JPPIPA 9(5) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Physical and Mechanical Characteristics Analysis of Partition Composite Board Made of Coconut Shell Material

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Received: February 17, 2023
Revised: May 18, 2023
Accepted: May 28, 2023
Published: May 31, 2023

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DOI: 10.29303/jppipa.v9i5.3221

Abstract: This research aims to examine the effect of the thickness of coconut shell composite board on elasticity, sound absorption, water absorption, and density. The elasticity test was conducted using the tensilon RTF2350 machine at the Faculty of Mechanical Engineering and the sound absorption test was conducted using the sound level meter GM1352 at the Faculty of Science and Mathematics of the State University of Yogyakarta. The thickness of the composite board was varied, and its elasticity was measured using the tensilon RTF2350 machine, the sound absorption measurement was determined using a sound level meter with a sound source from a sound generator with a frequency of 1000Hz and intensity of 20 dB, while the thickness was varied. The elastic modulus decreased with the increase in partition thickness, sound absorption decreased with the increase in partition thickness, and water absorption increased with the increase in partition thickness. Water absorption was determined by submerging the partition into distilled water for 30 seconds and observing the mass before and after immersion into the water.

Keywords: Coconut shell; Elasticity test; Polyvinyl acetate (PVAc); Sound absorption; Tapioca glue; Water content.

Introduction

The quality of partition boards is determined by many factors. The first factor is its elastic strength in facing pressure (Manurung et al., 2020; Sulardjaka et al., 2020; Widnyana et al., 2020). This elasticity indicates the level of difficulty of the partition not easily broken. The second is its ability to absorb sound, which shows the usefulness of the partition in reducing noise (Adwimurti et al., 2022; Salas-Ruiz et al., 2019). The third is its resistance to water or its ability to absorb water, as partition materials are generally hollow and porous (Hidanto & Mora, 2019).

There are also other factors such as water absorption and density. Partitions can be produced using different materials. Usually, the materials used in partitions are wood chips, as there is a large amount of wood waste from sawmills that can be utilized and has added value (Ayu & Kurniadi, 2019; Simanullang, 2021). The second is bamboo plants because of its abundant supply and relatively low price (Fadlurahman et al., 2022; Ihsan, 2019; Zuraida & Pratiwi, 2020). Partitions can also be made using coconut shells because they have been considered waste and are abundant. If this waste can be utilized, it will have added value (Hidanto & Mora, 2019; Sanjay et al., 2018; Sood et al., 2018).

Partition waste coconut shell is also a concern for many researchers because its usage is highly needed today (Ayu & Kurniadi. 2019). The use of partition is usually as a floor or wall coating. Partition is also used as a desk divider in offices and institutions such as schools and government. With the increasing number of offices and institutions, the need for partition also increases (Fuadi et al., 2022; Zhang et al., 2018; Balachandar et al., 2019). The abundance of partition needs is one of the goals of this research.

This paper reports the results of a study on the physical and mechanical properties of coconut shell-based partition boards. Previously, an elasticity test was

How to Cite:
Safana, M., Suparno, S., & Faresta, R.A. (2023). Physical and Mechanical Characteristics Analysis of Partition Composite Board Made of Coconut Shell Material. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2737–3743. https://doi.org/10.29303/jppipa.v9i5.3221

performed on the partition using the Tensilon RTF2350 tool to determine its resistance to pressure.

The sound absorption test was performed using a sound level meter GM1352 to determine its sound insulation ability. Based on these findings, a study was conducted on the physical and mechanical properties of coconut shell-based composite partition boards. The characteristics of the partition production are based on the Indonesian National Standard for composite materials (SNI 03-2105-2006).

Method

This type of research is a quantitative research to examine the effect of the thickness of coconut shell partition on the elasticity test, sound absorption, water absorption capacity, moisture content and density. The elasticity test was conducted in the Building Material Engineering Laboratory of the State University of Yogyakarta using the Tensilon RTF2350 testing tool. Coconut shell as the filler base, tapioca flour (Abral et al., 2018) and polyvinyl acetate PVAc as the binder. In this research, the comparison of materials was made, where the mass of the binder remained at 50 grams of tapioca flour, 10 grams of PVAc, and the mass of coconut shell powder changed to 50 grams, 100 grams, 150 grams, and 200 grams.

The samples in the research were divided into 4, namely in sample 1 with a size of 1:1, 50 grams of coconut shell powder obtained a thickness of 0.25 cm, sample 2 which was 1:2 100 grams of coconut shell powder with a thickness of 0.5 cm, sample 3 with a size of 1:3 150 grams of coconut shell powder with a thickness of 1 cm, and sample 4 with a size of 1:4 200 grams of coconut shell powder with a thickness of 1.5 cm. The mold used was 26 x 26 x 5 cm in size. The finished sample was then dried using sunlight for 3-4 days until it was dry and suitable for testing.

Figure 1. The Sample Mold

The Process of making this partition starts with melting the coconut shell into coconut powder, then weighed according to the size and comparison. On the other hand, the main binder uses 50 grams of tapioca flour, then pour 320 ml of water and stir until evenly mixed, then heat until it becomes dense. The dense tapioca flour glue is then mixed with the coconut shell powder, stirred until evenly mixed, then poured into the mold, then leveled, then given pressure and finally dried Baley et al., 2019).

The dried partition is then ready for testing, for tensile and bending tests, a 25 cm x 5 cm is used and printed according to the machine test standard. Then 5 cm x 5 cm is used for sound and water absorption tests. Density testing is conducted in dry air conditions and dry air volume, the sample measuring 5cm x 5cm is weighed and then the average length, width, and thickness are measured to determine its volume. The modulus of elasticity uses the following formula:

$$E = \frac{\sigma}{e} = \frac{\frac{F}{A}}{\frac{\Delta l}{l_0}} \quad (1)$$

With:
MOE : modulus of elasticity (kgf/cm^2)
σ : stress (N/m^2)
e : strain
F : force (N)
A : cross sectional-area (cm^2)
Δl : length increased (cm)
l_0 : first length (cm)

Water absorption is calculated using the following equation.

$$DSA = \frac{m_1 - m_2}{m_2} \; x \; 100\% \quad (2)$$

With:
DSA : water absorption (%)
m_1 : first mass of sample (gr)
m_2 : final mass of sample (gr)

For sound absorption, the following equation is used:

$$Sound\ Absorption = \frac{Incident\ sound - Reflected\ sound}{Incident\ sound} x100\% \quad (3)$$

The density of the composite particle board sample is calculated using the formula. The physical and mechanical properties test of the particle composite partition composite on density and MOE refers to the Indonesian National Standard 03-02105-2006 to determine its feasibility can be seen in the following Table 1.

$$\rho = \frac{m}{v} \quad (4)$$

With:
ρ : density (gr/cm^3)
m : mass (gr)
v : volume (cm^3)

Table 1. SNI Standard Composite Board

Physical and Mechanics Characteristic Composite Board	SNI 03-02105-2006
Density (gr/cm³)	0.5 – 0.9
MOE (kgf/ cm²)	Min 15000

As for water absorption and sound absorption capacity, they have not been specified in the Indonesian National Standard.

Results and Discusion

The physical and mechanical tests of the composite partition were conducted in accordance with the Indonesian National Standard 3-02105-2006 using 4 samples. The tests performed include the modulus of elasticity, sound absorption power, water absorption power, and density. The results obtained are shown in the Table 2.

Table 2. Composite Partition Testing Results

Sample	MOE (Kgf/cm²)	NOC (Hz)	Water absorption (%)	Density (gr/cm³)
1	23,924.4	90.5	0.25	3.2
2	6,808.6	90.1	0.5	1.75
3	6.538,4	89.8	0.6	1.12
4	1.133,4	88.7	0.7	0.82

Tensile Modulus of Elasticity (MOE) Test

There are 4 samples to be tested for Modulus of Elasticity, sample 1 with a thickness of 0.25 cm, sample 2 with a thickness of 0.5 cm, sample 3 with a thickness of 1 cm, and sample 4 with a thickness of 1.5 cm. Before the test is conducted, the sample is first formed according to the testing standard as shown in the following diagram.

Figure 2. Elasticity Testing Standard

The MOE test was conducted using the Tensilon RTF2350 device in the Mechanical Engineering Faculty Laboratory at State University of Yogyakarta, as shown in the following Figure 3.

Figure 3. The Tensilon RTF2350 Machine

The results of the elasticity tensile test are shown in the following figure, from right to left, respectively, sample 1, 2, 3, and 4.

Figure 4. Elasticity Testing Results

The results of the modulus of elasticity test are shown in the following figure from right to left are sample 1, 2, 3, and 4. The results obtained in the modulus of elasticity test are that sample 1 with a thickness of 0.25 cm obtained a MOE test result of 23.924.4 Kgf/cm2, then sample 2 with a thickness of 0.5 cm obtained a test result of 6.808.6 Kgf/cm2, then sample 3 obtained a test result of 6.538.4 Kgf/cm2 and sample 4 obtained a test result of 1.133.4 Kgf/cm2. From the results presented above, the following graph is obtained.

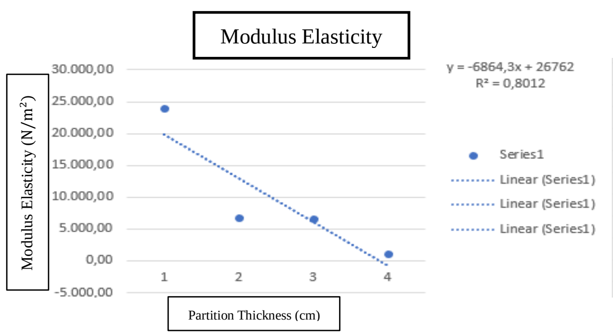

Figure 5. Graph of the Results of the Tensile Elasticity Test

The results of the test showed that the highest data generated was in sample 1 and the lowest in sample 4. The thicker the partition, the lower the tensile strength obtained and vice versa, the thinner the partition, the stronger the tensile strength obtained. This is because of the ratio of filler and adhesive, in sample 1 the ratio of filler and adhesive is 1:1, 50 grams of adhesive and 50 grams of coconut shell or filler, and in sample 4 is 1:4, 50 grams of adhesive and 200 grams of filler, so the elasticity level of sample 4 is lower. The results are in line with the research by (Hidanto & Mora, 2019) who found the results of tensile elasticity tests using coconut shell powder, where the thicker the composite and the more filler used, the tensile elasticity test results will decrease. On the other hand, (Judilla, 2021; Faria et al., 2020) showed that the higher the amount of coconut fibers, the stronger the modulus of elasticity will be. This is because resin was used as the adhesive.

The results of this study refer to SNI 03-02105-2006 for MOE testing with a minimum of 15000 Kgf/cm2. From the obtained data, it shows that only sample 1 meets the SNI, this is because the elasticity strength of sample 1 has a high tension in facing the traction compared to other samples.

Sound Absorption

The sound absorption test was carried out using a GM1352 sound level meter in the Wave and Sound Laboratory of the Faculty of Mathematics and Natural Sciences at State University of Yogyakarta, as shown in the following Figure 6.

Figure 6. Sound Level Meter GM1352

The measurement was carried out using a sound source from a speaker and a room measuring tool using a 5 cm diameter pipe with a length of 30 cm, as shown in the Figure 7.

Figure 7. Sound Measurement Process

The sound source uses 1000 Hz at the left end of the paralon and the sound level meter is located at the right end of the paralon, then the composite partition is placed 15 cm away from the sound source and sound measuring device. The measurement results obtained, in sample 1 with a thickness of 0.25 cm was able to absorb sound from 1000 Hz to 90.5 Hz, then in sample 2 with a thickness of 0.5 cm obtained a result of 90.1 Hz, sample 3 with a thickness of 1 cm obtained a result of 89.8 Hz and sample 4 with a thickness of 1.5 cm obtained a result of 88.7 Hz, resulting in the following graph of results.

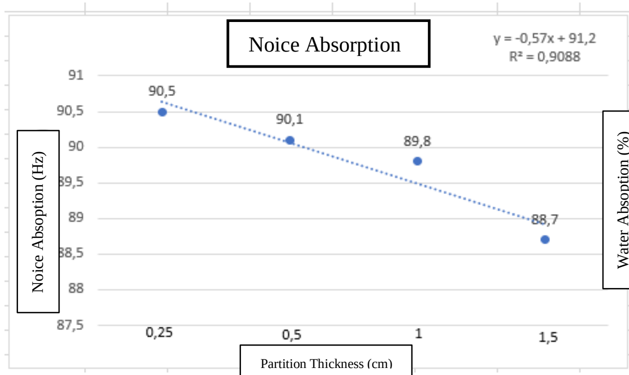

Figure 8. Sound Absorption Graphic

From these results, it can be concluded that the thicker the sample, the higher the sound insulation and vice versa. This is also due to the ratio of filler and binder samples, the thicker the high sample ratio, the weaker its binding power so that there are gaps in the sample that can effectively dampen sound, which is in line with the theory Said et al. (2019), that reveals that good partitions in sound absorption are those with pores and cavities and fiber because they have a sound absorption coefficient value. This research also coincides with Lestari et al. (2019) which revealed that the thicker the particle board, the better the sound insulation. Particle boards made from empty palm oil bunches and acacia have the potential to be sound insulation materials, especially for reducing noise in buildings or public facilities. Therefore, it can be said that the ability of partitions to effectively absorb sound is especially in enclosed spaces.

Water Absorption

The water absorption test was conducted at the Physics Laboratory of Yogyakarta State University. The water absorption was tested using 830 liters of aquades liquid. First, each sample was weighed to see the weight of the sample before treatment. The first sample had a weight of 20 grams and then was placed into the prepared aquades liquid. The sample was then soaked for 30 seconds. After soaking, the sample was lifted and weighed again. The weight produced in the first sample after soaking was 27 grams. Then, each sample was given the same treatment. The second sample had an initial weight of 22 grams and then weighed 47 grams after soaking.

The third sample had an initial weight of 28 grams and the result obtained after soaking was 78 grams. Then, the last sample had a weight of 31 grams and obtained a result after soaking of 107 grams. The results above then performed calculations to obtain the water absorption results using the water absorption equation above. So that the calculation of water absorption is obtained. In sample 1 with a thickness of 0.25 cm, the water absorption obtained was 0.25%. Then, in sample 2 with a thickness of 0.5 cm, the water absorption was 0.5%. Sample 3 with a thickness of 1 cm obtained a water absorption result of 0.6%. Then, sample 4 with a thickness of 1.5 cm obtained a water absorption of 0.7%. From these results, the following graph was obtained, as shown in the figure 9.

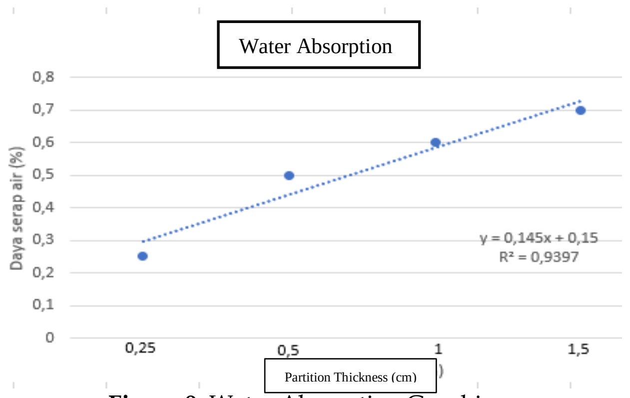

Figure 9. Water Absorption Graphic

From the graph above it can be concluded that the thicker the insulation, the greater the water that can be absorbed. This is also influenced by the ratio of adhesive to the coconut shell used. The thicker the insulation, the more air cavities that are in the partition so that the ability to muffle sound is better.

Density

Each sample was measured for its length, width and height to determine its volume and then weighed to determine its mass. This density test is carried out using the density equation above where the equation is used to find the partition density. The partition density can be obtained by dividing the mass of the partition and the volume of the partition. The highest bulkhead density was found in sample 1 with a density of 3.2 gr/cm3 and the lowest density was in sample 4, namely 0.82 gr/cm3.

From the graph above the insulation density decreases with increasing thickness. This is influenced by the ratio of glue and coconut shells used. The more coconut shells used, the lower the density because the amount of glue used is controlled or corrected so that the more coconut shells the adhesive will be looser and produce air voids in it. This research is in line with research Irfandi (2018) and Ayu & Kurniadi (2019) which reported that the density produced had reached the desired standard density of 0.8 gr/cm3. The more coconut shells used, the higher the resulting density. This shows that the distribution of Coconut Shell Flour is quite dominant so that there is reinforcement in the particle board which causes differences in density. This research refers to the SNI 03-02105-2006 standard that ranges between 0.5-0.9 gr/cm3. The results of the research showed that the partition density meets the SNI.

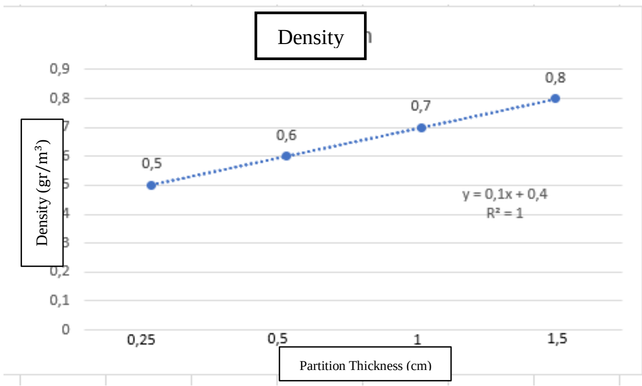

Figure 10. Density Graphic

Conclusion

Based on the established research results, it can be concluded that the thickness of partitions affects the physical and mechanical tests of coconut shells. In addition, the influence of the ratio of binder and filler materials also affects the results of the physical and mechanical tests of the partition board, this also affects the thickness of the material. The more coconut shells that are used, the thicker the partition will be. From the tests above, coconut shell particle boards can be used as partitions with good strength, good sound absorption capabilities and low water absorption, and have a good density that meets SNI 03-02105-2006.

Acknowledgement

I would like to thank my friends who helped run this research to completion.

Author Contributions

In this study, the authors made different contributions, including conceptual analysis carried out by authors 1 and 2, data collection was carried out by author 1, and paper writing was carried out by authors 1 and 3.

Funding

This research received no external funding

Conflicts of Interest

Interest in the publication of the Electrodynamics course

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