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# A Study of Sugarcane Bagasse and Wood Dust as Acoustic Panel in Building

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**Abstract**: Sugarcane bagasse and wood dust are a positive front on natural fibre-sound insulation panels study. Into the matrix, wood dust is added to protect the pores. This work involves identifying the sugarcane bagasse to absorb sound, assess and obtain sound absorption data from sugarcane bagasse and wood dust. This acoustic panel also uses natural binder that is starch flour to bind both materials and will result in a discovery of natural acoustic panels. Study technique for the preparing and production of the acoustic panel includes frame planning, sugarcane bagasse fibre, wood dust and sound analysis. The samples are divided into three, with separate sugarcane bagasse, wood dust, and binder ratios. Each of the material must be combined by hand with determining weight-based proportions. The mixture is then set in a mould and ready to print. It must press with the hot press with 150 °C in 6 minutes with pressure 1.0 tonne. After that, let it cool in 1 hour. Testing involves 3 types. The panel were testing physically, thermal conductivity and acoustical.

**Keywords**: Natural Fibre-Sound Insulation, Natural Binder, Sound Absorption

## 1. Introduction

The UNSD Glossary of Environment Statistics defines waste as items that are not prime goods for which the manufacturer has no other use in terms of its output, manufacturing or consumption purposes and which it wants to dispose of [1]. There are several forms of waste, such as industrial waste, urban waste, toxic waste, biomedical waste, nuclear waste, dangerous waste, and electronic waste (e-waste) included. Agricultural waste from agro-based industries, such as palm oil, rubber, and wood processing factories. The waste can provide beneficial use by performing all of these functions, including recycling reusable waste products and reintroducing non-reusable waste products into the environment [2]. Nowadays, in the acoustic panel, many organizations or companies are using the fibre from the plant.

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Noise a largely subjective evaluation of sound is related to auditory perception and can significantly affect human health and well-being. Without proper care, agricultural waste will pose many problems, and the survival of associated businesses and communities would be adversely affected. In this research, the acoustic panel from natural materials were used to against the problems. The objectives of this study are:

- To identify the optimum ratio of sugarcane bagasse, wood dust and starch glue used in forming acoustic panel
- To determine the physical properties, thermal conductivity and the sound absorption of the panel
- To design a prototype of a green acoustic panel by using sugarcane bagasse and wood dust reinforced with starch glue.

## 2. Materials and Methods

### 2.1 Provision of the materials

#### 2.1.1 Sugarcane bagasse

Sugarcane bagasse are taken after extraction of the sugar-bearing juice from sugarcane. Sugarcane bagasse is rinsing one day and then clean it to remove the sweet taste from the bagasse. Used stringed brush to remove any dirt. Then dried up in 7 days. The next process is was put in the fibre extruder to get fibre and then cut between 2 mm until 5 mm.

**Figure 1: Sugarcane bagasse that dried in 7 days**

#### 2.1.2 Wood dust

Wood dust was naturally taken from wood lab in UTHM Pagoh Campus. After the wood dust was taken, it must sieve with 0.02 cm sieve to take the size that are suitable for making acoustic panel.

**Figure 2: Wood dust in sieve process**

#### 2.1.3 Binder

After the main material are provided, the binder was used to combine the material which are sugarcane bagasse and wood dust. Therefore, the binder type is natural which glue starch to make this acoustic panel. The binder was used 10 g of cornstarch powder added with 500 ml of water. Then mixed them together and heated them until becomes clear.

**Figure 3: Corn starch and tap water were heated until becomes clear**

### 2.2 The formation of the panel

The mould using by steel was having measurement with 0.3 m width, 0.3 m length and 0.005 m height are used in the making the acoustic panel. The ratio was used to determine the amount of ideal for the materials. The selected ratios were used from predetermined ratio. The selected ratios:

- 50.0 % sugarcane bagasse fibre : 20.0 % wood dust : 30.0 % binder
- 40.0 % sugarcane bagasse fibre : 30.0 % wood dust : 30.0 % binder
- 30.0 % sugarcane bagasse fibre : 40.0 % wood dust : 30.0 % binder

All materials were having hot compressed with 150 °C in 6 minutes with pressure 1 tonne. After that, let it cool in 1 hours.

### 2.3 Testing

#### 2.3.1 Density testing

Density is the mass divided with volume. To determine the density of the product, the formula is

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

2.3.2 Rate absorption of water

This testing was measured by using a standard that had been set which Malaysian Standard (MS 147:2001). In order to remove all moisture content in the samples, all samples were dried for 24 hours at 100 ˚C prior to the testing. Every specimen was cooled and weighted when removed from the oven to achieved the initial weight, W1. The specimen was then completely immersed in distilled water for up to 1 hours and 30 minutes, then the sample was removed from water and dried with a cloth as quickly as possible until all free air was drained from the surface. Once again, each sample was weighed and the final weight was recorded. The water absorption of the acoustic panel was calculated by using:

$$\text{Percentage of absorption water (\%)} = (Wet\ weight - Dry\ weight) / \text{Wet Weight x 100} \qquad Eq.\ 2$$

2.3.3 Thermal conductivity

Thermal conductivity was running to determine whether the pane; was suitable used as heat insulator. This testing was used Thermal Conductivity of Building Material (Solteq: 110). Thermal conductivity can be determined by using this formula:

$$K = Qd / A\Delta T \qquad Eq.3$$

Where:

K = Thermal condition

Q = The amount of heat transfer through the material

d = The thickness of the panel

A = Area of the panel

$\Delta T$ = Difference temperature between the panel

2.3.4 Acoustic testing

This testing was carried out by following the international standard, which is ASTM E 1050-98. Sample testing had a diameter 100 mm for low frequency and 28 mm for high frequency. Impedance Tube (AED 1000-Acoustic Tube) was used.

## 3. Results and Discussions

3.1 Density

Three samples with different densities had been prepared to study the relationship between density and thermal conductivity. All three samples were weighed on a digital balance with the precision of 0.01 g and the results had been analysed in graph form in Figure 1:

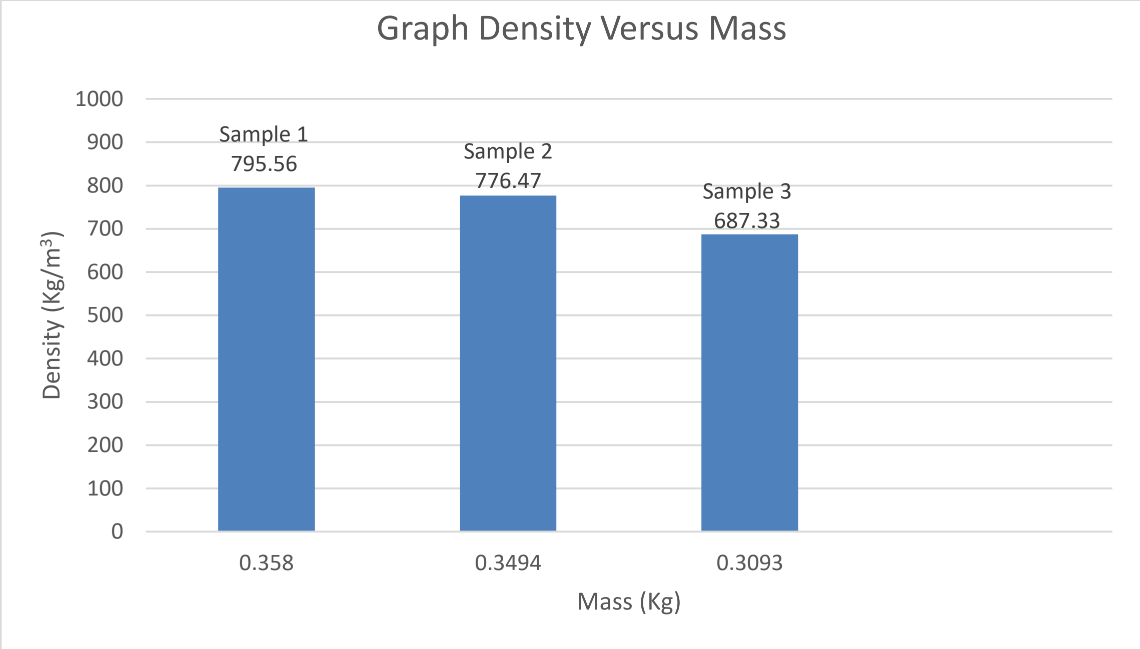


**Figure 4: Graph Density Versus Mass**

The graph from Figure 4 shows the mass of sample decrease, and the density also decreases. This means that density is directly proportional to mass. The samples' mass of fibres and binder were weighed by using a weighing scale with precision 0.01 g. The highest density is 795.56 kg/m$^3$, and the lowest is 687.33 kg/m$^3$.

The nearest density from the past research with the result obtained was in the study of rice husk insulation boards' production. The panels were generally made with thickness 5 mm to 25 mm. Their densities ranged from 500 kg/m$^3$. Low-density boards possessed better thermal and acoustic insulation properties compared to medium density boards [3].

3.2 Thermal conductivity

Thermal conductivity was tested by Thermal Conductivity of Building Materials Apparatus (Model: HE110). The result for thermal conductivity as shown in Figure 5:

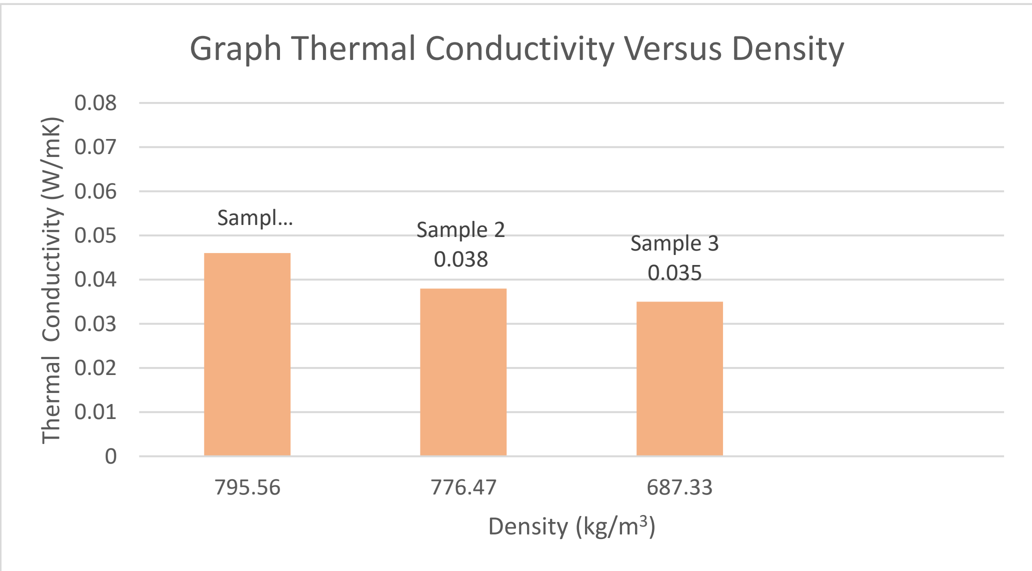


**Figure 5: Graph Thermal Conductivity Versus Density**

From Figure 5, thermal conductivity varies according to density. When the density is 795.56 kg/m$^3$, the thermal conductivity is 0.046 W/mK for Sample 1. Then, for Sample 2, when the density is 776.47 kg/m$^3$, the thermal conductivity is 0.038 W/mK. For Sample 3, the density is 687.33 kg/m$^3$ the thermal conductivity is 0.035 W/mK. The average thermal conductivity achieved is 0.040 W/mK.

Thermal conductivity is affected by air space sizes inside fibres. The sample with the highest density had the highest thermal conductivity due to too much sugarcane bagasse touching the surface of a hot plate, which means the air spaces are insufficient to transfer heat [4]. The sample with the lowest density had the lowest thermal conductivity because sugarcane bagasse and wood dust containing air spaces decreased, and the sample's air space sizes also reduced. The smaller the air space sizes, the lesser the effect of heat transfer by convection through the air in the sample [5].

### 3.3 Water absorption

All samples were weighing and immersed in distilled water up to one hour and thirty minutes because the samples could no longer retain their shapes after that.

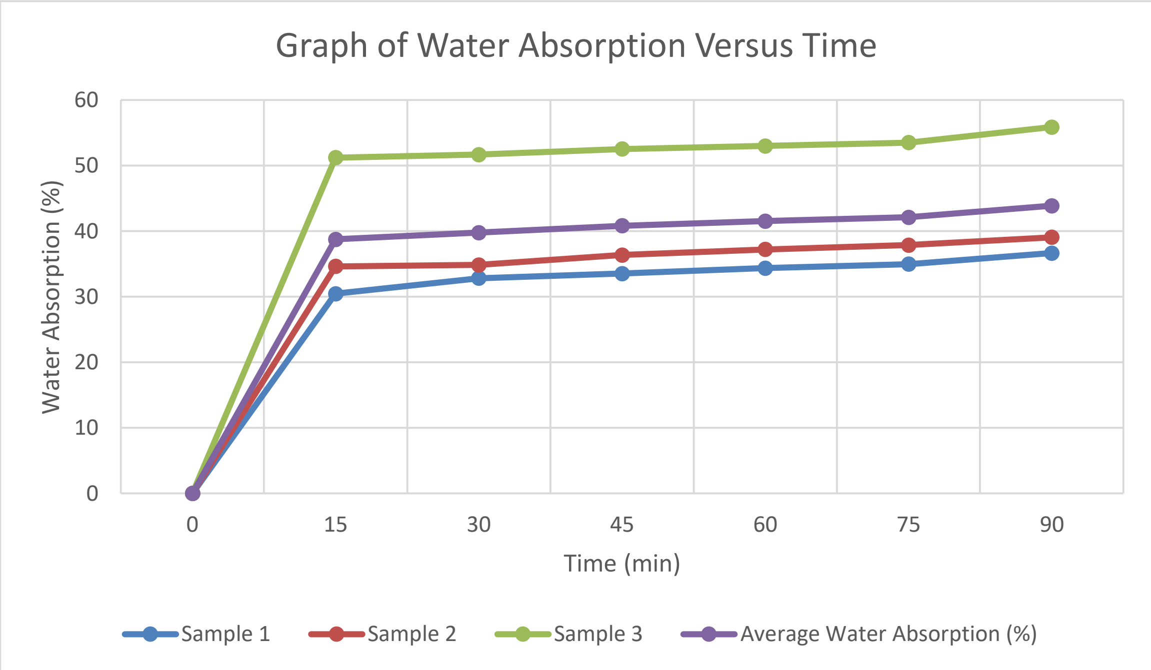


**Figure 6: Graph of Water Absorption Versus Time**

The figure showed the water absorption of sugarcane bagasse and wood dust acoustic panel that increase over time. For sample 1, the water absorption increases until 36.66 % at 90 minutes. While sample 2 increases until 39.08 % and sample 3 increases until 55.88 % at 90 minutes. The highest value of average water absorption for the three samples at 90 minutes is 43.87 %.

The increasing of the water absorption also due to the characteristic of starch glue. Starch films or layers are susceptible to moisture content, and hence at high humidity, starch films absorb water and become soft and flexible [6]. Therefore, it was easy for the water to penetrate the samples. High levels of water absorption in this study are due to the acoustic panel with porous and hygroscopic nature. Many modifications can be made to this acoustic panel to reduce the level of water absorption, such as make a treatment to the sugarcane bagasse and wood dust before the formation of the panel. This can also be avoided by increasing the samples’ density by sealing the edges of the samples and coating the sample with a water resistance substance.

3.4 Sound absorption

The testing was done using Impedance Tube. For low frequency, the frequency range used was from 0 Hz to 2000 Hz using three sample. The results are shown below:

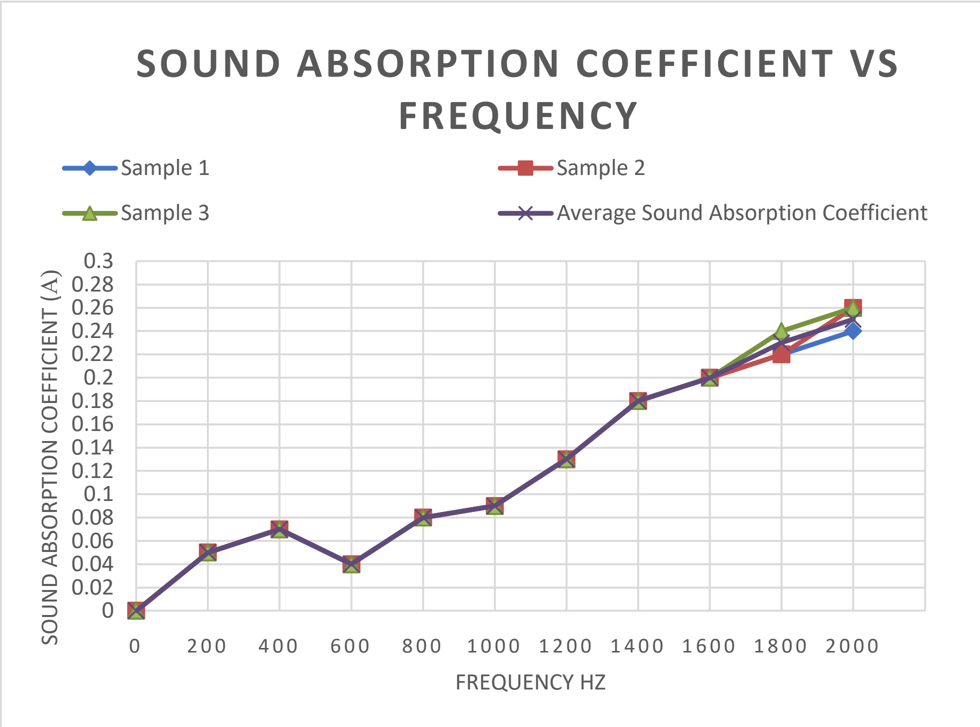


**Figure 7: Graph of Sound Absorption Coefficient of Low Frequency**

From Figure 7, all minimum sound absorption coefficient is 0.04 at frequency 600 Hz. For Sample 1, the maximum sound absorption coefficient is 0.24 while for Sample 2 and 3 had the same amount, 0.26 at frequency 2000 Hz. For high frequency, the range used was from 2001 Hz to 6300 Hz using three samples. The results collected were analysed in Figure 5:

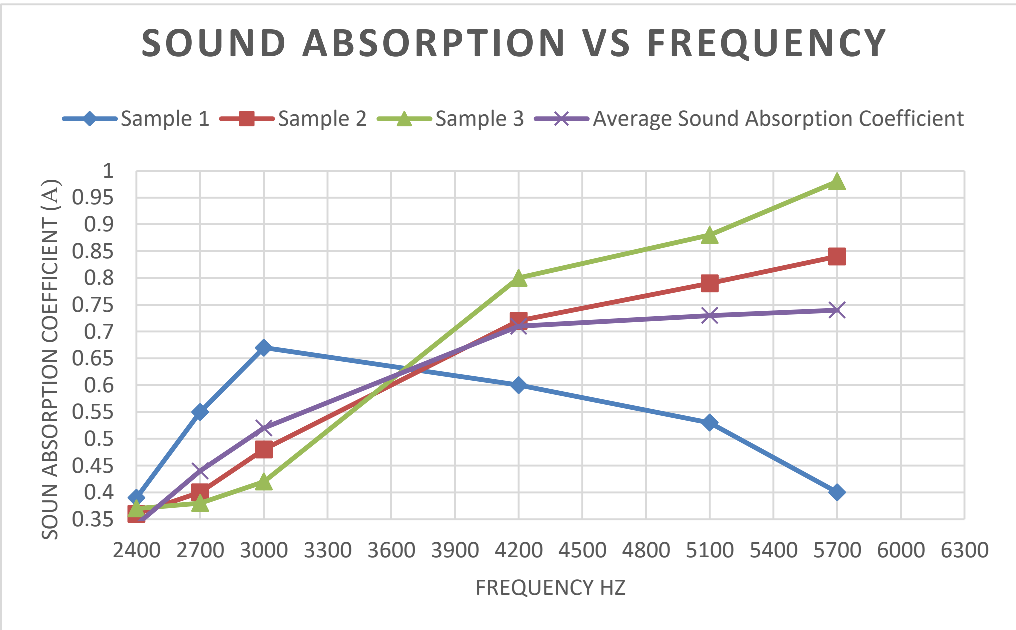


**Figure 8: Graph of Sound Absorption Coefficient of High Frequency**

Based on Figure 8, all minimum sound absorption at frequency 2400 Hz. For Samples 1, the maximum coefficient of sound absorption at 3000 Hz is 0.67 and minimum at 2400 Hz is 0.39. Next. Sample 2. The maximum coefficient of absorption at 5700 Hz is 0.84, and the lowest at 2400Hz is 0.36. For Sample 3, the sound absorption coefficient's highest value at 5700 Hz is 0.98, and the lowest value at 2400 Hz is 0.35.

The best sound absorption coefficient has the value 1, which means 100.00 % of the sound is absorbed. All samples achieved low sound absorption coefficient for low frequency, but for high frequency, the sound absorption coefficient values nearest to 1 are performed by sample 2 and 3. The large difference between Sample 1 with other samples might be due to Sample 1 not fully covering the Impedance Tube during testing.

For low frequency, the average maximum sound absorption is 0.28 showing that 28.00 % sound is absorbed. This means that they are deficient in absorbing low-frequency sound. However, this does not mean that the acoustic panel could not absorb sound, but some improvements need to be done in the future to absorb low-frequency sound better. For high absorption, the average maximum sound absorption coefficient is 0.74 at frequency 5700 Hz, which means 74.00 % sound is absorbed. This shows that sugarcane bagasse and wood dust acoustic panel can be a good absorber for high-frequency sound. From comprehensive data for high and low-frequency sound absorption, it indicates that Sample 3 are the best in absorbing sound due to the highest value of high frequency which are 0.98 at 5700 Hz and low frequency is 0.28 at 2000 Hz.

## 4. Conclusion

This research succeeded in creating renewable green acoustic panel using the sugarcane bagasse and wood dust reinforced starch glue mix proportion. Based on the results, the highest sound absorption coefficient was given by sample 3 with a mixture ratio of 30:40:30 (sugarcane bagasse, wood dust and reinforced starch glue percentage by weight) with 0.005 cm thickness. The spongy properties created by the sugarcane bagasse and wood dust characteristic in sample 3 created many void spaces that encouraged more ability to absorb the sound. As for sample 1 and sample 2 sound absorption, it can be said that the results are achieved marginally due to the high percentage by weight of sugarcane bagasse rather than wood dust, giving more characteristic of reflection rather than absorption when compacted into a panel. It also has the lowest thermal conductivity, which means sample 3 is the best one to put in the building as the acoustic panel that generates low heat transfer. The sample 3 panel was found with the highest amount of water absorption of 55.88 % rather than sample 1 and 2 panels, 36.66 % and 39.08 % respectively. These disadvantages can be overcome sugarcane bagasse can be immersed in alkali treatment to enhance the water absorption properties and put waterproofing material or coating at the sample to low water absorption.

This acoustic panel can be used as a green acoustic panel for buildings. Besides, this green acoustic panel will contribute to agricultural waste management by adding new values to its properties. In summary, the objectives of this study have been accomplished.

## 5. Recommendation

These are some recommendations in order to improve effective performance of sugarcane bagasse, wood dust and starch glue panel in future:

i. Sugarcane bagasse should undergo the alkali treatment in order to enhance its water resistance and durability properties.

ii. Increasing the density value for the sample.

iii. Use a water proofing or coating to prevent high absorption of water.

iv. After fabrication of panel, it should be left at room temperature for at least 24 hours or curing. The longer the time of curing, the stronger the structure of panel.

v. Thickness of panel may increase over 15 mm in order to improve the sound absorption and thermal insulation characteristic.

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