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Modification of montmorillonite with sawdust as noise dampening bricks

Sri Hilma Siregar[a], Olif Syahbella[a], Aulia Rizki Ramadhanti[a].

[a] Study Program of Chemistry, Department of Education of Mathematics, Natural Science and Health, Muhammadiyah University of Riau Jalan Tuanku Tambusai, Riau, Indonesia
*E-mail: srihilma@umri.ac.id

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Abstract: This research aims to determine the quality of bricks mixed with different variations of sawdust and three types of testing and two characterizations have been carried out. The process of making bricks with the addition of wood dust is carried out by mixing montmorillonite and wood powder until homogeneous, with a mixture percentage of wood powder and bentonite of 0% (as a control), 10%, 20%, 30% and 50%, then dried and burned. Then the bricks are tested for three parameters, namely compressive strength test, acoustic test and water absorption test. Based on the test results, each test parameter obtained was a minimum compressive strength value of 43.75 kg/cm^2 and a maximum of 82.57 kg/cm2, where variations 1 and 2 met the quality requirements (according to class III category according to SNI 15-2094- 2000). The acoustic test results obtained the best results in all variations in the second and third tests at Ls (night level) and the water absorption value was obtained at a minimum of 11.16% and a maximum of 60.98%, where variation 1 meets the quality requirements (according to SNI 15 standards –2094–2000).

Keywords: bricks, montmorillonite, wood powder, compressive strength, acoustics.

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INTRODUCTION

The increasing population has resulted in an increase in the number of needs for residential areas and transportation facilities. This has resulted in many settlements directly facing highways, airports and terminals. Transportation facilities are needed to help the community carry out mobilization activities. However, along with its development, transportation does not always have a positive impact, transportation also has quite a variety of problems, including congestion, accidents, air pollution and noise problems [1].

Noise is unwanted excessive sound and is often referred to as invisible pollution that causes physical and physiological effects on humans. According to the American Academy of Ophthalmology and Otolaryngology, sounds with an intensity ranging between 50-55 dB(A) are referred to as noise which can cause sleep disturbances so that when you wake up the body is tired and tired, while sounds with an intensity of 90 dB(A) can be disturbing. autonomic nervous system. Noise with an intensity of 140 dB(A) can cause vibrations in the head, severe pain in the ears, balance problems and vomiting. Apart from having an impact on health factors, noise also has a psychological impact on individuals who are exposed to it. The impacts include emotional disturbances such as irritation and confusion, loss of concentration at work and so on [2].

Currently, many efforts have been made to reduce noise in a room, namely by using dampening and soundproofing materials, these materials in a building usually act as acoustic panels installed on dividing walls (partitions) and ceilings. Sound dampening or absorbing materials have an important role in room acoustics, designing recording studios, office spaces, schools and other rooms to reduce noise which is generally very disturbing. This material is called acoustic material whose function is to absorb and dampen sound [3]. The condition of the generator room was lined with styrofoam dampening and the generator room was lined with styrofoam and carpet as a sound dampener. However, the weakness of the raw material in this research is that styrofoam contains chemicals, is not environmentally friendly, and cannot withstand pressure or impact [4].

In this research, it is proposed to mix the basic brick material using sawdust. This can provide an alternative for utilizing industrial waste that is left unattended. montmorillonite is a basic material to maintain the compressive strength of bricks. Sawdust is waste obtained from sawing wood using machines or manually [5].

MATERIALS AND METHODS

The tools used are a mixing place or medium, digital scales, brick molds, furnaces, Sound Level Meter (SLM), Fourier Transform Infra Red (FTIR), Compression Machine, Scanning Electron Microscopy (SEM) and Personal Protective Equipment (PPE). The materials used in this research were montmorillonite, sawdust and distilled water.

The brick making in this study used montmorillonite and sawdust as the main ingredients. The initial treatment in making these bricks is the preparation of tools and materials. montmorillonite and wood powder are mixed with water and then stirred to form a homogeneous mixture with variations in the ratio between montmorillonite and wood powder of 0% (control), 10%, 20%, 30% and 50%. After that, the dough is molded by labeling each variation, then left to dry. The resulting brick mold is then placed in a furnace to reduce the water content, burned at a controlled temperature of 900oC for ± 3.5 hours in the furnace. Tests were carried out on compressive strength tests, acoustic tests and water absorption tests. Then the bricks are cooled slowly so that they do not crack and break. Once cool, the bricks are ready to be tested. The same thing is done with other comparisons.

To see the morphology of the samples, they were examined using a scanning electron microscope (SEM). Characterization of bricks using SEM aims to determine the surface shape, particle uniformity and size of the bricks. To see the chemical structure of the bricks, they were analyzed using Fourier Transform Infra Red (FTIR) by examining the bonds and composition.

Data processing

This research consists of three parameters, namely the first parameter is testing the compressive strength value using a Compression Machine. For the second parameter, namely acoustic testing with a Sound Level Meter (SLM). Meanwhile, for the third parameter, namely the water absorption test which was carried out within 24 hours of immersion. Sample characterization test using Scanning Electron Microscopy (SEM) at the Integrated Research and Testing Laboratory, Gadjah Mada University (UGM, Yogyakarta). Fourier Transform Infra Red (FTIR) characterization test at the Chemical Instruments Laboratory, FMIPA, Padang State University (UNP, Padang). Compressive strength test, water absorption capacity and acoustic test at the Soil Survey Laboratory, Riau University (UNRI, Pekanbaru). The compressive strength test refers to (SNI 15-2094-2000), the acoustic test refers to (SNI 8427:2017), while the water absorption test is adapted to SNI 15-2094-2000.

RESULTS AND DISCUSSION

Compressive strength testing is the ability of lightweight bricks to accept compressive force per unit area. The amount of compressive strength can be calculated by dividing the maximum load when the test object is crushed by the cross-sectional area of the test object referring to (SNI 15-2094-2000). Based on the compressive strength test results data, the following graph is obtained:

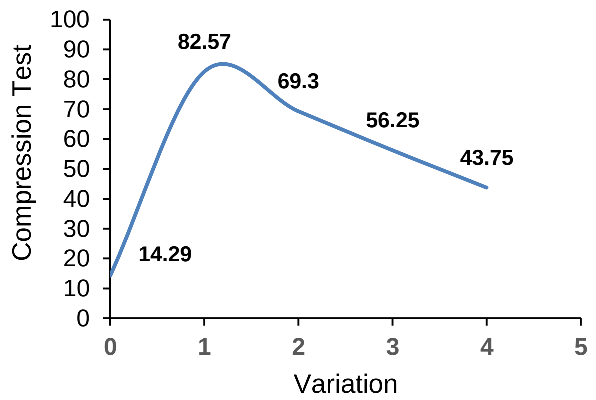

Figure 1. Compression Test for Bricks

Compression testing of brick samples with various mixtures of montmorillonite and sawdust has shown that they meet the compression quality requirements in terms of SNI 15-2094-2000. The value obtained meets the category in level III based on SNI 15-2094-2000 standards.

The results of compression test of bricks with varying percentages of montmorillonite and sawdust mixtures can reduce the compression values of existing bricks. It can be seen that compositions of 10% and 20% wood powder have the highest compressive strength values. This is because the wood powder in this composition has the ability to bind particles and fill pore cavities maximally. But at compositions of 30% and 50% it decreases. Figure 1 explains that it can be seen that the compression of the bricks has decreased. A decrease in compression occurs when the wood powder mixture is 30 - 50%. This decrease in compression is caused by the addition of sawdust and the amount of water used when mixing is less homogeneous as well as the pressure carried out manually in the brick making process which causes the water content value in the brick mortar to increase, when the wood dust is burned it evaporates and appears. cavity so that the resulting compressive strength decreases.

Sound dampening materials are generally divided into three types, namely porous materials, absorber panels, and cavity resonators. This grouping is based on the process of changing the sound energy that accumulates on the surface of the material into heat energy. The characteristics of a sound dampening material are expressed by the value of the sound absorption coefficient for each excitation frequency. In general, sound-absorbing materials have absorption levels in certain frequency ranges only [6].

Table 1. Equivalent Continuous Noise I

Variation	La (dB) (Afternoon)	Le(dB) (Evening)	State Minister of Environment No. Kep-48/MENLH/11/1996
0	108.5	103.5	Max 85
1	100.6	91.2	Max 85
2	100.9	90.4	Max 85
3	98.5	89.3	Max 85
4	98.1	87.6	Max 85

Table 2. Equivalent Continuous Noise II

Variation	La (dB)	Le(dB)	State Minister of the Environment No. Kep-48/MENLH/11/1996
0	90.7	85.9	Max 85
1	88.3	84.4	Max 85
2	88.2	84.1	Max 85
3	85.1	79.6	Max 85
4	83.8	77.7	Max 85

The combination of montmorillonite and sawdust will form a unity and strengthen each other from various weaknesses in each material. The percentage composition between mixtures must be in accordance with the reasonable limits of the mixture, in order to create panels that have good sound absorption and are strong enough to be used as wall material.

Table 3. Equivalent Continuous Noise III

Variation	Ls (dB)	Lm (dB)	State Minister of the Environment No. Kep-48/MENLH/11/1996
0	96.9	86	Max 85
1	90.6	81.3	Max 85
2	89.7	80.4	Max 85
3	88.2	76.1	Max 85
4	87.5	74.3	Max 85

Based on the table above, it is explained that the noise level that occurs still exceeds the quality standard value set by the Decree of the State Minister for the Environment No. KEP48 / MNLH / 11 / 1996, the total number of location bricks that exceed the quality standard is La (day level), because daytime is the time when noise is more common.This water absorption test is designed to determine how much the level of water absorption is influenced by the pores or cavities in the brick material after the firing time. The larger the pores in the brick material, the greater the water absorption. This is caused by a lack of density or level of density of the brick material.

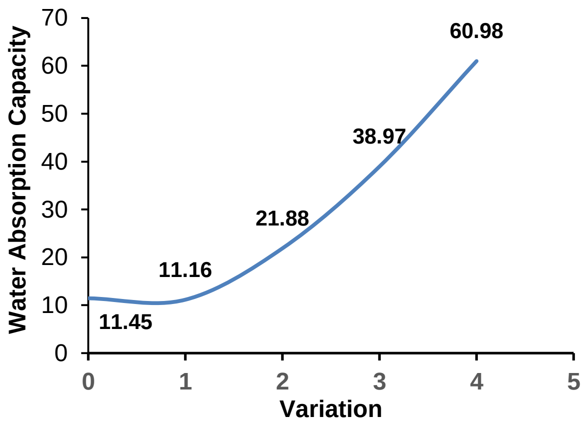

Figure 2. The water absorption capacity of bricks

From Figure 2, it can be seen in the graph that the water absorption capacity of bricks mixed with sawdust increases. The higher the variation in the mixture of sawdust, the greater the resulting water absorption value, this is due to the large amount of water contained in the bricks as a result of the mixing process of adding water continuously until the montmorillonite and wood dust feel homogeneous for mixing. During the drying and burning process, the water contained in the bricks will evaporate, causing many cavities in the bricks. Wood dust is hygroscopic, meaning it will absorb water if the environmental conditions are humid and will release water if the environmental conditions are dry. The particle bond between montmorillonite and sawdust is not perfect due to the large amount of water contained in the bricks. As the value of water absorption increases, the resulting compressive strength will be lower, this is what causes the bricks to become brittle.

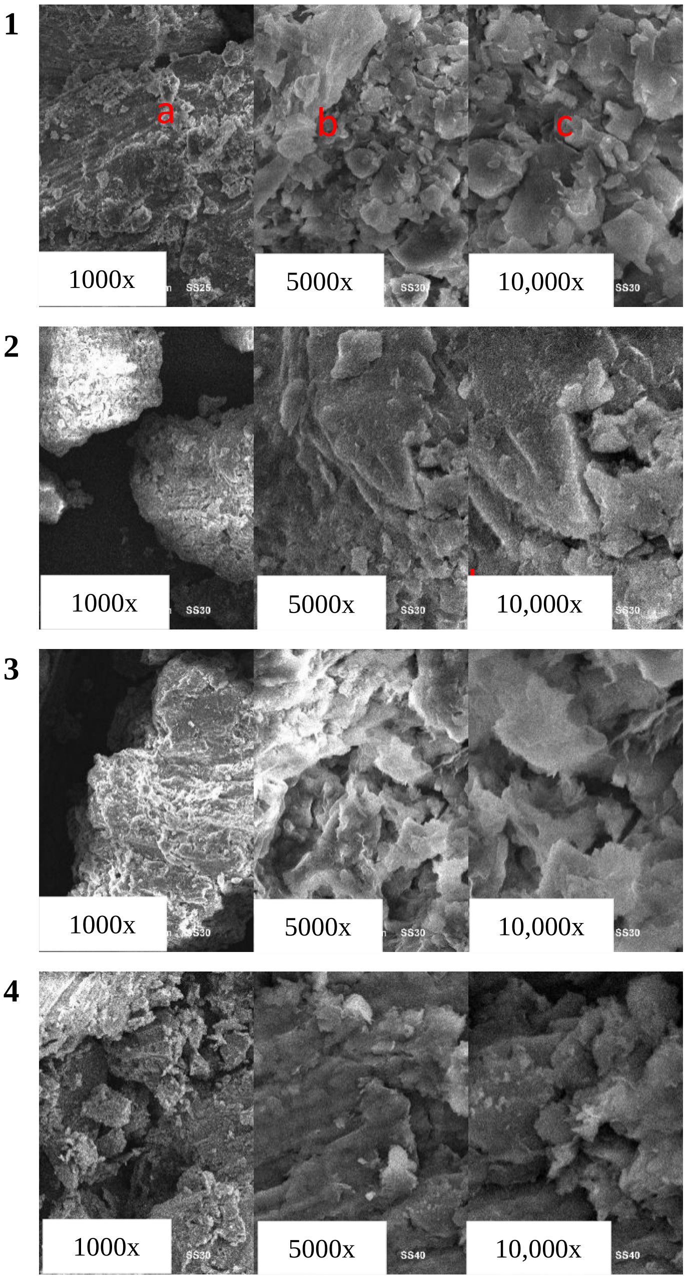

Figure 3. Morphology of brick variations 1, 2, 3 and 4 (a) 1000x magnification, (b) 5000x magnification, (c) 10,000x magnification

This is because when bricks are soaked in water, the hydration process of the silica particles occurs. Hydration of silica particles is a condition where the clay particles are surrounded by water molecules. As a result, the hydrogen bonds between clay particles and water molecules are greater than the hydrogen bonds between clay particles and clay particles. This can be strengthened from the FTIR data in Figure 4 which shows the presence of Si-OH & CO groups which have the ability to form hydrogen bonds. and resulting in the hydration process [7].

It was interpreted that the addition of various montmorillonite contents to the pressed bricks resulted in a dense bright microstructure consisting of CSH and calcium hydroxide (CH) as shown in Figure 4, the concentration of the CSH phase being identified as a flaky and dense granular morphology. The CSH element is the main element that supports the strength of the brick, so a large reduction in CSH will greatly reduce the strength of the brick. Therefore, the SEM results of the compressed brick specimens show the densification of the microstructure achieved by physical and chemical effects. The physical contribution is caused by narrowing of the pores by the filler effect due to micro-sized particles. One way to improve the quality of bricks is by adding mineral additives or chemical additives. The addition of this additional material is useful for improving performance and increasing the compression of normal bricks according to standards.

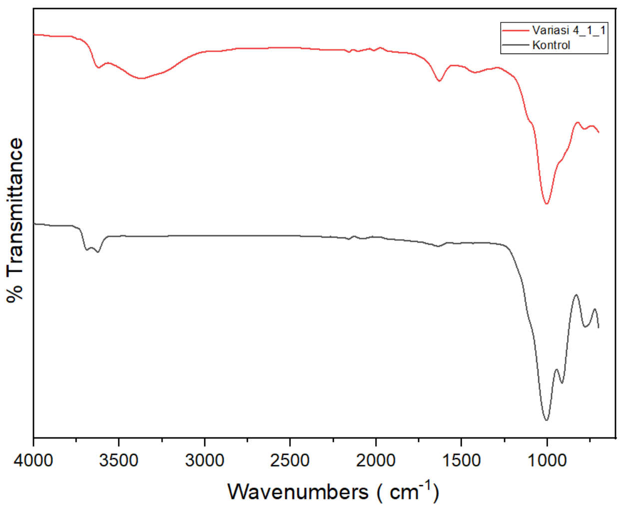

Figure 4. FTIR spectrum of (a) montmorillonite (b) montmorillonite -sawdust

A change in the vibration of a molecule occurs, namely when the molecule absorbs infrared rays at a certain frequency. If there is an energy transition in the molecule, the energy transition that occurs in the infrared rays is what causes a change in vibration in a molecule. FTIR spectroscopy quickly detects the samples to be tested and the results obtained consistently provide the information contained in the analysis results.

The results of reading the spectrum of several brick samples in variations 0 and 4 using FTIR, namely at wavelengths between 4000 cm-1 to 700 cm^{-1}, can be seen in figures 1 and 5. The FTIR plot identifies the hydration phase based on the intensity of the absorbed infrared energy frequency band. by the vibration of the chemical bonds of the hydration phase at its natural frequency. The frequency bands are classified into three broad bond vibration frequency ranges, namely 850-1200, 1200-1800 and 3000-3800 cm^{-1} [8]. The first frequency band (850-1200 cm^{-1}) is associated with the stretching vibrations of water molecules present in the CSH gel formed as a result of montmorillonite hydration. At the 3600-san wave, there are functional groups Alcohol, Phenol, Carboxylic Acid OH (alcohol, phenol) where there is the mineral montmorillonite.

Based on Figure 4, the spectrum produced from samples of variations 0 and 4 in the infrared region is 700 cm^{-1} –4000 cm^{-1}. The spectrum patterns produced by both variations have almost the same pattern, only the intensity is different. The properties and composition contained in the two samples cause differences in the intensity of each transmittance peak.

The existence of OH groups and hydrogen bonds by OH groups and water molecules (as discussed in Figure 3 is indicated by the appearance of several peaks in the FTIR data. The peak at 3622 cm^{-1} shows the stretching vibration of isolated or non-bonded hydroxy groups (-OH). This OH group comes from free water molecules which are still abundant in bricks. The existence of water molecules is strengthened by the appearance of the bending vibration peak of the HOH bond at a wave number of 1631 cm^{-1}. The sharp peak at 3622 cm^{-1} indicates the stretching vibration of the hydroxy group (-OH) from the cellulose structure (the content of wood powder). Based on this FTIR data, the explanation for the ability of water adsorption by bricks is due to the presence of –OH groups. The –OH groups in these bricks come from Si-OH groups and from the cellulose structure.

Table 4. Functional groups and mineral ingredients

No	Wave Number (cm^{-1})	Functional groups	Mineral Materials
1	3622.32	Alcohol, Phenol, Carboxylic Acid OH (alcohol, phenol)	montmorillonite
2	3374.31	Alcohol, Phenol, Carboxylic Acid OH (alcohol, phenol, hydrogen bond)	montmorillonite
3	1631.11	C=O which comes from salicylic acid	-
4	1004.19	Alcohols, Ethers, Esters, Carboxylic Acids, CO Anhydrides	*Feldspar*
5	783.17	Aromatic Para	montmorillonite

CONCLUSION

The addition of sawdust to bricks affects the physical and mechanical properties of the bricks. The addition of sawdust can increase the compression value of bricks with a compression variation 4 is 43.75 kg/cm2 The research results show that the highest noise values occur during the day, due to the large number of community activities that cause excessive noise during the day rather than at night.The addition of sawdust can affect water absorption capacity. By adding sawdust in variations 2, 3 and 4, the water absorption value increases, while the compression value decreases. Bricks with a water absorption value of variation 0 is 11.45%, variation 1 is 11.16%, variation 2 is 21.88%, variation 3 is 38.97%, and variation 4 is 60.98 %. These five samples do not meet the requirements except for variation 0 and variation 1. In the water absorption test that meets SNI 15-2094-2000 standards, there are mixed variations of 0 - 10% with water absorption values: 11.45% and 11.16%.

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