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Utilization of Sugarcane Bagasse Fiber in Composite Board Mixtures as a Sound Absorber

Ihat Solihat[1]*, Yusuf Sopian[2]
Mechanical Engineering Study Program, Pamulang University, Indonesia

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Corresponding author*:
dosen00990@unpam.ac.id

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Abstract: An Noise occurring in a room can be reduced or dampened in intensity by installing composite boards on the walls. Composite board material is made from a mixture of resin and sugarcane bagasse fiber. Sugarcane bagasse is a by-product of sugarcane juice extraction, commonly found around sugar factories or as waste from sugarcane juice processing. The utilization of this bagasse as a mixture in composite boards with resin was carried out using board dimensions of 30 × 30 × 1 cm. The composition ratios between bagasse and resin were 60:40, 70:30, 75:25, and 80:20.Based on sound wave testing at frequencies of 250 Hz, 500 Hz, and 750 Hz, the best sound absorption performance was found at the 60:40 composition at a frequency of 750 Hz, where the initial sound intensity was 95.5 dB and was reduced by 62.8 dB. This result indicates a sound absorption coefficient of 0.408, which is relatively good. The lowest absorption was observed at the 80:20 composition with a coefficient of 0.0296 at a low frequency of 250 Hz. This phenomenon occurs because a higher resin content results in a denser structure that reduces sound absorption, whereas a higher fiber content leads to increased porosity, enhancing the composite's ability to absorb sound.

Keywords: Sound Absorber, Volume Fraction, Compressive Strength, Resin, Composite

INTRODUCTION

Sugarcane bagasse is a by-product of the white sugar industry and constitutes one of the largest organic agricultural wastes. Every year, sugar factories across Indonesia produce approximately 9.6 million tons of sugarcane bagasse. This waste holds significant economic value and contains unique material properties. Sugarcane bagasse has large pores in each of its molecules and contains up to 90% carbon. Carbon is a substance that plays a vital role in sound absorption due to its ability to absorb and convert wave energy into thermal energy [10]. In addition, the porous fiber surface area of sugarcane bagasse is extensive; the surface area and fiber size strongly influence sound-absorbing properties. The composition of sugarcane bagasse is dominated by carbon and silica, which account for approximately 90% and 10%, respectively [8]. These components contribute to the bagasse's potential for optimized sound absorption.

According to a study by Zahid on microwave wave absorption modeling at frequencies between 0.1 Hz and 20 Hz, sugarcane bagasse exhibits composite characteristics with high relevance in bioethanol production and effective sound wave applications. In Indonesia, sugarcane bagasse is abundantly available as an organic waste with significant potential for scientific development [2].

Another study conducted by Hermiatati demonstrated that particleboard made from coconut powder bagasse achieved a sound absorption coefficient at 600 Hz with a board thickness of 1.15 cm [5]. Similarly, pineapple fiber also showed a high sound absorption coefficient of 600 Hz with a flow resistance of 0.2 cm²/s [10]. A prior study by Lokantara et al. (2012) revealed that a composition ratio of 50:50 between PVA powder and sugarcane bagasse resulted in a high absorption value of 0.89 at a frequency of 600 Hz. These studies confirm that plant-based fibers can be utilized as sound-absorbing materials, provided the absorption coefficient (α) meets standard sound absorption requirements.

Such research forms the foundation for further investigation into how sugarcane bagasse, with its high carbon content, can effectively absorb sound and be used as a composite material for noise reduction [10]. Based on these findings, sugarcane bagasse is used to fabricate composite boards designed to absorb sound at low frequencies, with absorption levels adjusted according to board thickness. The objective of this study is to determine the sound damping coefficient of composite boards reinforced with resin [5], and to assess how varying volume fraction ratios between sugarcane fiber and resin (60:40, 70:30, 75:25, 80:20) affect the sound absorption of the bagasse fiber composite.

RESEARCH METHOD

The fabrication of the composite board was carried out through several stages. The research procedures were conducted in the following steps:

1. Collection of Sugarcane Bagasse Fiber

   The sugarcane bagasse used in this study was obtained from waste generated by sugarcane juice vendors along the streets of Ciganjur, South Jakarta. The bagasse collected consisted of thick and clean fibers, free from impurities. The collected sugarcane bagasse was then sun-dried and separated into fibers using wire tools to facilitate the formation of composite boards. The sugarcane bagasse used was in fibrous form, which was mixed with resin to form composite boards. The dimensions of the composite boards produced were 30 cm in length, 30 cm in width, and 1 cm in thickness.

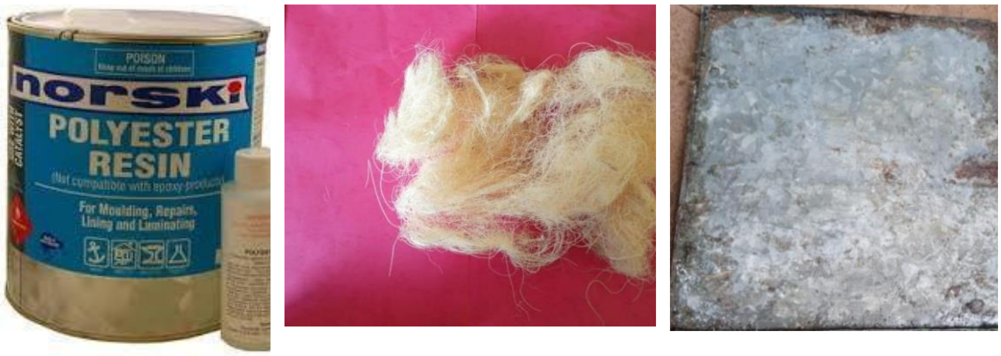

Figure 1. Polyester Resin, Sugarcane Bagasse Fiber, and the Produced Composite Board

2. Composite Board Fabrication Process

   The volume fractions used in the fabrication of the composite board consisted of various ratio combinations. Four different composition ratios between sugarcane bagasse and resin were prepared: 60:40, 70:30, 75:25, and 80:20. The composites formed from these mixtures were then dried for 5 hours. Each composition ratio was cast into molds to produce individual samples. Two samples were produced for each ratio, resulting in a total of 8 composite board samples. The dimensions of each composite board were 30 cm in length, 30 cm in width, and 1 cm in thickness.

Figure 2. Composite board made from sugarcane bagasse mixed with resin

3. Sound Absorption Testing Equipment

The medium used as a sound absorber testing device was a box that functioned as a sound absorption testing chamber. The box had the dimensions of 58.5 cm in length, 28.5 cm in width, and 30 cm in height. It was made of glass panels and shaped like a rectangular prism, with each corner sealed using adhesive. The box structure was made from wood and fully lined with carpet on all interior surfaces.

The sound used in the test was generated using a mobile phone application called Frequency Generator, which was capable of producing noise at maximum frequency levels. The sound absorption test also utilized a Sound Level Meter to measure the intensity of the generated and absorbed sound in decibels (dB). The frequencies used in testing the composite board were 250 Hz, 500 Hz, and 750 Hz.

The composite was mounted inside the testing box, and the sound output was compared between the box without and with the sound-absorbing composite. The composite specimen and testing box were fully enclosed. The Arbitrary Function Generator (AFG) and sound source were activated at predetermined frequencies and connected to a speaker to generate maximum noise levels. Two testing boxes were prepared—one without the composite and one with the composite installed under the same frequency variations. Data were read and displayed repeatedly on the AFG until it stabilized. The sound absorption readings were repeated three times for each specimen. Each frequency variation was tested for every specimen installed in each test box.

4. Density Testing

Density testing was carried out by measuring and recording all composite specimens attached to the testing device. The dimensions of each side of the composite boards were measured inside the box, followed by weighing each cut specimen. The composite specimens were then placed into a graduated cylinder filled with 1000 ml of water. This procedure was conducted for all specimens, and the results were recorded for density calculation.

5. Compressive Strength Testing

The compressive strength testing of the specimens was conducted by cutting the composite boards to match the size required by the testing device. The specimen samples were inserted into the testing machine after the power source was activated. Each composite specimen was pre-weighed before being tested. The sample was placed at the pressure point of the compressive testing machine. Loading was applied until the specimen failed, and the maximum load at the point of failure was recorded [6].

RESULT AND DISCUSSION

Test Results

The initial stage involved testing the composite using various volume fraction compositions of sugarcane bagasse mixtures. The composite fractions used were in the ratios of 60:40, 70:30, 75:25, and 80:20. The composites were formed into boxes with a total volume of 50,017.5 cm². Data readings were taken three times for each specimen at different frequencies—250 Hz, 500 Hz, and 750 Hz. The following table presents the results of sound absorption for each volume fraction**:**

Table 1. Sound absorption data using composite boards

Sound Frequency (Hz)							
		250		500		750	
Fiber Volu me Fracti	**Testi ng stage**	**Sound intensit y Incomi**	**Sound intensity Absorbed (dB)intens**	**Sound intensit y Incomi**	**Sound intensity Absorb ed**	**Sound intensity Incomi ng**	**Sound intensity Absorbed (dB)intens**
	1	59,7	**58.0**	71,2	**61,7**	95,5	**62,6**
60:40	2	59,7	**57.9**	71,2	**62,3**	95,5	**62,4**
	3	59,7	**58,5**	71,2	**61,8**	95,5	**62,8**
Average		**59,7**	**58.1**	**71,2**	**61.9**	**95,5**	**62.6**
	1	59,7	56,0	71,2	**60,2**	95,5	**61,7**
70:30	2	59,7	56,9	71,2	**61,5**	95,5	**62,4**
	3	59,7	56,8	71,2	**61,9**	95,5	**62,3**
Average		**59,7**	**58.1**	**71,2**	**61,2**	**95,5**	**62,3**
	1	59,7	57,2	71,2	57,5	95,5	60,7
75: 25	2	59,7	57,4	71,2	58,4	95,5	61,6
	3	59,7	57,5	71,2	59,3	95,5	62,5
Average		**59,7**	**57,3**	**71,2**	**58,4**	**95,5**	**61,6**
80: 20	1	59,7	**57,6**	71,2	55,0	95,5	**59,6**
	2	59,7	**57.9**	71,2	54,9	95,5	**59,5**
	3	59,7	**57,8**	71,2	54,8	95,5	**60,4**
Average		**59,7**	**57,7**	**71,2**	**54,9**	**95,5**	**59,7**

The sound intensity levels varied across each test specimen, even among those with identical or different fiber volume fractions. The highest sound intensity absorption occurred in specimen 1 with a 60:40 fiber-to-resin ratio at a frequency of 750 Hz, successfully absorbing 62.6 dB. In contrast, the lowest sound absorption was observed in the specimen with a fiber volume fraction of 20% (80:20 ratio) at a frequency of 750 Hz, with an absorption level of 59.7 dB, and another low value occurred at 500 Hz for the 80% fiber volume fraction.

For further clarity, the average sound intensity distribution is illustrated in the graph below:

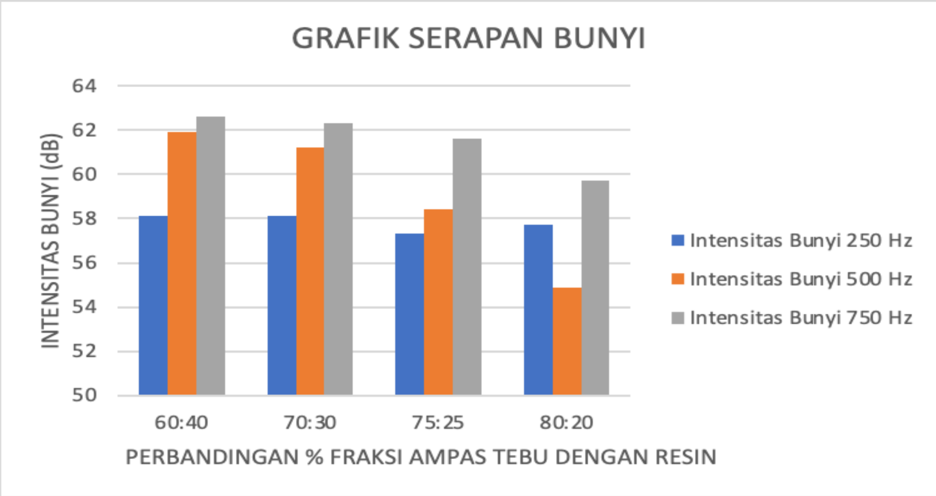

Figure 3. Sound Absorption Graph

The sound pressure level correlates with the sound absorption coefficient (α), meaning that the higher the sound intensity experienced by the composite sound-absorbing material, the greater the resulting sound attenuation or absorption coefficient [4]. This is supported by the calculated results of the sound absorption coefficient. Based on the processed sound pressure level data, the following values of sound absorption coefficients were obtained:

Table 2. Sound absorption coefficient values (α) for each fiber volume fraction and input frequency

Volume Fraction (%)	Frequency (Hz)		
	250 (Hz)	500 (Hz)	750 (Hz)
	Sound Absorption Coefficient (α)		
60: 40	0.0236	0.122	0.408
70:30	0.0236	0.151	0.371
75:25	0.0298	0.172	0.381
80:20	0.0296	0.226	0.267

The sound absorption coefficient values varied across the test specimens. The quality of sound-absorbing materials is determined by the value of the sound absorption coefficient (α), which ranges between 0 and 1 [10]. A higher α value indicates that less sound is reflected, and thus, the material has better sound absorption capabilities. The highest sound absorption coefficient was found in the specimen with a 40% fiber volume fraction, which achieved a value of 0.408 at a frequency of 750 Hz. Meanwhile, the lowest sound absorption was recorded in the specimen with a 30% fiber volume fraction, with a coefficient of 0.0236 at a frequency of 250 Hz.

The absorption coefficient is influenced by the lignocellulose content, which contributes to sound absorption. The higher the absorption coefficient, the greater the lignocellulose content [6]. According to a previous study by Obimita, the highest absorption was found in white corn cob content at specific sound absorption fractions. In this study, the sugarcane bagasse composition with a 40% fiber fraction exhibited the highest sound absorption ability, particularly at a high frequency of 750 Hz.

Theoretically, as stated by Gibson R.F. in 1994, the density of a sound-absorbing fraction may hinder sound penetration when the material's porosity is too low. Sugarcane bagasse, however, has large pores that allow smaller sound particles to be absorbed effectively. Its high impedance causes more sound to be absorbed rather than reflected [9]. The optimal composition of sugarcane bagasse fiber was found at the 60:40 ratio, with the best performance at a 750 Hz frequency.

CONCLUSION

The sound absorption test using the composite board with various fiber-resin fractions showed that the highest absorption was achieved at the 60:40 composition at a frequency of 750 Hz, where the initial sound intensity was 95.5 dB and 62.8 dB was successfully absorbed. This range is considered satisfactory, resulting in a sound absorption coefficient of 0.408. Conversely, the lowest absorption was observed at the 80:20 composition with a coefficient value of 0.0296 at a low frequency of 250 Hz. This result is attributed to the fact that a higher resin content increases the material's density, making it more resistant to sound absorption, whereas a higher fiber content increases the porosity of the composite, enhancing its ability to absorb sound.

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