

CORN COB ABSORPTION RATE AS ACOUSTIC MATERIAL

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Abstract

Reducing CO₂ emission through innovation discovery is essential to respond to the global warming issue. The research states that construction material contributes 11% of CO₂ emission on building. Agricultural waste in Indonesia is plentiful, but it has not been used optimally, one of examples is corncob waste. The study to theoretically identify the absorption level on acoustic panel of corncob waste using two kinds of panel thickness dimensions composed of natural corncob through literature study and laboratory test of impedance tube by identifying the absorption panel coefficient phenomenon of corncob waste. The physical characteristic of corncob is porous, and this study found that there was a good absorption level in two dimensions of panel thickness of 3 cm and 5 cm. It was strengthened by the finding of a frequency shift phenomenon of two dimensions of panel thickness due to resonance in air cavity/gap among corncobs.

Keywords: corncob waste, acoustic panel, absorption coefficient.

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1. Introduction

Global warming is an issue that many people talk about. Building construction consumes as much as 40% of global energy and produces emissions during the construction and operation stages (Dixit et al. 2012). To deal with the problem of global warming in the development sector, it is necessary to move towards the application of sustainable architecture. Sustainable architecture is a building that is designed and built using renewable energy and sustainable materials so that it does not burden the next generation (Prabowo et al. 2019). Selection of the right materials in buildings is very important to achieve sustainable architecture. At this time, material innovation in the construction sector is growing rapidly along with the development of technology. Raw materials for sustainable materials are better to use raw materials that do not take new natural resources, for example, waste materials. Waste material can come from the rest of the industrial process or the rest of the agricultural process (Agustono et al. 2018). On the one hand, agricultural waste that is simply piled up or left alone can pollute the surrounding environment.

Corn is one of the largest agricultural products in Indonesia because it is quite popular with farmers in all regions. The short planting period is 80-110 days so that in one year farmers can plant 3 times (Musa 2012) and easy plant care is the reason for farmers to plant corn. This relatively short harvest period resulted in a very large stock of corn.

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Unfortunately, the harvesting process is not entirely optimal because the farmers only take some parts of the corn plant for use. Meanwhile, in fact, the corn plant can be utilized in all its parts, and can be used to make many processed products (Purwanto 2008) . However, the fact is that people still have not made the most of it. Based on data from the Central Statistics Agency (2015), in 2014 corn production in Indonesia increased by 49.57 tons compared to corn production in 2013. If calculated, the increase in production productivity was 1.1 quintals per hectare. This causes a lot of corncob waste. Every year, it is estimated that Indonesia produces 5.7 tons of corncob waste. It can be seen in Figure 1. Most of the waste is simply disposed of and burned. If anyone uses it, corncob waste is used as animal feed and mushroom growing media. (Liputan6.com 2019)



Figure 1. Corn cobs waste on fire
Source: <https://www.kompasiana.com/>

There are previous studies regarding the relationship between the content of *segnocellulose* in corn cobs and sound absorption. And found a type of corn that has a high content of *segnocellulose*. Namely corn type *zea may*. The content of *segnocellulose* is very good to be able to become an absorbent material, the higher the content of *segnocellulose* , the higher the absorption capacity (Permatasari 2014) . In general, corn cobs have a porous, light weight. (Nugroho, Diharjo, and Himawanto 2013) . Based on its physical properties, there is a potential that corn cobs can be used as acoustic panels as absorber panels. There is a previous study, which used fine corncob flour (milled) and a mixture of *polyurethane* to make acoustic panels. (Nugroho, Diharjo, and Himawanto 2013) .



Figure 2. Acoustic panel of corncob flour
Source: AGRITEK: Journal of Exact Sciences Research, 2013

From previous research, it was found that corncob flour has the potential to be used as acoustic panels. However, this study did not take advantage of the shape and natural physical properties of corn cobs. Natural fibers from natural products have irregular fiber directions (Rizal, Elvaswer, and Fitri 2015) and good sound absorption abilities generally come from natural materials (Wirajaya 2007) . So this study aims to identify theoretically and laboratory test the absorption coefficient / absorption ability on acoustic panels from corncob waste. This test uses a panel composed of pieces of corn cobs without modification of the shape. This research is expected to be one of the evidences that organic waste material can be used as material that has more value and is beneficial for environmental sustainability.

2. Materials and Methods

This research is based on literature studies and laboratory tests using the impedance tube test method which focuses on identifying the absorption coefficient of corncob panels.

Physical characteristics of corn cobs

In Figure 3. Corn cobs have 3 main layers, and have different physical properties, layer I is quite soft (*pith*), layer II is similar to dense softwood (*woody ring*), and layer III is very irregular and smooth (*glume*) . (Zou et al. 2021) .



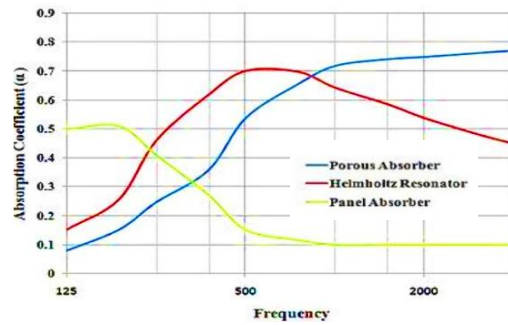
Figure 3. Corncob layer
Source: (Zou et al. 2021)

On the corncob there are hard parts and some are absorbent and there are parts that have combined properties so that they don't have a chemical reaction/inert making the corncobs biodegradable. (Zou et al. 2021) .

Sound absorbing material

In general, sound absorbing material / absorber serves to reduce the presence of reflections / echoes in the room. The absorption rate of a material is determined by the absorption coefficient (α) (Mediastika 2005) . The requirement for an acoustic material to have a good acoustic impedance value is to have a high sound absorption coefficient (Samsudin, Ismail, and Kadir 2016) . Each absorbent material has a different absorption coefficient (α). The value of the absorption coefficient on acoustic materials can be influenced by several factors, namely material density, panel thickness, air cavity, temperature, and sound frequency (Permatasari 2014) . The absorption coefficient of a material has a value between 0-1. = 0 means that the material cannot absorb sound, and vice versa if = 1 means that the material can absorb sound very well. (Egan, M. David 1972) .

Acoustic materials can be divided into 3 types, namely *absorber* material, barrier material , and damper material (H. Bell and H. Bell 1994) . The absorbent material itself is divided into 3 types, namely porous absorbers, absorbent panels, and cavity absorbers (Fandi Ahmad Nugroho 2008) . Absorber material *has* a porous or fibrous structure, this is due to the change of sound energy into other energy such as vibration energy or heat energy. (Lee and Joo 2003) The value of the absorption coefficient on the absorbent material has different values, depending on the type and nature of the material. (Howard and Angus 2009) . Helmholtz resonator / absorbent cavity is a combination of several other types of absorber materials (N Susilo, L Kristanto 2011) . This type of absorbent material has a perforated surface. This material uses air trapped in the neck or pipe above a field filled with air (Pradana 2017) . It can be seen from graph 1. There are differences in the level of absorption coefficient in each type of absorbent material. The absorbent panel material has a good absorption coefficient value at low frequencies, while the porous absorber material has a good absorption coefficient value at high frequencies above 1000Hz, and the Helmholtz absorber cavity / resonator material has an absorption coefficient value that can be adjusted as needed because it can capture at a specific frequency as desired.



Graph 1. Graph of sound absorption type
Source: (Howard and Angus 2009)

Test panel

The materials used in this study were corn cobs that had been preserved, sanded, cut with a thickness of 3 cm and 5 cm (figure 3.), wood glue, and plywood board (as a base).

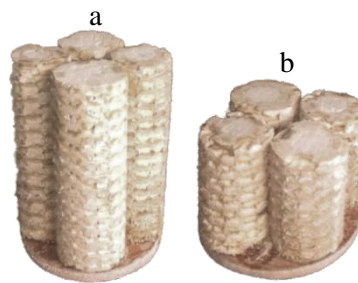


Figure 3. (a) 5cm thickness; (b) thickness 3 cm
Source: author

Samples were made into 2 sizes, namely with a diameter of 10 cm and 3 cm. The purpose of making these two panel sizes is to obtain the absorption coefficient values for low and high frequencies. In figure 5a. a diameter of 10 is required for low-frequency measurements (80 Hz - 500 Hz), and in figure 5b. 3 cm diameter is used for high frequency measurement (630 Hz-5000Hz).

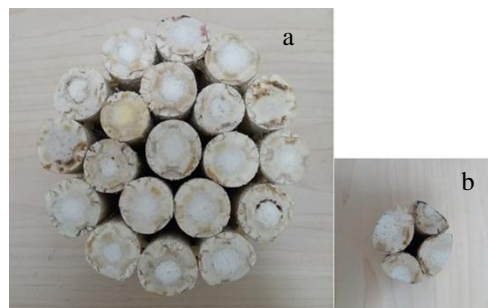


Figure 5. (a) 10 cm in diameter; (b) diameter 3 cm
Source: author

Laboratory test

In this study, sample testing using an impedance tube. Generally, there are two types of impedance tubes that can be used to measure the absorption coefficient. The first is, the impedance tube using a probe type microphone and the second is using 2 microphones. In this research, the impedance tube transfer method is used which uses 2 microphones. Measurements using impedance tubes only measure the sound coefficient of a sound source that is perpendicular. The tool used is an impedance tube type SW420+SW470. Impedance tube, SW420 100mm inner diameter. This type of instrument performs low-frequency measurements, namely 63-500 Hz. Impedance Tube SW470 Impedance tube, SW470 30mm inner diameter. This type of instrument performs low-frequency measurements of 500-6300 Hz.



Figure 6. Tube impedance type SW420+SW470
Source: author

3. Result and Discussion

This test is carried out using two types of tubes. In low-frequency testing using an impedance tube SW420, and high-frequency testing using an impedance tube SW470 using a corn cob test panel with a thickness of 3 cm and 5cm. **Absorption coefficient of panel thickness 3 cm.** It can be seen in table 1. The absorption coefficient value at a thickness of 3 cm with a testing frequency of 80Hz - 6300Hz shows an absorption potential, but at low frequencies it has a low coefficient level, which is below 0.12.

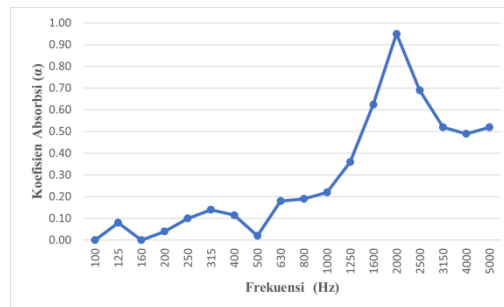
Table 1. Absorption coefficient value of thickness 3 cm

Frequency (Hz)	Absorption coefficient ()
80	0.04
100	0.00
125	0.08
160	0.00
200	0.04
250	0.10
315	0.14
400	0.12
500	0.02
630	0.18

800	0.19
1000	0.22
1250	0.36
1600	0.63
2000	0.95
2500	0.69
3150	0.52
4000	0.49
5000	0.52

Source: Author

In graph 1. It seen that, at a frequency of 500 Hz, this drastic decrease occurred from a frequency of 400 Hz with an absorption coefficient of 0.12 to 0.02 at a frequency of 500Hz. This phenomenon can occur due to several factors, one of which is the impedance tube which has a limit and initial at a frequency of 500Hz so there is a possibility that the frequency is not fully captured. It can be seen in graph 1. if the absorption coefficient level at the thickness dimension of 3cm has a peak at a high frequency, namely at a frequency of 2000 Hz.



Graph 1. Absorption coefficient of thickness dimension 3cm

Source: Author

The absorption coefficient of the panel thickness is 5cm

At a thickness of 5 cm has the ability to absorb at high frequencies. It can be seen in table 2. The increase in the frequency value starts at a frequency of 500Hz.

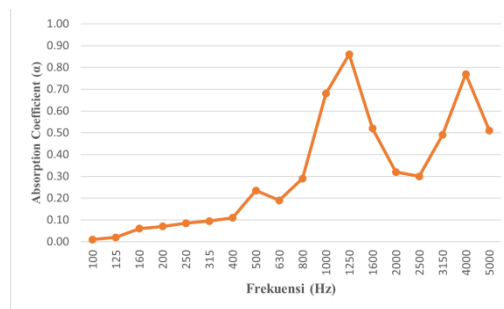
Table 2. Absorption coefficient value of 5cm thickness

Frequency (Hz)	Absorption coefficient ()
80	0.21
100	0.01
125	0.02
160	0.06
200	0.07

250	0.09
315	0.10
400	0.11
500	0.24
630	0.19
800	0.29
1000	0.68
1250	0.86
1600	0.52
2000	0.32
2500	0.30
3150	0.49
4000	0.77
5000	0.51

Source: Author

The peak value occurs between the coefficients of 1250 Hz, and 4000 Hz. Based on graph 2. it seen that there is a repetition of peak points and at low frequencies the corncob panel lacks the ability to absorb, this also occurs in graph 1. i.e. a panel with a thickness of 3 cm.



Graph 2. Absorption coefficient of thickness dimension 5cm

Source: Author

Air cavity

When viewed as a whole in graphs 1 and 2, the absorption coefficient levels of the two thicknesses experience the phenomenon of mountains and valleys. This phenomenon occurs due to a gap in the corncob panel, as shown in Figure 7.

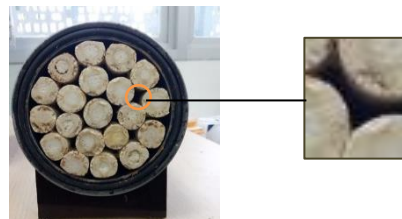
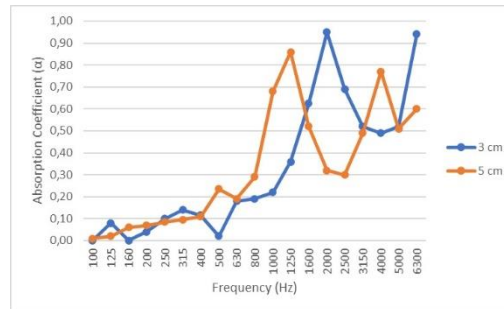


Figure 7. Air gaps between corn cobs

Source: autho

The air *cavity* can affect the absorption of the panel. This is because the larger the cavity, the repeated reflection and absorption will occur in the cavity, so that more energy is absorbed (the value of the absorption coefficient is higher).

Panel thickness



Graph 3. The combined absorption coefficients of 3cm (orange) and 5cm (blue) thickness dimensions
Source: Author

Not only the air cavity factor, the thickness of the panel also affects the absorption coefficient value. When viewed as a whole, the absorption coefficient value of the corncob panel has a graphic form like a cavity resonator material. The graph forms peaks like mountains and decreases like valleys. When the two thicknesses of 3cm and 5cm are compared as in graph 3, it can be seen that there is a shift in frequency. This phenomenon occurs as a result of resonance in the air gaps between the corn cobs. This indicates that there is a relationship between the size of the air cavity and the thickness of the panel. The thicker the panel, the longer the air cavity, so that the peak point will shift towards a lower frequency.

4. Conclusion

The shape of the corncob panel in this study can be a new phenomenon. The use of natural forms of corn cobs has proven to be a sound absorbing medium, because of its porous shape. After identifying the level of absorption in the two dimensions of the thickness of the panel, namely 3 cm and 5 cm. It was found that the absorption ability was quite good. The comparison between the absorption coefficient levels of the two thickness dimensions produces a frequency shift phenomenon. The air cavity and the thickness of the panel cause resonance so that it affects the value of the absorption coefficient, the thicker the material, the absorbed frequency will shift to a lower coefficient.

With the possibility of a shift in the peak point of the absorption coefficient value towards a lower frequency, further research needs to be done with the addition of corn cobs thickness.

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