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Comparison of Sound Absorption Coefficient for Natural Fiber

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Abstract: The application of acoustic panels is one of the most important methods for sound insulation in buildings. Moreover, sound absorption materials for sound control are distinguished due to their high efficiency in sound absorption. Most materials are synthetic and cannot be disposed of as solid waste in nature or burned by industry, as they are highly polluting. The aims of this study to evaluate the sound absorption coefficient of four natural fibers: kenaf, chicken feather, coconut and sugarcane. Ten articles was reviewed focused on density, thickness (20, 30 and 40 mm) and Sound Absorption Coefficient (SAC) at low frequency (2000 Hz). The results for four natural fibers found that SAC of 0.90, 0.79, 0.66 and 0.59 at 2000Hz frequency. However, the increase in frequency rate of 250 Hz to 2000 Hz shows that kenaf fiber and coconut fiber alone are always increasing for the level of sound absorption. Meanwhile the density for three natural fibers increase namely kenaf fiber, chicken feathers and sugarcane with 837.5 kg/m^3, 790.0 kg/m^3 and 730.0 kg/m^3 at 40.0 % weight of natural materials proportion. Regarding the thickness of natural fibers that has been selected give an important role that sound absorption in porous materials has a direct relationship with thickness at low frequency by having a thickness of 10 mm to 40 mm for acoustic panels. In conclusion, kenaf fiber proved to have good sound absorption performance in normal and random occurrence sound absorption while applied for building materials.

Keywords: Natural Fiber, Acoustic Panel, Sound Absorption Coefficient, Density, Thickness

1. Introduction

Acoustic panels have been widely used in reducing noise pollution, it can reduce echo and background noise through absorption. The current study conducted is a bibliographic observation of the tendency that occurs in the expansion of acoustic absorption by natural fiber composites. Despite having adverse effects on the environment and overall availability, natural fibers are still not suitable for widespread implementation in industrial purposes (Tabrej Khan, 2018) [1]. There are shortcomings such as moisture content, thicker diameter and lower antifungal qualities prevent the advancement of

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natural fiber composites to continue to compete with synthetic composites. Reviews show the importance of the early manufacture of fresh natural fiber to overcome this shortcoming. However, pre-use of natural fibers results in the removal of moisture content resulting in a decrease in its acoustic absorption performance. The incorporation of granular materials into the treated fiber composites is expected to play an important role as a substitute for moisture content. This study aims to examine the acoustic absorption behavior of natural fiber composites due to the incorporation of granular materials from the studies that have been conducted. It is intended that this study will provide an overview of the analytical approach to the modeling of acoustic wave propagation through natural fiber composites. The influential factors of fiber and grains have been explained in this study for the increase in the acoustic absorption of low frequency composites (Hasina Mamtaz, 2016) [2].

Noise pollution is on the rise, especially in areas with high population density. Noise pollution from machines such as motorcycles and vehicles automatically makes people innovate in maintaining sustainability in their residential, recreational and even workplaces. The manufacture of acoustic panels according to the process produces acoustic panels that are very functional to reduce noise. The use of natural fiber to make acoustic panels, it can not only reduce noise pollution, but the product will be more environmentally friendly. At the same time, the acoustic panel will control the rate of food waste disposal. The main problem identified with natural fibers is the inconsistency between the hydrophilic natural fibers and the hydrophilic thermoplastic matrix during aggregation, leading to the undesirable properties of the composite. Therefore, it is necessary to overcome this problem with various modifications of the fiber-polymer interface to increase the 3 adhesions between the fibers and the matrix, resulting in improved performance producing composites. Considering the ecological aspects in material selection, replacing fiber synthetics with natural fibers is just the first step. Limiting the effects of greenhouse gas-induced greenhouse gas (CO_2) emissions into the atmosphere and growing awareness of the ever-evolving fossil energy sources for new materials based on renewable resources.

Natural fiber is an ingredient found in plants including leaves, stems and fruits in providing additional alternatives to replace the use of fiber from synthetic materials. Natural fiber has the advantage of controlling the release of greenhouse gases caused by some gases and makes a solution to control the environment. In today's modern world, the use of natural fibers in place of synthetic fibers has been widely used. Among the advantages of natural fiber are, renewable, cost saving, readily available, user-friendly, biodegradable materials and have continuity for future generations.

This review is done to identify previous researchers who studied of acoustic panels using natural fibers. It also to analyze panel sound absorption plan data at low frequency 2000 Hz. Lastly, to compare the acoustic value with the standard of absorption coefficient of the material studied.

2. Materials and Methods

The method used is a method of comparative study of sound absorption coefficient from natural fiber material on acoustic panels. The methodology of this study is the method and design, collect and analyze data in order to produce a comparison of sound absorption from various natural fibers effectively. Figure 1 illustrates the flow chart of an overview and clearer about the study conducted.

The research methodology describes the collection of data involving natural fiber material from journals and theses of previous studies. The focused method is a method of comparative study of sound absorption coefficient, density and thickness of natural fiber material on panel acoustics. Various journals and theses have been referred to involving natural fiber materials for panel acoustics as well as deciding for the study to select some natural fibers that have good sound absorption such as kenaf, coconut, sugarcane, hemp, oil palm, cork and chicken feathers. However, only four fibers have a sound absorption coefficient value of 0.59 to 0.90. In addition, data collection and analysis methods use Microsoft excel to create line graphs and bar charts.

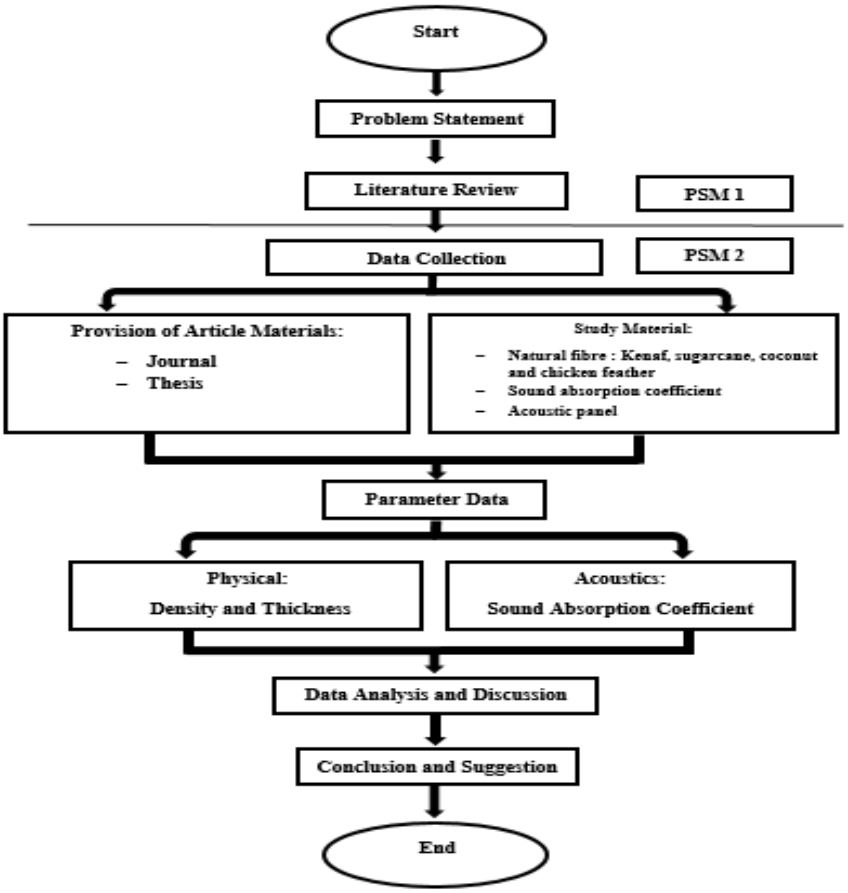

Figure 1: Chart of methodology

In this study, data collection, included test data and study results from previous research. With this research methodology, research can be completed further in a more structured study and follow the procedures that have been set in achieving objectives. Among the material of the article used are journals and thesis. Data analysis is the process for handle and provide statistical data for useful information. Data obtained from previous thesis studies and journals combined to identify natural fiber materials that have a coefficient rate excellent sound absorption. The data obtained will be analyzed using Microsoft Excel to facilitate more organized collection and calculation. Discussion of the data related to parameters that is comparison in terms of sound absorption coefficient, density and material thickness. Fiber is a material like unit yarn, or more precisely like filamentous continuous hair. These can be spun into stronger threads and ropes or can be made into other structures such as sheets or paper by dragging them together using different techniques. Natural fibers are taken from plants and animals, while synthetics are usually entirely or at least man-made. The use of natural fibers in the production of acoustic panels has been produced even at the research and development stage. However, the ability to use natural fibers in producing an acoustic panel is comparable to the use of synthetic fibers that are mostly used in the market (Layth Mohammed, 2015) [3].

3. Results and Discussion

The results show the values of sound absorption coefficients, density and thickness of the natural fibers of the fiber material in the acoustic panel. The data values of sound absorption coefficients are summarized in the form of tables to make it easier to determine the best material in the production of acoustic panels at low frequencies below 2000 Hz. In addition, the values of density and the value of natural fiber thickness to determine side effects on acoustic panels were also analyzed and studied. Relating the sound absorption coefficient to density, density with the weight of natural fibers and the

thickness of natural fiber material will also be discussed. Table 1 shows the value of the sound absorption coefficient as well as the density of the selected natural fiber material.

Table 1: Summary of sound absorption coefficient and density

Natural fiber	Frequency (Hz)				Density (kg/m^3)			
	250	500	1000	2000	0	20	30	40
Kenaf	0.19	0.33	0.68	0.90	304.5	613.2	716.1	837.5
Chicken Feather	0.06	0.19	0.55	0.59	360	360	680	790
Coconut	0.20	0.34	0.67	0.79	270.81	234.04	224.3	219.9
Sugarcane	0.15	0.46	0.39	0.66	290	350	598	730

Natural fiber is an ingredient found in plants including leaves, stems and fruits in providing additional alternatives to replace the use of fiber from synthetic materials. Natural fiber has the advantage of controlling the release of greenhouse gases caused by some gases and makes a solution to control the environment. In today's modern world, the use of natural fibers in place of synthetic fibers has been widely used. Among the advantages of natural fiber are, renewable, cost saving, readily available, user friendly, biodegrading materials and have continuity for future generations. Among the natural fibers in the study are coconut fiber, sugarcane fiber, chicken feather fiber and kenaf fiber. In addition, study data related to fiber porosity, density and sound absorption coefficients are also discussed. The methods in producing panel acoustics from various types of natural fibers are almost the same, i.e. using the heat compression method.

3.1 Sound Absorption Coefficient

Sound absorption is the ability of a substance to convert sound energy into other energy. Absorbent materials also help reduce reflected sound resistance. Reduction of noise resistance occurs by eliminating the amplitude of the reflected wave and preventing sound from forming in enclosed spaces. Generally, absorbent materials are reactive and resistive, i.e. fibrous or porous. The absorption power of sound is influenced by the diameter of the fiber, the thickness and density of a fiber.

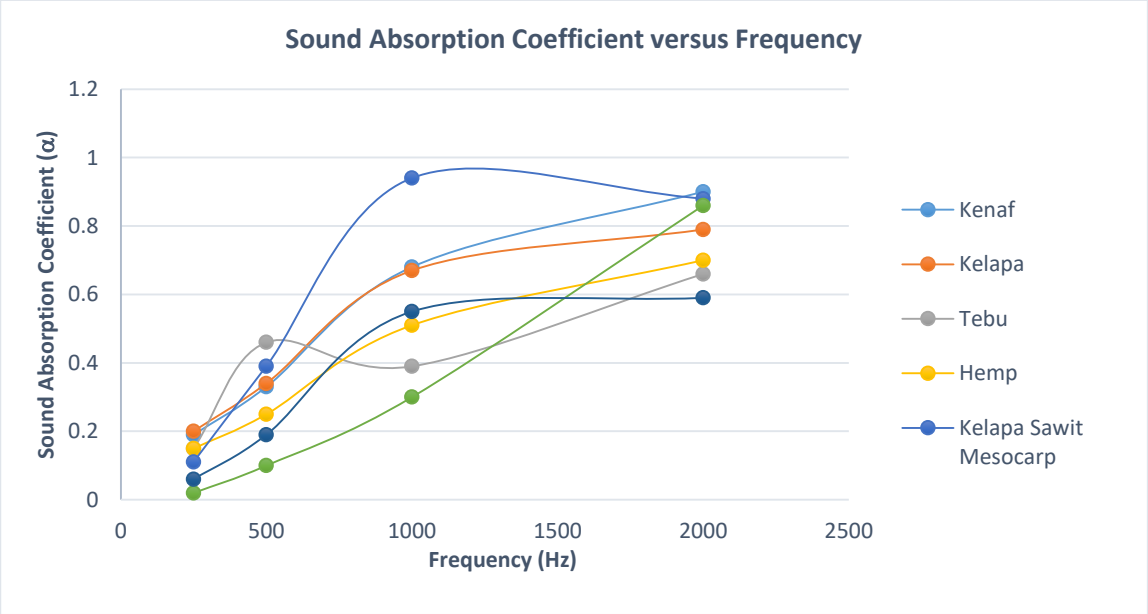

Figure 2: Natural fiber result on sound absorption coefficient at low frequency

Figure 2 shows more clearly through a line chart of the various types of natural fibers that have been set and collected. At a frequency of 25 0Hz coconut fiber has a high absorption coefficient of 0.20 compared to the lowest cork fiber is 0.02. Frequency of 500 Hz sugarcane fiber is in a high position for a sound absorption coefficient of 0.46. In addition, at a frequency of 1000 Hz mesocarp palm fiber soared higher than other fibers with a sound absorption coefficient of 0.94. Therefore, at low frequencies there is a natural fiber that grows with different frequency of 250 Hz to 2000 Hz consisting of kenaf fiber, coconut fiber, hemp fiber and cork fiber. The highest level of the sound absorption coefficient at low frequency is kenaf fiber which is 0.90 at 2000 Hz. This process provides a comprehensive understanding of the available natural fiber capabilities allowing us to select the best natural fiber acoustic panels to produce the best level of sound absorption. Therefore, sound absorbing materials that are more efficient and capable of absorbing sound in a wider frequency are desired (Jayamani and Hamdan 2013) [4]

3.2 Density

Density is the physical property required for the creation of an acoustic panel. Density values are seen to vary according to the type of acoustic fiber. There are four types of natural fibers that will be discussed, namely kenaf fiber, wool, coconut and sugarcane. The density of the material plays an important role in the absorption of sound from various types of natural fiber materials. Materials with high density having a larger surface are effective in absorbing sound associated with fibers containing porous material. Materials that have a less dense fiber size density cause the fiber to move more easily between its manufacture as well as higher airflow resistance will occur (M. N. A. A. Nordin, 2016) [5].

Density in this study is to analyze the density of acoustic panel boards from natural fiber materials consisting of kenaf fiber, chicken feathers, coconut and sugarcane. Density give an important role in sound absorption. The higher the frequency value, the higher the sample density value. For the weight of the material is focused on the percentage of material used on the acoustic panel that has been analyzed. It shows the percentage weight of the material weight from 0 to 40 percent used in sound absorption testing for panel acoustics.

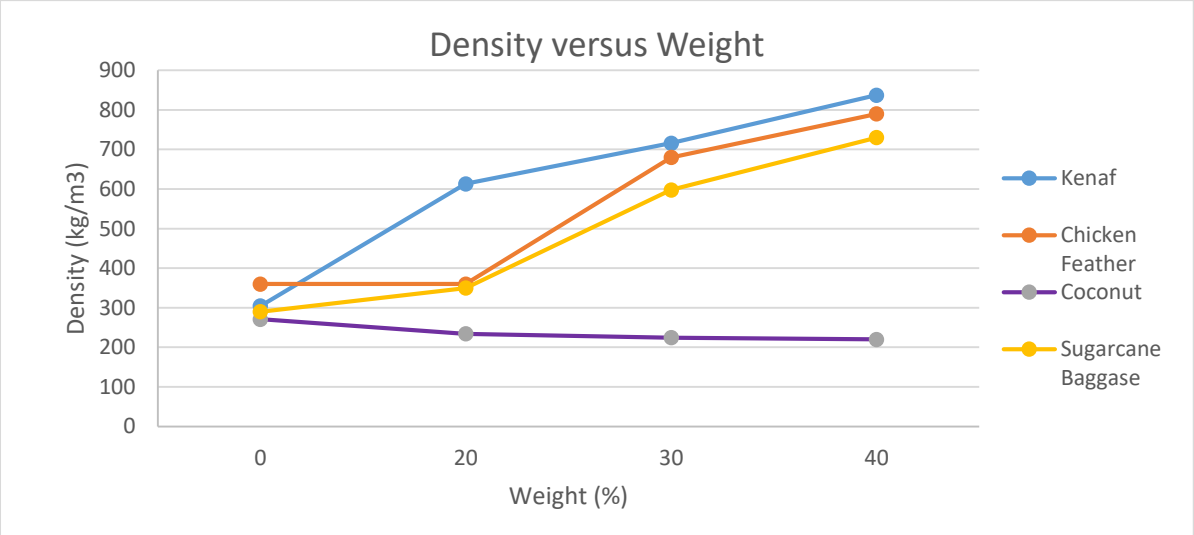

Figure 4: Density against weight percentage of natural fiber material

Figure 4 shows density against weight percentage of kenaf, chicken feather, coconut and sugarcane fibers. There is an increase in the density of natural fibers in the weight percentage of 30 percent. Kenaf fiber shows a significant increase in density and is constantly increasing based on Figure 4 according to the weight weights of 0, 20, 30 and 40 (Z. Y. Lim, 2018) [6]. Sugarcane and chicken feather also increased by 30.0 % by 598.0 kg/m^3 and 680.0 kg/m^3 (Ulhas Arun Malawade, 2020) [7]. Kenaf fiber

and sugarcane waste fiber show an increasing percentage of material consumption density compared to coconut fiber. Weight percentage rates of 0, 20, 30 and 40 percent of the material used on kenaf fiber obtained 304.5 kg/m^3, 613.2 kg/m^3, 716.1 kg/m^3 and 837.5 kg/m^3. Meanwhile, sugarcane waste fiber also obtained 290.0 kg/m^3, 350.0 kg/m^3, 598.0 kg/m^3 and 730.0 kg/m^3 at the set percentage rate. Meanwhile, for chicken feathers showed a constant density rate of 0.0 % and 20.0 % which is 360 kg/m^3 and increased at a percentage of 30.0 % and 40.0 % by obtaining densities of 680 kg/m^3 and 790 kg/m^3 (Ansarullah, 2020) [8].

3.3 Thickness

Natural fiber panel samples with thicknesses ranging from 10 mm to 40 mm thick for acoustic measurements were discuss. Measurements of the noise reduction coefficient (NRC) of the sample fiber were made based on the average material sound absorption coefficient at 250 Hz, 500 Hz, 1000 Hz, and 2000 Hz frequencies. There are four natural fibers studied kenaf, chicken feathers, coconut and sugarcane. The efficiency of these fibers is assessed according to the sound absorption coefficient.

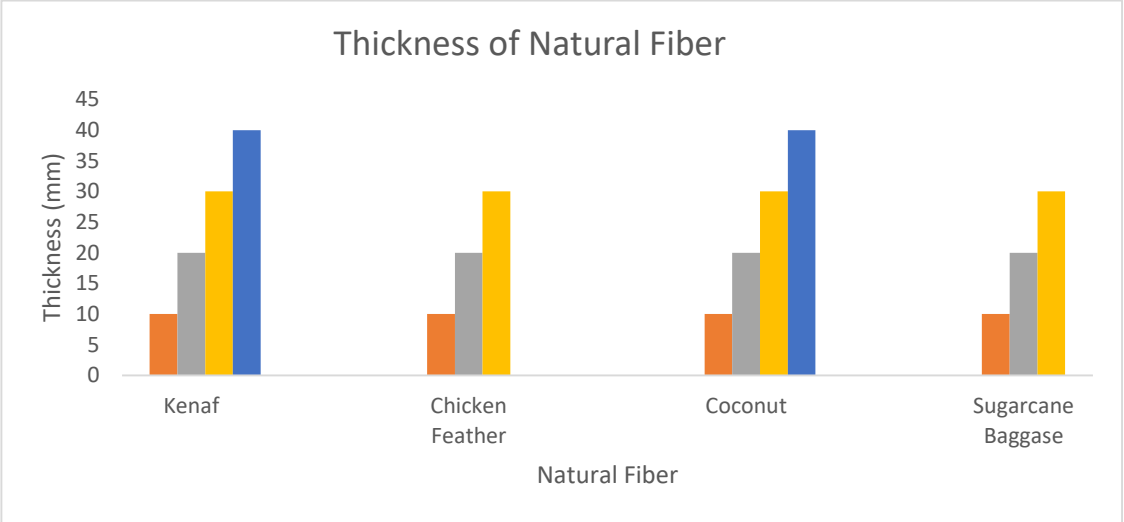

Figure 5: The average values of the samples were measured according to the thickness of the natural fibers with thicknesses of 10, 20, 30 and 40 mm

Figure 5 shows the chart produced to understand the comparison of the thickness of natural fibers between kenaf fiber, chicken feathers, coconut fiber and sugarcane bagasse. Methods of data collection taken based on ten previous studies as well as studies that have been selected to obtain data appropriate for the acoustic thickness of natural fiber panels. Various studies related to sound absorption in porous materials have concluded that low frequency sound absorption has a direct relationship with thickness.

The thickness shown in figure 5 is the thickness of the kenaf fiber which has a thickness from 10 mm to 40 mm as well as coconut fiber. In addition, kenaf fiber has a high sound absorption coefficient of 0.90 compared to 0.79 coconut fiber at low frequency. However, kenaf and coconut fibers show increased sound absorption at different thicknesses. After that, the chicken feathers and sugarcane bagasse have the same sample thickness and use of polyvinyl acetate (PVAc) binder, but the level of sound absorption coefficient is different at 0.59 for chicken feathers and 0.66 for sugarcane bagasse.

4. Conclusion

The study is about to choose the best material to produce acoustic panel by using natural fibers. The best materials are kenaf fiber which is achieved 0.90 in sound absorption coefficient. Then, there are parameters that affect the values of the sound absorption panel i.e. density and thickness. There are seven types of natural fibers studied to identify the level of sound absorption coefficient for low frequency which is 2000 Hz. However, only four of the seven natural fiber materials are best selected

because the absorption level of the sound absorption coefficient is high such as kenaf fiber, chicken feathers, coconut and sugarcane. In conclusion, the best fiber is kenaf fiber which has a sound absorption coefficient of 0.90 at a frequency of 2000 Hz. Kenaf fiber has a high sound absorption and has a high thickness of 40 mm.

Acknowledgement

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