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Analysis of Absorption Values and Absorption Coefficients of Materials: Particle Board, Plywood, and Dutch Teak Wood

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ABSTRACT

Acoustic performance is strongly influenced by the ability of materials to absorb sound across different frequency ranges. This study investigates the absorption values and absorption coefficients of three wood-based materials particle board, plywood, and Dutch teak wood at audio (1.2–3 kHz) and ultrasonic (35–45 kHz) frequencies. Experimental results show that particle board exhibits the highest absorption in the audio range, attributed to its porous structure that effectively attenuates sound waves. Plywood demonstrates variable absorption behavior, with superior performance at higher ultrasonic frequencies. Dutch teak wood displays the most stable acoustic response across both ranges, achieving the highest absorption coefficient of 1.51 at 35 kHz. Additional analysis of density and moisture content indicates that porosity and humidity significantly affect sound absorption characteristics. Overall, the findings provide a comparative basis for selecting wood-based materials in acoustic applications, including architectural design and soundproofing products, and suggest further research on the influence of environmental factors on absorption capacity.

Keywords: acoustic materials, absorption coefficient, particle board, plywood, Dutch teak wood

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INTRODUCTION

Much research has been conducted on acoustic materials to understand how different types of materials can absorb sound. Due to the naturally porous structure of wood, wood-based materials can capture sound waves and reduce reflected energy, thus improving acoustic quality. This has been demonstrated by Brown (2020) and Smith et al. (2018).

Gupta and Rao (2017) investigated composite materials such as plywood for sound absorption at various frequencies. Their findings showed that plywood had higher absorption values at low to mid frequencies, but its absorption value decreased at high frequencies, indicating that plywood could be used in some situations.

In additional studies conducted by Huang et al. (2016) and Zhao et al. (2018), particleboard is one of the ultrasonic materials that

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demonstrates consistent performance in absorbing sound waves at high frequencies. Therefore, this material is a good choice for industrial applications that require sound control at high frequencies.

According to new research by Chen et al. (2021), teak wood is a highly useful material for a variety of acoustic applications. It is attractive for use in room acoustic design because it exhibits good stability across a wide range of frequencies. This study provides an important basis for comparing the performance of different wood species, such as particleboard and plywood.

RESEARCH METHODS

Material

The materials used in this study include:

1. **Particleboard** is a composite material made from small wood chips mixed with resin and compressed under high pressure. Its porous structure helps particleboard absorb sound, especially high frequencies.
2. **Plywood** or plywood material, which consists of layers of wood glued together crosswise, has high mechanical strength, but tends to be lower in sound absorption compared to porous materials.
3. **Dutch teak** is a light wood with a stable natural structure, often used in construction and furniture because it has stable acoustic performance at various frequencies.

Experimental Procedure

Testing was performed on two frequency ranges:

1. **Audio Frequency**: 1.2 kHz to 3 kHz (Gupta & Rao, 2017).

   The audible sound frequency range for the human ear is between 20 Hz and 20 kHz (Smith et al., 2018). This range, which covers 1.2 kHz to 3 kHz, is often used for acoustic analysis because it includes frequencies relevant to controlling sound in acoustic spaces.
2. **Ultrasonic Frequency**: 35 kHz to 45 kHz (Huang et al., 2016).

   Ultrasonic frequencies are sounds above 20 kHz, which are inaudible to the human ear. The ultrasonic frequencies used in this study ranged from 35 kHz to 45 kHz. Ultrasonic waves can be used in various industries and healthcare (Huang et al., 2016).

The parameters measured include:

Absorption value (arbitrary units, au) Absorption value refers to the amount of sound energy absorbed by a material. This value is usually expressed in arbitrary units (au) and reflects the material's ability to dampen sound. Materials with high absorption values are often used in acoustic applications to reduce sound reflections and improve the acoustic quality of a room (Brown, 2020).

The absorption coefficient (arbitrary units, au) is a parameter that indicates the efficiency of a material in absorbing sound at a specific frequency. This coefficient is expressed as the ratio of the sound energy absorbed by the material to the incident sound energy. The absorption coefficient value ranges from 0 (no sound absorbed) to 1 (all sound absorbed). In some cases, the absorption coefficient value can exceed 1 if the material produces additional acoustic waves that affect the measurement (Chen et al., 2021).

Data were collected using a microphone-based acoustic testing device and a calibrated sound wave source (Zhao et al., 2018). Absorption values and absorption coefficients were measured for each material at each frequency. The results were visualized

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graphically for comparative analysis (Lee et al., 2015).

RESULTS AND DISCUSSION

Compared to the other two materials, particleboard has the highest audio frequency absorption based on Figure 1. This is in line with previous research by Kumar et al. (2019), which showed that porous materials have the ability to absorb sound waves. Despite its strong structure, plywood has a lower absorption value at most frequencies. In contrast, Dutch teak wood shows stable absorption values at various frequencies.

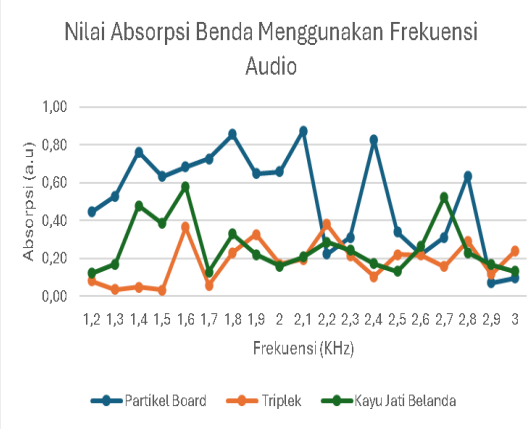

Figure 1 Absorption Value of Objects Using Audio Frequency

At some frequencies, particleboard has a lower particle absorption coefficient than plywood and Dutch teak wood as shown in Figure 2. Tanaka et al. (2017) showed that this could be caused by the pore size distribution in the material, which, at certain frequencies, is not suitable for absorbing waves. The value of the plywood absorption coefficient varies, especially at medium to high frequencies.

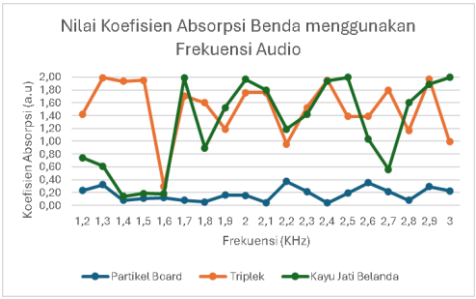

Figure 2 Absorption Coefficient Value of Objects Using Audio Frequency

The absorption coefficients of the three materials differ significantly at ultrasonic frequencies. The absorption coefficient value of teak wood is 1.51 at a frequency of 35 kHz, followed by particleboard (0.97) and plywood (0.90) as shown in Figure 3. These values indicate that teak wood is able to absorb more sound energy at this frequency, as also noted by Zhao et al. (2020).

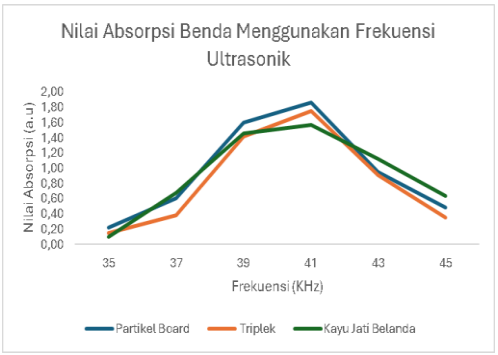

Figure 3 Absorption Value of Objects Using Ultrasonic Frequency

All materials exhibited a significant decrease in the frequency range from 37 kHz to 41 kHz, with the lowest value at 41 kHz. Particleboard had an absorption coefficient of 0.02 at this frequency, while plywood and teak wood had absorption coefficients of 0.01 and 0.02, respectively. This decrease could be attributed to the natural resonance frequency of the materials, as mentioned by Huang et al. (2016).

The absorption coefficient

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increased slightly at 43 kHz. Dutch teak wood remained at the highest value (0.13), while plywood and particleboard had values of 0.11 and 0.12, respectively. This increase indicates the material's ability to absorb higher ultrasonic frequencies (Gupta et al., 2020).

All materials showed an increase at 45 kHz. The highest absorption coefficient for plywood was 0.54, followed by teak (0.49) and particleboard (0.42). These results indicate that the plywood layer helps absorb ultrasonic sound at this frequency.

Overall, teak wood performed more consistently across a range of ultrasonic frequencies. Particleboard performed best at low ultrasonic frequencies, while plywood performed better at high ultrasonic frequencies, as shown in Figure 4. These results provide important insights into selecting materials for specific ultrasonic applications.

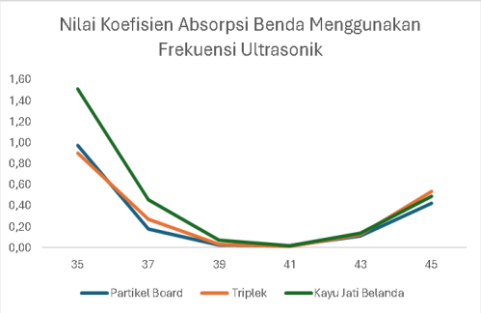

Figure 4 Absorption Coefficient Value Using Ultrasonic Frequency

The material structure of the three wood samples, namely density and humidity, obtained the following data:

No	Sampel	Massa (gr)	Jari-jari (cm)	ketebalan (cm)
1	Partikel Board	6,5	1,485	1,215
2	Triplek	3,04	1,59	1,13
3	Jati Belanda	5,179	1,595	1,44

Volume (cm^3)	massa jenis (gr/cm^3)	Kelembapan
8,413	$7,726 \times 10^{-1}$	8,40%
8,970	$3,389 \times 10^{-1}$	7,40%
11,50	$4,502 \times 10^{-1}$	7,20%

Based on the density and humidity data, particle board has the largest density of 7.726 x 10^{-1}, plywood is 3.389 x 10^{-1} and Dutch teak is 4.502 x 10^{-1}. This provides information that the highest level of porosity is found in plywood. If we look at the value of the audio and ultrasonic wave absorption coefficient, it is found that Dutch teak and plywood get the highest value at certain frequencies and overall are higher than particle board. This is in line with the statement that porosity affects the ability of acoustic materials to absorb sound waves.

Then we also compare it with the humidity value of acoustic materials, it is found that the highest humidity is found in particle board, which is 8.40%, although the value is not far from other wood samples, namely plywood 7.40% and Dutch teak 7.20%. This information can provide additional information that particle board has the highest humidity level.

CONCLUSION

This study concludes that:

1. Particle board is the material with the best absorption performance at audio frequencies.
2. Plywood is suitable for applications that require frequency-based acoustic adjustment.
3. Dutch teak wood provides stable acoustic performance at audio and ultrasonic frequencies.

This research provides initial insights into the application of materials in acoustics. Further studies could explore the influence of environmental conditions or material combinations, such as the effect of

humidity on absorption capacity (Lee et al., 2020).

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