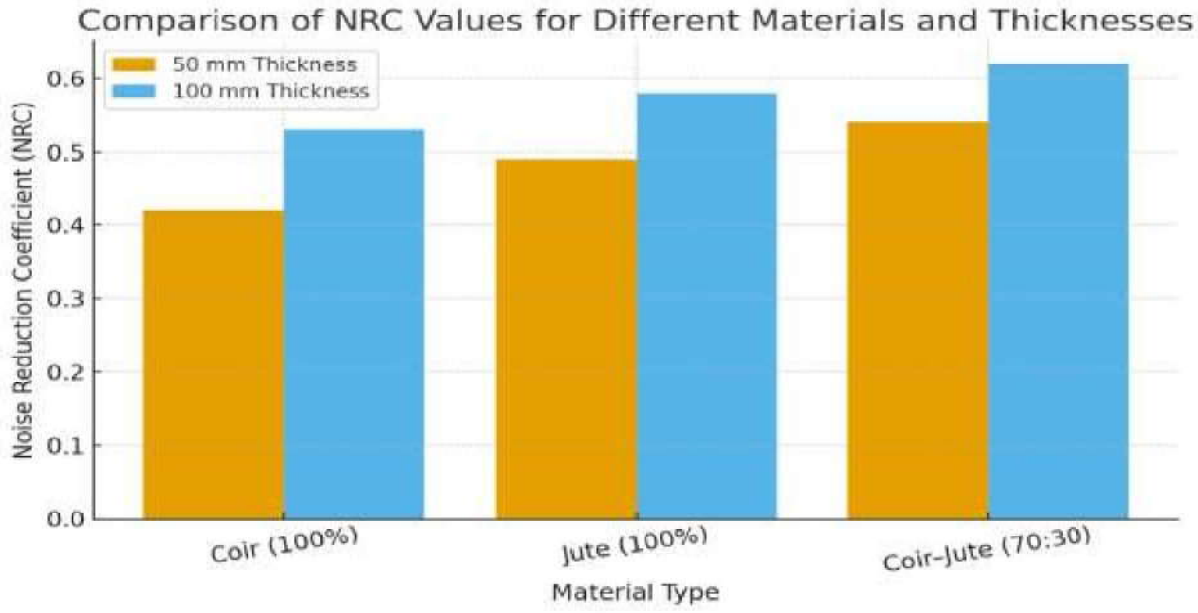
The fabrication process ensured uniform fibre dispersion, strong adhesive bonding, and high acoustic performance. Coir and jute fibres were thoroughly cleaned to remove impurities and dried until moisture content was below 10%. Fibers were cut to ~30 mm for better bonding and compaction. The binder was prepared by dissolving starch in distilled water and heating to gelatinize it into a viscous paste. Tannin extract was added as a crosslinker to enhance rigidity and water resistance while maintaining biodegradability. Three fibre compositions (100% coir, 100% jute, and 70:30 jute-to-coir) were mixed with the starch–tannin binder to achieve uniform coating. The mixture was placed into a steel mold lined with release film, hot-pressed at 130°C and 4 MPa pressure for 8 minutes, then dried at 60°C for 24 hours. Panels were then trimmed and inspected for defects. The resulting panels were lightweight, rigid, and porous—ideal for sound absorption. The fabrication method proved simple, economical, and fully eco-friendly with no synthetic additives.

Fiber Preparation → Binder Mixing →Molding→ Hot Pressing → Drying → Testing

4. RESULTS AND DISCUSSION

4.1 Sound Absorption Coefficient

Material Type	Thickness (mm)	NRC	Best Absorption Frequency (Hz)
Coir (100%)	50	0.42	1250
Jute (100%)	50	0.49	1000
Coir Jute (70:30)	50	0.54	800
Coir (100%)	100	0.53	1000
Jute (100%)	100	0.58	800
Coir–Jute (70:30)	100	0.62	630



The 70:30 jute-to-coir hybrid panel showed the highest NRC of 0.62, effectively absorbing sound over a broad frequency range. Increasing thickness from 50 mm to 100 mm enhanced low-frequency absorption due to greater air volume and longer sound travel paths.

4.2 Testing

Two primary tests were conducted:

- Sound Level Measurement: Using a Class-2 Sound Level Meter inside a 3 m × 3 m × 2 m chamber to assess noise reduction.
- Impedance Tube Testing: Per ASTM E1050, measuring absorption coefficient from 250 to 4000 Hz.
- Arduino-based SPL measurement with an ESP32 microcontroller and MEMS microphone was used for frequency analysis.

4.3 Noise Reduction in Industrial Simulation

Condition	Average Noise Level (dB)
Without panel	92.5
With coir panel	84.8
With jute panel	81.6
With coir–jute panel	78.9

The hybrid panel reduced noise by 13.6 dB, demonstrating its practical suitability for industrial noise control.

4.4 Morphological Analysis

Microscopy revealed an irregular, interlocked fibre network with high porosity, facilitating multiple internal reflections and frictional sound energy loss. The starch–tannin binder maintained panel rigidity without blocking pores, ensuring acoustic efficiency and strength.

5. CONCLUSION

This work successfully developed an eco-friendly, economical noise reduction panel using natural coir and jute fibres bonded with a starch–tannin adhesive. The 70:30 jute-to-coir compositions at 100 mm thickness yielded the best sound absorption results, reducing industrial noise by over 13 dB. These biodegradable, lightweight panels offer a promising alternative to synthetic acoustic materials, supporting environmental sustainability and green manufacturing.

6. FUTURE SCOPE

- Incorporate additional agricultural fibres such as banana, hemp, or sisal for enhanced hybrid panels.
- Investigate bio-nanocomposite binders utilizing cellulose or lignin nanoparticles.
- Apply natural flame-retardant treatments for safety improvements.
- Perform long-term durability tests for humidity, mechanical strength, and biodegradation.
- Expand applications to architectural acoustics and automotive cabin insulation.

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