Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram
https://e-journal.undikma.ac.id/index.php/prismasains/index
e-mail: prismasains.pkpsm@gmail.com

October 2024. Vol. 12, No. 4
p-ISSN: 2338-4530
e-ISSN: 2540-7899
pp. 665-676

The Potential of Light Brick from Plywood Industrial Waste as Sound-Absorbing Construction Material

[a]Noer Af'idah, [a]*Andri Wahyu Wijayadi, [b]Elly Indahwati
[a]Science Education Department, Faculty of Science Education, [b]Electrical Engineering Department, Faculty of Engineering, Hasyim Asy'ari University, Tebuireng Jombang, East Java 61471, Indonesia

*Corresponding Author e-mail: diaandri@gmail.com

Received: July 2024; Revised: October 2024; Published: October 2024

Abstract

This research aims to examine the potential of light bricks made from plywood industry waste as a construction material with sound-dampening capabilities. Plywood sawdust waste was chosen as a mixing material due to its abundant availability and its lightweight and porous characteristics, which are expected to enhance the acoustic performance of the bricks. In this study, variations in the composition of plywood powder in bricks were made with the aim of evaluating its effect on physical, mechanical, and acoustic properties. The materials needed for this research are sand, cement, water, and plywood powder. The process of mixing and molding the bricks is done manually. Bricks are dried for 28 days to ensure the mechanical strength and stability of the bricks. Testing was conducted to evaluate physical properties through mass measurement and density testing, mechanical properties through compressive strength testing, and acoustic properties through sound absorption coefficient testing at various frequencies. The research results show that the addition of plywood powder significantly affects the reduction of brick density, making it lighter compared to conventional bricks. Based on the compressive strength test results, it is known that the addition of plywood powder has reduced the compressive strength value of the brick. However, bricks with an additional 10% and 20% volume of plywood powder still meet the minimum compressive strength requirements based on SNI 03-0349-1989. Meanwhile, the results of the sound absorption coefficient test indicate that the increase in the sound absorption coefficient is not significant, presumably due to the structural properties of the bricks that still require porosity optimization. In conclusion, lightt bricks with plywood powder filler have the potential to be environmentally friendly and lightweight construction materials, but they require improvement in optimizing sound absorption for more specific applications in buildings with acoustic insulation needs.

Keywords: Light Brick, Plywood Waste, Sound Absorbing Material

How to Cite: Af'idah, N., Wijayadi, A., & Indahwati, E. (2024). The Potential of Light Brick from Plywood Industrial Waste as Sound-Absorbing Construction Material. *Prisma Sains : Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram, 12*(4), 665-676. doi:https://doi.org/10.33394/j-ps.v12i4.13016

https://doi.org/10.33394/j-ps.v12i4.13016

INTRODUCTION

The plywood industry in Indonesia has experienced very rapid development in the past few decades. In the production of plywood, the emergence of waste is unavoidable. Almost every plywood production process contributes to waste generation with varying amounts and characteristics (Purwanto, 2009); (Subari et al., 2012). Plywood industry waste consists of wood remnants that are economically considered worthless in a specific process, time, and place. However, this material can still be utilized in different processes, times, and places. (Mintarsih, 2006). Purwanto (2009) in his research mentioned that the amount of waste produced by the plywood industry on average per year can reach 54.81% of the raw materials used. The waste can consist of dolok pieces, dolok peel scraps, wet veneer, dry veneer, plywood edge trimmings, sawdust, and plywood dust. So far, the waste produced by the plywood industry has not been utilized to its full potential. Until now, its utilization has only been as firewood or handicrafts, but in limited quantities. Because the waste is increasing and piling up, it is causing problems for the company and the environment, especially those near the industry.

On the other hand, the rapid growth of the construction industry has spurred an increasing demand for environmentally friendly, efficient building materials with special capabilities, such as soundproofing. One of the materials widely used in construction is bricks, due to their advantages in terms of ease of production, low cost, and mechanical stability. However, conventional bricks still have limitations, especially in terms of specific gravity and their ability to dampen sound. Therefore, the development of light bricks with sound-dampening capabilities has become a relevant topic in addressing the needs of modern construction, particularly for dense and noisy urban areas. (Setyawan&Mulyadi, 2018). Actually, several studies have been conducted on light bricks by adding mixed materials that can reduce the weight per cubic meter of the produced bricks (Afidah et al., 2020); (Masthura et al., 2021); (Simanjuntak, 2011); (Nugroho&Susilowati, 2023). Light bricks are a form of engineered material from regular bricks by adding certain mixed materials, so that they can produce bricks with a smaller mass than regular bricks. In the production of light bricks, materials with a low specific gravity are used, one of which is natural fiber materials. Some natural fiber materials commonly added in the production of light bricks include fly ash, wood powder, corn husk powder, coconut coir, rice husk, and others. (Annisa, 2022).

Plywood industry waste is one of the largest waste sources in the wood and furniture industry sector (Kurniawan&Sari, 2020). Plywood industry waste is often not utilized optimally and only becomes environmental pollution. In the perspective of the circular economy and the concept of sustainability, the use of this waste as an alternative raw material in the production of bricks is a potential solution (Wulandari&Prasetyo, 2019). Plywood industry waste in the form of powder has lightweight and porous properties, so it is expected to reduce the specific gravity of bricks and improve sound insulation properties by forming a porous microstructure that effectively dampens sound waves. (Rahman&Ismail, 2017). Wood waste is essentially organic waste that is easily decomposed by microorganisms. However, if this waste is in large quantities and not handled properly, it will certainly have a negative impact on humans and the surrounding environment. The easiest way to handle plywood waste is by burning it, but this solution will create a new environmental problem, namely air pollution. Therefore, an appropriate solution is needed to address this issue. The application of appropriate technology is needed as an alternative solution to a problem (Sujarwata & Sarwi, 2006); (Af'idah et al., 2020).

One of the problems that currently occurs is that buildings located along the highway, in the city center, or near industries are highly susceptible to noise. Noise caused by loud or continuous sounds can lead to disturbances in the human auditory system. Even gradually, if this noise is left unchecked, it will impact human psychological disturbances, such as difficulty sleeping and loss of concentration. One of the best ways to reduce noise is by constructing buildings or rooms using soundproofing materials (Butar, 2018).

Wood is one of the natural organic materials that has the potential to be used as a soundproofing material. Plywood industry waste processed into powder form can be utilized as a filler in the synthesis of lightweight bricks. Because the filler material is natural fiber, the resulting lightweight bricks fall into the category of biocomposites (Af'idah, 2020). Composite is a combination of matrix and filler. The main material in a composite is called the matrix, and the other materials are referred to as fillers, reinforcements, or fillers, which can be in the form of fibers, sheets, or particles (Annisa, 2022); (Pratama et al; 2014).

Research on the use of plywood industry waste in light bricks has not been extensively conducted, especially regarding its potential as a sound-damping material. Therefore, it is important to explore how the composition of plywood wood powder affects the physical and acoustic properties of bricks (Nurcahyo, 2021). Thus, this research will evaluate the potential of light bricks that utilize plywood industry waste as a building material that is not only environmentally friendly but also has better soundproofing characteristics compared to conventional bricks. (Suryani&Harahap, 2020). In addition, this research also supports industrial waste management efforts with a waste-based material approach, while simultaneously addressing the needs of modern construction that is efficient and environmentally friendly. (Widiastuti&Puspitasari, 2019).

Based on the above description, the researcher attempts to provide an alternative solution by utilizing wood waste produced by the plywood industry as a filler in the synthesis of sound-dampening light bricks. This study aims to determine the potential of plywood waste as a filler in sound-dampening light bricks. Through this study, it is hoped that light bricks made from plywood waste can provide an innovative solution in the construction industry with dual benefits, namely minimizing the environmental impact of plywood waste and producing lightweigh, economical building materials with sound-dampening capabilities (Hasibuan&Fauzi, 2021). In this study, plywood industry waste was processed into wood powder with a size of approximately 2.0-2.5 mm using a wood chipper machine. The production of bricks is done manually. The bricks that have been made are then tested for physical properties through density tests, mechanical properties through compressive strength tests, and sound absorption through absorption coefficient tests.

METHOD

This research was conducted to evaluate the potential of light bricks made by utilizing wood dust waste from the plywood industry as a sound-dampening construction material. This research uses an experimental method based on previous research titled "Pemanfaatan Limbah Serbuk Gergaji Kayu Sebagai Substitusi Campuran Bata Ringan Kedap Suara" (Purba et al; 2017). However, in this study, the plywood industry waste is still in the form of irregular sheets, so it will be ground with a wood grinder until it becomes fine powder, which will then be used as a filler material for light bricks. The research method applied includes several stages, namely material preparation, sample creation, physical and mechanical property testing, and acoustic testing. This research design uses a laboratory experimental method with systematically controlled and measured variables. Here are the complete steps:

Raw Material Preparation

The materials needed are cement as the main binding agent, fine aggregate in the form of sand as a filler, and plywood powder as a filler in various composition variations, and water. Meanwhile, the tools needed for this research are a digital scale, beaker, measuring cup, sieve, bucket, trowel, brick mold, wood chipper, Newton spring scale, stand, oven, 1 set of compression testing equipment, and 1 set of sound absorption testing equipment.

Plywood waste is ground using a wood chopper machine, then the wood powder is sieved first to obtain uniform particle sizes, resulting in fine wood powder with a size of about 2.0 – 2.5 mm. The utilization of this wood waste aims to reduce the use of conventional fine aggregates and to provide lighter and more porous characteristics to the bricks (Kurniawan & Sari, 2020; Wulandari&Prasetyo, 2019).

Making Brick Samples

Bricks are made with various compositions of plywood powder mixed with cement and fine aggregate. The composition of plywood powder varies between 0%, 10%, 20%, and 30% of the total aggregate volume to observe its effect on the physical, mechanical, and acoustic properties of the bricks. The selection of plywood powder composition in this study is based on the consideration of the physical properties of plywood material, which is lightweight, porous, and has the potential to enhance sound absorption. The addition of plywood wood powder aims to reduce the density of the concrete blocks, resulting in a lighter material. Higher compositions such as 10%, 20%, and 30% were chosen to evaluate the extent to which weight reduction can be achieved without compromising structural strength. Plywood powder has a porous structure that is expected to enhance sound absorption. With variations in composition (10%, 20%, and 30%), it is hoped that an optimal balance can be found between increased sound damping and reduced compressive strength. Although plywood powder increases porosity, it can also reduce the mechanical strength of the bricks. Therefore, different compositions are explored to find the optimal balance between enhancing the acoustic properties and the structural durability of the material. The variations in the composition of the materials used to make the bricks can be seen in Table 1.

Table 1. Variations in composition of bricks

Sample Code	Cement (% Vol)	Sand (% Vol)	Plywood Powder (% Vol)
A	20	80	0
B	20	70	10
C	20	60	20
D	20	50	30

Sample preparation is carried out by mixing wood powder, cement, sand, and water. After being thoroughly mixed, the process of molding and pressing the bricks is carried out using the solid method. The brick mold used in this study measures 31 cm x 10 cm x 15 cm. The process of heating the brick samples utilizes solar heat for 28 days. In the production of these concrete bricks, composite technology is used, which is the technique of mixing or combining two or more types of materials for a specific purpose. The objective of this research is to produce a composite product in the form of light bricks that possess good mechanical properties and sound absorption capabilities.

Characterization of Physical, Mechanical, and Sound Damping Properties

The characterization of physical properties (density), mechanical properties (compressive strength test), and sound damping properties is conducted after the brick samples are dried for 28 days.

Density Testing

Density testing is carried out with the following steps:

1) The hardened samples (28 days of heating) are placed in an oven at 105±5 °C for 1 hour.
2) The dried samples are weighed using a digital scale (ms).
3) After weighing, the samples are soaked for 1 hour to maximize the water penetration process. Once the water penetration process is achieved, the samples are wiped with a cloth and then weighed (mb).
4) The samples are suspended in water and then the sample mass is measured with the hanging mass (mg).
5) After the samples are removed from the hanging string, the hanging mass is weighed. (mk). Next, the density of the sample can be calculated using the Archimedes method according to the ASTM C 134-95 standard. (Simanjuntak, 2011).

Compressive Strength Testing

The compressive strength of a material is the ratio of the maximum load it can withstand to the cross-sectional area of the material experiencing the force. For the measurement of the compressive strength of bricks, refer to the ASTM C 133-97 standard. (Simanjuntak, 2011). The compressive strength test is conducted with the following steps:

1) The sample is shaped into a cylinder and its diameter is measured.
2) Then, the power supply is set to 40 volts, which functions to move the UTM up and down.
3) The sample is placed exactly in the center of the force applicator, then the loading speed is set to 2mm/min, and the ON switch is pressed, causing the loading to automatically move downwards.

4) After the light brick breaks, then record the magnitude of the force displayed on the screen.

Sound Absorption Testing

Sound absorption testing is conducted to determine the absorption coefficient (sound damping) value of each light brick sample. The sound absorption test procedure is conducted based on the ASTM E1050-98 standard using equipment in the form of a two-microphone impedance tube. The following are the steps for the sound absorption test:

1) The brick sample is placed at one end of the impedance tube.
2) Sound waves are generated at various frequencies ranging from 0-1600 Hz.
3) The microphone located inside the tube measures the sound reflected by the sample.
4) The absorption coefficient is calculated as the ratio between the intensity of the sound absorbed by the concrete block and the intensity of the sound hitting the surface of the brick, expressed in a value ranging from 0 (no sound absorbed) to 1 (all sound absorbed) (Rahman & Ismail, 2017). (Nurcahyo, 2021).

The flowchart of this research can be seen in the following Figure 1.

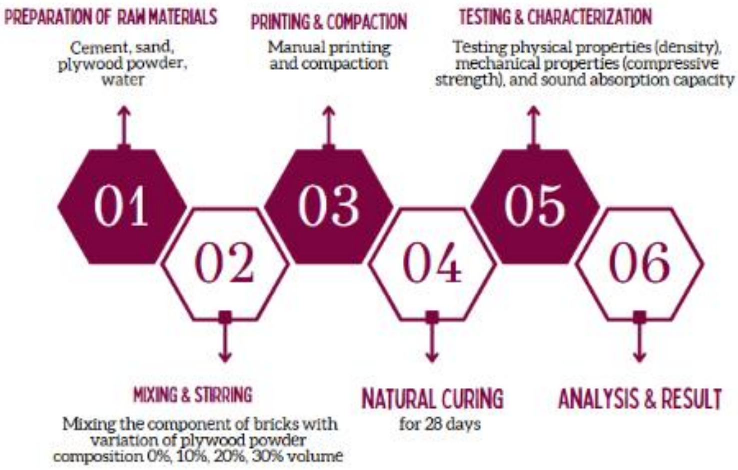

Figure 1. The flowchart of this research

RESULTS AND DISCUSSION

The following is the data from the weighing of the mass of the bricks after drying for 28 days, as shown in Table 2. From the results of the weighing of the bricks, it is known that the addition of the volume of plywood powder can reduce the total mass of the produced bricks. This aligns with the statement by Purba & Lubis (2017) that the addition of wood powder in the production of bricks can reduce the total mass of the resulting bricks. Figure 2 shows the graph of the relationship between the % volume of plywood powder added in the production of bricks and the mass of the bricks after being dried for 28 days. The bricks were weighed using a digital scale. From Figure 2, it can be seen that the mass of the bricks decreases as the volume of plywood powder used increases. In other words, the more plywood powder is used, the lighter the resulting bricks will be. This can be caused by several factors:

1) The lightness of plywood dust compared to conventional sand aggregate can reduce the total mass of the brick.
2) The pores in the plywood dust contribute to the mass reduction because this dust decreases the density of the mixture.

The mass reduction in bricks with plywood powder can reach about 10–20% more than the mass of conventional bricks. This reduction demonstrates the potential of this material in reducing structural load, which has implications for energy efficiency in construction as well as ease of transportation and installation of the material.

Table 2. The mass of bricks was measured after drying for 28 days

Sample Code	Mass (Kg)
A	8,34
B	7,45
C	6,75
D	6,56

The characterization of the physical properties of the bricks was further conducted to determine the effect of adding the volume of plywood powder on the density value of the bricks. Measurement of the density value of bricks using Archimedes' principle (Syahrun et al; 2019). The following Figure 3 shows that the greater the % volume of plywood powder used in the production of bricks, the lower the density value of the resulting bricks. From Table 3, it can be seen that block D has the lowest density value of 1,41 grams/cm³. Wood is a material that has many pores and a very low density, much lower than the density of sand and cement (Setyoningrum et al; 2023).

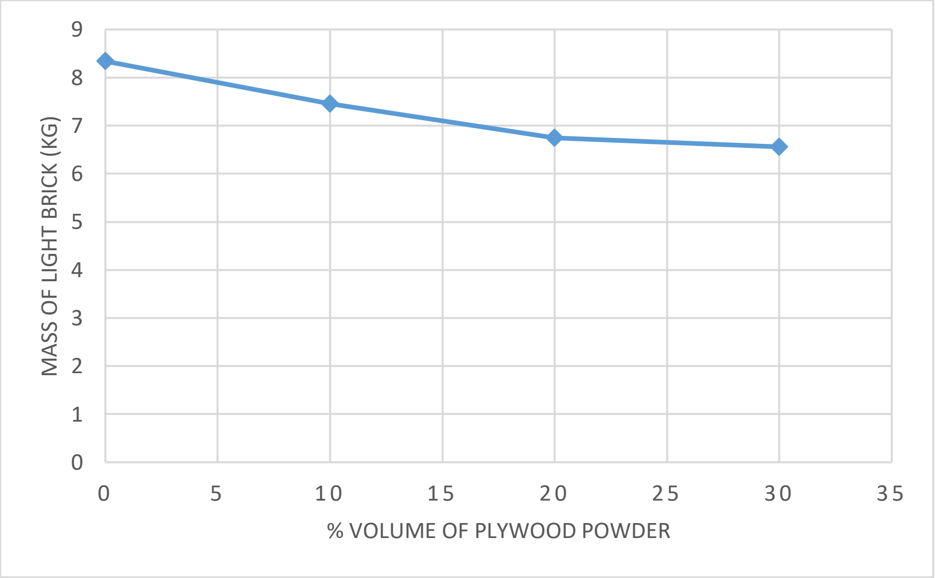

Figure 2. The relationship between the % volume of plywood powder and the mass of bricks.

The addition of plywood powder in the production of bricks causes the density value of the bricks to decrease. This is in line with the research conducted by Hartono (2020); (Hami et al; 2021); (Hadi, 2014) that the addition of wood powder composition can reduce the density value of the resulting bricks. The density of the brick is calculated based on the ratio between the mass of the brick and its volume. The results show that the increase in the composition of plywood powder consistently reduces the density of the bricks. The decrease in density occurs because:

1) Plywood powder creates porosity in the brick mixture, reducing the solid volume without increasing the material mass.
2) The substitution of fine aggregates with plywood powder also adds a hollow property that contributes to the overall reduction in density.

Table 3. The density of bricks

Sample Code	Density (gram/cm3)
A	1,87
B	1,66
C	1,53
D	1,41

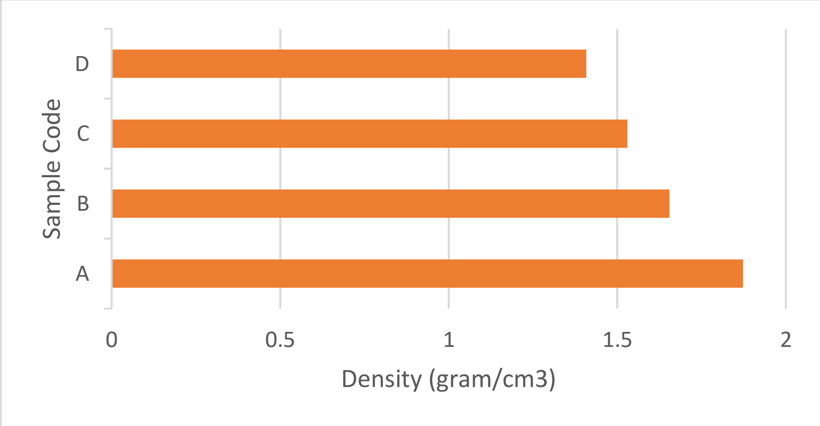

Figure 3. The bricks density of any varian sample

The characterization of the mechanical properties of bricks is obtained by conducting compressive strength tests. The compressive strength testing of concrete bricks was conducted at the Material Innovation Laboratory of the Materials Engineering Institute of Sepuluh Nopember Institute of Technology. This test was conducted to determine the effect of adding plywood powder in the production of light bricks on compressive strength. The compressive strength test of the bricks is conducted after the drying process of the bricks for 28 days. The following Figure 4 shows the results of the compressive strength test on several variations of brick samples. From the image, it can be seen that the compressive strength of the brick decreases as the percentage of plywood powder added increases. The minimum compressive strength of the bricks is 19.8 Kg/cm^2 in the sample with an addition of 30% plywood powder. This aligns with the research on "Mechanical Testing of Bricks with the Addition of Teak Wood Sawdust (Tectona Grandis)," which indicates that the addition of teak wood sawdust reduces the compressive strength and impact strength of the resulting bricks (Masthura et al; 2021). Similarly, the research results of Sujatmiko (2016) indicate a decrease in the compressive strength of concrete bricks with the addition of sawdust up to 30% of the weight of the cement, with an average of 62.61 kg/cm^2, which falls into quality category III according to SNI 03-0349-1989. From the results of the compressive strength test presented in Table 4, it can be seen that samples A, B, and C have met the minimum compressive strength requirements based on SNI 03-0349-1989, which is 21 kg/cm^2. Meanwhile, sample D does not meet the requirements.

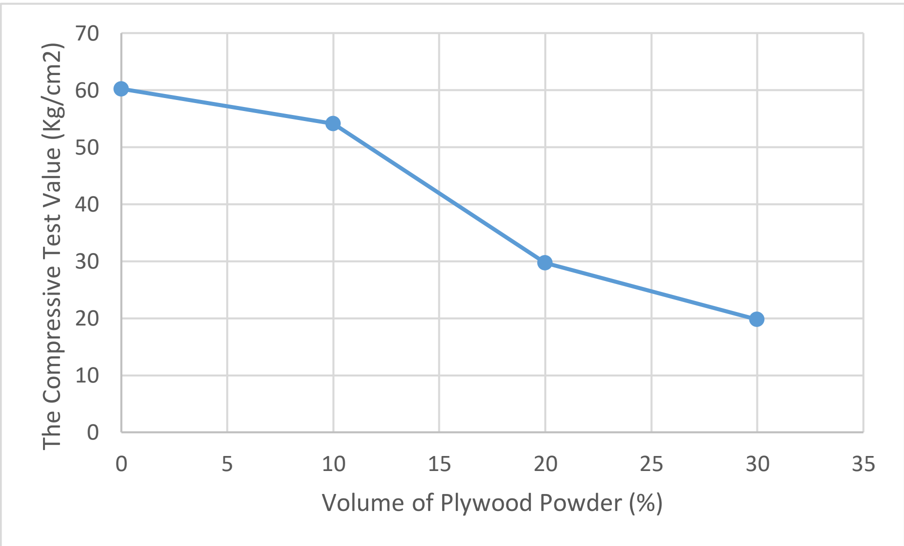

Figure 4. The compressive strength test value of bricks at various volumes of plywood powder

Table 4. The compressive test value of bricks

Sample Code	Compressive Test (Kg/cm^2)
A	60,2
B	54,1
C	28,8
D	19,8

The addition of plywood powder to concrete blocks directly affects the mechanical strength, especially compressive strength, due to the physical properties of wood powder being different from conventional aggregates. Plywood powder has a lower density and a porous structure, which tends to reduce the compactness of the mixed material and form micro-cavities within the bricks. Here is the observed relationship between the increase in the volume of plywood powder and the decrease in compressive strength in concrete bricks:

1) Decrease in Material Density

As the volume of plywood powder in the brick mixture increases, the concrete bricks become lighter due to the reduction in the content of fine aggregates (such as sand) which have a higher density. The lightweight and porous nature of plywood powder causes the overall density of the bricks to decrease. This reduction in density, while beneficial in producing lightweight material, significantly reduces the compressive strength because the material is not as dense as when using fully solid aggregates.

2) Formation of Porous Structure

The addition of plywood powder increases the porosity of the brick material, as the wood powder tends to form small air spaces between the particles. The higher the volume of plywood powder, the larger the pores or cavities that form inside the bricks. These voids reduce compressive strength because the contact area between particles decreases, making the ability of the bricks to withstand pressure or load weaker compared to bricks with full aggregate.

3) Decrease in Intermatrix Bonding Strength

The binder material in the brick mixture, such as cement, experiences a decrease in effectiveness in binding particles in bricks that contain a higher volume of plywood powder. This is due to the natural properties of wood, which is hydrophobic and not as compact as sand or other aggregates. As the volume of wood powder increases, the bond between particles in the brick becomes weaker, resulting in an overall reduction in compressive strength.

4) Optimal Composition for Compressive Strength and Lightweight

Several studies have shown that although the increase in plywood powder reduces the compressive strength of the bricks, there is an optimal composition where the reduction in compressive strength is not too significant but the weight remains light. According to the study by Rahman & Ismail (2017), the use of plywood powder at a composition of around 5-10% can maintain compressive strength that is still acceptable for non-structural use. The use of plywood powder exceeding 15% shows a drastic decrease in compressive strength, thereby reducing its reliability as a construction material. However, the results of this study show that the compressive strength of the bricks with the addition of plywood powder at a composition of 10-20% still meets the SNI 03-0349-1989 standard.

Sound absorption testing was conducted in the Iwany Acoustic Research Group (iARG) laboratory of the Physics Study Program at Sebelas Maret University. Testing was conducted to determine the sound absorption coefficient value of each light bricks sample. The sound absorption testing procedure was carried out in accordance with the ASTM E1050-98 standard using equipment consisting of an impedance tube with two microphones. The following Figure 5 shows the schematic of the sound damping test device.

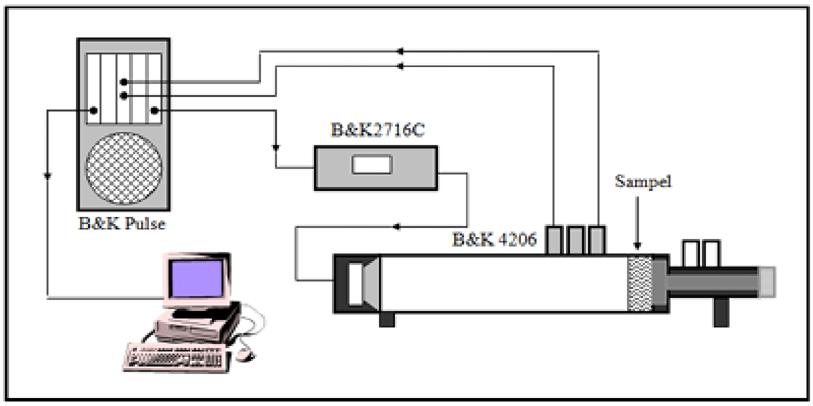

Figure 5. Schematic of the sound damping test device based on ASTM E1050-98

The purpose of sound absorption testing is to determine a material's ability to absorb sound waves. The quality of soundproofing material is determined by the price α. (material sound absorption coeffition). The larger the value of α, the better the material's ability to absorb sound. The value of α ranges from 0 to 1. If α is 0, then no sound is absorbed by the material, while if α is 1, then 100% of the incoming sound is absorbed by the material (Fatkhurrohman&Supriyadi, 2013); (Lindawati et al; 2019); (Puspitarini et al; 2014); (Risandi &Elvaswer, 2017); (Royani et al; 2014);. The following Figure 6 shows the sound absorption coefficient values in the frequency range of 0-1600 Hz. From Figure 6, it can be seen that sample A has the smallest absorption coefficient value, while sample D, with an increase of 30% in plywood powder volume, has the largest absorption coefficient value. This is in line with the research conducted by Purba, Irwan, and Nurmaidah (2017) which indicates that the sound absorption coefficient values show an increasing trend with each addition of wood powder variation.

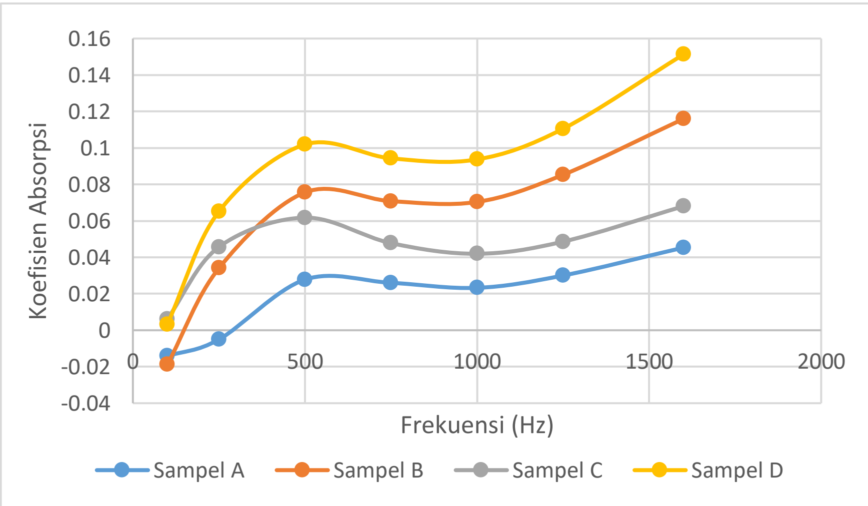

Figure 6. The relationship between the absorption coefficient and frequency at any variants of brick samples.

The addition of plywood powder as a filler in light brick has the potential to enhance the bricks' sound-dampening capabilities. This is due to the characteristics of plywood powder that can increase the porosity of the material, thereby providing more space to absorb sound energy. The relationship between the volume of plywood powder and the soundproofing ability of the brick can be explained through the following mechanisms:

1) Increased Material Porosity

By adding plywood powder to the brick mixture, the structure of the brick becomes more porous compared to brick without organic materials. These pores function as spaces that allow sound waves to be absorbed and diffused, thereby reducing the intensity of the reflected sound.

Materials with high porosity, such as those produced with a sufficient volume of plywood powder, are known to have better sound-damping capabilities due to the presence of spaces to impede and absorb sound waves. (Rahman & Ismail, 2017).

2) The Effect of Plywood Powder as a Hollow Material

Plywood powder has a hollow structure that can inhibit sound propagation. When sound hits the surface of a brick containing plywood powder, the sound energy will be absorbed by the wood fibers and the cavities formed within the material. As the volume of plywood powder increases, the number of cavities also increases, allowing for an improvement in the sound absorption coefficient. However, it should be noted that an excessive amount of plywood dust can weaken the physical structure of the bricks, so a balance must be maintained in the addition of wood dust volume. (Setyawan & Mulyadi, 2018).

3) Improvement of Sound Absorption through the Acoustic Properties of Plywood Powder

Wood materials, such as plywood powder, have natural acoustic properties that can absorb sound, especially at low to mid frequencies. The more plywood powder in the brick mixture, the greater the block's ability to dampen sound through internal absorption produced by the wood fibers. According to Wulandari and Prasetyo (2019), materials containing organic compositions can dampen sound more effectively due to the properties of wood fibers that absorb sound energy instead of reflecting it back.

4) The Influence of Optimal Plywood Powder Composition on Sound Damping Ability

Although increasing the volume of plywood powder can enhance the sound damping ability of bricks, there is an optimal limit that must be considered. An increase in plywood powder by more than 20% can reduce the structural strength of the brick Kurniawan & Sari (2020), a composition of 10-12% plywood powder showed the best results, with a fairly good sound dampening ability without compromising the physical strength of the bricks. Therefore, the proper composition of plywood powder needs to be considered to achieve optimal acoustic performance while maintaining adequate mechanical properties.

CONCLUSION

This research successfully demonstrated that the addition of plywood powder to light bricks not only enhances the material's sound-dampening capabilities but also has the potential to be a sustainable and environmentally friendly construction solution. As a material that combines lightweight characteristics and acoustic properties, bricks with plywood powder have wide practical applications in the construction field, especially in buildings that require sound insulation, such as office buildings, hospitals, educational facilities, and industrial areas. In addition, its lightweight can reduce the overall structural load, which is very useful in high-rise construction and in areas with seismic risk, where materials with lighter mass are preferred for safety and ease of transportation. The application of light bricks made from plywood powder also integrates the principles of a circular economy through the use of wood waste from the plywood industry, reducing dependence on limited natural raw materials and minimizing environmental impact from wood industry waste. By processing this waste into high-value construction materials, this approach supports global efforts in more efficient waste management and promotes a sustainable economy.

RECOMMENDATION

In this research, compaction was done manually. For the compaction of samples in future research, it is recommended to use a pressing machine to make the bricks denser. Additionally, during the mixing process of the bricks components, it should be done thoroughly to ensure that all components are evenly distributed. However, this study also notes the limitations that need to be addressed in future research. Among them is the decrease in the compressive strength of the material that occurs with the increase in the volume of plywood powder. This emphasizes the need for the development of material compositions or modifications to the mixed structure to find the optimal balance between acoustic properties and structural durability. Further research can focus on variations of additives, such as binders or chemical additives that can enhance the mechanical strength of the bricks without compromising their sound-damping ability. In addition, further field-scale testing is needed to ensure the stability, durability, and performance of this material under various environmental and weather conditions. Another potential area for future research is the development of variations in the size and shape of the bricks that can maximize sound absorption, as well as an analysis of the durability and longevity of these materials in the long term. By delving into these aspects, plywood dust bricks have great potential to become a multifunctional construction material of the future—providing effective sound insulation, being environmentally friendly, and meeting strength standards for structural use.

ACKNOWLEDGMENT

The author expresses heartfelt gratitude to the Ministry of Research, Technology, and Higher Education (Kemenristekdikti) for the support and facilitation provided in the implementation of this research. This support is very helpful in ensuring the smoothness and achieving optimal research results.The author also expresses gratitude to the Research and Community Service Institute (LPPM) of Hasyim Asy'ari University Tebuireng Jombang for the invaluable assistance and administrative support during the research process. The assistance provided by these two institutions has greatly contributed to the success of our research.

REFERENCES

Af'idah, N. (2020). Biokomposit dari Limbah Organik. Jombang: LPPM Unhasy Tebuireng Jombang.

Af'idah, N., Manasikana, O.A., & Mayasari, A. (2020). The Effect of Additional Corn Husk Toward The Mechanical Properties of Light Brick. Jurnal Pena Sains, 7(2), 88-95.

Annisa, N. (2022). Inovasi Material Komposit Sebagai Peredam. Thesis. Hasanuddin University.

Butar, R.B. (2018). Pemanfaatan Sekam Padi Sebagai Bahan Agregat Tambahan Untuk Pembuatan Batako yang Kedap Suara. Thesis. Medan Area University.

Fatkhuurohman, M.A., Supriyadi. (2013). Tingkat Redam Bunyi Suatu Bahan (Triplek, Gypsum, dan Styrofoam). Jurnal Fisika, 3(2), 138-143.

Hadi, T. (2014). Analisa Mix Design Batako dengan Penambahan Limbah Kayu Pada Kuat Tekan standar. Teknis, 9(3).

Hami, W.G., Alfa, A., & Kinanda, R. (2021). Pengaruh Pencampuran Serat Kulit Pinang dan Serbuk Gergaji Terhadap Kuat Tekan Batako. Selodang Mayang: Jurnal Ilmiah Badan Perencanaan Pembangunan Daerah Kabupaten Indragiri Hilir, 7(2), 69-76.

Hartono. (2020). Kajian Pemakaian Bata Semen dengan Agregat Limbah Gergajian Kayu Sebagai Bahan Dinding Konstruksi Gedung. Wahana Teknik Sipil: Jurnal Pengembangan Teknik Sipil, 16(2).

Hasibuan, T., & Fauzi, A. (2021). "Potensi Limbah Kayu dalam Produksi Material Konstruksi Berkelanjutan." *Jurnal Teknik Lingkungan dan Material*, 14(2), 35-42.

Kurniawan, A., & Sari, P. (2020). "Pengelolaan Limbah Industri Kayu Lapis: Potensi dan Tantangan." *Jurnal Pengelolaan Lingkungan*, 15(2), 110-119.

Lindawati, L., Yusrizal, Y., & Fitriadi, N. (2019). Uji Mampu redam Bunyi Pada Material Batu Marmer Aceh Selatan. Jurnal Abulyatama, 534-541.

Masthura, Daulay, A.H., & Lubis, D.F., (2021). Uji Mekanik Batako dengan Penambahan Serbuk Gergaji kayu Jati (Tectona Grandist). Jurnal Sains dan Pendidikan Fisika, 17(2), 153-158.

Mintarsih, TH. (2006). Panduan Praktis Pengelolaan Lingkungan Industri Plywood. Jakarta: Asdep. Bidang Pengendalian Pencemaran Agro Industri.

Nugroho, M.W. & Susilowati. (2023). Pengujian Statistik Kualitas Batako Bersubsidi Bonggol Jagung. Buletin Profesi Insinyur, 6(1), 44-49.

Nurcahyo, W. (2021). "Analisis Karakteristik Batako Ringan dengan Bahan Pengisi Organik." *Jurnal Teknologi Material Bangunan*, 17(1), 45-52.

Pratama, A., Karo, P.K., Sembiring, S. (2014). Pembuatan dan Karakterisasi Batako Ringan dengan Campuran Sekam Padi sebagai Bahan Pengisi untuk Konstruksi Bangunan Redam Suara. Jurnal Teori dan Aplikasi Fisika, 2(1), 49.

Purba, R. E. S., Irwan, & Nurmaidah. (2017). Pemanfaatan Limbah Serbuk Gergaji Kayu Sebagai Substitusi Campuran Bata Ringan Kedap Suara. JCEBT, 1(2), 87-95.

Purba, R.E.S., & Lubis K. (2017). Pemanfaatan Limbah Serbuk Gergaji Kayu sebagai Substitusi Campuran Bata Ringan Kedap Suara. Portal Jurnal Teknik Sipil, 9(2).

Purwanto, D. (2009). Analisa Jenis Limbah Kayu Pada Industri Pengolahan Kayu di Kalimantan Selatan. Jurnal Riset Industri Hasil Hutan, 1(1), 14-20.

Puspitarini, Y., Musthafa, F., & Yulianto, A. (2014). Koefisien Serap Bunyi Ampas tebu sebagai Bahan Peredam Bunyi. Jurnal Fisika, 4(2), 96-100.

Rahman, M., & Ismail, Z. (2017). "Efek Penambahan Bahan Berpori pada Material Konstruksi dalam Peningkatan Insulasi Suara." *Journal of Building Acoustics*, 8(4), 345-352.

Risandi, A., & Elvaswer. (2017). Koefisien Absorpsi Bunyi dan Impedansi Akustik dari Panel Serat Kulit Jeruk dengan Menggunakan Metode Tabung. Jurnal Fisika Unand, 6(4), 331-335.

Royani, I. F., Basuki, A., & Sunarmasto. (2014). Kajian Kuat Tekan, Kuat Tarik, Kuat Lentur dan Redaman Bunyi Pada panel Dinding Beton Ringan dengan Agregat Limbah Plastik PET dan Limbah Serbuk Kayu. e-Jurnal Matriks Teknik Sipil, 641-648.

Setyawan, T., & Mulyadi, H. (2018). "Inovasi Material Konstruksi Berkelanjutan di Era Modern." *Jurnal Teknologi Bangunan*, 12(1), 25-30.

Setyoningrum, A., Anisah, & Saefudin, A. (2023). Literature Review Pemanfaatan Limbah Kayu gergaji Sebagai Pengganti Agregat Halus dalam Pembuatan Batako. Jurnal Deformasi, 8(2), 126-131.

Simanjuntak, V.H., (2011). Pembuatan dan Karakterisasi Batako Ringan dengan Memanfaatkan sabut Kelapa Sebagai Agregat untuk Bahan Kedap Suara. Magister Thesis. Sumatera Utara University.

Subari, D., Udiansyah, Yanuwijayadi, B., & Setiawan, B. (2012). Efektifitas Pengelolaan Limbah Cair Pada Industri Kayu Lapis di Kalimantan Selatan. Buana Sains, 12(1), 99-108.

Sujarwata & Sarwi. (2006). Pemanfaatan Limbah Serbuk Gergaji Sebagai Bahan Peredam Bunyi. Jurnal Pendidikan Fisika. 4(2), 115-119.

Sujatmiko, Heri. (2016). Penelitian Pemanfaatan Serbuk Bekas Penggergajian Kayu Sebagai Bahan Substitusi Pembuatan Bata Beron (Batako) Untuk Pemasangan Dinding. 17 Agustus 1945 Banyuwangi Universitiy.

Suryani, T., & Harahap, N. (2020). "Studi Komparatif Batako Ringan dan Konvensional sebagai Material Konstruksi Ramah Lingkungan." *Journal of Sustainable Construction*, 11(3), 112-118.

Syahrun, Ahzan, S., & Pangga, D. (2019). Uji Tekan Batako Ringan dari Limbah Pengolahan Emas dengan Variasi Komposisi Abu Sekam Pagi. Jurnal Penelitian dan Pengkajian Ilmu Pendidikan: e-Saintika, 2(2), 120-126.

Widiastuti, R., & Puspitasari, M. (2019). Pengaruh Material Limbah pada Batako Ringan untuk Peningkatan Efisiensi Energi. *Jurnal Energi Bangunan*, 16(2), 67-75.

Wulandari, E., & Prasetyo, A. (2019). Ekonomi Sirkular dalam Pemanfaatan Limbah Kayu pada Industri Konstruksi. *Jurnal Material dan Konstruksi*, 22(3), 78-85.