Penerbit Akademia Baru

Journal of Advanced Research in Materials Science
ISSN (online): 2289-7992 | Vol. 17, No.1. Pages 1-9, 2016

Development of Green Curtain Noise Barrier Using Natural Waste Fibres

A. Y. Ismail [*], *N. A. M. Shadid and A. M. M. Nizam*

Faculty of Engineering Technology, Universiti Teknikal Malaysia Melaka,
Hang Tuah Jaya, Durian Tunggal, Melaka 76100, Malaysia.
[*] *ahmadyusuf.ismail@utem.edu.my*

Abstract – *Noise pollution is one of the major problems in industry. Noise, which is commonly known as undesired sound, comes from numerous industrial machineries and very harmful to the human body. One of the simplest ways to solve this problem is by employing a noise barrier or partition. Current noise barrier are mostly made from synthetic materials which apparently causes another serious problem to the human health. Investigation on the alternative acoustic materials particularly natural fibres has therefore been widely conducted by researchers to solve the problem. This paper introduces natural fibres i.e. paddy straw and coconut fibres as an additional acoustic material to form an eco-friendly noise barrier system. The natural fibre is mixed with synthetic fibre to form a dissipative layer inside the barrier to absorb sound energy. The sample is then tested inside an anechoic chamber to measure its sound pressure level, which is the most common considered value in industrial noise. From the experimental results, it is found that the natural fibres give considerable performance and very potential to substitute the synthetic fibres.*

Keywords: Noise barrier, natural fibre, sound pressure level, green technology

1.0 INTRODUCTION

It has long been known that noise can affect human comfort and health. Noise can be generally defined as unwanted or undesired sound, which is usually generated from turbulence fluid flow or from vibration of mechanical structures [1]. In industry sector, particularly, noise is one of the most pervasive occupational health problems which can cause sleep disturbance and psychological condition [2, 3]. If a person works with continuous high level of environment noise, the person will have a serious harmful health effect such a temporary or even permanent hearing loss [4]. Picarda, *et. al*. found that around twelve percent of workers accidents are attributed from noise exposure and noise-induced hearing loss [5]. Therefore, regulation for the maximum permissible noise exposure has been made to protect the hearing system from high level noise [6].

In order to reduce noise in a system, there are three basic elements to be considered namely source, path and receiver. The simplest way is by controlling noise path in which many researchers have been working. The idea is by installing a partition to effectively block the sound energy and transmitting only few of the rest. The reflection is obtained due to large change of acoustic impedance in the transmission path [7]. The partition nowadays has been widely developed in terms of design and applications. This includes panel-like barrier [8], double panels [9], double panel with additional material insertion [10], sandwich panels [11], as well as portable curtain-like barriers [12]. The latter gives the most usable barrier since it is light weight, portable and easy to be moved. Moreover, it can also be designed following the shape of the noise sources. Usually, noise curtain is made from special fabric with porous materials inside. The example of commercial noise curtain can be seen in Figure 1.

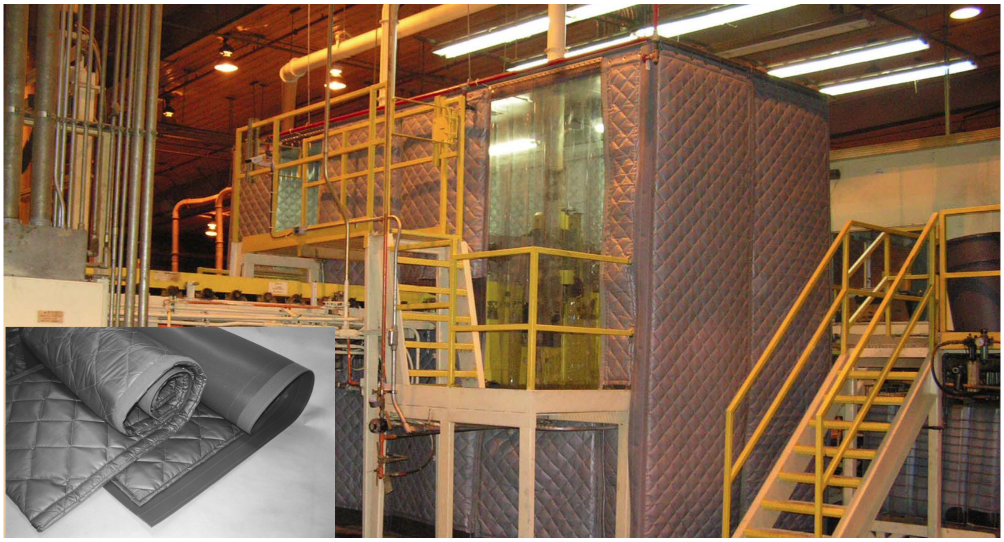

Figure 1: Noise curtain in a machinery [12].

Nevertheless, most of the commercial partition is made using synthetic porous absorber materials i.e. glass wool or fiberglass [12] which possibly causes another serious problem to the human health. Jackel, *et al*. found that asbestos fiber such as glass wool, basalt wool, ceramic fiber and mineral wool in different sizes and geometries can give various lung damages [13]. Asdrubali also concluded that synthetic materials like foam glass makes high Global Warming Potential (GWP) [14].

Researches on natural fiber (NF) have been of interest since it apparently provides good sound proofing performances. Additionally, they are bio-degradable, non-abrasive, abundance and better for health and safety [15]. D'alesandro and Pispola investigated the use of *Kenaf* and blankets of recycled polyester as sound absorber materials. It was found that both samples give good absorption performance at 1000 – 5000 Hz with average of 0.8 [16]. Lindawati, *et al*. found that *Arenga piñata* fibers performs well as acoustic absorber from 2000 – 5000 Hz [17]. A comparison study had been interestingly conducted by Ersoy and Kucuk, where a woven textile cloth was compared with tea-leaf natural fibers in terms of sound absorption performance. The results showed that six layers of woven textile cloth give similar absorption performance with only 1 cm thick of tea-leaf fibers at 500 – 3000 Hz [18]. Zulkifli *et al*. found that single layer of coconut coir fiber has good absorption performance at mid and high frequencies and performs well at low frequencies if the layer is multiplied [19]. Additionally, combination of such coir absorber with perforated panel had apparently shifted the peak towards low frequencies [20]. Recently, Abdullah *et al*. have also found that dried paddy straw and sugarcane fibers are adequately feasible to be used as an acoustic absorbers. Increasing the thickness gives better performance at low frequencies [21].

This paper, therefore, performs a further investigation on the use of natural waste fibers as additional acoustic absorbers in a more practical application i.e. noise curtain in industry. The investigation is made through experimental work in an anechoic chamber in order to accurately obtain exact performance value.

2.0 METHODOLOGY

Penerbit Akademia Baru
Journal of Advanced Research in Materials Science
ISSN (online): 2289-7992 I Vol. 17, No.1. Pages 1-9, 2016

2.1 Material Preparation

In this experiment, paddy straw (PS) and coconut fibers (CF) were chosen as green acoustics filling materials since both are abundantly available in South East Asia. Some of current home appliances and crafts i.e. ceiling and mattresses are even already made from such fibers [22].

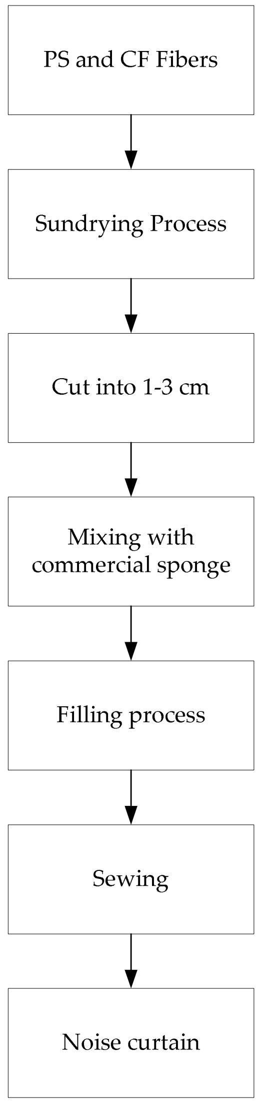

Figure 2: Flow chart of material preparation process.

The preparation was generally divided into four processes which were drying process, cutting process, mixing process and finishing process. In the first stage, PS and CF were sundried to evaporate the remaining water in the fiber. It was then followed by the cutting process according to the size of the curtain. Then, after mixing evenly with commercial polyurethane sponges inside the filling space, the last stage was sewing into a curtain product. Each curtain size was kept constant with 72 cm of height and 54 cm of width. The curtain was placed surround the noise source. The process flow chart can be seen in Figure 2, while Figure 3 shows an example of the polyurethane sponge and half-finished natural fiber.

Journal of Advanced Research in Materials Science
ISSN (online): 2289-7992 I Vol. 17, No.1. Pages 1-9, 2016

Figure 3: Sponge and PS natural fiber after drying and cutting

In order to investigate clearly the effect of natural fiber, several compositions of natural fibers and sponge had been made which is shown in Table 1.

Table 1: Natural fibres vs Sponge composition

Sample	**Natural Fibers**	**Composition**	
		Natural Fiber	Sponge
1	PS	0%	100%
2	PS	15%	85%
3	PS	30%	70%
4	PS	60%	40%
5	CF	0%	100%
6	CF	15%	85%
7	CF	30%	70%
8	CF	60%	40%

The test was performed in an anechoic chamber using standard sound pressure level measurement method. The acoustic microphone used were the ½" Prepolarized free field microphones (PCB 378B02) with ½" ICP preamplifier (426E01) and TEDS. Data acquisition system used was VibPlot m+p SO Analyzer. Figure 3 shows the experimental setup of the measurement. Air compressor JUN-AIR OF302-25B is used as a noise source which operates at constant speed. Air compressor was used as it is one of the most troublesome noises in industry which can produce noise up to 105 dB as reported by World Health Organization (WHO) [23].

The sound pressure level (SPL) equation is given by

Journal of Advanced Research in Materials Science
ISSN (online): 2289-7992 I Vol. 17, No.1. Pages 1-9, 2016

$$SPL = 10 \log (p/p_{ref})^2 \quad (1)$$

which can also be written as

$$SPL = 20 \log (p/p_{ref}) \quad (2)$$

Where p is the measured acoustic pressure obtained from the measurement and p_{ref} is reference sound pressure given by 2 x 10^{-5} Pascal.

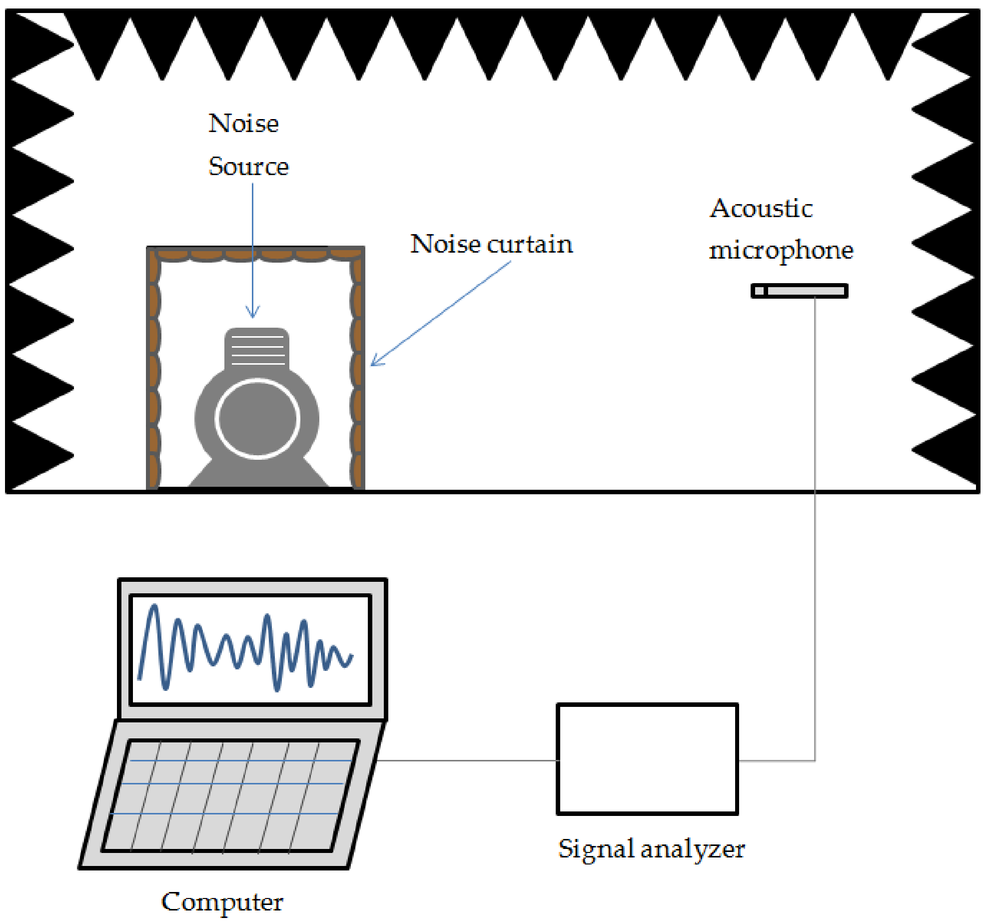

Figure 3: Measurement setup.

3.0 RESULTS AND DISCUSSION

Penerbit Akademia Baru
Journal of Advanced Research in Materials Science
ISSN (online): 2289-7992 I Vol. 17, No.1. Pages 1-9, 2016

Figure 4 shows SPL comparison between curtained and non-curtained noise sources. Generally, it can be seen that the curtain system has effectively achieved the purpose of reducing noise level. At low frequency region between 0 – 500 Hz, however, the reduction cannot yet be seen due to cut off frequency limitation from the microphones. Starting from 1000 – 5000 Hz, the proposed system gives significant reduction from 5 dB even up to 15 dB at around 5000 Hz. This can be considered as high performance as compared to the commercial one. At medium high frequencies around 5000 – 15,000 Hz, the reduction level can be seen to be constant at around 15 – 20 dB. In general words, the NF curtain system shows adequate possibilities to be implemented in practice.

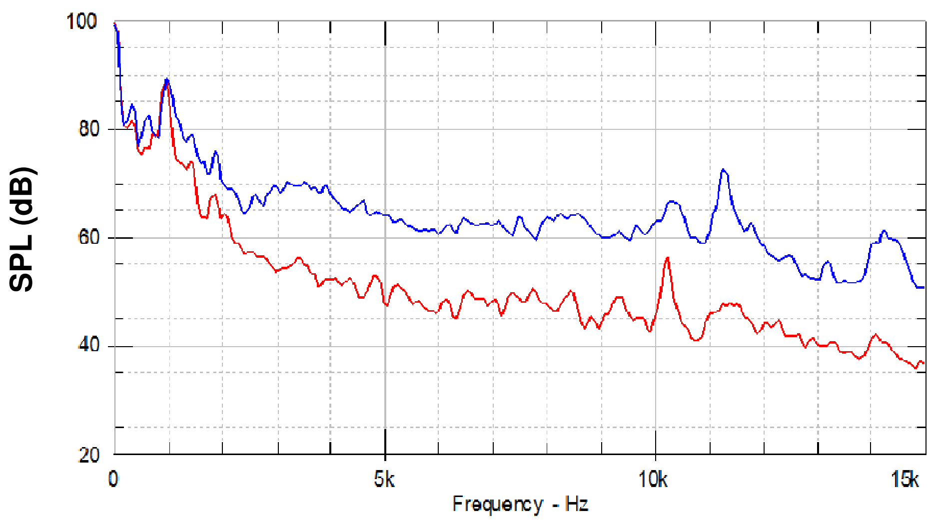

Figure 4: SPL of non-curtained noise source (blue line) and curtained with 60% of PS (red line)

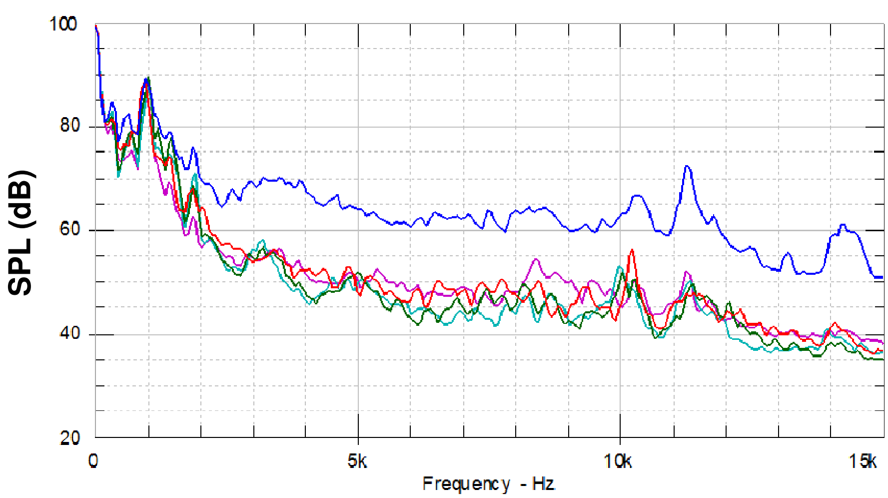

Figure 5: The effect of PS on the SPL performance (—without curtain, —0%, —15%, —30%, —60%)

Figure 5 shows the effect of amount of PS in the curtain system. The increment of PS gives only slight changes on the SPL performance as around 1 – 2 dB differences occur for all

Journal of Advanced Research in Materials Science
ISSN (online): 2289-7992 I Vol. 17, No.1. Pages 1-9, 2016

compositions. Theoretically, as the amount of PS increases, more pores are made inside the system. More porosity means more absorption possibility as described by Abdullah *et al*. [21]. But in this case, the amount of PS might be too small and the sponge still shows domination for the absorption performance. Nevertheless, the best reduction performance is apparently obtained from 15% and 30% PS composition giving the lowest SPL.

The effect of CF on the SPL, meanwhile, is shown in Figure 6. Similar with that of PS fibre, the increment of CF in the curtain does not give considerable effect on the SPL performance. Curtain with 30% even shows the worst performance since it gives high SPL performance. Most likely, 30% of CF inside the system forms very minimum pores and reduces the domination of the sponge. This is taken into account to be the critical composition for the curtain showing the less SPL performance. However, the other PS compositions constantly reduce noise level up to 15 – 20 dB from 3000 – 15, 000 Hz. This also means that those PS composition exclude 30% could possibly be implemented as additional absorptive acoustic materials.

There needs to be more and broader investigations regarding the best composition for each NF which might be done by adding more optional percentages particularly within 30% of PS. Moreover, the amount of synthetic sponge is highly recommended to be reduced or even totally neglected.

In order to do so, binding agent is needed and new fabrication process should be made for the NF. The effect of binding agent on the absorption performance could be investigated separately which will probably give many differences with the NF without binder. According to Abdullah *et.al.* [17] large amount of binder creates more pores inside the NF. While in terms of safety issue, anti-flammable material which is also not included yet in this research could also be studied to give more comprehensive information.

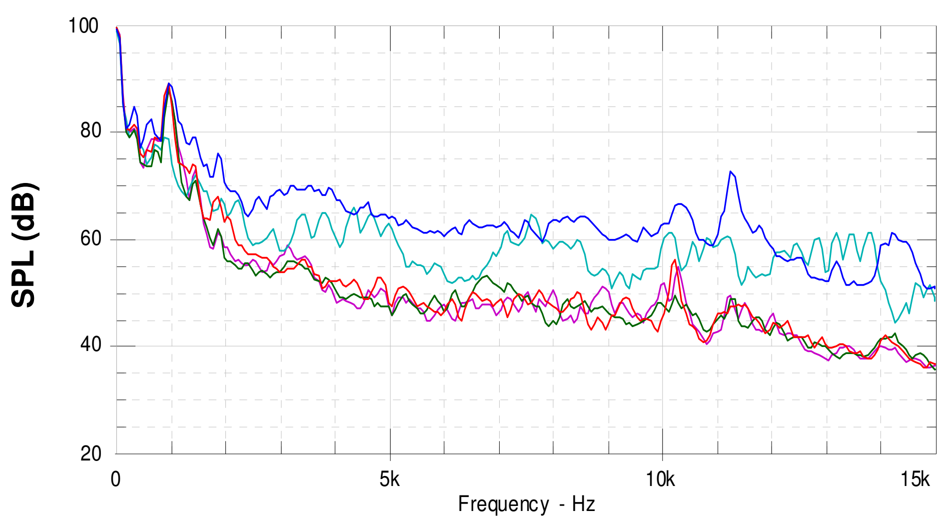

Figure 6: The effect of CF on the SPL performance
(—without curtain, —0%, —15%, —30%, —60%)

4.0 CONCLUSSION

Journal of Advanced Research in Materials Science
ISSN (online): 2289-7992 | Vol. 17, No.1. Pages 1-9, 2016

The effect of natural fibre as additional acoustic materials in a noise barrier system has been investigated experimentally. Two different natural fibre i.e. paddy straw and coconut fibre have shown a feasibility to be a modern eco-friendly acoustic material. However, further investigations is necessary in order to obtain more effective performance involving the use of binding agents for the fibres as well as anti-flammable agents that is obviously needed in practice.

5.0 ACKNOWLEDGEMENTS

The authors would like to be obliged to Faculty of Engineering Technology, Universiti Teknikal Malaysia Melaka (UTeM) for providing laboratory facilities, materials preparation process and financial assistance.

REFERENCES

[1] H. Kuttruff, Acoustics : An Introduction, Taylor and Francis, London, 2007.

[2] P. J. Lee, M. H. Shim, J. Y. Jeon, Effect of different noise combination on sleep, assessed by general questionnaire, Applied Acoustics 71 (2010) 870-875.

[3] T. Saeki, T. Fujii, T. Yamaguchi, S. Harima, Effects of acoustical noise on annoyance, performance and fatigue during mental memory task. Applied Acoustics 65 (2004) 913-921.

[4] M. D. Fernandez, S. Quintana, N. Chavarra, J.A. Ballesteros, Noise exposure or workers of the construction sectors, Applied Acoustics 70 (2009) 753-760.

[5] M. Picarda, S. A. Girard, M. Simard, R. Larocque, T. Leroux, F. Turcottec, Association of work-related accidents with noise exposure in the workplace and noise-induced hearing loss based on the experience of some 240,000 person-year observation, Accident Analysis and Prevention 40 (2008) 1644-1652.

[6] ISO, Acoustics-determination of sound absorption coefficient and impedance in impedance tube, Part 2 : Transfer function method, 2001.

[7] F. Fahy, P. Gardonio, Sound and Structural Vibration : Radiation, Transmission and Response, Academic Press, London, 2007.

[8] K. Chen, Study on the Acoustic Transmission Loss of a Rigid Perforated Screen, Applied Acoustics 47 (1996) 303-308.

[9] A.Y. Ismail, A. Putra, Md.R. Ayob, Sound transmission loss of a double-leaf solid-microperforated partition under normal incidence of acoustic loading, IIUM Engineering Journal (2011) 162-174.

[10] A. Putra, A.Y. Ismail, R. Ramlan, Md.R. Ayob, M.S. Py, Normal incidence of sound transmission loss of a double-leaf partition inserted with a micro-perforated panel, Advances in Acoustics and Vibration (2013) 1-8.

Journal of Advanced Research in Materials Science
ISSN (online): 2289-7992 I Vol. 17, No.1. Pages 1-9, 2016

[11] A. Omrani, I. Tawfiq, Vibro-acoustic analysis of micro-perforated sandwich structure used in space craft industry, Mechanical Systems and Signal Processing 25 (2011) 657-666.

[12] Kinetics Noise, 2012, Industrial Noise and Vibration Control. [online] Available at : www.kineticsnoise.com/industrial/ [Accessed on 16 March 2015].

[13] M. Jackel, A. Safrany, P. Hargittai, R. Szoke, F. Pott, T. Krenyi, Lung effects of conventional and biosoluble glass fibres as asbestos substitutes. An experimental study, AARMS 4 (2) (2005) 275-283.

[14] F. Asdrubali, Survey on the Acoustical Properties of New sustainable materials for noise control, Euronoise, 2006.

[15] R. Zulkifli, Zulkarnain, M. J. M. Nor, noise control using coconut coir fibre sound absorber with porous layer backing and perforated panel, American Journal of Applied Sciences 7 (2) (2010) 260-264.

[16] F. D'Alesandro, G. Pispola, Sound absorption properties of sustainable fibrous materials in an enhanced reverberation room, The 2005 Congress and Exposition on Noise Control Engineering, 2005.

[17] L. Ismail, M. I. Ghazali, S. Mahzan, A. M. A. Zaidi, Sound absorption of Arenga Pinnata natural fibre, World Academy of Science, Engineering and Technology, 2010.

[18] S. Ersoy, H. Kucuk, Investigation of industrial tea-leaf-fibre waste material for its sound absorption properties, Applied Acoustics 70 (2009) 215-220.

[19] M. J. M. Nor, N. Jamaludin, F. M. Tamiri, A preliminary study of sound absorption using multi-layer coconut coir fibre. Electronic Journal Technical Acoustics, 2004.

[20] M. H. Fouladi, M. J. M. Nor, M. Ayub, Z. A. Leman, Utilization of coir fiber in multilayer acoustic absorption panel, Applied Acoustics 71 (2010) 241-249.

[21] Y. Abdullah, A. Putra, H. Effendy, W. M. Farid, M. R. Ayob, Investigation on natural waste fibre from dried paddy straw as a sustainable acoustic absorber, IEEE First Conference on Clean Energy and Technology CET, 2011.

[22] V. C. Chinh, H. A. Quoc, Manufacturing heatproof ceiling from agricultural waste, Journal of Engineering Technology Education 10 (2) (2013) 111-117.

[23] S.N.Y. Gerges, G.A. Sehrndt, W. Parthey, Noise sources. World Health Organization, 103-124.