

Sustainable Absorption Panels from Agricultural Wastes

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Abstract. Noise has become a serious environmental problem and there are demands for alternative sustainable materials which capable to reduce the noise level at various frequency ranges. Therefore, the aim of this research is to study the potential of turning the agricultural waste and waste paper into a sound absorption panel. For the purpose of this study, combination of two materials was under studied; coconut coir fibre from agriculture waste and shredded waste paper from the office. There were two main objective of the research; first is to develop absorption panels from coconut coir powder that available locally with a combination of shredded paper at different percentage of mixture. Second objective is to identify the absorption rate of the panels. The study encompasses the fabrication of the particle board using the coconut husk powder mix with shredded waste paper and using the gypsum powder as the binder for the two materials. Four acoustic panels of size 0.5m x 0.5m and 0.012 m thick were fabricated with different mix ratio; 25% of coconut coir powder mixed with 75% of shredded waste papers for sample 1, 50% both of the material for sample 2, 75% of coconut coir powder mixed with 25% of shredded waste paper for sample 3, and lastly 100% of coconut coir powder for sample 4. The absorption coefficient of the panels was tested in a reverberation chamber and in accordance with ISO 354:1985 standards. Based on the results, sample 1 gave the highest absorption coefficient compared to sample 2, 3 and 4. It can be concluded that the acoustic panel made from a mixture of 25% coconut coir powder with 75% shredded waste paper provided higher absorption coefficient compared to the performance of the other samples. This might be caused by the size of the coir powder which is very small, creating less void space in between the panel and thus causing it to absorb less sound. Since sound absorption is very much affected by the availability of void space of the panel, further studies on other potential materials from waste should be conducted.

1 Introduction

Noise pollution has becoming a major concern worldwide. Many researchers have come forward sharing views and conducting studies pertaining to the noise issue. Whilst majority agrees at some level that the current traditional sound absorption panels using synthetic materials such as glass, mineral wool, felts or polyester fibers are the solution to the noise problems, others on the other hand voice out concerns on the health and environmental impacts of such synthetic materials. Thus, new researches on sustainable sound absorption panels are now trending. By looking at the current hype of green and sustainable approach, waste is now the major highlight as the possible alternative. Natural cellulose fibers which can usually be found in agricultural waste such coconut husk has proven in

previous studies to have the capability to absorb sound. Not only this could mitigate the noise issue, it might also overcome the waste problem. When a sound wave hits a surface, those are not reflected is absorbed. According to Salter [1] all materials have some sound-absorbing properties. The more fibrous a material is the better its absorption capability; and denser materials on the other hand are less absorptive. Sound absorption coefficient describes the efficiency of the material or the surface to absorb the sound. Absorption coefficients for building materials normally vary from about 0.01 to 0.99. Materials with medium to high sound absorption coefficients (usually > 0.50) are referred to as sound – absorbing; those with low coefficients (usually 0.20) are sound reflecting [2]. Many absorption panels in the market are made from traditional material such as gypsum which are not sustainable and could affect the health of the occupants. There are need and demand for alternative materials which are sustainable that capable to reduce the noise level at various frequency ranges. For this reason the recycling of the agricultural waste has become more popular that can replace the traditional one. There are many research initiated to study the potential of waste especially the agricultural waste as an acoustic panel. Malaysia has plenty of agricultural waste products such as coir (*Cocosnucifera*) fiber, rice (*Oryza sativa*) husk and oil palm (*Elaeisguinnessis*) frond fibre. In some research conducted by Zulkifli et al [3], they found that organic natural fibres have various usages in many structural and non-structural applications such as automotive lining component and acoustic absorption barrier. Khedari *et al.* [4] has developed particle composite boards from agricultural waste products using combinations of durian peel and coir fibre straw particles instead of wood as an insulation board in wooden construction industry. Yang *et al.* [5] study the acoustic properties of rice straw-wood particle composite boards and found that the sound absorption coefficient in the frequency range of 500 to 8000 Hz is higher than other wood-based materials which are due to the low specific gravity of the composite boards. Jan E.G. and Van Dam [6] stated that coconut husk fibres are suitable as raw material for the production of environmentally safe and high performance construction materials such as high performance fibre boards, poles and panels, which will be locally produced, can be applied in low-cost housing and other suitable places. Banzo and Valesco [7], Dam et al [6] and Tejano [8] all agreed that at some level the coconut coir can be made an acoustic panel for its sound absorption character such as spongy and fibrous. Current traditional sound absorption panels using synthetic materials such as glass, mineral wool, felts or polyester fibres are not sustainable and can be hazardous to human's health and occupancy of the building. At the same time, more sustainable and green approach solution is craved around the world to solve such issues. Looking at this, attention is moved to waste for the possible solution. For instance, agricultural waste such as coconut husks and other waste such as papers are left abandoned in dumping areas. These wastes could be used as an alternative material for sound absorption panel.

Therefore the aim of this research was to study the potential use of the coconut coir as a sound absorption material to replace synthetic materials such as glass, mineral wool, felts or polyester fibres in the current market. This study revolved around the sound absorption properties of the coir fibres together with its characteristics and the form of the coir fibres.

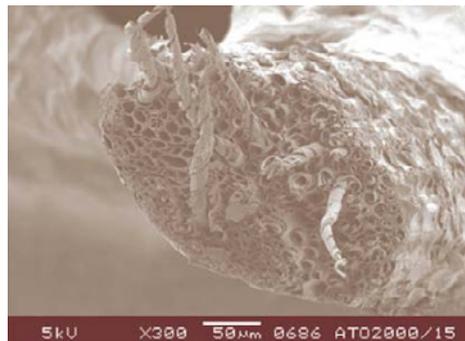


Figure 1: Close-up Image Coconut Husk Fibre (Coconut Coir) X300 (Keijsers, 2011)

2 Experimental Procedures

2.1 Target Materials

For the purpose of the study, two types of waste were used; coconut coir powder from agriculture waste and shredded waste paper. Gypsum powder was used as the binder.

Property	Coir Dust	Shredded Paper
Ash (%)	9.00 ^(b)	18.8 ^(c)
Bulk density (kg/m ³)	0.074 ^(a)	-
Particle density (g/cm ⁻³)	0.758 ^(a)	-
Total pore space (% vol)	96.264 ^(a)	-
Cellulose (%)	35.99 ^(b) 53.5 ^(b)	50.1 ^(c)
Lignin (%)	11.206 ^(b)	11.6 ^(c)
Shrinkage (% vol)	-	-

Source: *Asiah et. al (2004), Israel et. al (2011), Sissine et al (2005)*

2.2 Specimen preparation

Four samples of acoustic panels were fabricated from a mixture of coconut coir powder and shredded waste papers as follow:

- Sample 1 (25% of coconut coir powder, 75% of shredded waste paper)
- Sample 2 (50% of coconut coir powder, 50% of shredded waste paper)
- Sample 3 (75% of coconut coir powder, 25% of shredded waste paper)
- Sample 4 (100% of coconut coir powder)

The measurement of the panels is 0.5m x 0.5m x 0.012 m. Gypsum powder was used as the binder. The process began with dispensing waste pulping paper into the mixer and mix them with water. After that the gypsum powder and coconut coir powder were added. The mixture was left for about 5 minutes in the mixer for all the three ingredients to blend well. The mixtures were then casted into the mould which already coated with oil and later compressed manually by using a cylindrical concrete. Once compressed, plywood was used to level and to set the thickness. Finally, the samples were set in the oven at 90 degrees Celsius and left for 1 day (24 hours) to cool off and settle.

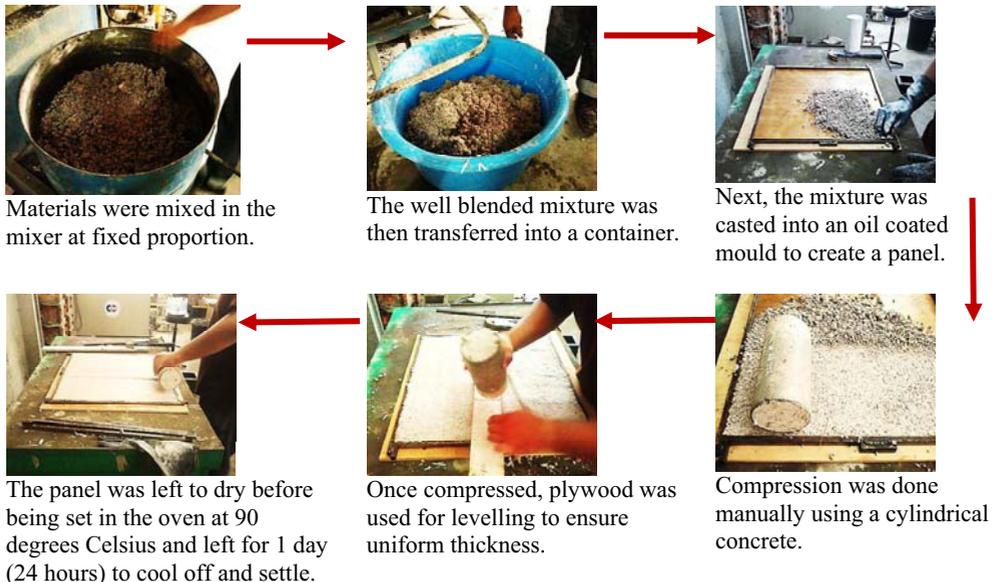


Figure 2: Fabrication process of the panels.

2.3 Sound Absorption Coefficient Test

The measurement of sound absorption coefficient of the test sample was conducted in the reverberation chamber. The procedure of the test was carried out in accordance with ISO354:1985 standard. The required inputs are reverberation time for empty room, RT_0 and reverberation time for room with sample, RT_m . Volume for an empty reverberation room and samples testing area were required as parameter for the experiment setup. The samples were laid directly over the reverberation chamber floor. The schematic diagram of the experimental setup and the arrangement layout of the absorption test can be seen in Figure 3 and Figure 5 respectively. For the test simulation, dBBA132 Building acoustics software was used. This programme allows a quick configuration of the measurement analysis and measurement could be carried out in batch mode.

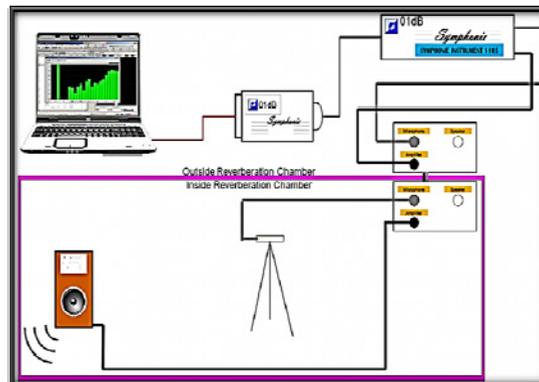


Figure 3: Arrangement of the samples and sound source in the reverberation room.

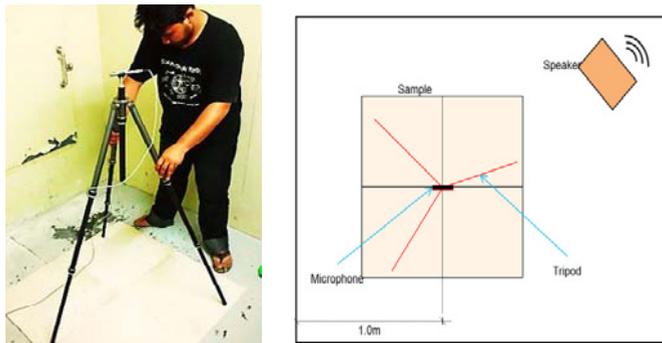


Figure 4: Arrangement of the samples and sound source in the reverberation room.

3 Results and Discussions

Table 1: Absorption coefficient data of the samples.

Sample	Content (%)		Absorption Coefficient					
	Coconut coir powder	Shred paper	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
1.	25	75	0.03	0.24	0.26	0.27	0.36	0.40
2.	50	50	0.14	0.16	0.27	0.26	0.30	0.26
3.	75	25	0.10	0.16	0.22	0.24	0.26	0.24
4.	100	0	0.05	0.12	0.27	0.26	0.26	0.26

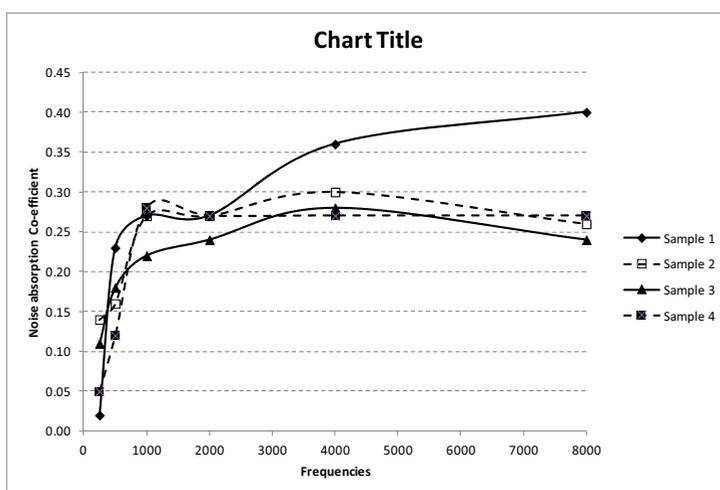


Figure 5: The absorption coefficient graph for the samples.

The aim of the research was to study the potential of creating a sustainable sound absorption panel using waste such as coconut husk powder and shredded waste paper. From the results it can be said that these materials could absorb sound especially at higher frequency.

The first objective of this research was to produce the acoustic panel using the mix proportion on different percentages of agricultural waste. 4 sound absorption panels were produced using cultural waste such as coconut husk powder and shredded waste paper. All the samples measuring 1.0m x 1.0m x 0.012m sized with different proportion of materials; sample 1 has 25% of coconut coir powder with 75% of waste pulping papers, sample 2 mixed with 50% both of the material, 75% of coconut coir powder mix with 25% of waste pulping paper for sample 3, and sample 4 with 100% of coconut coir powder.

The second objective of this research was to measure the absorption coefficient of the panels. It can be seen from the results that the absorption coefficient of the panels ranging from 0.03 to 0.4 at frequency of 250Hz to 8000Hz.

For sample 1 which was a mixture of 25% of coconut coir powder with 75% of shredded waste paper, the absorption coefficient are 0.03, 0.24, 0.26, 0.27, 0.36 and 0.40 at respective frequency of 250Hz, 500Hz, 1000Hz, 2000Hz, 4000Hz and 8000Hz. It can be seen that more sound were absorbed at higher range of frequency. The void space provided by the shredded waste paper increased the sound absorption performance of the panel.

For sample 2 the absorption coefficient are 0.14, 0.16, 0.27, 0.26, 0.30 and 0.26 at respective frequency of 250Hz, 500Hz, 1000Hz, 2000Hz, 4000Hz and 8000Hz. Meanwhile for sample 3 the absorption coefficient are 0.10, 0.16, 0.22, 0.24, 0.26 and 0.24 at respective frequency of 250Hz, 500Hz, 1000Hz, 2000Hz, 4000Hz and 8000Hz. It can be seen that the sound absorption performance had decreased 0.20 at 8000Hz.

The average sound absorption coefficient for sample 2 and 3 is 0.26 and both samples showed a decrement in absorption performance after 4000Hz. It can be seen that the similarity of the results for sample 2 and 3 might be affected by higher amount of the coconut coir powder used compared to sample 1 with higher ratio of shredded waste paper used.

Sample 4 which contained 100% of coconut coir powder showed that the highest absorption coefficient was 0.27 at 1000Hz before it decreased and became stagnant with 0.26 absorption coefficient at higher frequency. Since the particle of the coconut coir powder is too small, combining it 100% has resulted in tighter space in the panel thus lowering the ability to absorb the sound.

4 Conclusions

Based on the results, sample 1 gave the highest absorption coefficient compared to sample 2, 3 and 4. It can be concluded that the acoustic panel made from a mixture of 25% coconut coir powder with 75% shredded waste paper provided higher absorption coefficient compared to the performance of the other samples. This might be caused by the size of the coir powder which is very small, creating less void space in between the panel and thus causing it to absorb less sound. Since sound absorption is very much affected by the availability of void space of the panel, further studies on other potential materials from waste should be conducted.

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