# PROCEEDINGS VOL. 2

# The 3rd International Conference on Engineering & ICT

*"Green Technology For Sustainable Development"*

3rd International Conference on Engineering and ICT (ICEI2012)
Melaka, Malaysia
4 – 6 April 2012

# THE EFFECT OF BINDER ON THE ACOUSTICAL PERFORMANCE OF THE PADDY STRAW 'GREEN' SOUND ABSORBER

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**Abstract**
Sound absorbing material are widely use in application. It was started from asbestos-based material and now generally fabricated from synthetic materials. These non-biodegradable materials do not only cause pollution to the environment, but also contribute significantly in increasing the $CO_2$ causing the effect of global warming. Therefore researchers have now driven their attentions to find sustainable and eco-friendly materials to be an alternative sound absorber. This paper discusses the use of natural fibers from dried paddy straw as fibrous acoustic material. Since these are common natural waste materials found across South East Asia, the usage will also minimize the production cost. Panels of sound absorbers from paddy straw are fabricated using hot press and their acoustic properties are investigated through experiment. The effect of the binder on the acoustic performance of the panel is investigated. In average, good sound absorption coefficient is found particularly above 2 kHz.
***Keywords*—Global warming; non-biodegradable; sustainable.**

## I. INTRODUCTION

Porous materials as sound absorbers are widely uses in building industries. Generally, they are made from synthetic-based fibers (SF) such as glass wool and asbestos. Building wall and ceiling are some examples where the sound absorbers are applied. It requires about more than 60% spaces of the whole building. However, when it comes to disposal, problems arise since these materials are non-biodegradable and also hazardous while handling. The effect of these synthetics in their fabrication on the increasing of $CO_2$ has also been discussed [1]. Therefore existing materials need to be replaced with alternative eco-friendly materials such as natural fibers (NF).
Due to several beneficial factors using NF as shown in Table 1, several works have been done to investigate natural fibers as sound absorbers. These include *kenaf* fibers [2], *Arenga pinnata* fibers [3], tea leaf fibers [4], coir fibers [5-7] and reed [8]. The measured absorption coefficient shows good sound absorption coefficient particularly at mid to high frequencies.

This paper investigates the effect of binder in determines the optimum acoustic performance. This fiber can be found abundantly as agricultural waste in Malaysia particularly and South East Asia in general.

**Table 1.** Comparison between NF and SF [9].

| | NF | SF |
|---|---|---|
| Density | Low | Higher than NF |
| Cost | Low | Slightly higher than NF |
| Renewability | Yes | No |
| Recyclability | Yes | No |
| Energy Consumption | Low | High |
| Health risk when inhaled | No | Yes |
| Disposal | Biodegradable | Non biodegradable |
| Environment Impact | No | Yes |
| Greenhouse Gas Emission | Low | High |

## II. METHODOLOGY

### A. Material Preparation

Construction into samples is divided into two stages, namely the pre-treatment stage and preparation stage as in Fig. 1. In the pre-treatment stage, raw material was cut into 5 to 10 mm length as shown in Fig. 2. Then it was sundried and again heated in the oven at $80^0$C for 5 minutes. In preparation stage, the raw material was mixed with different composition of binders. The mixture was then hot-pressed in a mould to obtain a round shape as shown in Fig. 3.

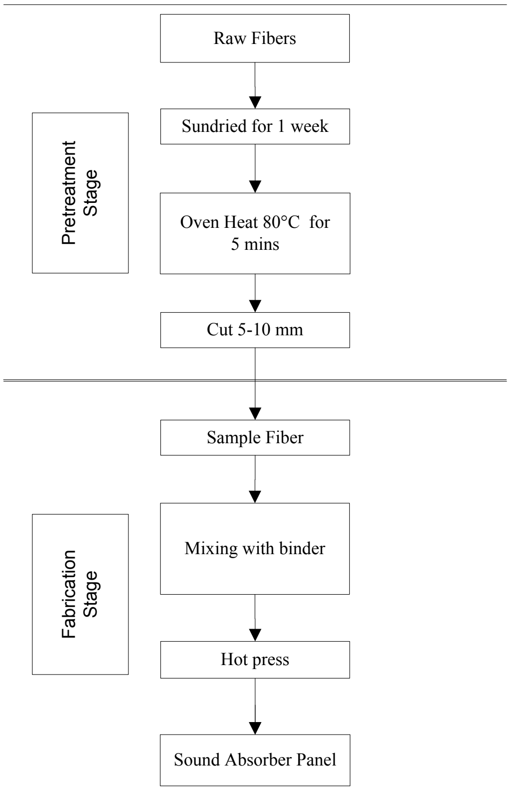



**Figure 1.** Flow chart of pre-treatment and fabrication processes.


**Figure 2.** Sample of paddy straw

**Figure 3.** Constructed sound absorber panel

*B. Composition of binder*

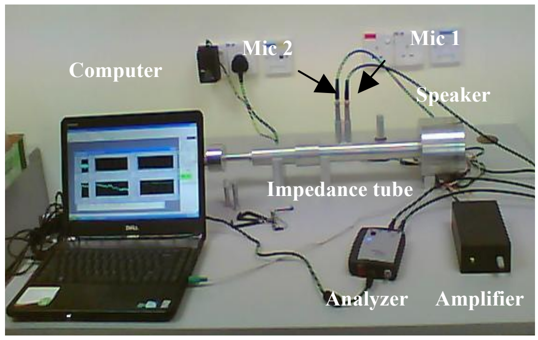
Binder and fiber were mixed with composition shown in Table 2 showing the weight ratio, panel weight and panel density used in order to investigate an optimum acoustic performance of the panel. The binder used in this experiment is a polyester resin. The thickness of samples is 12 mm. Here the weight of the paddy straw was retained while the amount of the binder was changed with the weight ratio between them was noted in Table 2.

**Table 2.** Binder ratio

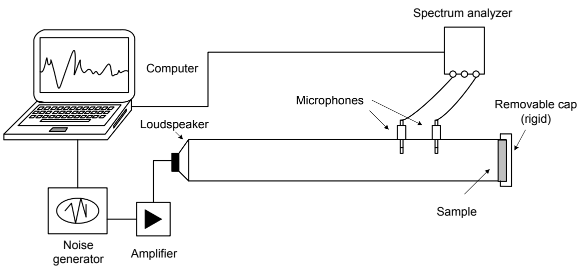
| No | Ratio (%) | Weight (g) | Density (g/cm3) |
|---|---|---|---|
| 1. | 90:10 | 2.9 | 0.256 |
| 2. | 80:20 | 3.08 | 0.295 |
| 3. | 70:30 | 3.1 | 0.297 |
| 4. | 60:40 | 3.74 | 0.370 |

*C. Absorption Coefficient Testing*

The test was performed using an impedance tube by applying two-microphone transfer function method according to ISO 10534-2:2001 international standard [10] and User's manual [11]. The sample was placed at the end of the impedance tube and backed by a rigid surface. The instrument setup was shown in Fig. 4.




(a)




(b)

**Figure 4.** (a) Equipment used in the experiment and (b) diagram of the measurement setup

## III. RESULT

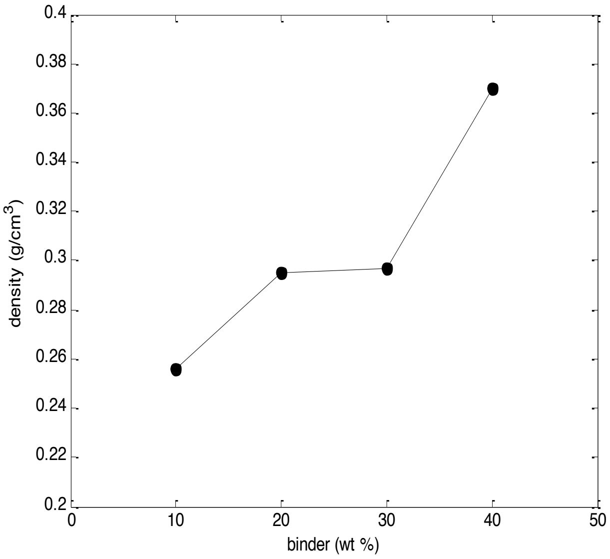



**Figure 5.** Density of samples

Fig. 5 shows the density of each sample with different binder composition. At 20 - 30% binder, there is not much difference of density if compared to 10 - 20% and 30 – 40% binder. This is due to the heat given while hot-press was applied causing lignin inside fibers releasing leftover moisture which makes fibers lighter.

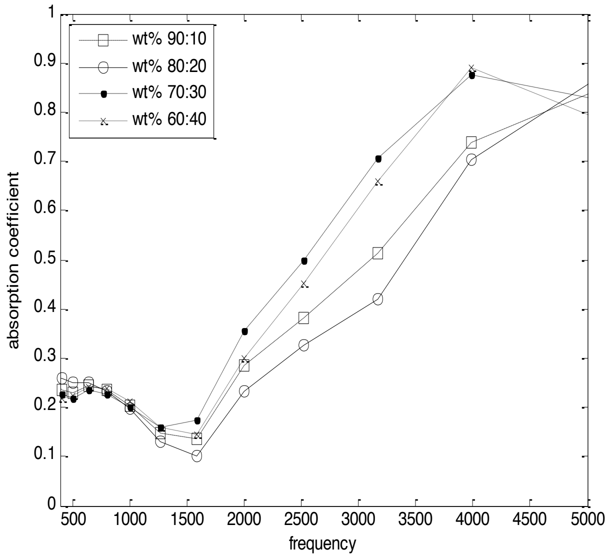



**Figure 6.** Absorption coefficient of samples

Fig. 6 shows that absorption coefficient increased from 1.5 kHz to 4 kHz. Above 4 kHz, the absorption coefficient is around 0.8 on average. From 400 Hz, the coefficient decreases slightly to 0.1 until reaches its maximum at 4 kHz with absorption coefficient value of 0.9.

From Fig. 6, it is interesting to note that the composition of 70:30 has the highest maximum sound absorption between 1.5 kHz to 4 kHz. This might be that at this composition, optimum pores are formed inside the panel which effectively enhances the absorption of sound energy.

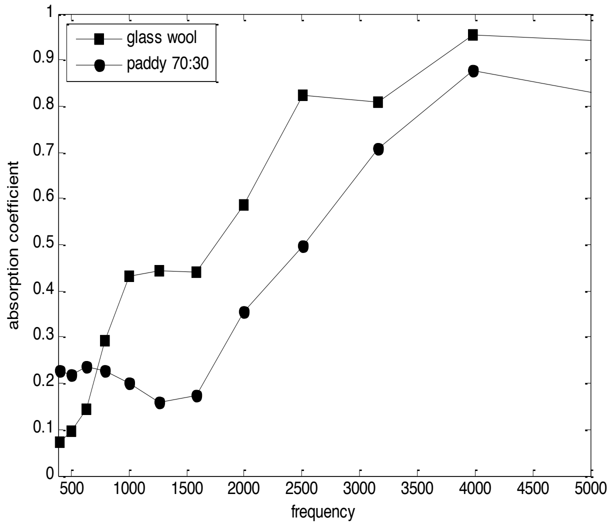



**Figure 7.** Comparison between paddy straw and commercial glass wool

Fig. 7 showing the comparison of absorption coefficient between paddy sample with commercial glass wool. Even though from overall frequencies the paddy still lacking, but it is still comparable to glass wool.

## IV. CONCLUSION

Acoustic performance of the natural paddy straw has been investigated. It is found that the binder composition affects the acoustical performance of the sound absorber. Optimum acoustic performance was obtained when the composition of binder are 30% of the total weight of the fibers. Details of the microscopic pores inside the samples are on interest to support this finding.

## ACKNOWLEDGMENT

The authors would like to acknowledge the Universiti Teknikal Malaysia Melaka (UTeM) for supporting this work under Short Term Research Grant Scheme; PJP/2010/FKM(23B) S737.

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