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Research Article

Analysis Of Noise Absorption Coefficients in Wood Materials Commonly Used as Wall Coverings (Plywood, Wooden Boards, and Kalsiboard)

Syahrir[1),3,*)], Kadek Subagiada[1)], Suhadi Muliyono[1)].
[1)]*Department of Physics, Faculty of Mathematics and Natural Sciences Mulawarman University*
[2)]*Electronics and Instrumentation Laboratory, Mulawarman University Street. Mount Kelua No. 4, Samarinda, East Kalimantan, Indonesia*
(*)e-mail: syahrir.syaher@gmail.com 2025

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ABSTRACT

Noise is a sound that humans do not want and it is an environmental factor that can negatively affect health. To overcome the noise issue, many efforts have been made to reduce noise levels. An example is the manufacture of the walls of a house using materials with sound and absorbent standards. The materials used can also be derived from types of wood such as plywood, wood panels and calcite-boards. Therefore, the value of its sound absorption coefficient is calculated to find out which active material is to be used in the manufacture of the building. Based on the research results, the value of the sound absorption coefficient of the three types of materials, it can be seen that the shape of the graph and its analysis states that the lowest sound absorption coefficient is most likely at the lower frequencies and the highest value of the sound absorption coefficient tends to be at the higher frequencies. In fact, when viewed as a whole, the magnitude and magnitude of the sound absorption coefficient on the graph is not in line with the increase in the frequency value.

Keywords: Damping, Noise, Wood Material..

INTRODUCTION

Humans are beings that possess several sensory organs, such as the sense of sight, sense of hearing, sense of taste, and others. These sensory organs are usually used as detectors of various objects that are visual or auditory in nature within the social life of their surroundings. The presence of these sensory tools sometimes causes humans to experience various problems, such as with the sense of hearing related to sound. Sound is often used by humans as a means of communication or an abstract medium of information. Sound can also come from various sources, such as the sound of transportation vehicles or the sound of machines in factories, leading to a problem known as noise.

Noise is an unwanted sound by humans and is an environmental factor that can negatively affect health. To address this issue and the occurrence of noise, various efforts are made to reduce the noise level, such as creating soundproofing on the walls of houses or buildings. One example of a soundproofing material is one made from wood. Wood materials or acoustic materials can include calcium silicate boards, plywood, and wooden boards. These materials are not only more affordable but also easy to obtain. The wood material used has thickness and damping criteria to absorb sound waves.

When sound waves pass through a physical medium, the intensity of the sound will be measured from the moment the sound source occurs, and this phenomenon is known as attenuation. Sound experiences attenuation while the medium absorbs acoustic energy, causing it to heat up. The occurrence of the change into heat is a form of attenuation known as sound absorption [1].

According to research from [1], it investigates the sound absorption coefficient of particle boards made from coconut wood powder. The research used particle board material made by mixing coconut wood powder with starch flour, molded, and dried. The samples are cylindrical. The material is made with thicknesses of 1.15 cm, 1.95 cm, 2.95 cm, and 4.05 cm. The research results show that the thickness of the sample affects the sound absorption coefficient value

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at a frequency of 600 Hz. The sound absorption coefficient decreases as the thickness of the particle board increases. The sound absorption coefficient value of the material is measured using the sound absorption coefficient formula.

The research conducted by [2], on the determination of the absorption coefficient and impedance of acoustic materials in perforated plywood panel resonators using the tube method. The samples used were concrete and plywood materials. The research results explain that the sound absorption coefficient of concrete is 0.25 at a frequency of 2000 Hz. After being coated with a plywood panel resonator, it increased to 0.51. Concrete coated with a perforated plywood resonator panel achieved the highest sound absorption coefficient, which is 0.61. The frequencies used are 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz.

According to previous research [3], the results of sound absorption testing are obtained from the comparison of intensity before and after passing through the medium. The propagation of waves through the boundary will experience reflection, absorption, and transmission. The magnitude of the absorption coefficient, in addition to depending on the frequency of sound and the characteristics of the boundary material, also depends on the angle of incidence of the sound wave.

Therefore, based on the explanation from the background that has been outlined, this research develops acoustic materials used with wood materials. The wood materials used are plywood, wooden boards, and calcium silicate board. The frequency used in this research is 1000 Hz – 3000 Hz. Each type of wood has different thicknesses and characteristics. The material will be evaluated for its sound absorption coefficient using the sound absorption coefficient formula to determine the efficiency of plywood, wooden boards, and calcium silicate board.

OBJECTIVES

Waves and Sound

Waves are disturbances that occur due to the propagation of oscillation energy. Waves based on their propagation direction are divided into two, namely transverse waves and longitudinal waves. Transverse waves are waves whose vibration direction is perpendicular to the direction of propagation, while longitudinal waves are waves whose vibration direction is parallel to the direction of propagation. In explaining wave phenomena, there are many issues that are studied in depth. One of them is regarding wave attenuation. In a wave transmission system, such as in signal transmission, the signal received at the receiver is usually not the same as the one transmitted. This is caused by the presence of noise encountered during the propagation of the signal. Attenuation is the phenomenon of signal weakening as the distance from the transmitter to the receiver increases [4].

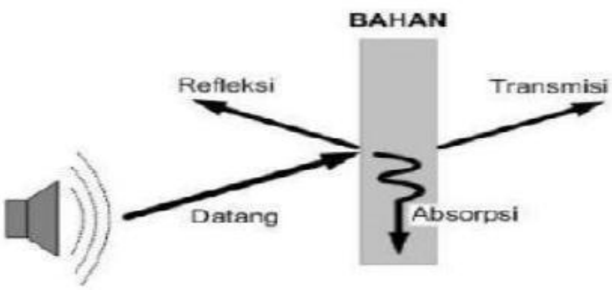

Figure 1. The occurrence of reflection, absorption, refraction, and transmission on an object
Acoustic Material

The word "acoustic" comes from the Greek word "acoustics," which means everything related to hearing in a space condition that can affect sound quality. Acoustics is the science that studies sound or noise. Acoustics in architecture is often divided into room acoustics, which deals with desired sounds, and noise control, which deals with unwanted sounds. Acoustic materials are engineering materials whose main function is to absorb sound/noise. Acoustic material is a substance that can absorb sound energy coming from a sound source [5].

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According to research from [6], all materials can absorb sound energy. The amount of sound energy absorbed varies for each material. The sound energy is converted into thermal energy, which is the result of friction and resistance from various materials to move and deform. Sound damping is an important aspect of acoustic design and can be classified into four parts, namely:

1. Porous material;
2. Absorption membrane;
3. Absorbing cavity;
4. Humans and furniture.

Definition of Noise

Noise is an unwanted sound or noise that can disturb health and environmental comfort, measured in decibels (dB). Noise can also be defined as an unwanted sound, a disturbing noise, or an irritating sound. Based on the decision of the Minister of Manpower, noise is an unwanted sound originating from tools and production processes that, at certain levels, can cause health and hearing disturbances. Noise above safe levels can cause a number of health impacts, namely: psychological disturbances, increased emotions, disrupted sleep, inability to concentrate, and loss of productivity. In addition to affecting health, the noise factor can also impact the work process and work results in a company. Moreover, when it is raining, the noise can certainly affect the quality of conversations in the room [5]. The human ear or standard hearing responds to sound within the audio frequency range of approximately 20 to 20,000 Hz. Generally, sound (speech, music, and noise) consists of many frequencies, which are components of low, mid, and medium frequencies. The standard frequencies that can be freely chosen as significant representatives in environmental acoustics are 125, 250, 500, 1000, 2000, and 4000 Hz or 128, 256, 512, 1024, 2048, and 4096 Hz. The ratio between the sound energy absorbed by a material and the sound energy incident on the surface of that material is called the absorption coefficient. The absorption coefficient is one of the important parameters in determining the extent to which a material can absorb/reduce sound, and the quality of soundproofing materials is indicated by the absorption coefficient value [7].

Sound Absorption Coefficient

Sound absorption is the transformation of energy into another form, usually heat, that has passed through a surface material. In addition, it also involves sound passing through the surface of the material, so the sound that has passed through the material will undergo a change to become smaller. The principle of sound absorption occurs when a material loses energy as a sound wave strikes and is reflected from the surface of the material, causing the sound to be transmitted, absorbed, and reflected. However, the amount of sound absorbed, reflected, and transmitted depends on the type of material used [8].

According to previous research [9], the equation for the sound absorption coefficient can be solved using the description of the linear attenuation coefficient, where a sound-absorbing material depends on the type of material with sound insulation following an exponential function. If sound with an intensity of I penetrates a material with a thickness of x cm, there will be a reduction in sound by dI, and it is written in the equation:

$$dI = -I.\alpha.dx \tag{1}$$

with:
dI = change in intensity (dB)
I = initial intensity (dB)
= sound absorption coefficient (cm-1)
dx = change in material thickness (cm)
by integration, equation (1) becomes, Context: (2)

$$I = I_0 e^{-\alpha x} \tag{2}$$

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Change to

$$\alpha = \frac{\ln(I_0)-ln(I)}{x} \qquad (3)$$

With:
I = sound intensity after passing through the sample (dB)
Io = sound intensity before passing through the sample (dB)
= sound absorption coefficient (cm-1)
x = thickness of the sound absorption barrier or sample (cm)
The Relationship Between Sound Absorption Coefficient and Frequency

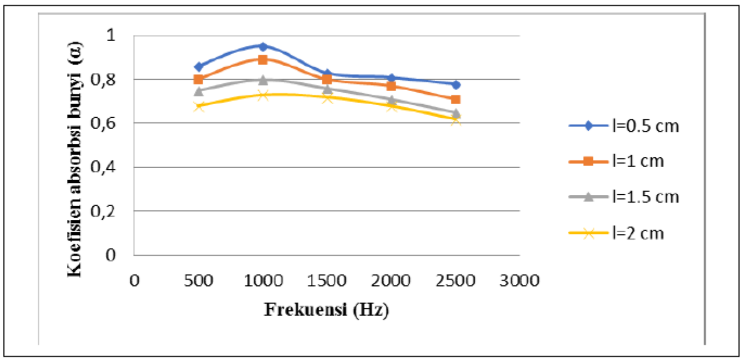

Figure 3. Relationship Between Sound Absorption Coefficient and Frequency

The relationship between the sound absorption coefficient and frequency is that if the frequency value is low, the sound absorption coefficient value will be higher, and vice versa. However, this is also influenced by the thickness of the material used; if the material used is thicker, the sound absorption coefficient value becomes smaller or lower, and vice versa. The sound absorption coefficient can increase in thin acoustic materials due to their porous nature, allowing sound waves to easily enter and be absorbed. Conversely, the sound absorption coefficient decreases in thick acoustic materials because their denser composition makes it difficult for sound waves to enter and be absorbed. This phenomenon is illustrated in Figure 3, which shows the relationship between the sound absorption coefficient and its frequency [10].

METHODS

Time and Place of the Research

This research was conducted from March 2020 to March 2021 at the Electronics and Instrumentation Laboratory, Faculty of Mathematics and Natural Sciences, Gunung Kelua Campus, Mulawarman University, Samarinda City, East Kalimantan Province. The data for this research uses primary data with an experimental method. This data was obtained from sound absorption data collection.

Research Tools and Materials

This research uses tools such as a mobile phone installed with a signal generator application and a sound level meter application, which are used as the sound source (Io) and receiver (transmission (IT), reflection (Ir), and reflection (Is)), a static pole used as a place for the mobile phone and the research material, which is made of zinc. This material is designed so that the sound source does not directly reach the receiver, as shown in Figure 4. The materials used in this research are plywood with dimensions and thickness, wooden boards with dimensions and thickness, and calcium silicate board with dimensions and thickness. The sizes used have been adjusted to fit the dimensions of the research material's location.

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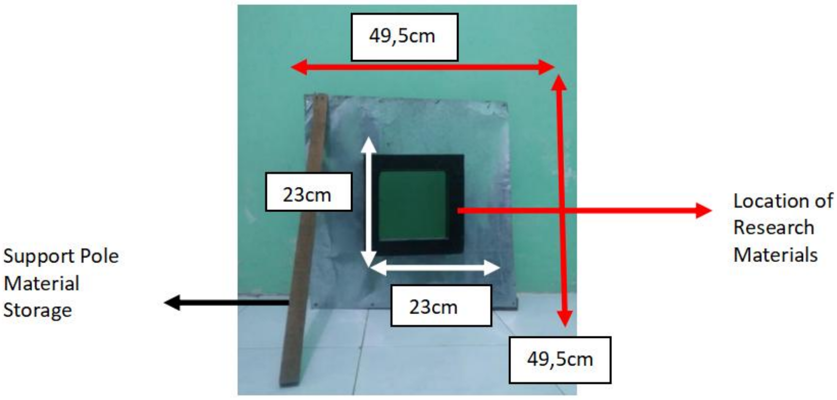

Figure 4. Research Material Location

Data Collection Stage

The steps for data collection include plywood, Wooden boards and cement boards are cut to the size of the research material area, then the cut materials are placed in the designed research material area. One mobile phone equipped with a signal generator as the sound source is placed in front of the material at a distance of 25 cm, two mobile phones as receivers equipped with sound level meters to measure the initial sound and reflected sound (echo) are placed to the right and left of the sound source at a distance of 25 cm from the material and a distance of 10 cm between the sound sources, and two mobile phones as receivers equipped with sound level meters to measure the sound passing through the sample or transmission sound and refraction sound are placed at the front side of the sound source. The distance between the sample and both receivers is 25 cm. The sound source is played at varying frequencies. In the study, the frequencies used ranged from 1000 Hz to 3000 Hz, then increased by 100 Hz for each data collection. Data collection was performed 5 times for each frequency increase, and the measurement results were recorded for all receivers.

Data Calculation Stage

This calculation method is used to determine the sound absorption coefficient value of materials such as plywood, wooden boards, and calcium silicate boards. The formula used in the calculation is the sound absorption coefficient formula, and the data calculated is the transmission data or the sound that has passed through. In the sound absorption coefficient formula, it involves the thickness of the material, the initial sound, and the sound that has passed through the research material to obtain the sound absorption coefficient value. The processed sound absorption coefficient values are then presented in the form of a graph.

RESULTS

After conducting data analysis, the sound absorption coefficient values (transmission in plywood, wooden boards, and calcium silicate board) are presented in Table 2 as follows.

Table 2. Coefficient Values of Sound Transmission Absorption in Plywood, Wooden Boards, and Kalsiboard

No	Frekuensi (Hz)	Amplitudo	α (cm-1) (Triplek)	α (cm-1) (Papan Kayu)	α (cm-1) (Kalsiboard)
1	1000	4	0.189	0.242	0.308
2	1100	4	0.183	0.155	0.257
3	1200	4	0.242	0.171	0.260
4	1300	4	0.600	0.209	0.298

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5	1400	4	0.238	0.131	0.284
6	1500	4	0.239	0.135	0.288
7	1600	4	0.342	0.119	0.248
8	1700	4	0.422	0.237	0.182
9	1800	4	0.552	0.255	0.229
10	1900	4	0.519	0.350	0.205
11	2000	4	0.334	0.350	0.289
12	2100	4	0.396	0.119	0.231
13	2200	4	0.605	0.244	0.372
14	2300	4	0.215	0.332	0.466
15	2400	4	0.293	0.179	0.294
16	2500	4	0.217	0.072	0.179
17	2600	4	0.171	0.140	0.371
18	2700	4	0.181	0.088	0.336
19	2800	4	0.254	0.082	0.267
20	2900	4	0.275	0.111	0.198
21	3000	4	0.507	0.102	0.211

Based on the data from the table of sound transmission absorption coefficient values above, the resulting graph for the plywood material with a thickness of 0.4 cm is shown in Figure 5,

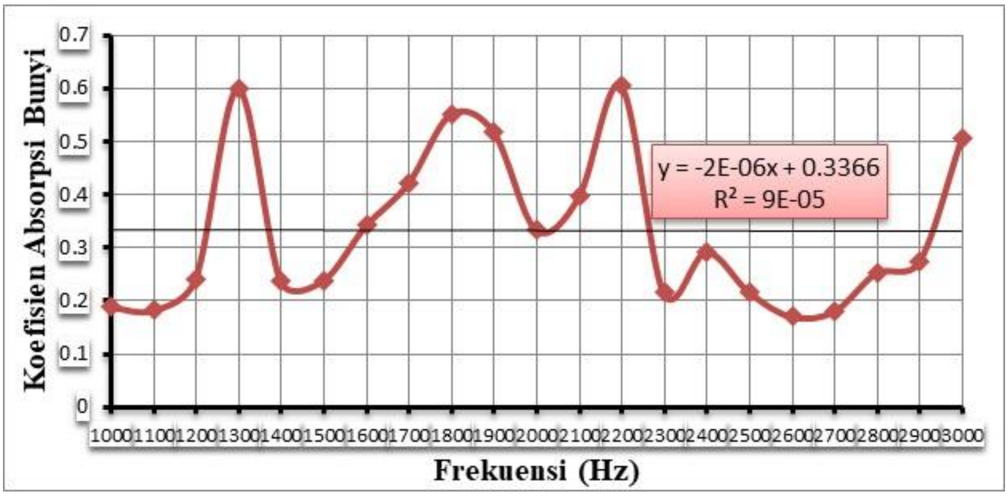

Figure 5. Graph of the Sound Absorption Coefficient Values for Transmission on Plywood
Based on the data from the table of sound transmission absorption coefficient values above, the resulting graph for the wooden board material with a thickness of 1 cm is shown in Figure 6 as follows.

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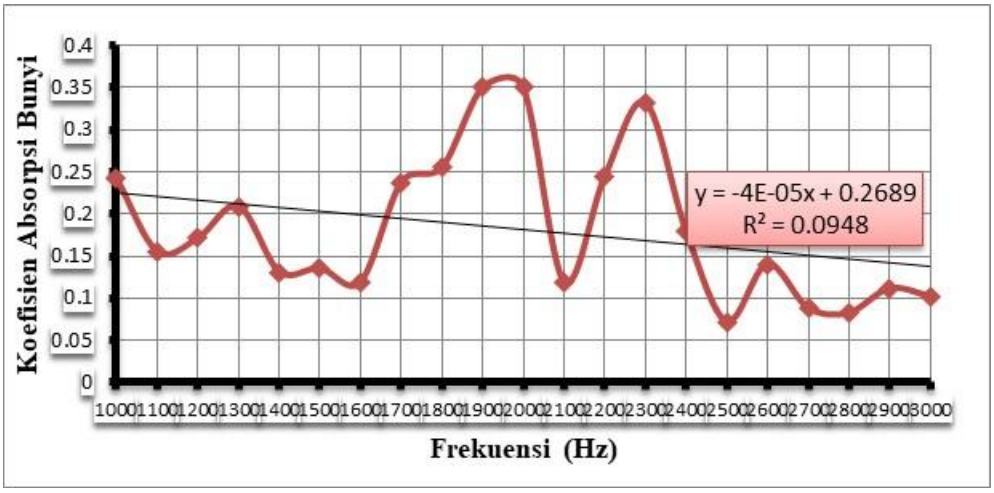

Figure 6. Graph of the Sound Absorption Coefficient Values for Transmission on Wooden Boards

Based on the data from the table of sound transmission absorption coefficient values above, the resulting graph for the 0.4 cm thick calcium board material is shown in Figure 7 as follows.

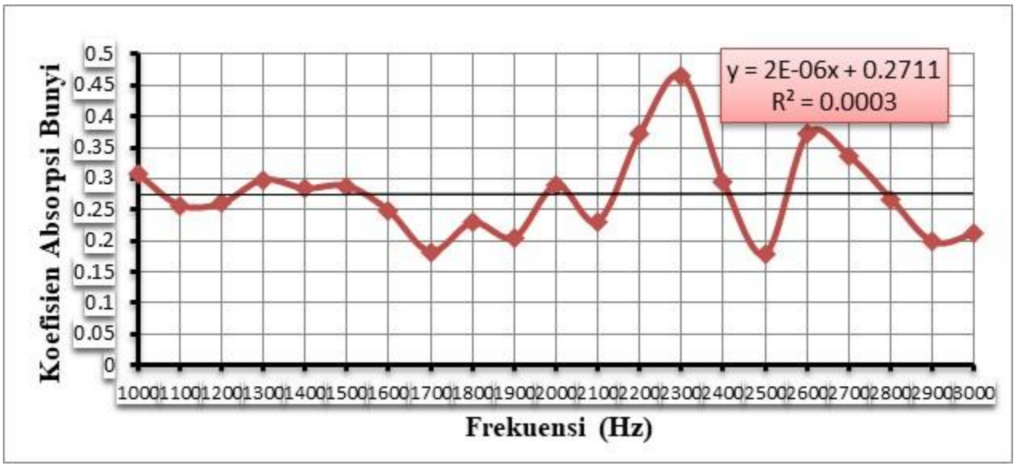

Figure 7. Graph of the Sound Absorption Coefficient Values of Transmission on Kalsiboard

Figure 7. Graph of the Sound Absorption Coefficient Values of Transmission on Kalsiboard The results of the study on the sound transmission absorption coefficient or the sound transmitted after passing through the material are presented in the form of graphs in Figures 5, 6, and 7. Based on the results of the graphs in Figures 5, 6, and 7, it can be seen that the graph showing the highest peak represents the highest sound absorption coefficient value, while the graph showing a decline represents the lowest sound absorption coefficient value in the transmitted sound results. The graph results in Figure 5 for the plywood material show the highest sound absorption coefficient value of 0.605 cm-1 at a frequency of 2200 Hz, while the lowest sound absorption coefficient value is 0.171 cm-1 at a frequency of 2600 Hz. The graph results in Figure 6 for the wooden board material show two peaks of the highest sound absorption coefficient values with the same value of 0.36 cm-1 at frequencies of 1900 Hz and 2000 Hz, while the lowest sound absorption coefficient value is 0.075 cm-1 at a frequency of 2500 Hz. The graph results in Figure 7 for the calcium board material show the highest sound transmission absorption coefficient value of 0.466 cm-1 at a frequency of 2300 Hz, while the lowest sound transmission absorption coefficient value is 0.172 cm-1 at a frequency of 2500 Hz.

The sound that is transmitted or the sound that is passed through a material does not transmit all the energy; some of the energy is absorbed. Based on the explanation of the sound transmission absorption coefficient values of the

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three materials, it can be seen that the material with the highest sound transmission absorption coefficient value is plywood. Meanwhile, the material with the lowest sound transmission absorption coefficient is wooden board.

Materials can be categorized as good sound-absorbing materials if the materials used have a sound absorption coefficient value of 0.15 cm-1 [1]. Based on the description, it can be stated that out of the 3 materials, namely plywood, wooden board, and calcium silicate board, the materials that can be categorized as sound-absorbing materials are plywood and calcium silicate board. The materials plywood and calcite-board have a minimum sound absorption coefficient value above 0.15 cm-1, and these two materials have the characteristic of being denser compared to wooden boards because wooden boards are slightly porous

Based on the concept of the relationship between the sound absorption coefficient and frequency, if the frequency value is high, the sound absorption coefficient value is low, and vice versa. This concept, when applied to this research, can be seen from the three forms of graphs and their analysis, where the lowest sound absorption coefficient values tend to occur at low frequencies and the highest sound absorption coefficient values tend to occur at high frequencies. Actually, if viewed as a whole, the magnitude of the sound absorption coefficient values on the graph does not align with the increase in frequency values, or it can be said that the sound absorption coefficient values are unrelated to their frequency values. This is likely influenced by the type of material used and also factors such as the testing location for the material, which is not adequate because it does not cover the entire material, and another factor is the equipment that has not been properly calibrated. The influence of external noise or sound also greatly affects the data collection process due to the nature of the SLM (sound level meter), which is very sensitive to external sounds or noises. Generally, the sound absorption coefficient will be optimal and tend to be high when exposed to lower frequency sounds, and conversely, the sound absorption coefficient will tend to be lower when exposed to higher frequency sounds. In this study, variations in thickness for each material were not used, so they do not affect the sound absorption coefficient value.

DISCUSSION

The sound that is transmitted or the sound that is passed through a material does not transmit all the energy; some of the energy is absorbed. Based on the explanation of the sound transmission absorption coefficient values of the three materials, it can be seen that the material with the highest sound transmission absorption coefficient value is plywood. Meanwhile, the material with the lowest sound transmission absorption coefficient is wooden board.

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