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The Acoustical Characteristics Analysis on Different Type of Natural Fibres

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Abstract. Natural fibres are fibre that can be directly obtained from an animal, mineral, or vegetable sources. Recently natural materials are becoming a good alternative for synthetic material as they provide good health to a greener environment. This aim of this study to investigate and compared the acoustic characteristics of three natural fibres; Kenaf fibre *(Hibiscus Cannabinus)*, Ijuk fibre *(Arenga Pinnata*), and Coconut coir fibre, where each material is qualified for acoustical absorption. During the processing stage, each fibre is reinforced with 60:40 ratio of pure latex separately. The fibres are then compressed after the pure latex treatment into circular samples, of 28 mm and 100 mm diameters respectively. The thickness of each sample is fixed at 50mm. The acoustical performances were evaluated by using an impedance tube instrument. This study also investigates the effect of air gap of 10mm and 50mm in the sound absorption performance. The results show that, all the three fibres have reached an optimum level of sound absorption value of more than 0.7. The frequency peak value of Kenaf is obtained in a range of 700 Hz – 800 Hz, while for coconut coir is at 1000 Hz – 1075 Hz frequency range. Only Ijuk has obtained the highest frequency range of 3200 Hz – 3400 Hz. The results demonstrate that these three fibres are a promising light and environment-friendly sound absorption material as they are ready to replace the common synthetic fibre.

Introduction

In this technology era, sound control in a building or in human living space has improved considerably. Following the progress, technology has improved the control of room interior`s sound quality, but at the same time, the balance of the development and application of advanced materials should also be considered. Besides that, there are some hazardous sounds that have become much more complex and serious for human life [1]. Therefore, a thin, lightweight and low-cost material that will absorb sound waves at wider frequency regions are strongly desired [1]. In common building structure industry, usage of synthetic materials for sound absorption panels are still a regular practice for them. But using synthetic material can cause pollution to the environment and health in the short term time period [2]. Due to that, many researchers are interested in natural based materials rather than using synthetic materials. Fibres that can obtain from fauna and flora are naturally bio-degradable, non-harmful and less hazardous to human health and the environment including low safety risk on their process [2]. Moreover, in sustainable chart, natural fibres are leading. Several researches investigate the capability on the performance of natural fibres uses an acoustic absorber. Nevertheless, sound absorption properties α, of natural fibres are not investigated much and there is very less information about them.

Many studies focused on a similar group of natural fibres, which have discovered and suggested to use them as acoustical panel. Coconut coir fibre has good sound absorption at higher frequencies, but less value for the lower frequencies, the same goes for oil palm fibre [3][4][11]. Higher noise absorption of oil palm is due to its higher density [5]. Coir has higher absorption coefficients from middle to high frequency range of 1400 Hz to 6300 Hz that revealed by S.

Mahzan and A. A. Zaidi studies [6]. D'alessandro and Pispola [7] used Kenaf (Hibiscus Cannabinus) and blankets of recycled polyester (PET) fibres to make sound absorption panels. The acoustic properties results of both samples concluded that the absorption level is good at the frequency range of 1000 Hz to 5000 Hz with the average of 0.8. In the case study of Lindawati Ismail [8], Ijuk (Arenga Pinnata) are tested at 40 mm thickness and the obtained sound absorption coefficients were good for the medium to high frequency which is from 2000 Hz to 5000 Hz within the value range of 0.75 – 0.90. Dried paddy straw fibres are also used as a sound absorption panel by Y. Abdullah and A. Putra [9]. The result obtained at 1500 Hz has an average absorption coefficient of 0.8 which contain carboxymethyl cellulose (CMC) as a binder. At the same time, the researcher also found that the performance at low frequencies can be increased by increasing the composition of the CMC binder [9][10].

This research study about sound absorption coefficient on few selected natural fibres that are easily obtained around these ASEAN countries. The chosen natural fibres are Kenaf fibre (Hibiscus Cannabinus), Ijuk fibre (Arenga Pinnata), and coconut fibre also known as coir. The sound absorption coefficient test samples are made of natural latex rubber as a binder and the listed natural fibre as raw materials on fixed ratio of 60:40. Acknowledge by that the previous researchers, Urea-formaldehyde and Polypropylene are used as reinforcing agent that contains chemical behaviour. However, it could affect and pollute the environment in the long run [2][8][9][10]. So far not many studies are done on natural sound absorption properties by using pure latex rubber as a binder. Also in this study, the thicknesses of this sample are fixed according to the global standard of acoustic synthetic panel`s thickness size, which is 50 mm. Other strategies such as adding air gap may be utilized to further enhance the absorption coefficient. Hence the air gap is used to improve the acoustical properties of the natural fibre in two different ranges, 10mm and 50 mm. Normally an optimum level acoustic performance is found at the range between 1000-5000 Hz with the average absorption coefficient of 0.8 [2].

Materials and Method

A. Material Preparation

There are two main parts comprise in this study. The raw fibres are obtained from local factories and farm. After chopping and crushing into average length 10-20 mm, the raw fibres that contain cellulose layer and unwanted properties are soaked in the alkaline treatment of sodium hydroxide 2% (NaOh) for 24 hours to remove this dirt. Then the fibres are heated up to 80°C for 2 hours to remove the alkaline wetness. By using the weight percentage calculation, the ratio combination of 60:40 of fibre and pure latex are measured in gram capacity. Both fibre and pure latex is mixed well and fill up into a cylindrical mould. The composite mould was relocated into a hot press machine which was heated up to 130°C. The pressure of the machine is initially set to 15 bars for 10 minutes. These parameters are constant for each sample. The size of the samples as follows the impedance tube diameter, but the thicknesses are fixed at 50 mm as shown in Figure 1 (a) (b) (c).

(a) (b) (c)

Fig. 1: Samples (a) Ijuk (b) Kenaf (c) Coconut coir

B. Sound Characteristics Test

The sound characteristic test of Kenaf, Ijuk and Coconut coir that are reinforced with pure latex are studied in this work. The testing was done using Impedance Tube Method (ITM) by applying standard two-microphone transfer function that is based on ASTM E1050-09. The small impedance tube kits consisted of a 28mm diameter tube (small tube for high frequency), a sample holder, and an extension tube of the same diameter. The large impedance tube kit consisted of a similar tubular apparatus with a diameter of 100mm (low frequency). The small and large tube setups were used to measure different acoustical parameters and later the large and small tube measurements were combined to determine the sound absorption coefficient α, for the frequency range of 1Hz - 4500 Hz as shown in Figure 2.

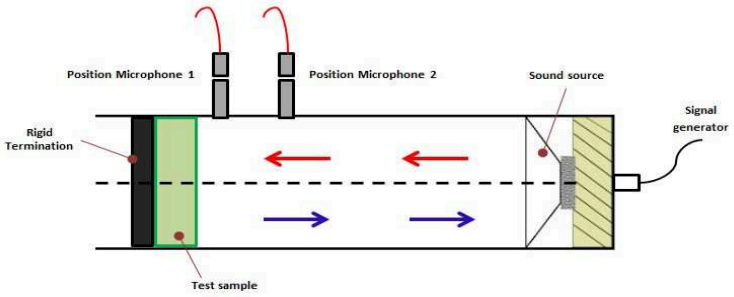

Fig. 2: Schematic diagram of Impedance Tube

Result and Discussion

A. Sound Absorption Coefficient of Natural Fibres

Figure 3 shows the results of sound absorption coefficient α, among the three fibres, Kenaf, Ijuk and Coconut coir that are reinforced with pure latex in a combination ratio of 60:40. Among the three chosen fibres, coconut coir composite shows the highest absorption value of 0.99 in the frequency range 1000 Hz - 1075 Hz. Kenaf at frequency range of 700 Hz - 800 Hz reached its maximum value of sound absorption value which is 0.92, then gradually drops to 1400 Hz. As for Ijuk, its absorption value is 0.96 at the peak. But compare to Coir and Kenaf, Ijuk reaches its optimum value at higher frequency ranges that is 3200 Hz - 3400 Hz. The comparison of the previous acoustical researchers on natural fibres, Lindawati (2010) used Ijuk without any binder and obtained an optimum value of sound absorption is 0.88, at medium range frequency. In this study, using Ijuk as fibre and pure latex on 60:40 mixing ratio, 0.95 values of sound absorption are obtained in the medium range. Hosseini Fouladi (2011) use 45mm of coir as the sample`s thickness with the binder gained is 0.8 as sound absorption value at low frequency. In this research, coir with pure latex reached 0.99 at the low frequency range. Figures 3 also show that Kenaf and coconut coir absorption value are mostly consistent after the range of 1300 Hz. From the graph, it can be seen that the three natural fibres that use pure latex as binder give an optimum value range from 0.7 to 0.9.

B. Sound Absorption Coefficient of Natural Fibre with Air Gap

The value of sound absorption coefficient for each selected natural fibre obtained in the presence of air respectively on the back of the samples in the range of 10 mm and 50 mm air gap. Air gap also increases the performance of sound characteristics. When the air gap increases, the optimum value also differs. Figure 4, Figure 5 and Figure 6 shows the differences of both air gaps value on the same sample of different fibres. From each of air gap graphs, it can be seen that within different air gaps the sound absorption coefficient α, reach the peak value earlier compare to the sample without air gap. Furthermore the values obtained are shifting more towards the lower frequency such as in

Kenaf result. Figure 5 shows the highest value of absorption coefficient is at 0.92, from 600 Hz onwards with a 10mm air gap. Drastic changes occur in Ijuk sample test. The value of sound absorption reached its peak earlier than the test without air gap. In the same Ijuk sample test with difference air gap values testing are also showing the similar value changes. In the Figure 4, the lines are smoother compared to the graph of no air gap test. At overall, the result coefficient values of samples with and without air gap are reaching its optimum level with a slight difference.

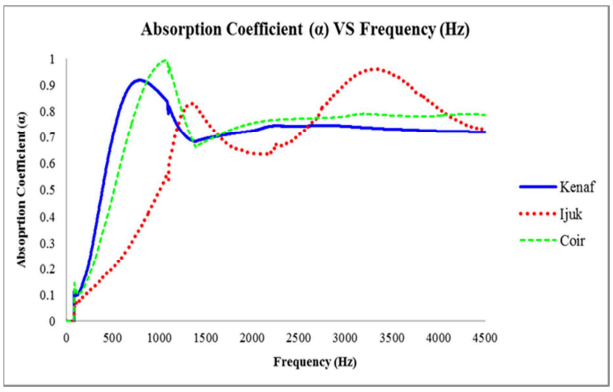

Fig. 3: Sound absorption of natural fibres

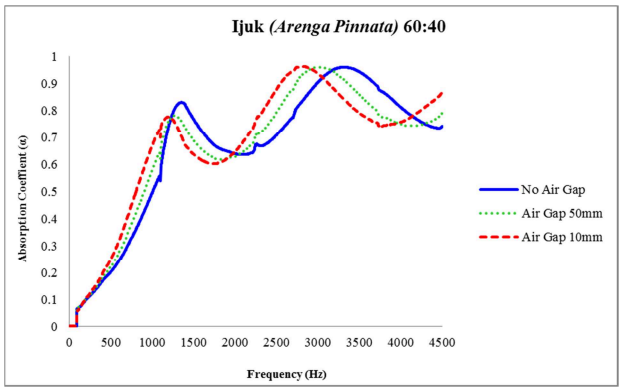

Fig. 4: Sound absorption of Ijuk fibre with 10mm and 50mm air gap

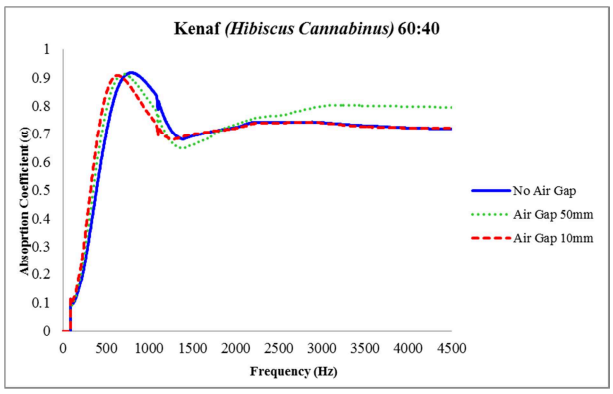

Fig. 5: Sound absorption of Kenaf fibre with 10mm and 50mm air gap

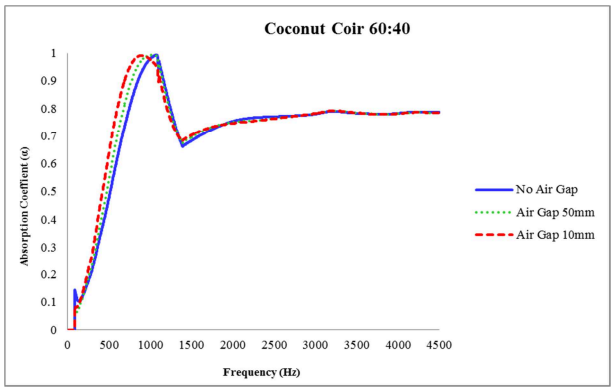

Fig. 6: Sound absorption of Coir fibre with 10mm and 50mm air gap

Conclusion

This study shows that by using the impedance tube test method to determine sound absorption coefficients of selected natural fibres have been successfully carried out. Samples of sound absorber have been made from Kenaf, Ijuk and Coconut coir which go through a 2% alkaline treatment. The experiment shows that these natural fibres can be a good alternative sound absorber compared to synthetic fibres. The thickness of each 50mm natural fibre shows the optimum level of sound absorption coefficient value of more than 0.7. Also known that, air gap gives better sound absorption result and earlier shift at low frequency compare to without air gap. The performance at higher frequency can be improved by increase the mixing ratio of fibres and binder. These will be investigated in the future work.

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