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Comparison of Natural Fibers as Acoustic Panels

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Abstract: Global demand for acoustic panels has increased due to its increasing as a medium to control noise in the industry especially in improving the quality of acoustics in buildings. Therefore, this study was conducted to study the composite characteristics of acoustic panels reinforced using natural fibers. In addition, the properties of natural fibers will be studied in the effectiveness of the panel on its acoustic properties that is the coefficient of sound absorption in the building will be tested in this study. Next, this study was conducted to find alternative materials from natural materials that are 'green' to the environment and also sustainable for future generations. The objective of this study is to identify previous sound absorption coefficient study methods that study natural fiber-based acoustic panels and review on sound absorption coefficient data based on different thickness and density for each study method. The important things to have such as the collection of article material and the material studied. Pineapple leaf fiber and hemp fiber show relatively stable and high sound absorption not only in the frequency range of 500-2048 Hz but also in the high frequency range. In addition, density and thickness are very important for practical applications, as light and small-sized sound absorbers can be used more widely. Therefore, it can be concluded that pineapple leaf fiber and hemp fiber can be an ideal alternative as acoustic panels.

Keywords: Natural Fiber, Acoustic Panel, Sound Absorption Coefficient

1. Introduction

Synthetic fibers such as stone wool and glass wool are practically used as sound absorbers in industrial buildings. It is used for many applications in the building and construction industry such as partition boards, floors, wall tiles and roofs [1]. However, it is found that the negative effect of synthetic fiber on the environment is very high so acoustic materials and natural fibers are also sustainable now increasing in popularity [2]. For this reason, natural fibers including those derived from agro, crop and industrial waste are selected. Natural fibers such as fiber, pineapple, sugarcane, jute, ramie, kapok, rattan etc. are being studied carefully.

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Acoustic absorption panels can be used to prevent echoes and to reduce the intensity of sound outside the room. Acoustic absorption panels are usually filled with a porous layer of material capable of controlling echoes and background noise [3]. The sound energy of the event turns to heat and vibration of the fiber, and eventually disappears [4]. Acoustic absorption panels are placed on the ceiling and walls for repair speech comprehension in the room. This study was conducted to help reduce the problems faced by the construction industry in Malaysia involving the performance of acoustic panels.

Acoustic absorption panel is placed on ceilings and walls to improve the comprehensibility of speech in the room. Commercial acoustic panels are made from synthetic fibers that may be hazardous to health and environment. Current trend is to replace them with natural fibers that are cheap, environmental friendly and free of risks. Nowadays, the concept of green technology has been incorporated in many fields in the industry. Companies are constantly researching for alternatives to further improve their choice of materials that are more environmentally friendly.

This study was conducted to help reduce the problems faced by the construction industry in Malaysia involving the performance of acoustic panels. It is hoped that the results of this study show good acoustic properties for panels that will increase the sustainability of buildings in helping in terms of energy saving in Malaysia. This product also has the high potential to be an alternative substitute for natural-based commercial products. This is because by introducing ceiling panel boards made from recycled waste materials and natural fibers, it is an environmentally friendly product that will help preserve the environment. In this research, the acoustic panel from natural fiber were used to against the problems. The objectives of this study are:

- Identify previous sound absorption coefficient study methods that study natural fiber-based acoustic panels
- Review on sound absorption coefficient data based on different thickness and density for each study method.

2. Materials and Methods

This chapter provides an overview of the characteristics of natural fibers used as a study in this analysis.

2.1 Types of Acoustic Materials

Among the physical characteristics of acoustic panel materials are density, water absorption panel and hollow surface.

2.1.1 Hollow Materials

This hollow material will change energy, from sound energy to vibration energy, heat or momentum changes. The absorption power or damping type of material is a function of frequency. Absorption is low at low frequencies and the thickness of the material increases. Low frequency absorption can be increased with a layer of material so that it increases the thickness [5].

2.1.2 Water Absorption Panel

The higher the water absorption rate of natural fibers, the higher the mechanical and physical properties of the composite that can be affected and it will result in a weak bond between the fiber and the matrix [6]. Water absorption is an important aspect that should be taken into account for natural fiber materials used in various industries with different local conditions. Some factors that influence the percentage (%) of water absorption such as the surface of the fiber and its matrix size, the condition of the hollow fiber and the bond structure between the fibers.

2.1.3 Density

The density of a material is often considered one of the important factors in the sound absorption of a material. Materials with different densities will have different sound absorption properties. A study by reported that the density of porous materials greatly affects the sound coefficient of absorption of acoustic materials [7].

2.2 Method

In order to obtain data in this scientific study, there are two important things that need to be there such as the collection of article material and the material studied.

2.2.1 Collection of Article Material

To complete this research, there are two materials that have been collected to complete this study. Among the article materials used are journals and theses.

2.2.2 Materials studied

Through the objectives and scope of the study that has been made, there are three materials to be studied such as natural fibers, sound absorption coefficients and even acoustic panels.

2.3. Equations

2.3.1 Density Equation

Density is the weight of an object per unit volume. However, this quantity is better known as a specific weight. Different materials have different densities. Therefore, density is an important concept in buoyancy, authenticity and packaging. Osmium and iridium are the densest masses according to standard temperature and pressure while both use densely matter materials.

$$\text{Density (Kg/m}^3\text{)} = \frac{mass\ (g)}{Volume\ (cm3)} \qquad \textit{Eq.1}$$

2.3.2 Rate absorption of water

According to the British Standard BS EN ISO 62: 1999 (Determination of water absorption) procedure for air absorption testing, all samples will initially be dried in an oven at 60˚c for 24 hours and then left to cool at room temperature before weighing the sample to approximately 0.1 mg. Once the sample is soaked in air for 12 hours, the weight of the sample is measured where it is the average period the sample will form.

$$\text{Wa (\%)} = \frac{wt-wo}{wo}\, x\ 100 \qquad \textit{Eq. 2}$$

Wt = Wet weight

Wo = Dry weight

3. Results and Discussion

In this chapter discusses the results of each experiment and data collected by conducting research from two sources, namely journals and theses on the comparison of natural fibers as acoustic panels are discussed. All the results of the analysis of this previous study on the discovery of natural fibers have been scheduled and explained briefly using the line graph process.

3.1 Sound Absorption Coefficient

Figure 1 shows a graph of the sound absorption coefficient for ten different types of natural fiber materials. Among them are kenaf fiber mixed with wood glue, sisal fiber mixed with wood glue, coconut husk mixed with wood glue, sugarcane mixed with wood glue, coir fiber, coarse wool mixed with binder fiber, pineapple leaf fiber, rice husk mixed resin and also hemp fiber.

Table 1: Sound Absorption Coefficient for Natural Fiber by Tube Impedans Method

Materials	Production Methoc	Sound Absorption Coefficient (SAC)	Frequency (Hz)
Kenaf fiber + PVA	Glued together unde pressure	0.04-0.81	63-6300
Yucca Gloriosa fiber	Glued together unde pressure	0.035-0.79	63-6300
Sisal fiber + PVA	Glued together under pressure	0.08-0.81	172-2000
	Glued together under pressure		
	Glued together		
Coconut husk + PVA	Glued together under pressure	0.07-0.82	172-2000
Sugar cane + PVA		0.09-0.91	172-2000
Coir fiber		0.03-0.845	63-6300
Coarse wool + Binding fib	Laminated by heat pressing	0.3-0.81	60-6300
Pineapple-leaf fiber		0.42-0.76	500-4500
Rice husk + glue	Glued together under pressure	0.22-0.35	200-6400
Hemp fiber		0.85-0.81	1000-4500
	Glued together		
	Thermal bonded		

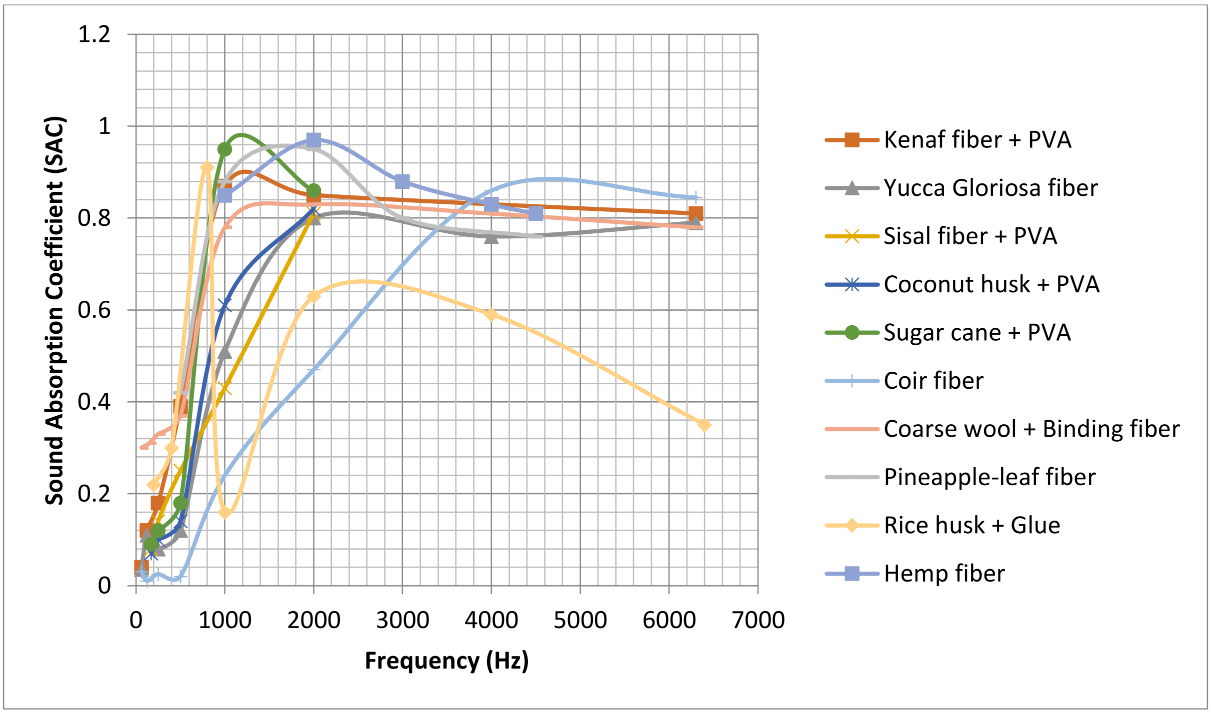

Figure 1: Graph of Sound Absorption Coefficient Versus Frequency

The absorption coefficient extracted from the fiber absorber begins in Figure 1. For a clear comparison between the absorbers, the sound absorption curve in the graph. Audio frequency is approximately in the frequency range of 20 Hz - 20 kHz. The most sensitive frequency ranges for the human auditory system are between 500 and 4000 Hz [8]. Meanwhile, the most important frequencies for listening and understanding communication are between 500 and 2048 Hz [9]. This frequency range has been highlighted in the graph. The peak sound absorption of some materials is close to 1, but the peak is not located in the range of 500 - 2048 Hz, such as Yucca Gloriosa fiber for sound absorption coefficient is 0.75 at 2000 Hz, for coir fiber has been show that 0.50 for sound absorption coefficient at at 2000 Hz also for coarse fibers shows that 0.65 at 2000 Hz.

Kenaf fiber, sugarcane fiber, hemp fiber and pineapple leaf fiber show good sound absorption in the frequency of 500 - 2048 Hz, while glass fiber does not show good sound absorption performance at this frequency range. From the graph, kenaf fiber shows that 0.85 at 2000 Hz while sound absorption coefficient for sugarcane fiber is 0.86 at 2000 Hz, 0.97 at 2000 Hz and 0.95 at 2000 Hz for hemp fiber and pineapple leaf fiber respectively. However, Yucca Gloriosa fiber, sisal fiber and coconut husk do not show absorption performance comparable to kenaf fiber. Due to the loose fiber structure, coir fibers show worse sound absorption compared to thinner absorbers. Moreover, most natural absorbers show better sound absorption.

3.2 Density

Figure 2 shows the result readings for total density (kg / m^3), for eleven types of materials. Among the materials are coir fiber, coarse wool mixed with binder fiber, pineapple leaf fiber, rice husk mixed with resin and hemp fiber.

Table 2: Density for natural fiber

Materials	Density (Kg/m^3)
Kenaf fiber	200
Coir fiber	130
Coarse wool + Binding fiber	249.54
Pineapple-leaf fiber	117
Rice husk + glue	170
Hemp fiber	141

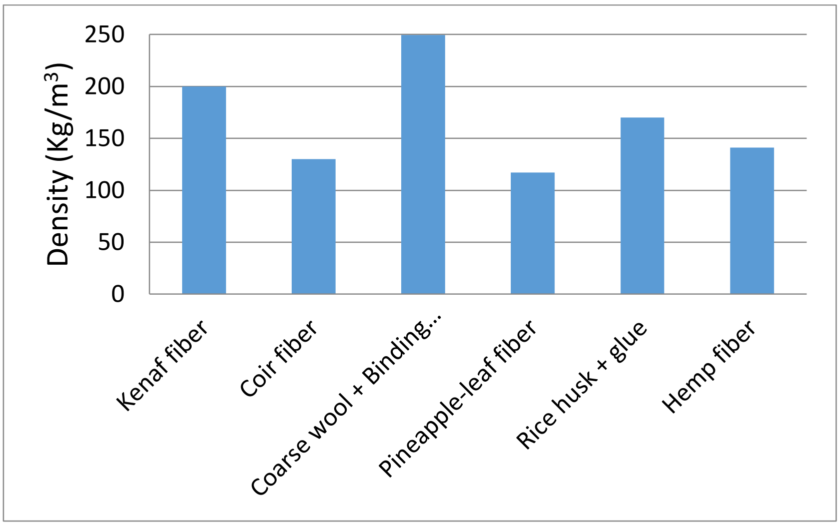

Figure 2: Graph of Density for Natural Fiber

The graph shown an increase in density values of 117 kg/m^3, 130 kg/m^3, 141 kg/m^3, 170 kg/m^3 and 200 kg/m^3 from the lowest to highest density for pineapple leaf fiber, coir fiber, hemp fiber, rice husk and coarse wool mixed with binder fiber respectively. Coarse wool mixed with natural fibers has a greater effect on the density value where the percentage of filler loading compared to the binder glue increases [10].

3.3 Thickness

Figure 3 shows the thickness results for the eleven types of natural materials studied in this study. Among them are fiberglass, kenaf fiber mixed with wood glue, sisal fiber mixed with wood glue, coconut husk mixed with wood glue, sugarcane mixed with wood glue, coir fiber, coarse wool mixed with binder fiber, pineapple leaf fiber, rice husk mixed resin and also hemp fiber.

Table 3: Thickness of Natural Fiber

Materials	Thickness (mm)
Glass fiber	25.4
Kenaf fiber + PVA	30
Sisal fiber + PVA	30
Coconut husk + PVA	30
Sugarcane + PVA	30
Coir fiber	25
Coarse wool + Binding fiber	24
Pineapple-leaf fiber	30
Rice husk + glue	15
Hemp fiber	25

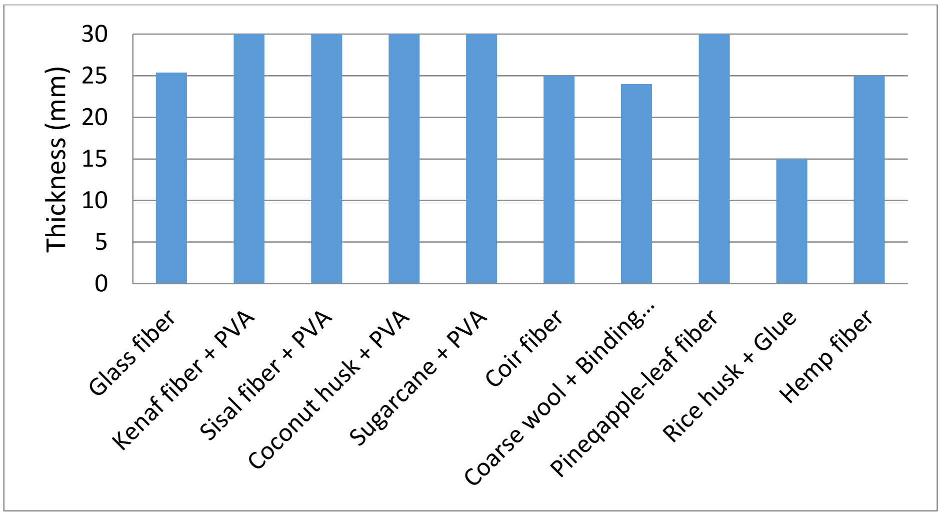

Figure 3: Graph of Thickness for Natural Fiber

The graph shows that kenaf fiber mixed with wood glue, sisal fiber mixed with wood glue, coconut husk mixed with wood glue, sugarcane mixed with wood glue has the same material thickness of 30 mm. Furthermore, for materials such as hemp fiber and coarse wool mixed with binder fibers as well as fiber and rubber fibers showed an increase in thickness of 24 mm, 25 mm and 25.4 mm respectively. Meanwhile, the remaining material is rice husk mixed with glue showing the smallest amount of thickness which is 15 mm.

4. Conclusion

The main objective of this study is achieved with previous studies that study natural fiber-based acoustic panels have been identified that the use of natural fibers as sound absorber can make a positive contribution to developing a competitive, resource-efficient and low carbon economy due to large advantages, such as simple availability , lightness, novelty, low CO^2 emissions, economic pricing and biodegradation. Therefore, we study different natural sound absorbers in the following categories, namely raw materials, fiber assembly and composite. It is found that various types of raw natural fibers, loose natural fiber installations as fillers, and natural fibers stacked with other materials can be used as sound absorbers. A number of natural materials show excellent sound absorption properties in the most sensitive frequency range of the human auditory system of 500 - 2048 Hz. It is concluded that pineapple leaf fiber and hemp fiber are ideal alternatives to conventional sound absorbers as panel acoustic. This is because pineapple leaf fiber shows that at frequency range of 500 Hz to 2048 Hz stated that at 0.95 for the sound absorption coefficient with density of 117 kg/m^3 and thickness 30 mm. The other fiber, hemp fiber also shows the good in sound absorption coefficient which is 0.97 at range 500 Hz to 2048 Hz. The density for hemp fiber is 141 kg/m^3 and thickness is 25 mm.

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