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Noise absorbing construction material from waste(s)

A. Aneesul Nayeem
aneesul777@gmail.com
Sri Ramakrishna Institute of Technology, Coimbatore, Tamil Nadu

Dr. K. Murali
murali.ce@srit.org
Sri Ramakrishna Institute of Technology, Coimbatore, Tamil Nadu

ABSTRACT

The noise absorbing panels are made from both natural and artificial materials. Due to the increased manufacture and usage of artificial fibres, carbon footprint levels get increased. In the Coimbatore region with the presence of numerous coir industries, a huge quantity of waste in the form of coir pith are produced. To overcome the use of artificial fibres, this study intends the usage of the coir waste as the noise absorbing material. A noise absorbing panel is designed and made from the coir with the addition of polypropylene. The polypropylene is used for binding purpose. The prepared sample is tested with the impedance tube method. The sound absorbing coefficient value of the sample which is compared with the other materials. For phase, I of the project, the properties of coir and the test which has to be carried out is studied with the help of literature reviews. The test procedure is discussed and the methodology is prepared. Further in phase II of the project experimental part is carried out. The results are tabulated and compared with artificial materials which are then concluded that coir can be used as an absorbing material.

Keywords— *Coir, Noise absorbing panel, Polypropylene, Impedance tube method*

1. INTRODUCTION

Noise is generally referred to as unwanted or unpleasant sound. Noise absorption is one of the major requirements in daily life. Glass wool, foam, mineral fibres are some the artificial sound absorbing materials which are widely used. The usage and manufacture of these material results in increasing the carbon footprint. As an approach of green construction instead of using artificial fibres, we can utilise the natural fibre as an alternative. My research is to develop and design a cheap, renewable sound absorbing panel from the coir with the addition of polypropylene as a binding material. It would cheap, renewable, biodegradable, and recyclable material. The properties of coir are porous, light weight, insulator, hygroscopic and non-abrasive in nature. These panels can be used as construction material in the future.

2. REVIEW OF LITERATURE

Mohammad Ali Saadatnia, Ghanbar Ebrahimi, Mehdi Tajvidi. "Comparing sound absorption characteristic of acoustic boards made of Aspen particles and different percentage of Wheat and Barley straws". This paper makes the study of noise absorbing panel made with two different materials like wheat and barley straws combined with aspen particles. The sample is made with the difference in their proportions and then tested for results. The resulting from this paper helps us to set a boundary limit for our material. It also helps in the preparation and testing of samples.

Chanakan Asasutjarit, Sarocha Charoenvai, Jongjit Hirunlabh, Joseph Khedari. "Effect of pre-treatment on properties of coir-based green composite". The major study in this paper is of pre-treatment of coir before using it for any other purposes. The physical, chemical and mechanical properties of the coir are analysed. It is proved that the pretreatment process had made better adhesion results. It is examined with the help of Scanning Electron Microscopy (SEM).

S. P. Shree Vignesh, C. Sridharan, A. Tamilselvan, V. Saravanan, S. Rajaganapathy. "Mechanical Testing on Glass Fibre Reinforced with Jute Fibre Composites" This study helps to understand about the composite material made with jute fibre and glass fibre. The sample is made and tested for results with destructive and non-destructive tests. This composite material can be used for various applications and also as a construction material.

Zhihui Sun, Li Zhang, Dompng Liang, Wei Xiao, and Jing Lin. "Mechanical and Thermal Properties of PLA Biocomposites Reinforced by Coir Fibers". This study deals with biocomposites made with PLA polylactic acid additionally reinforced with coir fibres. All the mechanical and thermal properties were tested and the result is analyzed. The sample is prepared with different proportions of coir and tested. Results show the tensile strength is increased and the capacity of insulation is also found better.

Maria Virginia Gelfusoa, Pedro Vieira Gurgel da Silvab, Daniel Thomazinia. "Polypropylene Matrix Composites Reinforced with Coconut Fibers" This paper is about polypropylene matrix compound reinforced with coconut fibre. The sample is made into two categories chemically treated and mechanically treated with various proportions and tested as per ASTM. The material is also electrically tested and the result shows that mechanically treated composite gives better performance.

D. Verma, P.C. Gope, A. Shandilya, A. Gupta, M.K. Maheshwari. "Coir Fibre Reinforcement and Application in Polymer Composites: A Review" This review paper is based on the coir fibre reinforced polymer composites and their properties. The mechanical properties of coir fibre are found to be matching with glass fibres. Application of coir fibre has been developed widely at present.

Tara Sen, H. N. Jagannatha Reddy. "Application of Sisal, Bamboo, Coir and Jute Natural Composites in Structural Upgradation" The natural fibres like sisal, bamboo, coir and jute are studied in this paper. The mechanical, physical and chemical properties of all these fibres are studied comparatively. The application of these materials in a structural is examined. The advantages of each fibre are studied individually and compared with each other.

Riana Herlina Lumingkewas "Development of materials for construction with low environmental Impact made with low content of cement and with natural fibers" This purpose of this study is to identify new materials for the construction industry. The objective of this research is to develop coir fibre reinforced building material. The pretreated coir fibre increases the compressive and tensile strength of the concrete.

Shivaraj C Kavalastrahiremath, Dr B. Siddeswarappa, Mallikarjun Channalli. "Evaluation of Tensile and Flexural Properties of Coconut Coir and Coconut Shell Powder Reinforced Epoxy Composites" This study had made analysis between treated and untreated coir fibre. The treatment is done by HCL. After testing the results shows that the treated coir has good flexural and tensile strength than the untreated coir fibre.

Geetanjali Das. "Processing, Characterization and Erosion Wear Behaviour of Coir Fiber Reinforced Epoxy Composites" This paper deals with the coir fibre reinforced epoxy composites as an alternative for glass. This research studies all the physical, mechanical, and water absorption and erosion wear behaviour of coir with Al_2O_3 filler. The sample is made with and without fillers of different dimensions and tested. The results show the composites with fillers gives a good performance.

Han-Seung Yang, Dae-Jun Kim, Hyun-Joong Kim. "Rice straw–wood particle composite for sound absorbing wooden construction materials" This paper is about wood particles board added with rice straw. The urea formaldehyde is used as binding material. The samples are made with variation in the specific gravity and tested. The sound absorbing coefficients of the samples are tabulated. The result shows that the composite particle with specific gravity 0.4 to 0.6 is suggested for the manufacturing process.

M. G. Sreekumar, Deepa G Nair. "Stabilized Lateritic Blocks Reinforced with Fibrous Coir Wastes" This paper focuses on stabilized lateritic blocks reinforced with coir fibres. The sample is prepared with different proportions of coir content and tested. The results show good improvement in the strength and durability of fibre reinforced blocks with a fibre content of 0.5%. It can successfully use for load bearing structures.

Pne Naveen "Experimental analysis of coir fiber reinforced composite materials" The research focuses on the analysis of coir fibre reinforced composite material with epoxy resin. The main objective is to replace the artificial fibre with natural fibre in construction material. The prepared samples of different proportions and length of fibre are tested mechanically. The test results show the increase in properties and can be used for structural and non-structural construction application.

Achudhan "Experimental Study on Coir Fibre Mixed Concrete" This study is made to analyse that coir fibre reinforced concrete gives better performance than conventional concrete. The samples are made of different proportions in M20 concrete and tested. The result shows that the addition of 3% of fibre increases strength.

A. Zuraida, S.Norshahida, I. Sopyan and H. Zahurin "Effect of Fiber Length Variations on Mechanical and Physical Properties of Coir Fiber Reinforced Cement-Albumen Composite (CFRCC)". This paper shows the effect of length variation in fibre while making a composite. The cement albumen composite is prepared for the difference in their length. The samples were tested for flexural, compressive strength, moisture content, bulk density and water content. The results show that the increase in the length of fibre increases the strength but decreases the workability. It also increases the moisture content and water absorption property.

Samia S. Mir, Syed M. N. Hasan, Md. J. Hossain, and Mahbub Hasan "Chemical Modification Effect on the Mechanical Properties of Coir Fiber". This paper shows the chemical modifications in the coir fibre. This research is done to increase the adhesion between the coir fibre and the polymer. It will increase the strength of composite material. The coir is treated in two different stages for better performance. The samples of two staged treated coir are tested. The second staged treated fibre gives good mechanical performance than raw coir fibre.

Lamyaa Abd AL-Rahman, Raja Ishak Raja and Roslan Abdul Rahman "Attenuation of Noise by Using Absorption Materials and Barriers". This paper reviews on synthetic materials used for absorption purposes. It also gives summarization of considering organic materials as an alternative. This review helps us with the research carried out further in green materials.

Narendar, R and Priya Dasan.K "Recent Developments in Coir Pith Based Particle Boards: A Review". This paper describes the various work and function of coir pith. The availability of this material is good and research is carried out for making it a useful material. The experimental analysis shows good mechanical strength in coir pith.

J. Niresh, S. Neelakrishnan, S. Subharani and R. Prabhakaran "Performance Testing for Sound Absorption Coefficient by Using Impedance Tube". The sound absorption characteristics of the single and multi-layered porous materials are studied with the help of the impedance tube. In Impedance tube standing wave and transfer function methods are used more for its accuracy and reliability. The standing wave method is simple and the transfer function method is accurate. The materials are tested for their sound absorption co-efficient. The standing wave method is used in this study. The results are compared with the existing tube. The two different samples are compared with the existing tube.

Dariusz PLEBAN "Method of Testing of Sound Absorption Properties of Materials Intended for Ultrasonic Noise Protection" It is proposed to carry out measurements of the sound absorption properties of materials in the free field by means of a tone-burst technique in the frequency range from 4 kHz to 40 kHz at angles of incidence varying from 0 to 60^0. The absorption coefficient of a material is calculated from the reflection coefficient obtained by reflecting a tone-burst from both a perfectly reflecting panel and a combination of this panel and the sample of the tested material. The tests results show that mineral wool and polyurethane open-cell foam possess very good absorbing properties in this frequency range

3. METHODOLOGY

3.1 General

The methodology is the general research strategy that outlines the way in which research is to be undertaken and, among other things, identifies the methods to be used in it. These methods, described in the methodology, define the means or modes of data collection or, sometimes, how a specific result is to be calculated.

The methodology does not define specific methods, even though much attention is given to the nature and kinds of processes to be followed in a particular procedure or to attain an objective. So a detailed discussion is needed to overcome the issues and to increase the usage of natural fibres even more efficiently. Thus, the discussion for noise absorbing panel is analysed in a detailed manner (Aneesul Nayeem and Murali, 2018).

3.2 Literature study

A literature study is one of the most important processes in this project. The stated objective will meet only if the study is carried out properly without any error. The literature is collected from various journals on the internet. This detailed study helps to know about the coir properties and specifications about noise absorbing materials.

3.3 Study on acoustic materials

The details of the acoustic materials are studied in the literature study. This helps to figure out how an acoustic material should be made. Each acoustic material has its own pros and cons which is also to be considered.

3.4 Study on the properties of coir

The properties of coir have to be analysed in a detailed manner. This helps in matching the properties of artificial fibres used in making of acoustic panels. Even the natural fibre has some of its own unique properties which can be utilised effectively

3.5 Development of acoustic panels

Two types of fibers are prepared: fibers that are cleaned and thermally treated and fibers that are untreated. Treatment of fibers is done manually without any chemical additive. The cleaning consists of washing of fibers with tap water to obtain a smooth surface and to remove the rest of peat and dust that still exist on the surface after sieving. Fibers are dived in clean water during 1-2 hours. Then dirty water, loaded with peat and dust, is removed, and the operation is renewed with clean tap water, to separate fibers. Some peats and dust are then extracted manually from fibers skin and fibers are placed on a paper so that it can absorb water. Finally, fibers are combed and sieved, to release the residual peat and dust. The acoustic panel is developed after the initial preparations.

3.6 Testing of acoustic panels

The prepared panel is initially tested for its strength. After the initial testing of panels, it is tested for sound absorbing coefficient value with the help of Impedance Tube.

3.7 Results and discussions

The test results are compared with other artificial noise absorbing materials and can be concluded that natural fibre is a perfect replacement for artificial fibre.

4. DEVELOPMENT OF ACOUSTIC PANELS

4.1 General

The noise absorbing panels are commercially made by natural and artificial materials. The panels made in this research contain coir pith particles with coir. The samples are cast in size of 30x30x2.5 cm at SKS Coirs Private Ltd., Pollachi.

The casting of the panel is done with the help of high compression pressing machine. Synthetic resin coating is applied to ensure good bonding between the fibres. Due to the high availability of this pith, it can be added to the panels. This addition does not

affect the sound absorbing property but it enhances it. The pith added for the making of panels has varied from 0% to 30% to the weight of coir fibre used in making the panel.

4.2 Specimen

Fig. 1: Coir pith panel

5. TESTING OF ACOUSTIC PANELS

5.1 General

With today's growing focus on noise control issues and the emergence of sound quality as an important aspect of product design, acoustic material testing is becoming increasingly relevant to engineers, designers and manufacturers from a broad range of industries. Acoustic material testing is the process by which acoustic characteristics of materials are determined in terms of absorption, reflection, impedance, and admittance.

5.2 Procedure

There are many different methods to determine the acoustic properties of materials by exposing them to sound field and measure the effect caused by their presence. Concerning to the acoustic material testing methods, they have to be done according to the Standards (ISO 10534-2, ASTM E 1050-98) describing well-defined acoustical conditions and special instrumentation to ensure a high and known degree of repeatability and reproducibility.

Absorption Coefficient varies with the frequency and angle of incidence of the sound. Sound is absorbed when part of the sound energy striking a surface or an object is converted into heat energy in the pores of the material. Generally, higher frequencies are more easily absorbed than low frequencies. Materials that are good absorbers permit sound to pass through them relatively easily; this is why sound absorbers are generally not good sound barriers. They reduce the level of noise inside an enclosure because while the sound waves are being reflected from the surfaces in the room, they interact with the sound absorbing materials and lose some energy each time. However, it requires a large thickness or many paths for the sound energy to be significantly reduced.

Materials that prevent the passage of sound are usually solid, fairly heavy and non-porous. Sound-absorptive materials are used to reduce the level of steady sound in a room, from a machine for example, and to reduce the reverberation.

The sound absorption for material or an object is measured in sabins or metric sabins. One sabin may be thought of as the absorption of unit area (1 m2or 1 ft2) of a surface that has an absorption coefficient of 1.0 (100%). When areas are measured in square meters, the term metric sabin is used. The absorption for a surface can be found by multiplying its area by its absorption coefficient.

Thus for a material with an absorption coefficient of 0.5, 10 ft2 of this material has a sound absorption of 5 sabins and 100 m2 of 50 metric sabins. When sound waves strike one side of a partition, the pressure variations cause vibrations in the partition, and part of the power in the sound wave is transferred to the partition. All or part of this vibration energy, depending on the construction, will reappear at the opposite surface, where it is re-radiated as sound.

Fig. 2: Specimens used for testing

5.3 User interface

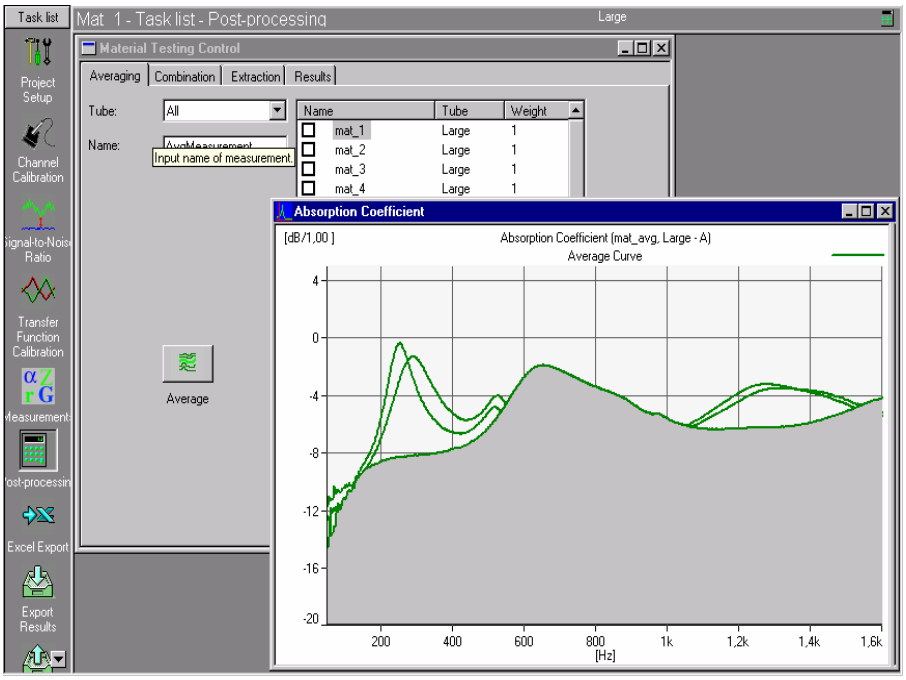

Fig. 3: User interface of impedance tube

PULSE Material Testing is the complete and fully integrated system for acoustic measurements on small material samples in the 50 Hz to 6.4 kHz frequency range. The PULSE Material Testing system can be used to measure the acoustic properties of almost any test sample, including composite and irregular materials, using a Brüel & Kjær impedance tube. The tube can replicate many acoustic settings and uses two fixed microphones to make simultaneous measurements at all frequencies of interest, saving time lost on serial testing.

The native Windows 2000® -based PULSE multi-analyzer system gives you a stable, familiar operating system to work with while the task-oriented user interface simplifies the measurement process from setup to documentation of final results via a series of straightforward, intuitive steps. It is shown in figure 2 as an example. The Material Testing software is designed to make life easier for the user and includes lots of helpful features including:

- Compensation for sample variations and simulations of composite materials by averaging results
- Batch support allowing easy execution of groups of measurements
- 1/nth-octave spectrum extraction enabling data comparison with the standing wave ratio method
- Advanced calibration features to eliminate the need to re-calibrate between tests
- Full integration with Microsoft® Word and Excel allowing further post-processing and easy reporting
- On-line, context-sensitive help ensuring quick understanding of software
- Support of custom measurement tubes, or tubes from other vendors, allowing greater measurement flexibility

Fig. 4: Experiment of Impedance Tube

5.4 Experiment

The system configuration of Material Testing Multi-Analyzer, PULSE is used as a front-end. As typical results, absorption coefficient Measurement Result of Absorption Coefficient Front-end (PULSE) Impedance Tube Power Amplifier Microphones Extension Tube.

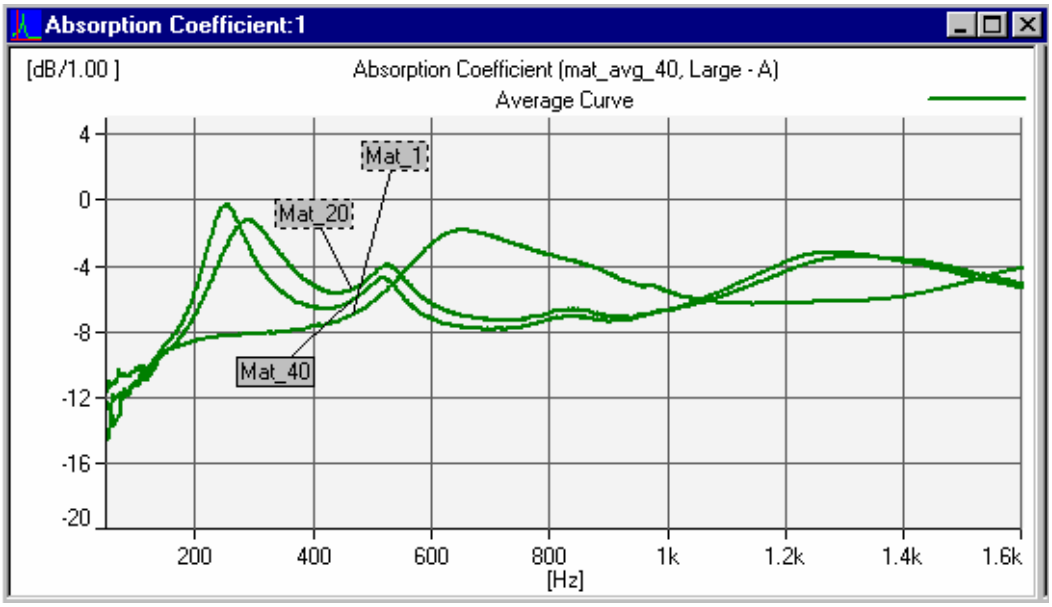

Fig. 5: Result graph

6. RESULTS AND DISCUSSION

6.1 Results

The objective of development of cost effective noise absorbing panel is initiated with the help of a literature study. The initial study is carried out to identify the property of coir and the same is compared with the artificial fibres. Several properties of noise absorbing panel have been inferred from the various reference works. Further, the development of noise absorbing panel is done. The result is obtained from the Impedance tube instrument.

6.2 Impedance tube test results

Table 6.1 Impedance Tube Test Results

Frequency (Hz)	250	500	1000	2000
5%	0.22	0.63	0.56	0.63
10%	0.22	0.67	0.63	0.68
15%	0.23	0.73	0.68	0.72
20%	0.24	0.79	0.75	0.78
25%	0.25	0.84	0.79	0.86
30%	0.25	0.89	0.84	0.91

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