International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 13 Issue: 11 | Nov 2026 www.irjet.net p-ISSN: 2395-0072

DEVELOPMENT OF BIO COMPOSITE ACOUSTIC PANELS USING BANANA FIBERS AND COCONUT FIBERS

Visakh V[1], Devika V [2], Ebin K Mathew[3], Minu V J[4], Dr.Deepa R[5]

[1234]*Student, Department of Civil Engineering, College of Engineering Pathanapuram, Kerala, India*
[5]*Assistant Professor, HOD College of Engineering Pathanapuram, Kerala, India*

Abstract - *The escalating demand for environmentally conscious solutions in various industries, including construction and interior design, has prompted the exploration of alternative materials with reduced environmental impact. This pa per focuses on the innovative utilization of sustainable and eco-friendly materials, namely banana fibers and coconut fibers, in the development of bio composite acoustic panels. Banana fibers and coconut fibers, being abundant agricultural byproducts, offer an excellent opportunity for sustainable development. The study involves the extraction and processing of banana and coconut fibers to create composite materials with desirable acoustic properties. These natural fibers, with their inherent acoustic damping characteristics, are expected to contribute to the effective sound absorption of the panels. Additionally, their lightweight nature and structural strength make them promising candidates for the construction of acoustic panels. The fabrication process involves combining banana and coconut fibers with a biodegradable rubber latex to form a composite material. Various testing methods, including impedance tube testing and sound absorption coefficient measurements, are employed to assess the acoustic efficacy of the developed panels. Other testing methods include flexural strength test and fire resistance. The treated banana fiber panel demonstrated more resistance (13s) to flame compared to other panels. In the case of low frequency sound absorption, it was identified that both panels made of treated banana fiber and coconut fibers and untreated banana fibers has the good sound ab sorption within the low frequency range of 100 to 1000Hz whereas untreated banana and coconut fiber panels exhibit the highest absorption in high frequency. The panels do not break under axial load, but has illustrated deformation, w the untreated banana fibers show greater resistance. In essence, the research illuminates the potential of utilizing both treated and untreated banana fiber-based composite acoustic panels, showcasing their promising capabilities. This project contributes to the advancement of sustainable materials for acoustic solutions, offering an eco-friendly alternative to conventional synthetic products. The developed bio composite acoustic panels have the potential to reduce the environmental footprint of building materials while enhancing acoustic comfort in indoor spaces. The outcomes of this research have the potential to contribute significantly to the development of sustainable acoustic solutions, addressing the increasing demand for environmentally responsible products in the construction and design industries. Additionally, the utilization of agricultural byproducts like banana and coconut fibers in bio composite materials pro motes the concept of circular economy and underscores the importance of resource efficiency in product development. Future research could focus on optimizing the fabrication process and exploring additional natural fibers for further improving the performance of bio composite panels.*

1. INTRODUCTION

Bio composite acoustic panels represent an innovative and sustain able solution in the field of acoustic engineering and construction materials. These panels seamlessly merge the principles of bio composites and acoustic design to create a versatile and environ mentally friendly product.

Many traditional acoustic panels are made from synthetic materials, such as foams and plastics, which are often non-biodegradable. This can contribute to environmental pollution and challenges in disposal. Artificial acoustic panels such as may have limited de sign options compared to natural or alternative materials. This can impact the aesthetic appeal of a space, especially in contexts where interior design is a crucial consideration. Depending on the materials used, artificial acoustic panels may experience wear and degradation over time. This can result in a reduction in their acoustic performance and overall effectiveness.

Bio composite acoustic panels represent a promising advancement in sustainable construction materials, providing a harmonious balance between effective acoustic design and environmental responsibility. As the demand for eco-friendly solutions continues to rise, these panels offer a compelling option for architects, builders, and individuals looking to enhance both the acoustic performance and sustainability of their living and working spaces.

2. LITERATURE REVIEW

2.1 ACOUSTIC PROPERTIES OF BANANA FIBERS

The paper authorized by Cl´audia Ohana Borges Mendes and Mari a Alzira de Ara´ujo Nunes published in 2022, the study explores the environmental impact of commonly used materials in acoustic treatment and suggests a shift towards natural alternatives. Specifically, the acoustic potential of banana pseudo stem fibers, without binders but with natural glue, was investigated. Using an impedance tube and the transfer function technique, sound ab sorption coefficients

were measured in a frequency range of 100 to 6300 Hz. Results indicate that banana pseudo stem fibers exhibit promising acoustic performance, particularly at high frequencies, with a coefficient of 0.89 at 6300 Hz. The fiber's sound absorption is comparable to yucca fiber and surpasses coconut fiber at frequencies above 4000 Hz. This suggests that banana pseudo stem fibers could be a viable and environmentally friendly replacement for traditional acoustic treatment materials.

2.2 POTENTIAL OF NATURAL FIBERS TO BE USED AS AN ACOUSTIC ABSORBER

The paper authorised by L´ydia Sobotov´a, Tibor Dzuro, Miroslav Badida and Marek Moravec published in 2022 and the research investigates the acoustic properties of natural fibers (cork, hemp, and fiberboard) and compare them with common insulation materials in building construction (mineral wool, propylat, and polyurethane foam).Sound absorption coefficients were determined using the impedance tube and two microphones method, following ISO 10534-2 standards, for thicknesses of 20, 40, 60, 80, and 100 mm. Hemp exhibited the highest sound absorption at 2000 Hz and a thickness of 20 mm, while cork showed the lowest performance at 100 Hz and the same thickness. Hemp outperformed other biomass materials across all frequencies and thicknesses, while mineral wool excelled among conventional materials.

2.3 SUSTAINABLEUTILIZATIONOF AGRO-WASTE IN BUILDING CONSTRUCTION

The paper authorized by Sangmesh B, Nagraj Patil b, Krishna Ku mar Jaiswal and T.P. Gowrishankar published 2023, this study emphasizes the potential of agro-waste, such as paddy husk and sugar cane residues, as sustainable alternatives in building construction. The work evaluates the physical, thermo-mechanical, methodological, and ecological aspects of utilizing agricultural waste in construction. The findings suggest that incorporating agricultural waste is a commercially viable and environmentally friendly solution to alleviate the demand for traditional building materials and conserve natural resources.

2.4 EFFECTIVENESS OF FIBRO GRANULAR ACOUSTIC PANELS OVER SYNTHETIC ONES

The paper authorised by Lekshmi .M.S, Subha Vishnudas, Anil.K.R published in 2023, the study investigates the effectiveness of fibro granular acoustic panels, incorporating coir fiber and rice husk with rice husk ash-replaced cement binder, for absorbing low-frequency sound waves. These panels aim to address the challenge faced by natural fibers in absorbing low-frequency waves. Addition ally, the use of these materials reduces toxicity compared to com mon binders. Sound absorption coefficients were tested in both an impedance tube and an anechoic room, revealing that the developed panels with a density of 200 kg/m^3 effectively absorb both low and high-frequency sound waves in the range of 100 Hz to 5000 Hz, with a noise reduction coefficient exceeding 0.4. The panels outperformed commercial sound absorbers, and statistical analysis identified key parameters influencing low-frequency sound absorption. The eco-friendly acoustic panels, made from agricultural residues, offer economic benefits without requiring significant capital investments. The study emphasizes the potential societal and economic advantages of incorporating waste materials into environmentally friendly acoustic panels.

2.5 THE IMPORTANCE OF MANAGING SOUND DUE TO INCREASING NOISE POLLUTION

The paper authorised by Majid Mohammadi ,Ebrahim Taban , Wei Hong Tan,Nazli Bin Che Din Azma Putra and Umberto Be rardi published 2024,the study discusses the growing importance of managing sound in modern society due to increased noise pollution from urbanization and industrial growth. It emphasizes the need for effective control measures in various engineering areas and highlights the development of acoustic materials with exceptional absorption efficiency. The study advocates for the substitution of conventional chemical and synthetic sound absorption materials with natural alternatives to address environmental concerns such as greenhouse gas emissions, health risks, pollution, global warming, and resource depletion. It aims to draw attention to promising natural sound fibers, recycled materials, and fibers from agricultural waste as sustainable, cost-effective, and eco-friendly alternatives.

2.6 VARIOUS APPLICATIONS OF BANANA PSEUDO STEM FIBERS (BPS) IN DIFFERENT FIELDS

The paper authorised by Abideen Temitayo Oyewo ,Oluleke Olugbe miga Oluwole, Olusegun Olufemi Ajide,Temidayo Emmanuel Omoniyi and Murid Hussain Published in 2023, the study emphasizes the importance of understanding processing parameters, hybridization, and characterization to widen the applicability of natural fibers across various industries. The focus is particularly on Ba nana Pseudo Stem (BPS) fibers, which have garnered attention due to their high strength, low cost, renewability, and eco-friendliness. This study mentions the potential applications of BPS fibers in polymer composites, engineering, marine engineering, construction, sports, and agriculture. It suggests hybridizing BPS fibers with other natural and synthetic fibers to improve thermal stability, reduce water intake, and enhance mechanical properties. The extraction methods, chemical composition, and treatments of BPS fibers are examined to enhance fiber quality. Additionally, the study highlights processing techniques, characterizations, and applications of hybrid composites using BPS fibers.

3. MATERIALS

In recent years, the demand for sustainable and eco-friendly building materials has surged, driven by a growing awareness of environmental issues and a shift towards green construction practices. Natural fibers, derived from

renewable sources such as plants, have emerged as promising alternatives to traditional synthetic materials in various applications, including acoustic panel manufacturing. Among these natural fibers, banana fibers and coconut fibers have garnered attention for their abundance, renewability, and favorable acoustic properties. Both banana and coconut fibers shows the better acoustic properties compared to other natural fibers. Banana fibers and coconut fibers are byproducts of agricultural industries, making them readily available and cost-effective raw materials for composite manufacturing. Banana fibers, extracted from the pseudo stems of banana plants, possess excellent tensile strength and flexibility, while coconut fibers, obtained from coconut husks, exhibit good acoustic damping properties and thermal insulation. By combining these natural fibers with eco-friendly binders, such as bio-based resins, i.e., latex, we aim to develop acoustic panels that not only offer superior sound absorption and insulation characteristics but also contribute to sustainability and environmental preservation.

Banana fibers and coconut fibers were collected. The banana fibers were collected from Kerala Agricultural University, Thrissur and coconut fibers were collected from coir factory in Thrissur. The banana fiber was converted into fiber form using machine. The binding material used is latex which was collected from Pathanapuram area.

3.1 BANANA FIBERS

Banana fibers, derived from the pseudo stems of banana plants, have been utilized for various applications, including textiles, pa per, and more recently, as a sustainable alternative in the field of acoustics. The porous structure of banana fibers can enhance their ability to trap and dissipate sound waves. Banana fibers offer an eco-friendly alternative to synthetic materials in acoustic applications. Banana fiber presents good potential for application at high frequencies. The microstructure analysis of banana fibers were done using Scanning Electron Microscopy



Fig - 3.2: Banana fiber extraction machine



Fig 3.1: Banana fiber

3.2 COCONUT FIBERS

Coconut fibers, also known as coir fibers, are derived from the husk of coconuts. The fibrous structure and the presence of voids in the coconut fibers enhance their acoustic performance. Coconut fibers are effective in absorbing mid to high-frequency sounds. Coconut fiber with a thickness of 20mm has a sound absorption coefficient between 0.8 and 0.9 within the frequency range 1300 Hz–2800 Hz. Coir fibers, being resilient and resistant to moisture, make them ideal for use in acoustic panels. The natural sound-absorbing qualities of coconut fiber contribute to reducing echoes and minimizing reverberation in indoor spaces. Beyond its acoustic performance, coconut fiber aligns with sustainable practices, as it is a renewable resource and supports local economies in coconut-producing regions. The microstructure analysis of coconut fibers were done using Scanning Electron Microscopy



Fig 3.3: Coconut fiber

3.3 LATEX

The binding material used is latex which was collected from Pathanapuram area. Latex originates from the Hevea brasiliensis tree, commonly known as the rubber tree. Latex

as many properties to improve the performance of the material such as:

1. Elasticity and Flexibility: Latex exhibits remarkable elasticity and flexibility, making it an ideal binding material for applications where materials undergo stress, strain, or movement. In industries such as textiles and construction, where flexibility is crucial, latex-based binders ensure that materials maintain their structural integrity even under dynamic conditions.

2. Water Resistance: Latex is inherently resistant to water, a property that makes it particularly valuable in applications where exposure to moisture is a concern. This water resistant quality is especially beneficial in the production of adhesives for outdoor use, such as in construction projects, where materials need to withstand the elements.

3. Biodegradability and Sustainability: One of the key ad vantages of latex as a binding material lies in its biodegradability. Unlike many synthetic binders, latex is derived from natural sources and can be broken down by microorganisms over time. This eco-friendly aspect positions latex as a sustainable choice in industries that prioritize environmental consciousness.



Fig 3.4: Latex (Natural rubber)

Acoustic panels made of banana fibers and coconut fibers represent a promising avenue for sustainable acoustic solutions in building design and construction. By leveraging the unique properties of these natural fibers, we can develop high-performance acoustic panels that meet both functional and environmental objectives. As research in this field progresses, further optimization of manufacturing processes and exploration of novel fiber combinations will unlock new opportunities for advancing eco-friendly building materials and promoting a greener built environment.

4. METHODOLOGY

4.1 PREPARATION OF SAMPLE

Samples are prepared using both banana fibers and coconut fibers. i.e., samples are prepared with and without treatment and by mixing treated and untreated banana fibers and coconut fibers. The first sample panel should be made using a mix of treated banana fibers and coconut fibers. Chemical treatment of the banana fibers and coconut fibers were done using sodium hydroxide (NaOH). The NaOH solution was made by mixing 5g NaOH in 500 ml distilled water. The fibers were immersed in the solution for about 4 hours. Then the sample was washed in distilled water until the pH became neutral (6-7 pH). Then dried in oven at 50°C for about 24 hours. These treated fibers will be used to make the first sample in the ratio 1:1 by weight. Second sample should be made using treated banana fibers only and the third one with untreated banana fibers only. The last sample is made of untreated banana fibers and coconut fibers in the ratio 1:1 by weight. The fibers are mixed together and latex is sprayed into it. The prepared sample is then pressed under a compression testing machine by giving a minimum load of about 5 KN. Different samples are prepared for different test needs.

For low frequency testing, circular samples of diameter 17.5 mm were made using circular mould and for high frequency, square samples of dimension 1m were made using a rectangular mould, arranged in a frame and was covered by acoustic cloth.



Fig 4.1: Treatment of banana fibers in NaOH



Fig 4.2: Treatment of coconut fibers in NaOH

4.2 TESTING AND ANALYSIS

4.2.1 SCANNING ELECTRON MICROSCOPY (SEM) ANALYSIS

The microstructure analysis of both coconut fibers and banana fi bres were done using a scanning eectron microscope.Scanning Elec tron Microscopy (SEM) analysis is a powerful technique widely employed in various scientific fields for investigating the surface morphology, composition, and structure of materials at high reso lution. By employing a focused beam of electrons to interact with the sample surface, SEM generates detailed images that offer valu able insights into the microstructure and properties of the material under

study. SEM enables researchers to visualize surface features such as texture, roughness, cracks, and defects, providing critical information for materials characterization and analysis.



Fig 4.4: SEM Analysis Instrumental Set up

4.2.2 TEST FOR FLAME RESISTANCE

Fire safety standards are crucial for any building material, ensuring the protection of lives and property. Therefore, flame resistance testing is a vital aspect of assessing the suitability of bio composite acoustic panels for various applications. The objective of this flame resistance test is to evaluate the behavior of bio composite acoustic panels when exposed to fire. This assessment aims to determine their propensity to ignite, sustain combustion, and contribute to flame spread. Understanding these characteristics is essential for regulatory compliance and ensuring the safety of occupants in buildings where these panels are installed.

Flame resistance test of bio composite material for acoustic panel should be performed on flat bar shaped specimens 125mm× 13mm×10mm as per ASTM D3801 and UL- 94 standard vertical burning test .The specimen is to be clamped vertically and a 20 mm tall flame was applied at a distance of 10 mm from the bottom of the specimen for 10 s. The specimen is then removed from the flame and time taken for the flame to extinguish is noted (t1). Once again, the procedure is repeated and the time taken for the extinguishing of flame is recorded (t2).A material that exhibits flame propagation up to the holding clamp or burns for longer than 30 s does not pass the UL-94 vertical burning test. The criteria conditions of the flame test is given below in table 4.1.

Table 4.1: Criteria conditions for Flame Test

Criteria Conditions	V-0	V-1	V-2
After flame time for each individual specimen (t1) or (t2)	≤10s	≤30s	≤30s
Total after flame time for any condition set ((t1) + (t2) for 5 specimens)	≤50s	≤250 s	≤25 0s
After flame plus afterglow time for each individual specimen after the second flame application((t2) + (t3))	≤30s	≤60s	≤60s
After flame or afterglow of any specimen up to the holding clamp	No	No	No
Cotton indicator ignited by flaming particles or drops	No	No	No

4.2.3 TEST FOR FLEXURAL STRENGTH

The flexural strength, or bending strength, of these panels is a mea sure of their ability to withstand external forces, stresses, and environmental conditions without deformation or failure. As acoustic panels are often installed on walls or ceilings and may be subject to accidental impacts or vibrations, understanding and verifying their flexural strength is essential for maintaining structural integrity. This quality assurance process ensures that the panels can endure bending stresses during installation, resist sagging or warping over time, and comply with industry standards and building codes. The flexural strength test was conducted on samples 150 mm × 40 mm × 40 mm as per ASTM C 348-14 and the average value is the bending strength of the acoustic panel. Sample position of flexural strength test and bending of the sample is given in fig 4.5 and 4.6 respectively.



Fig 4.5: Sample Position of Flexural Strength Test



Fig 4.6: Bending of Sample panel

4.2.4 TEST FOR ACOUSTIC PROPERTIES

The test for acoustic behavior has been done in both low and high frequency.

1. Low Frequency Sound Absorption

The sound absorption coefficient of bio composite acoustic disc sample at low frequency is to be measured in principle with standing wave ratio in an impedance tube. The measurement is customized method based on ISO 10534–2. The impedance tube was 12 m long with 175 mm inner diameter. The instrumental set up is given in fig 4.7.



Fig 4.7: Instrumental Set Up



Fig 4.8: Sample Position for Insertion loss (Air Pulse tube)

A broadband impulse signal with pulse width of 625 ls was used for measuring the transmission coefficient and reflection coefficient of disc shaped sample using 12 m long impedance tube. The test sample is to be positioned at the center of the tube for transmission coefficient measurement, and at the open-end of the tube for reflection coefficient measurement of the sample. The signals will be



Fig 4.9: Sample Position for Echo Reduction (Air Pulse tube)

captured using a hydrophone (equivalent to microphone for air measurement), which was positioned between the sound source and sample for reflection coefficient measurement and in between the sample and open end of the tube for transmission coefficient measurement. The test should be conducted in the frequency band 100 Hz-1000 Hz. Specimen of diameter 175mm is used to con duct the test. A circular mould of inner diameter 175 mm was used to make the specimen. It also consists of a base plate and a plunger. Sample panels made using untreated and treated banana fibers contains about 200g of fibers by weight and those of the panels made with a mix of untreated and treated banana fibers and coconut fibers contains 100g of each fibers in the ratio 1:1 by weight. Repeatability of the test results should be estimated by testing the same specimen thrice within the impedance tube.



a) Panel made of untreated banana fibers



(b) Panel made of treated banana fibers



c) Panel made of untreated banana fi bres and coconut fibers



(d) Panel made of untreated banana fibers and coconut fibers

Fig 4.11: Low frequency testing sample panels

2. High Frequency Sound Absorption

The performance of lignocellulose material-based acoustic panel under high frequency sound waves was evaluated by testing this panel in an anechoic room. A broad band signal with a half sine pulse width 41.66 ls and frequency 12 kHz at 200Vp amplitude was used for excitation. A hydrophone from M/s. Bf and K Denmark, Model B & K 8105 was used instead of microphone.

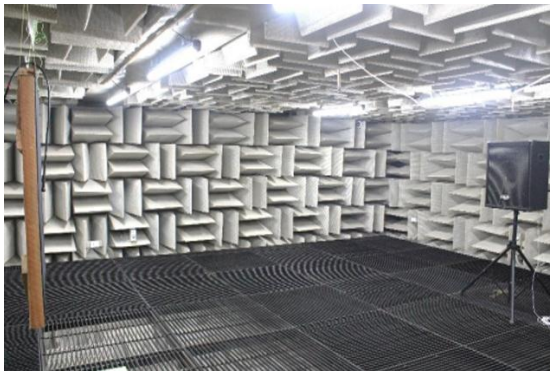

Fig 4.12: Panel position for insertion loss (anechoic chamber)

The sample in the form of rectangular panel was freely suspended at the center of the chamber and hydrophone was positioned in between the sample and end wall of the chamber for measuring signal transmitted through the panel (Pt). The distance of the hydrophone from the sample was determined such that the diffraction from the edge of the panel does not corrupt the signals. In order to measure the direct incident signal (Pi), the signal analyzer and the hydrophone output is connected to channel 2. Transfer function between these channels is used for transmission coefficient and reflection coefficient measurements. The test was conducted in the frequency band 1500 Hz to 2000 Hz. The test was repeated thrice with the same acoustic panel to minimize measurement errors. Square specimens of dimensions 1m was used for testing high frequency. Sample panels made using untreated and treated banana fibers. contains about 8 kg untreated banana fibers by weight and those of the panels made with a mix of untreated and treated banana fibers and coconut fibers contains 4kg of each fibers in the ratio 1:1 by weight. The specimens were made using a rectangular mould, pressed, arranged in frame and was covered by acoustic cloth.



Fig 4.13: Rectangular Mould



(a) Panel made of untreated banana fibers



(b) Panel made of treated banana fibers and coconut fibers



(c) Panel made of treated banana fibers



(d) Panel made of untreated banana fi bres and cococonut fibers

Fig 4.14: Sample panels for high frequency testing

5. RESULTS AND DISCUSSIONS

5.1 SCANNING ELECTRON MICROSCOPY(SEM)ANALYSIS

SEM analysis of both banana fibers and coconut fibers were done and analysed. SEM images gave the detailed views of the sur face of a sample, revealing features such as texture, roughness, and patterns in high resolution .SEM images also provided the in sights into the microstructure of fibre materials highlighting the hemicellulose and cellulose contents in the fibers.

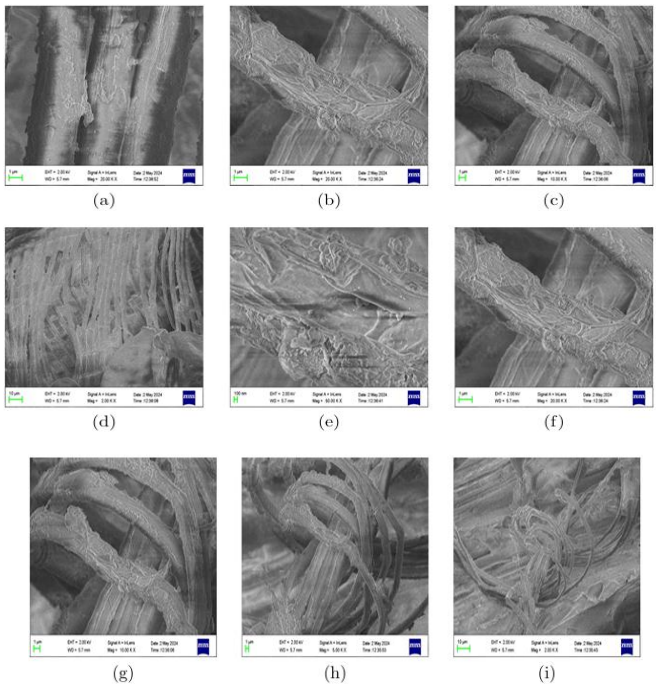

Fig 5.1: SEM images of banana fiber

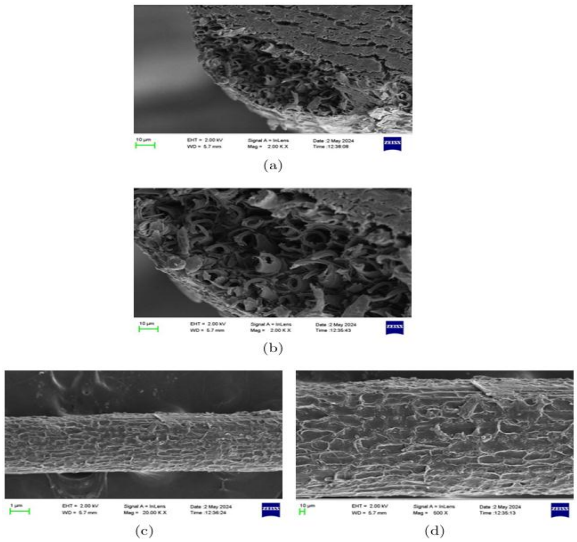

Fig 5.2: SEM images of coconut fibers

5.2 FLAME RESISTANCE

The results for the flame resistance test was obtained from the code ASTM D 3801 and UL- 94 standard vertical burning test.

The results of flame resistance tests of the four sample panels are given below:

Table 5.1: Flame resistance test results of untreated banana fibers

Criteria Conditions	Time	Remark
After flame time for each individual specimen (t1) or (t2)	15s	≤30s
Total after flame time for any condition set ((t1) + (t2) for 5 specimens)	75s	≤250s
After flame or afterglow of any specimen up to the holding clamp	No	No
Flame phenomena	Burning not sustained	V–1 Category

Table 5.2: Flame resistance test results of treated banana fibers

Criteria Conditions	Time	Remark
After flame time for each individual specimen (t1) or (t2)	13s	≤30s
Total after flame time for any condition set ((t1) + (t2) for 5 specimens)	75s	≤250s
After flame or afterglow of any specimen up to the holding clamp	No	No
Flame phenomena	Burning not sustained	V–1 Category

Table 5.3: Flame resistance test results of untreated banana and coconut fibers

Criteria Conditions	Time	Remark
After flame time for each individual specimen (t1) or (t2)	18s	≤30s
Total after flame time for any condition set ((t1) + (t2) for 5 specimens)	75s	≤250s
After flame or afterglow of any specimen up to the holding clamp	No	No
Flame phenomena	Burning not sustained	V–1 Category

Table 5.4: Flame resistance test results of treated banana and coconut fibers

Criteria Conditions	Time	Remark
After flame time for each individual specimen (t1) or (t2)	17s	≤30s
Total after flame time for any condition set ((t1) + (t2) for 5 specimens)	75s	≤250s
After flame or afterglow of any specimen up to the holding clamp	No	No
Flame phenomena	Burning not sustained	V–1 Category

The results of flame resistance conveys that the four sample panels conforms to the V-1 category of flame resistance since the after flame time for each individual specimen and the total after flame time for any condition set is less than 30 and 250 seconds respectively. Burning is not sustained. The panel made up of treated banana fibers show more resistance towards flame as the after flame time is 13 seconds while panel made up of untreated banana also shows good resistance towards flame i.e.; 15 seconds. Here, the panel made up of untreated banana and coconut fibers shows the least resistance towards flame .i.e.; 18 seconds after flame time compared to other panels. Through flame test, suitability of the panels as a safe acoustic absorber has been proved.

5.3 LOW FREQUENCY

Low frequency of acoustic panels was tested in an impedance tube. The impedance tube measurement obtains the normal incidence absorption coefficient of a layer of sound absorbing panels which has a frequency range of 100 Hz to 1000 Hz. The results can be used to compare the basic absorption performance of a material and for acoustics simulations. The sound absorption capability of the bio composite acoustic panels have been measured by insertion loss method and echo reduction method.

Insertion loss refers to the decrease in sound level (or any signal) that occurs when it passes through a device or medium, such as a filter, amplifier, or transmission line. It's typically expressed in decibels (dB). Insertion loss values and the graph showing insertion loss of the four samples are given below in the table 5.5.and fig 5.1 respectively.

Table 5.5: Result of insertion loss (dB)

Intersection Loss (db)				
Frequency (Hz)	S1-Treated Banana and Coconut Fiber	S2-Treated Banana Fiber	S3-Untreated Banana and Coconut Fiber	S4-Untreated Banana Fiber
100	11.2	8.1	8.0	11.4
200	8.5	9.9	6.6	10.5
300	11.2	12.0	8.8	13.2
400	11.7	13.2	9.1	14.7
500	12.2	14.0	9.7	16.2
600	12.4	14.8	9.8	15.3
700	11.4	13.8	9.4	14.8
800	12.3	14.6	9.9	16.6
900	13.3	15.2	10.7	18.4
1000	11.4	14.5	9.2	19.8

Untreated banana fiber acoustic panel shows the highest absorption of about 19.8 dB within the frequency range of 100 Hz to 1000 Hz. While panel made up of treated banana fiber also shows a good sound absorption value of 14.5 dB and panel made up of untreated banana and coconut fibers shows the least insertion loss value(10.7dB).High insertion loss indicates that the acoustic panels are absorbing a significant portion of the sound energy that strikes them. This absorption reduces the overall sound level in the room by preventing sound waves from reflecting off surfaces and causing reverberation. In short, panel made up of untreated banana fibers has an effective sound absorption capability in the low frequency range of 100 to 1000 Hz.

Echoes occur when sound waves reflect off surfaces and return to the listener's ears with a delay, causing a repetition of the original sound. While echoes can sometimes enhance the perception of spaciousness in large auditoriums or concert halls, they can be undesirable in many other situations, such as recording studios, conference rooms, or telecommunication systems. The result for the echo reduction is given in the table 5.6 and the graph showing echo reduction is given in fig 5.2. Treated banana fiber and coconut fiber sample shows the highest absorption of about 7.3 dB (in 1000 Hz) within the low frequency range of 100-1000 Hz. While panel made up of untreated banana fiber and coconut fibers also shows a good echo reduction value of 6.3 dB(in 400 Hz) and panel made up of untreated banana fibers shows the echo reduction value of 3.8 dB in 1000 Hz. As high echo reduction value (ER) of acoustic panels indicates effective sound absorption properties, treated banana fiber and coconut fiber acoustic panel is a good sound absorber.

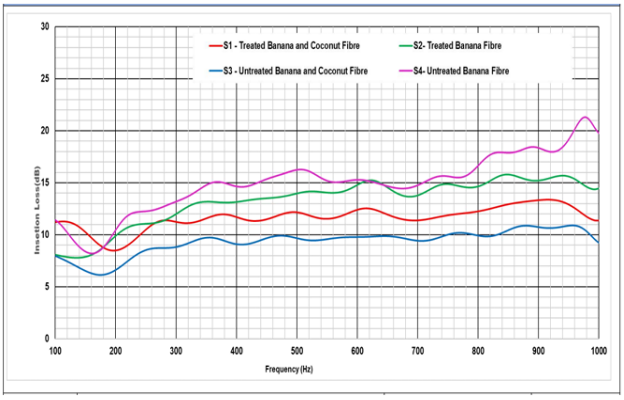

Fig 5.3: Graph of insertion loss (dB)

In a nut shell, both panels made of treated banana fibre and coconut fibers and untreated banana fibers has the good sound absorption in low frequency range.

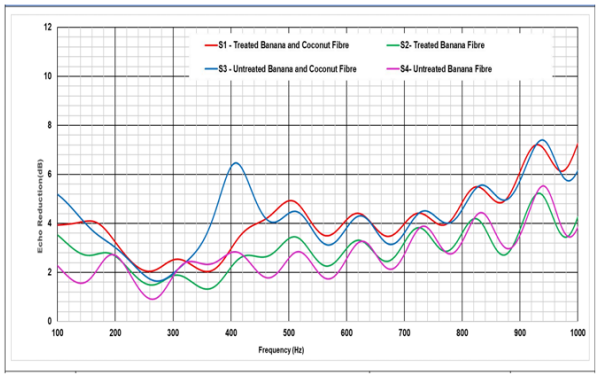

Fig 5.4: Graph of echo reduction (dB)

Table 5.6: Result of echo reduction (dB)

Echo Reduction (db)				
Frequency (Hz)	**S1- Treated Banana and Coconut Fiber**	**S2- Treated Banana Fiber**	**S3- Untreated Banana and Coconut Fiber**	**S4- Untreated Banana Fiber**
100	3.9	3.5	5.2	2.3
200	3.2	2.7	3.0	2.7
300	2.5	1.9	2.0	1.8
400	3.0	2.2	6.3	2.8
500	4.9	3.4	4.4	2.6
600	4.1	3.0	3.8	2.6
700	4.0	3.2	3.6	2.7
800	4.9	3.6	4.6	3.3
900	6.1	3.8	5.7	3.5
1000	7.3	4.3	6.1	3.8

5.4 HIGH FREQUENCY

The high frequency was tested in anechoic chamber. High frequency is where the most acoustic panels excel at absorption. High frequency is a strength for many panels, they may not be as effective for low frequencies. For high-frequency absorption, thicker and denser materials are typically needed. The insertion loss of the four sample panels were obtained. Insertion loss refers to the decrease in sound level (or any signal) that occurs when it passes through a device or medium, such as a filter, amplifier, or transmission line. It's typically expressed in decibels (dB). Insertion loss can be caused by various factors such as impedance mismatches, absorption, reflection, or dispersion. Insertion loss values of four panels are shown in table 5.7 and the graph showing insertion loss is given in fig 5.3.

Here, untreated banana fiber and coconut fiber sample shows the highest absorption of about 38.4 dB in 1792 Hz within the frequency range of 100-2000 Hz. While panel made up of treated banana fiber and coconut fiber also shows a good sound absorption value of 37.2 dB in 1792 Hz and panel made up of untreated banana fibers shows the least insertion loss value (35.5dB).High insertion loss indicates that the acoustic panels are absorbing a significant portion of the sound energy that strikes them. This absorption reduces the overall sound level in the room by preventing sound waves from reflecting off surfaces and causing reverberation.

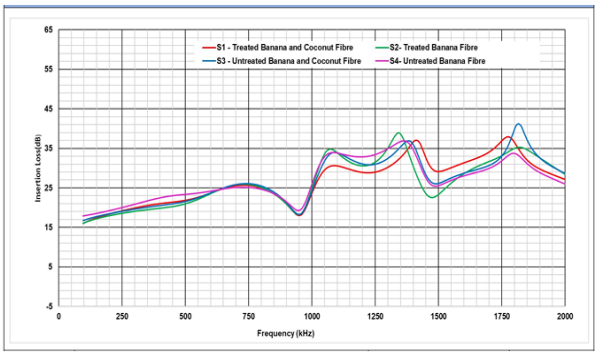

Fig 5.5: Graph of insertion loss (dB)

In brief, panel made up of untreated banana fiber and coconut fiber has an effective sound absorption capability in the high frequency range of 100 to 2000 Hz.

Table 5.7: Result of insertion loss (dB)

Intersection Loss (db)				
Frequency (Hz)	**S1- Treated Banana and Coconu**	**S2- Treated Banana Fiber**	**S3- Untreated Banana and Coconut Fiber**	**S4- Untreated Banana Fiber**

	t Fiber			
110	16.5	16.4	17.1	18.1
192	18.2	17.9	18.4	19.1
272	19.5	18.8	19.3	20.4
432	21.3	20.1	20.8	22.9
512	22.0	21.2	21.7	23.4
592	23.5	23.3	23.5	24.1
672	25.2	25.4	25.4	24.9
752	25.6	25.9	26.1	25.1
832	24.1	24.2	24.6	24.0
912	20.0	20.1	20.4	20.8
992	22.3	23.3	22.8	24.5
1072	30.5	34.8	33.6	33.8
1152	29.6	31.5	32.2	33.1
1232	28.8	30.9	30.8	33.1
1312	30.7	36.4	33.0	35.3
1392	36.0	31.9	36.6	35.5
1472	30.0	22.6	26.4	25.7
1552	30.2	26.3	27.6	27.0
1632	32.1	29.8	29.3	28.6
1712	34.6	32.0	31.1	30.3
1792	37.2	34.8	38.4	33.7
1872	30.8	33.8	34.6	30.0
1952	28.3	30.4	30.2	27.3
2000	27.2	28.4	28.7	26.0

5.5 FLEXURAL STRENGTH

The flexural strength test of the sample panels were done on flexural strength testing machine. A total four sample panels were pre pared in different proportions. Results of flexural strength test is given below:

Table 5.8: Result of Flexural Strength Test

Type of Panel	Flexural Strength
Untreated Banana Fibers	0.13 N/mm2
Treated Banana Fibers	0.12 N/mm2
Treated Banana Fibers and Coconut Fibers	0.12 N/mm2
Untreated Banana Fibers and Coconut Fibers	0.11 N/mm2

The panels did not break under axial load, but have exhibits a sort of deformation. From the above results, panel made of untreated banana fibers and coconut fibers show more deformation under axial load while panel made of treated banana fibers shows the maximum resistance to axial load.

6. CONCLUSION

Through comprehensive experimentation and analysis, the conclusions made from the project are as follows:

1. From flame test, it was revealed that the four panels meet the V-1 category of flame resistance, with a total after flame time of less than 30 seconds and 250 seconds. The treated banana fiber panel shows more resistance (13 s), while the untreated banana panel shows better resistance (15s). The untreated banana and coconut fiber panel shows the least resistance (18s).

2. According to insertion loss values, untreated banana fiber acoustic panel have the highest sound absorption value of 19.8 dB within the frequency range of 100 Hz to 1000 Hz. Panels made of treated banana fiber also show good sound absorption, while panels made of untreated banana and coconut fibers have the least insertion loss value of 10.7 dB. This high absorption reduces room noise levels.

3. In the case of echo reduction, the treated banana fiber and coconut fiber sample exhibits the highest absorption of 7.3 dB in the low frequency range of 100-1000 Hz, while panels made of untreated and coconut fibers show a good echo reduction value of 6.3 dB in 400 Hz indicating effective sound absorption properties.

4. On a whole, from low frequency results it was identified that both panels made of treated banana fiber and coconut fibers and untreated banana fibers has the good sound absorption within the low frequency range of 100 to 1000Hz.

5. From high frequency sound absorption test, it was determined that untreated banana and coconut fiber panels exhibit the highest absorption of 38.4 dB in 1792 Hz, while panels made of treated banana and coconut fibers show a good absorption of 37.2 dB, indicating that these panels ab sorb a significant portion of sound energy, reducing overall sound levels and preventing reverberation.

6. From high frequency sound absorption test, it was determined that untreated banana and coconut fiber panels exhibit the highest absorption of 38.4 dB in 1792 Hz, while panels made of treated banana and coconut fibers show a good absorption of 37.2 dB, indicating that these panels ab sorb a significant portion of sound energy, reducing overall sound levels and preventing reverberation.

From the above findings, we can conclude that panels made of both untreated and treated banana fibers exhibits a promising performance in terms of sound absorption. The untreated banana fiber panels excelled in low frequency sound absorption and load resistance but they exhibited limitations in flame resistance. Treated banana fiber panels excelled in high frequency sound absorption and flame resistance, but they exhibited limitations in resisting axial load. Overall, the study sheds light on the promising capabilities of bio composite acoustic panels made of both treated and untreated banana fibers to be an effective substitution for synthetic acoustic panels.

7. SCOPE FOR FUTURE STUDY

Future research holds potential in the following areas:

1. Different combinations of natural fibers such as banana fibers, hemp, jute, etc. with various combinations of binding agents like bio-resins, starch, or natural polymers can be done to enhance mechanical strength of bio composite panels.

2. Studying the long-term durability and aging characteristics of bio composite materials can be done to ensure their stability and performance over time, like resistance to UV radiation, microbial degradation etc.

Bibliography

[1] Cl´audia Ohana Borges Mendes, Maria Alzira de Ara´ujo Nunes"Acoustic Performance of the banana pseudo stem fibre" Applied Acoustics Volume 191, Article 108657 (2022).

[2] L´ydia Sobotov´a, Tibor Dzuro, Miroslav Badida and Marek Moravec " Experimental survey on the sound absorption performance of natural fibers in comparison with conventional insulating materials" Efficient Sustainable Material and Technology Solutions in Construction Industry, Sustainability 14(7), MDPI (2022).

[3] Lekshmi .M.S, Subha Vishnudas, Anil.K.R "Experimental investigation on acoustic performance of coir fibre and rice husk acoustic panels " ,Applied Acoustics ,Volume 204, Article 109244 (2023).

[4] Sangmesh B, Nagraj Patil b, Krishna Kumar Jaiswal, T.P. Gowrishankar. " Development of sustainable alternative materials for the construction of green buildings using agricultural residues: A review" Construction and building materials, Volume 368, Article 130457 (2023).

[5] Majid Mohammadi ,Ebrahim Taban , Wei Hong Tan,Nazli Bin Che Din Azma Putra, Umberto Berardi."Recent progress in natural fiber reinforced composite as sound absorber ma terial" Journal of Building Engineering 84, Article 108514 (2024).

[6] Abideen Temitayo Oyewo ,Oluleke Olugbemiga Oluwole, Olusegun Olufemi Ajide,Temidayo Emmanuel Omoniyi , Murid Hussain. " Banana pseudo stem fiber, hybrid composites and applications: A review" Hybrid Advances Article 100101(2023).

[7] UL-94 Standard Code Test for Flammability of Plastic Materials for parts in Devices and Aplliances (2001)