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SUSTAINABLE CONSTRUCTION MATERIAL AND TECHNOLOGY FOR AN ANECHOIC CHAMBER USING SUGARCANE BAGASSE

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Abstract: An anechoic chamber (meaning non-echoing or echo-free) is a specially designed room that completely absorbs or reduces reflections of sound or electromagnetic waves. These chambers are also insulated from external noise, creating an environment that simulates a quiet open space of infinite dimensions. This setup is crucial for obtaining accurate results free from external influences. Initially, anechoic chambers were developed for acoustic purposes to minimize room reflections of sound waves. Acoustics, the branch of physics concerned with mechanical waves in gases, liquids, and solids, encompasses topics like vibration, sound, ultrasound, and infrasound. Scientists specializing in acoustics are known as acousticians, while those working in acoustics technology are called acoustical engineers. The application of acoustics permeates nearly all aspects of modern society, particularly in the audio and noise control industries.

Keywords: - Anechoic, Electromagnetic waves, Acoustics, Vibration, Ultrasound, Sugarcane Bagasse

1. INTRODUCTION TO PROJECT WORK

The requirements for measuring sound and vibration are now higher than ever, with customers demanding quieter devices such as cars, computers, vacuum cleaners, washing machines, and refrigerators. These demands are reflected in ISO standards, which provide consistent requirements, specifications, guidelines, and characteristics to ensure products are fit for their purpose. In an anechoic chamber, background noise can be so minimal that it measures in negative decibels.

Many acoustic standards mandate the use of fully anechoic or semi-anechoic chambers for accurate acoustical measurements. However, designing and implementing such chambers can be costly due to the expense of standard acoustic materials. Many companies cannot afford these high costs, creating a need to reduce material expenses by selecting alternatives that perform similarly to standard acoustic materials.

This project aims to address this issue by identifying cost-effective materials that meet the requirements of a semi-anechoic chamber. The project will begin with testing various materials for their sound absorption properties, economic viability, and durability, ensuring they fulfill the necessary acoustic standards while being more affordable.

1.1 Problem Statement

As the motive of the project is to find replacement for standard acoustics material following are the problem which may pop while finding the suitable replacement of material and satisfy the customers need.

a) Sound absorption

b) Economical
c) Life
d) Application of material
e) Aesthetics

1.2 Objectives

- To reduce the echo in room or chamber.
- To achieve the economy of material as compared to standard material.
- Test the various material in sound lab test for the sound absorption or insulation of material.
- Make the wall look aesthetically better.

- Utilization of local and easily available material as sound absorber as a replacement of standard acoustic material.
- Knowing the properties of acoustics and acoustic materials

2. SCOPE OF PROJECT WORKS

The industries are growing up with new technologies there is a requirement for a quitter place, so as to get the p resides test results and for seeking the quitter environment inside the room, so this project is the approach towards the better and quite life to the people .The issue is we cannot make the machinery or the equipment fully silent, so there is need to make the room quite by providing the non-repellent sound material .
Following are the some of the places which may use this product for their benefits.

- School and lecture halls.
- Operation theaters / hospitals.
- Meditation centers.
- Various acoustic industries for testing their products i.e. microphone testing, headphone testing, exhaust of automobiles, aircraft industries, etc.
- Auditoriums halls for better sound effects.
- Audio record rooms.

3. EXPERIMENTAL ANALYSIS

Echo, a lingering sound that persists after the original source has stopped, is a common issue in many rooms, especially those with large spaces and hard walls. This repetition of sound can be mitigated or eliminated by using absorber panels, which absorb sound energy and convert it into heat. Sound absorbers are categorized into three types: porous absorbers, cavity absorbers, and membrane absorbers. Due to the high cost of traditional materials like glass wool and Rockwool, various alternatives such as plywood and fibrous materials have been explored.

Recently, natural fibers have gained attention for their use in various structural and non-structural applications, including as substitutes for synthetic fibers in composite materials and automotive linings. Natural fibers like coir fiber are also suitable replacements for synthetic fibers and wood-based materials in acoustic absorption. These fibers offer numerous advantages: they are cheaper, renewable, abundant, non-abrasive, and pose no health or safety risks during processing and handling. Research using the tone burst method on unprocessed egg cartons made from sugarcane waste fibers has shown promising acoustic properties. These fibers exhibit excellent acoustic performance, particularly in the 2 - 4.5 kHz range, with an average absorption coefficient of 0.65, comparable to traditional synthetic absorbers.

fig -1: sugarcane bagasse source

3.1 Material Composite

Due to their biodegradable, lightweight, inexpensive, non-toxic, and non-abrasive qualities, natural fibers are receiving significant attention in composite applications. They are particularly valued as substitutes for synthetic fibers in acoustic absorption materials. These natural fibers, with their desirable physical and mechanical properties, can be transformed into high-performance composites that offer environmental and economic benefits.

The acoustic performance of engineered synthetic absorptive materials typically surpasses that of natural absorptive materials because of their finer diameters and antifungal qualities. However, synthetic fibers have a higher environmental impact compared to natural fibers. In recent years, natural fiber-reinforced resin/polymer composites have garnered considerable interest due to their lightweight, abundant availability, cost-effectiveness, biodegradability, and eco-friendliness. These materials are cheaper and more environmentally friendly than glass fiber-reinforced composites. Nonetheless, natural fiber composites currently have lower popularity than synthetic composites due to issues such as low interfacial adhesion, poor moisture resistance, and inadequate antifungal properties.

Researchers are working to improve the quality of natural fibers through chemical treatments before composite production to overcome these limitations. It has been reported that mercerization, or alkali treatment, reduces fiber diameters and enhances their adhesive and antifungal properties. The reduction in fiber diameter improves low-frequency sound absorption by creating a more tortuous path and increasing the surface area, which enhances the airflow resistivity of the fibrous material. This increased airflow resistivity causes sound energy loss through the friction of sound waves with air molecules, thereby improving low-frequency sound absorption.

The study examines the limitations of natural fibers in achieving the desired level of acoustic absorption performance. Natural fibers, such as sugarcane bagasse, offer advantages like biodegradability, cost-effectiveness, eco-friendliness, low specific weight, abundant availability, high electrical resistance, excellent thermal and acoustic insulating properties, low toxicity, and minimal health hazards during processing and handling. However, they also have disadvantages, including lower antifungal and durability properties, poor moisture and fire resistance, negative impact on climate change (CO2 absorption), lower acoustic absorption compared to synthetic fibers due to larger diameters, and poor fiber-matrix adhesion which leads to swelling when exposed to moisture.

4. DENSITY OF MATERIAL

The thickness of a material has become a significant factor in determining its sound absorption capabilities. It has been observed that increasing the sample thickness enhances sound absorption in medium and high-frequency ranges. This increase in fiber density per unit area leads to higher sample thickness, resulting in greater energy loss of sound waves due to increased surface friction, thereby improving sound absorption performance. This effect can be achieved by increasing the weight of sugarcane bagasse to create a 30mm thick sample.

It is noteworthy that the measured absorption coefficient does not have a linear relationship with thickness. Adding more fibers and increasing thickness may result in the formation of end pores, which can significantly increase the airflow resistivity and eventually decrease the absorption capability.

4.1 Absorption Capacity of Material

The construction of fiber-based absorber samples involves two stages: pre-treatment and fabrication. In the pre-treatment stage, the raw material is cut into lengths of 5 to 10 mm, then sun-dried for one week, followed by heating in an oven at 90°C for 15 minutes to evaporate excess water. After this, the raw material is cut into lengths of 1 to 2 mm. In the fabrication stage, the raw material is mixed with varying compositions of binder, just enough for the sample to hold its shape.

The absorber specimens were manually produced using a simple press mold, resulting in different densities (0.372, 0.428, 0.470, 0.522, and 0.618 g/cm³). The samples were prepared to match the size of the impedance tube, cut into 100 mm diameter discs with a thickness of 30 mm. The tests were conducted using a B & K impedance tube type 4206, with frequencies ranging from 200 Hz to 1600 Hz.

The results indicate that increasing the density of the absorber specimens leads to a decrease in the noise absorption coefficient (NAC) due to reduced porosity. Among the specimens, the one with a density of 0.428 g/cm³ exhibited the highest NAC (0.72) at a frequency of 650 Hz. The absorption performance of the absorber can be enhanced by reducing density and increasing porosity.

5. BINDING MATERIAL

5.1 Chemical Binder

Polyvinyl acetate (PVAc) is a synthetic resin produced by the polymerization of vinyl acetate. In its primary applications, PVAc serves as the film-forming component in water-based (latex) paints and is also used in adhesives. Vinyl acetate ($CH_2=CHO_2CCH_3$) is synthesized from ethylene by reacting it with oxygen and acetic acid in the presence of a palladium catalyst. Under the influence of free-radical initiators, vinyl acetate monomers (single-unit molecules) can link together to form long, chain-like polymers (large, multiple-unit molecules). These monomers can be polymerized while dispersed in water to create a milky-white emulsion. This liquid can be directly processed into latex paints, where PVAc forms a strong, flexible, adherent film. It can also be made into a common household adhesive known as white glue or Elmer's glue. When used in coatings or adhesives, PVAc is often partially hydrolyzed to become water-soluble.

5.2 Organic Binder

Using chemical binders hinders the goal of making the product biodegradable. Therefore, to achieve complete biodegradability, the use of organic binders is preferable. Organic binders such as starch, derived from various grains like rice, wheat, and corn, are effective in improving adhesion properties. Starch glues are typically based on unmodified native starches with additives such as borax and caustic soda. A portion of the starch is gelatinized to maintain the slurry of uncooked starches and prevent sedimentation. This type of glue, known as Stein Hall adhesive, is applied to the tips of the fluting. The fluted paper is then pressed onto a paper called liner and dried under high heat, causing the remaining uncooked starch in the glue to swell and gelatinize. This process results in a fast and strong adhesive, ideal for corrugated board production.

5.3 Admixture

To protect against termite infestation, an antitermite admixture called PIDILITE Terminator Wood Preservative is incorporated into the organic material during manufacturing, comprising 1.0% of the total mix. This additive helps safeguard the material from termite attacks.

Furthermore, to enhance water resistance and prevent degradation when exposed to moisture, a water resistance admixture containing hydrophobic chemicals, such as Fevicol Marine Plywood Coating, is included at a concentration of 2.0% of the total mix. This not only shields the material from water penetration but also prevents capillary actions in lamination joints.

6. CONCLUSIONS

Utilizing sugarcane bagasse waste material for sound absorption presents a promising solution due to its natural, renewable, low-cost, lightweight, and biodegradable characteristics. A functional composite comprising Sugarcane-Bagasse/PVAc-Glue has been successfully developed and characterized. Optimal sound absorption coefficients were achieved with a thickness of 30 mm for sugarcane bagasse. The composite exhibited excellent sound absorption coefficients across low to medium frequencies, ranging from 400 Hz to 800 Hz, with NAC values between 0.46 and 0.71. Further enhancement of absorption performance can be achieved by reducing density and increasing porosity. The reclaimed sugarcane could potentially be utilized in sound insulation components.

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