Research Progress in Mechanical and Manufacturing Engineering Vol. 4 No. 2 (2023) 156-161
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RPMME

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rpmme
e-ISSN : 2773-4765

Design Evaluation on Sound Absorption Performance of Coconut Husk added with Pineapple Leaf Panel

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DOI: https://doi.org/10.30880/rpmme.2023.04.02.019
Received 01 December 2023; Accepted 01 April 2023; Available online 15 December 2023

Abstract: This paper compares the sound-absorbing properties of two different design panels of natural fibre composites with different compositions. Pineapple leaf and coconut coir fibres are used to make the composite panel. Sound absorption is evaluated with two different pane design iterations and various compositions of each fibre in a specimen. The test makes use of a simple impedance tube and two microphones. The transfer function of the two microphones in the frequency range of 0 Hz to 6000 Hz is used to compute the sound absorption coefficient. The volume fibres varied from 20 wt. %, 25 wt. %, and 30 wt. % while the polyurethane foam is 50 wt. % and is glued together to form a panel. The result shows that the sound absorption coefficient is directly proportional to the composition of pineapple fibre in the composite. This shows that pineapple fibre absorbs sound better than coconut husk fibre. It was also demonstrated that the design panel with holes has a better sound absorption coefficient compared to the plain design. The highest sound absorption coefficient recorded for the design with holes is 0.92, whereas the plain design recorded a 0.91 for its absorption coefficient.

Keywords: Sound Absorption Coefficient, Natural Properties, Noise Reduction, Pineapple Leaf, Coconut Husk, Polyurethane Foam

1. Introduction

The acoustical environment is now given a lot of attention. In order to create an environment that is acoustically pleasant, noise control and its concepts are crucial. This is possible by reducing the volume of the sound to a level that is safe for human ears. An appealing setting can be created by utilizing a variety of techniques and materials. One such method is by absorbing the sound. Currently, glass- or mineral-fibre materials are the only commercially accessible sound absorption materials for acoustic treatment employed in the building construction sector. In acoustic engineering, acoustical materials have a variety of crucial functions, including regulating room acoustics, industrial noise management, and studio acoustics. In addition, the panels built using a perforated plate design also

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help further enhance their acoustic qualities. According to Lee and Chen (2001), perforated plates with airspaces behind them improve the acoustic absorption of multi-layer materials.

One method to accomplish a satisfying environment is by absorbing sound using various techniques that utilize various materials. This method can also be achieved by creating a sound panel that can reduce noise pollution. The use of various sound-absorbing materials has substantially expanded as a result of technological advancements and a growing public awareness of the impact of noise in daily life. Modern architects and acoustical engineers have access to a wide range of sound-absorbing materials that are not just connected to acoustical qualities but also provide a larger range of colours, forms, sizes, light reflectivity, and attachment strategies.

In light of a recent rise in protecting the environment, many researchers are using recyclable and bio-degradable materials in creating products. Agriculture-derived natural fibres are now being researched more extensively for a variety of structural and non-structural applications, such as replacing synthetic fibres in composite materials. Kenaf, wood, hemp, cork, cane, cardboard, and sheep wool are among natural fibres with good potential for development as sound-absorbing materials [2], as well as extracted pineapple-leaf fibres [3], Arenga Pinnata fibre [4], and combinations of rice husk grain and coconut coir fibre [5]. To overcome the limitations of natural fibres due to moisture and mechanical qualities, some researchers tried to create fibre-reinforced composites [6–8]. Some of the natural fibres that are widely available in Asia include coconut coir fibre, and pineapple leaf fibre.

In this study, the features of natural fibre's sound absorption were examined after PVA glue and polyurethane foam were used to harden the composite. The fibre is comprised of pineapple leaf and coconut coir fibres. Different compositions of fibres and panel designs are examined for their sound absorption coefficients. The test is performed with a straightforward impedance tube equipped with two microphones. The transfer function of both microphones is used to calculate the specimens' sound absorption coefficient.

2. Materials and Methods

2.1. Materials

The pineapple plant and coconut husk components for the composite are collected from the local market around Parit Raja, Johor. The materials are then extracted to get the fibre. The extracted fibres were cleaned and washed thoroughly in order to remove any dirt and dust from the fibres. Once it is cleaned the components are then left dried in an open sunlight for five (5) days to remove the moisture inside the plant. Layers of fibres and polyurethane foam are glued together and compressed inside a mould and left dried for 1 day. The compositions of the natural fibres are as shown in Table 1.

Table 1: Weight Ratio of Composite

Parameter	Coconut Fibre (wt. %)	Pineapple Fibre (wt. %)	Polyurethane Foam (wt. %)
A	20	30	50
B	25	25	50
C	30	20	50

2.2. Design

The specimen was divided into two design models which is the plain design, and secondly the design with holes, as demonstrated in Figure 1. Figure 1(a) shows that the plain design whereas Figure 1(b) shows the specimen design with holes. For the design with holes specimen, the dimension of holes for 100mm specimen is 1.5mm, while for the 28mm specimen is 0.5mm. The Impedance Tube Method in accordance with the ASTM E1050-98, was used to determine the qualities of the material in terms of the sound absorption.

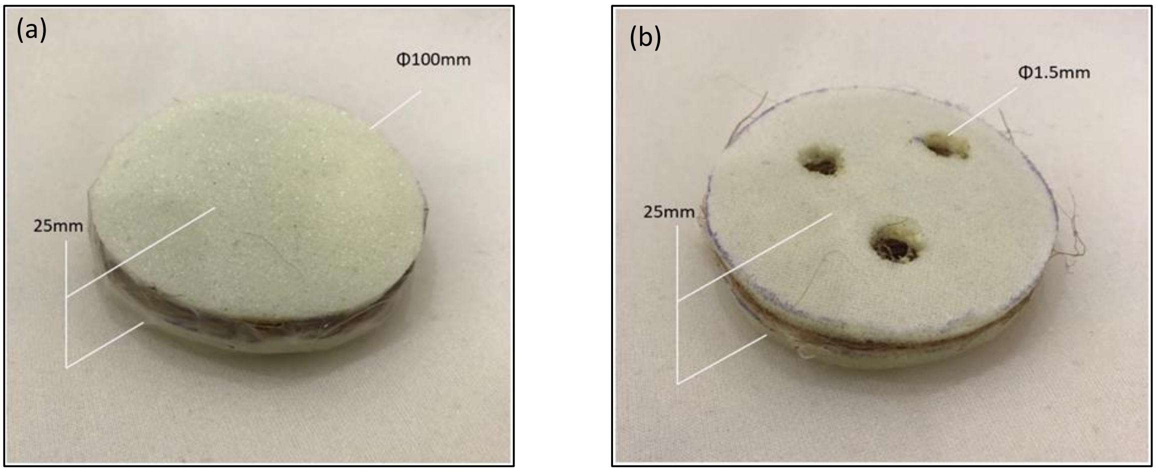

Figure 1: (a) Plain design (b) Design with holes

2.3. Impedance Tube

The Impedance Tube apparatus as shown in Figure 2 was used to determine the qualities of the material in terms of sound absorption. In general, this device measures the absorption, reflection coefficients, and acoustic impedance of the materials. This procedure was accomplished by inserting a speaker at one end of the impedance tube and the composite material specimen at the other end of the tube. The loudspeaker produces sound that travels through the tube and is reflected by the material, resulting in a standing wave interference pattern. The sound coefficient of the material was determined using the equipment' measurements.

Figure 2: Impedance tube

3. Results and Discussion

The results and data from the previous experiment and testing process were evaluated and discussed. The data gathered during the testing procedure provides the basis for additional analysis and explanation. The acoustic characteristics of the coconut husk and pineapple leaf specimens and the two design panels for this experience were also analysed.

3.1. Sound Absorption Coefficient for Different Designs

Based on the ASTM E1050-98 standard, the results of the sound absorption coefficient were obtained from the impedance tube. However, the deployment of an absorber at 5000 Hz was the main focus of this study. For the testing process, a total of 18 sets of specimens were analysed. Each set of specimens was created into three samples in order to achieve an average and produce accurate results.

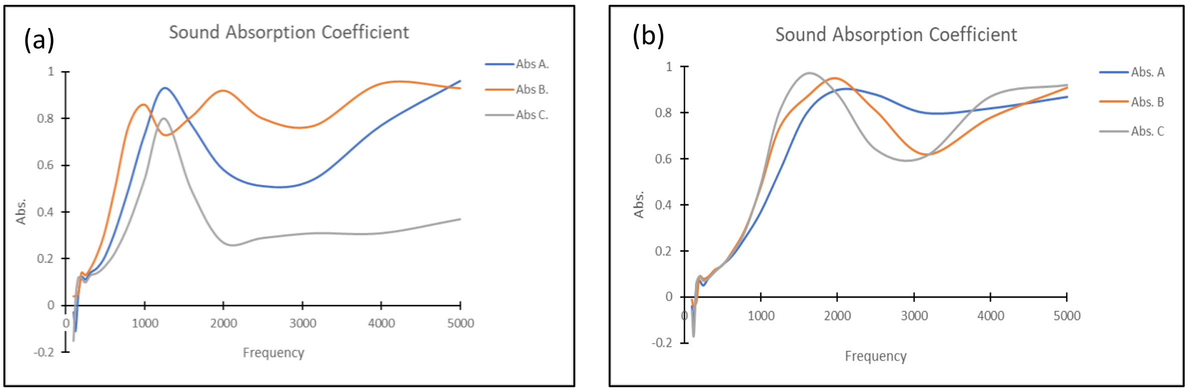

Figure 3: (a) Plain design (b) Design with holes

Figure 3(a) shows the sound absorption coefficient of composite with plain design. The absolute A, B and C represent the parameter mentioned in Table 1. For parameter A, it can be seen that the sound absorption coefficient is the highest at frequency 1250 Hz with 0.93 coefficient. However the sound absorption coefficient falls down steeply until 3150 Hz and it increase slightly. While for parameter B, the highest sound absorption coefficient is achieved at 4000 Hz. For parameter C, it can be seen that it has the highest sound absorption coefficient is at 1250 Hz. Then the reading drops sharply until 2000 Hz whereby the reading starts to constant. Nevertheless, parameter C has the lowest sound absorption coefficient as compared to the other parameters whereas parameter B has the better sound absorption coefficient.

Figure 3(b) demonstrates the absorption coefficient of the composite design with holes. For parameter A, it can be seen that the sound absorption coefficient is the highest at frequency 2000 Hz with 0.95 coefficient. However, the reading slightly drop a little bit at frequency 3150 Hz then constant increase until 5000 Hz. For the parameter B, the highest sound absorption coefficient is at frequency 2000 Hz which is 0.95 coefficient. Nevertheless, the graph undergoes huge drop at frequency 3250 Hz and then start increasing considerably. Next, for parameter C, the highest sound absorption coefficient is 0.97 at frequency 1600 Hz. The graph drops dramatically until 3150 Hz and then the graph starts to increase.

Table 2: Highest Sound Absorption Coefficient

Design	Sound Absorption Coefficient		
	Parameter A	Parameter B	Parameter C
Hole	0.92	0.88	0.90
Plain	0.91	0.91	0.81

From the data tabulated in Table 2, it can be seen that the highest sound absorption coefficient is obtained by the design with hole for Parameter A. This is because, the most affordable option to get an acoustic treatment with a high level of absorption is with perforated panels. Different amounts of absorption and aesthetically pleasing outcomes can be obtained by experimenting with different patterns and hole widths. A specific number of holes have been punched into the panel to allow sound to effectively pass through and into the backing material. The sound is then absorbed or dispersed from there. This technique enables a space to absorb the noise from entering the room in which it is installed. In addition, Berardi and Innace [9] in their studies describes the absorption peak shifts to a lower frequency as the natural fibre's thickness rises. However, the testing results show some disagreement with reference to the sound absorption peak since it shifts to a higher frequency as the thickness increases.

Parameter A with pineapple fibre content 30% and coconut fibre 20% shows the highest sound absorption coefficient. The result can be in line with one article by Rusli et al [10]. The authors have investigated on the sound absorption coefficient of three natural materials which are coconut coir, oil palm leaf and pineapple leaf, with different densities. It has been demonstrated that among the several types of fibre, pineapple leaf has the best ability to absorb sound. This fibrous material's ability to absorb sound energy is significantly influenced by the smaller and more uniform fibre diameter as compared to coconut coir.

It is also demonstrated that the pineapple leaf fibre contributes to a larger sound absorption coefficient when the volume is higher, which improves sound absorption at higher frequencies. The reason is pineapple fibre has a smaller and more uniform fibre diameter which plays a key role in absorbing sound energy as compared to coconut fibre. A study conducted by Putra et al [11] has noted the average sound absorption coefficient of the pineapple leaf above 2000 Hz is 0.9 when the thickness is 20mm. Another study by Bhingare and Rakash [12] also supported that the sound absorption coefficient of coconut fibre at 21mm thickness is 0.74, which is lower than the pineapple leaf fibre. This shows that the pineapple leaf fibre has a better sound absorption coefficient as compared to coconut fibre.

4. Conclusion

This paper has done an experiment on the sound absorption coefficient of the panel made of coconut husk and pineapple leaf with different designs. The findings of the impedance tube test for the sound absorption coefficient were successfully obtained. The composite panel with greater amount of pineapple leaf fibres are superior to the other composition. The panel with design holes has a higher sound absorption compared to a plain design panel. This is because as the sound goes through the holes of the panel, the reflection of the sound wave becomes minimal.

Acknowledgement

The authors would like to thank to the Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia and all the staff for their support.

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