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DESAIN OF ACOUSTIC SANDWICH COMPOSITE FROM FOAM CONCRETE AND PALM FIBER

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Abstrack. The purpose of this research were to investigate the influence of palm fiber composition and the number of hole cavities was varied with design Acoustic Sandwich Composite on sound absorption of acoustic panel. Acoustic panel were made of palm fiber as core and foam concreate as skin upper layer and bottom layer where there is a hole cavity on skin upper layer. Composition and the number of hole cavities was varied from 1 to 3 kg and the number of hole cavities from 25 to 81 hole. Sound absorption measurement was conducted by using reverberation room method based on ISO-354 (2003) with pink and white noise as sound source. The results showed that sample thickness affect acoustic absorption value effectively shifted at low frequencies, as in this research the best sound absorption occurs in panel with composition palm fiber most widely 3 kg, but coefficient absorpsi value effective is in the range of 250 Hz and use the number of hole cavities at skin upper layer of each sample effectively cause sound absorption coefficient value increased, for both pink and white noise from sound source.

Keyword : acoustic panel, foam concrete, palm fiber, sandwich composite, and absorption coefficient

I INTRODUCTION

In this modern period technological and population developments are increasing. Along with the development of technology and population then the development of equipment used by human also increasing. The equipment is in the form of information, communication, production, transportation and entertainment facilities. Most of the equipment produces unwanted sounds and is very detrimental to the surrounding environment because it can cause noise pollution. Generally speaking, noise can be addressed on three basic elements at source, transmission and receiver space. An effective way to deal with noise at the source is by moving the source out of earshot. At the receiver, noise can be overcome by wearing *headphone* or the like. While in the transmission chamber, noise can be overcome by using sound absorption principle that is using sound absorbing material or acoustic panel. Acoustic panel is a special material used for acoustic purposes of the room, in this case to absorb the noise. Currently, there are various kinds of acoustic panels circulating in the market. In general, the material is made of synthetic materials such as *rockwool* and *glasswool.* The material is able to reduce the noise level, but the price is relatively expensive and the raw materials used are not environmentally friendly. Therefore, an alternative material is needed as a raw material for acoustic panel that is relatively inexpensive and environmentally friendly. There has been much research in the development of acoustic panels from alternative materials that are environmentally friendly. Foam concrete is one of the alternative materials that can be used for various construction elements in buildings, such as for walls and roofs. The advantages of such foam concrete are light and easy to produce. In addition, foam concrete panels can be applied as acoustic panels. Research conducted by Zulfian et al. (2010) shows that this panel is able to absorb sound, but its optimum absorption is limited to low frequency that is below 500 Hz [1], and in previous research done by the present authors show that the development of wall panel of foam concrete with the addition of fiber fibers will produce sound absorption up to 1000 Hz frequency [2]. Palm fibers is one of the natural fibers whose availability is abundant in nature. Traditionally, the fibers have been used in building construction as a layer in a recharge well (*filter*) and as a base material for the construction of wooden structures planted in the soil to prevent termite attack. Palm fibers has a durable property that is not easy to rot either in the open or closed. Palm fibers also resistant to weather, pools of acid, and sea water [3]. In the research of acoustic panel of foam fiber concrete, the panel is able to obtain coefficient of absorption value up to 1000 Hz frequency which belongs to the clarification of audioconic sound group which is medium frequency sound group. Therefore, in order to maximize its absorption capacity over a wider range of frequencies, the foam fiber-reinforced concrete panel must be modified with better shape and characterization using the same natural fiber material that is high-absorbing fibers capable of absorbing at high frequencies. In the manufacture of this panel, the fibrous foam concrete will be composed like *Composite Sandwich*, which is a composite type consisting of 3 layers of the front and back of the *skin* layer and the existence of *cores* as a porous material material that is suitable to withstand the bending, impact and can reduce vibration and sound. The design has been done in previous research is the application of sound absorbing panel from *Sandwich Composite* material as interior wall of the room [4]. The foam concrete panel on the front *skin* layer will be made into a hollow panel resonator which is a hole-shaped panel that serves as a row of cavity resonators, the hole is circular, if the hollow panel is selected appropriately will increase the efficiency of sound absorption and will widen the area of the sound frequency where the absorption is large [5]. In this study, the fibers were selected as *cores,* with the back skin of foam concrete and the front of a foam concrete with a row of resonator cavities that are expected to increase the absorption of sounds of foam fiber foam concrete panels on a wider frequency range.

II METHODOLOGY

Testing is done based on ISO 354: 2003 measurement of sound absorption in the hum of reverberation room *(Measurement Of Sound Absorption In Reverberation Room).* Sample size of foam concrete and palm fibers is 1000x1000 mm with square shape and thickness vary for sample 1 to 3. Panel made in the form of *Acoustic Sandwich Composite*, it is a form of application of *cell* shape consisting of foam concrete as a *skin and* fiber as cores, and the foam concrete given the addition of *holes* resonator in each sample as *upper skin.* Variation of thickness is 4, 5 and 6 cm. Addition of holes also varied that is 25, 49 and 81 holes on the skin of the front of acoustic cells (Figure 1). The testing process was conducted at the Acoustical Laboratory, faculty of engineering, the building structure of Syiah Kuala University of Banda Aceh. Focused acoustic performance study at frequency range (250-4000 Hz). The acoustic performance of a material is strongly influenced by various factors. Porosity, t hickness, structure and shape and density. Acoustic performance will be obtained based on the sound absorption coefficient value which is first calculated based on the buzzing time in the blank space and the buzzing time in the space with the sample.

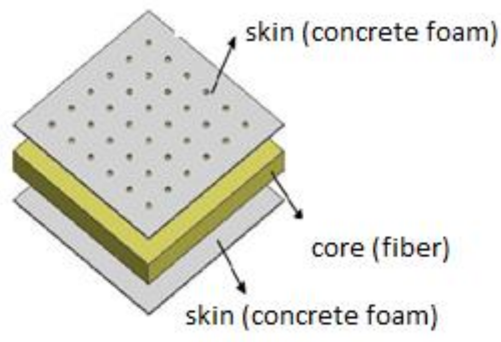

Figure 1 *Acoustic Sandwich Composite* design (ASC)

To calculate the magnitude of α in the hum space, the eqs (1) to (3) is used.

$$T_1 = \frac{55{,}3\,V}{cS\,\alpha_1} \qquad (1)$$

$$T_2 = \frac{55{,}3\,V}{cS\,\alpha_2} \qquad (2)$$

$$\alpha = \frac{55{,}3\,V}{c\,S}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) \qquad (3)$$

With T_1 is a time buzzy hollow space time, T_2 is time buzz room buzzing with sample to be measured, *V* is volume of hum space (m^3), *C* is speed of sound in air (m/s), *S* is total surface area of space (m^2) and α is a average absorption coefficient [6]. The absorption coefficient of the sound of a sample can be calculated by knowing the buzzing time before and after the sample in the hum room. The first time is to measure the humming time of the empty space (before there is a sample) and then measured the buzzing time after the sample. The measurement of the buzzing time is done using a *white noise* source with a 1/3 octave *filter*. The measuring scheme of the time drone with the sample is shown in Figure 2.

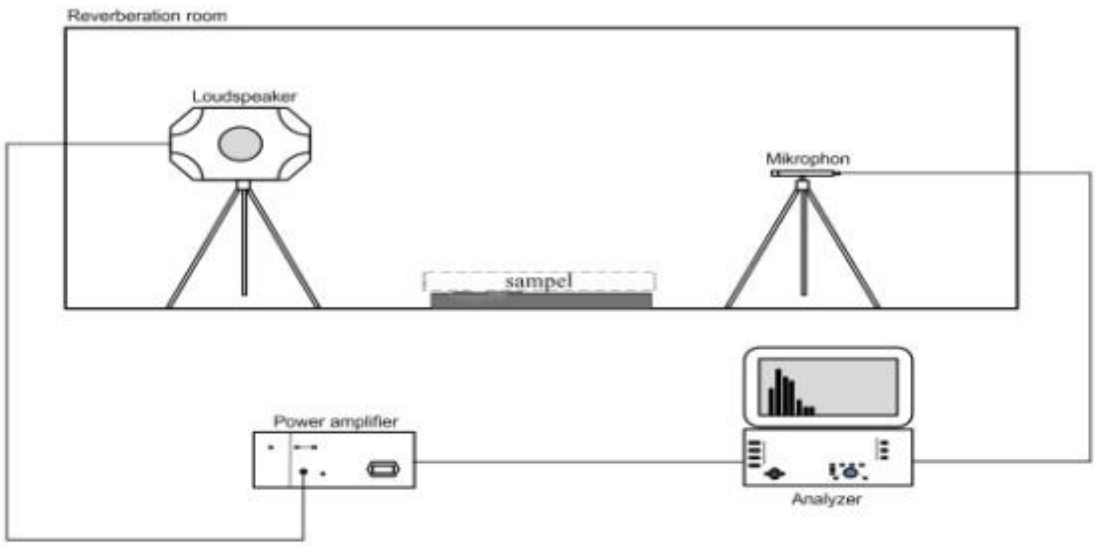

Figure 2 Time drone measurement scheme in a hum room.

***Acoustic Sandwich Composite* Panel Making Process**

The manufacturing process begins with the formation of a fibers into a square with the composition of each different sample The fibers in each sample are associated with a 6 cm long wire, where the wire is shaped like the letter "V" so that it can associate the fibers with the foam concrete at each angle, the number of connections as many as 4 links to each sample.

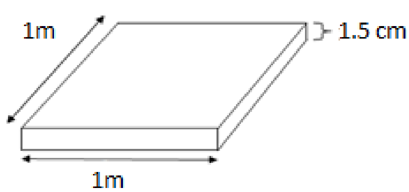

Figure 3 The shape and size of the sample

Figure 4 *Acoustic Sandwich Composite* Panel

The foam concrete on the acoustic panel is manufactured with a size of 1000x1000 mm in square shape and varying in thickness for sample 1 to 3. The formation in the sample begins with the manufacture of converted foam concrete, inserted into a square-shaped mold of 1000x1000x15 mm. Square-shaped molds are provided for 3 prints, in which each mold can create 2 foam concrete as upper and lower skins. As shown in Figure 3.

III RESULTS AND DISCUSSION

The humming time is the time required by the source to be stopped immediately. the measurement of the buzzing time of either the humming time of the blank space or the space with the sample is obtained from the sound source representing the range of the human hearing frequency of White noise (Figs. 5) and Pink noise (Figs. 6).

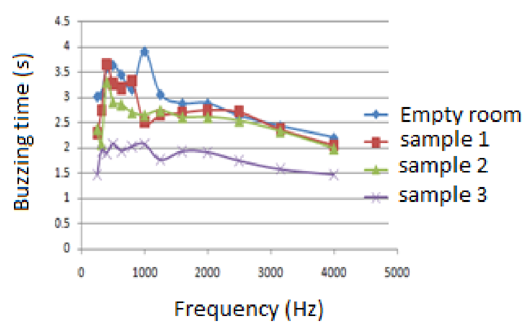

Figure 5 Graphic frequency measurement of buzzing time in free space with *White Noise* source and buzzing time using samples 1, 2 and 3 against a humming time of 20 dB (T20).

In general, it is seen that the buzzing time of the empty space (T1) in Figs 5 and 6 is greater than that of the hum in the chamber with the sample (T2), this is because when there is no sound absorber sample in an empty hum (T1) the coming sounds will be reflected entirely within the hum room so that the measured buzzer time is greater than that of T2, which is the buzzing time when there is a sample in the hum room.

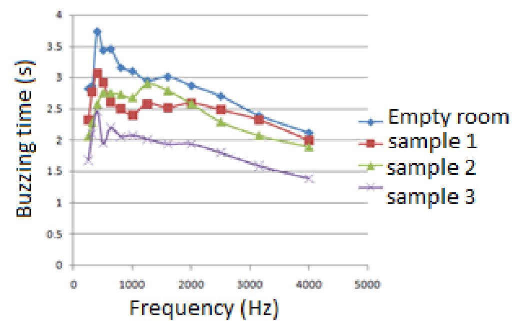

Figure 6 Graph of frequency measurement of buzzing time in free space with *Pink Noise* source and reverberation time using samples 1, 2, and 3 against a humming time of 20 dB (T20)

Figures 5 and 6 show that the variation of the palm mass and the number of holes found on the upper *skin* affect the time of buzz. This is due to the greater mass of fibers, the better the sample in absorbing sound, as well as the number of holes in the sample that is the more number of holes contained in the sample sound absorption will also be better. The same is also evident in previous research that the more the amount of material and the number of holes contained in the sample the better the sound absorption of sound.

Coefficient absorption of *Acoustic Sandwich Composite* design concrete board

In this research, the absorption coefficient of α sound was measured using the humming method based on ISO-354 (2003) ie the measurement of the absorption coefficient of sound in a buzzing space which will produce a reverberation time. Coefficient of absorption is the ability of an ingredient to absorb the coming sound, and has a value ranging from 0 and 1. The greater the value of the absorption coefficient of a material, the greater the ability of the material to absorb sound, The value of α is calculated based on eqs (3), and is obtained from the sound source type of *White noise* and *Pink noise*. The value of coefficient of absorption can be seen in Figure 7 and Figure 8. The figures show the relationship between the frequency of the absorption coefficient based on the composition of the fibers of various fibers which are 1, 2 and 3 kg and the number of holes contained in the first layer *skin* is 25, 49 and 81 holes *acoustic sandwich composite* design with using sound source *Pink noise* and *White noise*.

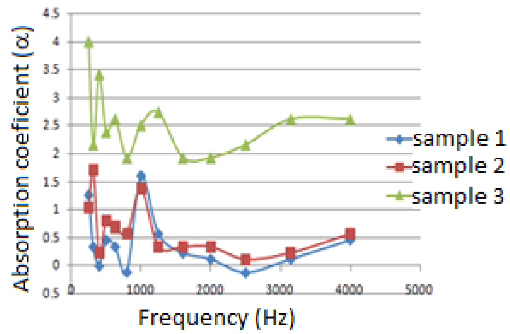

Figure 7 Relationship between the frequency and sound absorption coefficient based on the sound source *White noise* with a buzzing time at 20 dB (T20)

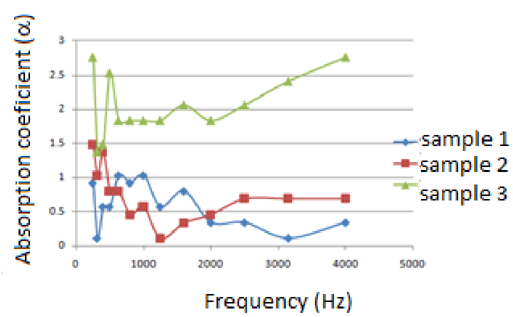

Figure 8 Relationship between frequency and noise absorption coefficient based on sound source *Pink noise* with a buzzing time at 20 dB (T20)

The difference of thickness influence in this research is that the thicker the fibers composition, the greater the value of absorption coefficient, as has also been reported from the results of research using bagasse as composite material to sound performance [7]. The use of the number of holes in the initial layer *skin* of each sample affects the sound absorption coefficient value of a material ie the more number of holes used in the sample the greater the resulting absorption coefficient value. The results are in line with the research of Wang and Mak, 2012 where the use of plural number of holes can provide good uptake performance [8]. This is because the use of the number of holes that accumulate by two-fold in each sample so that it will effectively improve the viscosity damping mechanism.

In all samples tested using *pink noise* and *white noise* sources, a small portion of the absorption coefficient value can be above 1 ($\alpha>1$) and below zero or minus as shown in Figure 7 and 8. This is caused by diffraction effects or better known *edge effects* resulting from wave diffraction in each corner of the sample, in addition the air gap between materials and floors can also increase the sound absorption so that the resulting absorption coefficient is greater than 1. Then there is a reflection on the sample when measuring the buzzing time of space with a sample that can make the resulting absorption coefficient minus. The same thing also happened in previous research about the effect of bagasse fiber composition on the absorption of acoustic panel sound [1]. In this study, the highest absorption coefficient value is found in sample 3 which has the greatest thickness compared to other samples and is present in low frequency range that is at the frequency of 250 Hz. This result is in line with the theory with sample thickness will shift the frequency to low frequency with high sound absorption coefficient value[9]. And it can be seen that the thicker the sample the sound absorption coefficient becomes shifted to a lower frequency. The same thing also happened in previous research, in the sound absorbing panel of *Sandwich Composite* material as interior wall of the room, where the increase of *Noise Absorption Coefesient* (NAC) value increased in low frequency range (400-1000 Hz) of 11.8% [4].

CONCLUSION

In this research has been successfully made panels with design of *acoustic sandwich composite* fiber-based fibers and foam concrete with masses of fibers and the number of cavities holes vary where the hole cavity is contained on the top layer *skin* of the sample. The thickness of the sample affects the acoustic absorption coefficient value which effectively shifts at low frequency, as in this research the best sound absorption occurs in the panel with the most fibrous fiber composition of 3 kg, but the effective absorption coefficient value is in the range of 250 Hz. The use of the number of cavities in the *skin* of the initial lining of each sample can effectively cause the sound absorption coefficient value to increase with a wider frequency range due to the increased viscosity damping mechanism along with its resonance absorption mechanism. To obtain better sound absorption coefficient measurement results by using the humming method, it is necessary to note several things, namely appropriate techniques at the time of conducting research, the completeness of adequate tools, and also the feasibility of tools that facilitate the process of taking research data with more well again, so the results obtained will be more in line with the expected research.

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