SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion it is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure and Material)".

Signature: ....

Supervisor: DR. AZMA PUTRA

Date: 29 JUNE 2012

INVESTIGATION ON THE PERFORMANCE OF A HYBRID MICROPERFORATED PANEL-NATURAL WASTE FIBRE AS AN ECO-FRIENDLY SOUND AND NOISE BARRIER

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledge."

Signature : ....

Author : DG HAFIZAH BINTI KASSIM.

Date : 29 JUNE 2012.

To my parents,

My supervisor,

and to all my friends.

Thanks for all the support and ideas.

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ABSTRACT

Noise can cause disruption to one's health when noise exposure levels are exceeding the certain limits. To reduce the sound and noise disturbance, new material has been developed as the potential sound absorption material. Conventional absorber is expensive and deteriorates through time. Recent development of natural fibre is increasing after their acoustic performances have been explored. Furthermore, the abundance source of fibre in Malaysia made fibre as the sustainable material for the sound absorption panels. In addition to the research, the researchers also find the employment of the microperforated panel (MPP) replacing the synthetic porous material. The objective of this project is to investigate the performance of a coupled absorber consisting of microperforated panel (MPP) and natural fibre. Coconut and sugarcane fibre are introduced in this study to be coupled with microperforated panel (MPP). The results obtained from the experimental tests by using impedance tube method show that both fibre has increase the transmission loss of the hybrid microperforated panel (MPP)-natural waste fibre at low frequency range but decrease at frequency more than 1000 Hz. Coir fibre enhance transmission loss (TL) performance at 300 Hz to 800 Hz while sugarcane fibre at 300 Hz to 600 Hz. Particularly, for noise source which is predominant at low frequencies below 1 kHz.

ABSTRAK

Bunyi bising boleh mengganggu kesihatan seseorang apabila tahap pendedahan bunyi melebihi had pendengaran. Bagi mengurangkan bunyi dan gangguan bunyi bising, bahan berpotensi baru telah dibangunkan sebagai bahan penyerap bunyi. Bahan penyerap konvensional adalah mahal dan merosot dengan perubahan masa. Perkembangan terkini gentian asli telah meningkat hasil daripada penerokaan ciri-ciri akustik bahan berkenaan. Selain itu, sumber yang banyak di Malaysia menjadikannya bahan yang mampan untuk bahan penyerap bunyi. Disamping itu, penyelidikan juga dibuat untuk mengenalpasti pengunaan plat panel berliang bagi menggantikan bahan poros sintetik. Objektif kajian ini adalah untuk menyiasat prestasi penyerap gabungan yang terdiri daripada plat panel berliang dan gentian asli. Gentian kelapa dan tebu diperkenalkan dalam kajian ini untuk digabungkan bersama plat panel berliang. Keputusan yang diperolehi daripada ujian eksperimen dengan menggunakan tiub galangan menunjukkan bahawa kedua-dua gentian asli telah meningkatkan kesan penebat pada julat frekuensi rendah tetapi menurun pada frekeuansi melebihi 1000 Hz. Gentian kelapa meningkatkan prestasi pada julat 300 Hz hingga 800 Hz, sementara gentian tebu meningkatkan prestasi pada 300 Hz hingga 600 Hz. Terutamanya bagi punca bunyi yang dominan pada frekuensi rendah di bawah 1 kHz.

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LIST OF ABBREVIATION AND SYMBOLS

kHz	=	kilohertz
NRC	=	Noise Reduction Index
MPP	=	Microperforated panel
TL	=	Transmission loss
STL	=	Sound Transmission loss
m	=	Meter
kg	=	kilogram
dB	=	Decibel
STC	=	Sound Transmission Class
mm	=	Milimeter
ft	=	feet
º C	=	Degree Celsius
%	=	Percent
d	=	Diameter
g	=	Gram

CHAPTER 1

INTRODUCTION

1.1 SOUND AND NOISE

Every day we are exposed to sound either it is not required, necessary, or beneficial, twenty-four hours a day, seven days a week. In a physical way, there was no different between sound and noise. Sound is a sensory perception by human [1] which it is can be define as a pressure variation that travels through air (wave) and can be detected by the human ear [2]. Sound wave that travels through air is the resulting of the physical disturbance of air molecules such when tapping a tuning fork and the waves will combine to reach the listener direct or indirectly [3].

In a general way, the sound wave is any disturbance that transmitted in an elastic medium consisting of gas, liquid, or solid [4]. Although sound travels and can be heard but not all the sound are audible. Limits of audibility are only from 20 Hz to 20 kHz [5]. Sound below 20 Hz is infrasonic sound and sound greater than 20 kHz is an ultrasonic sound.

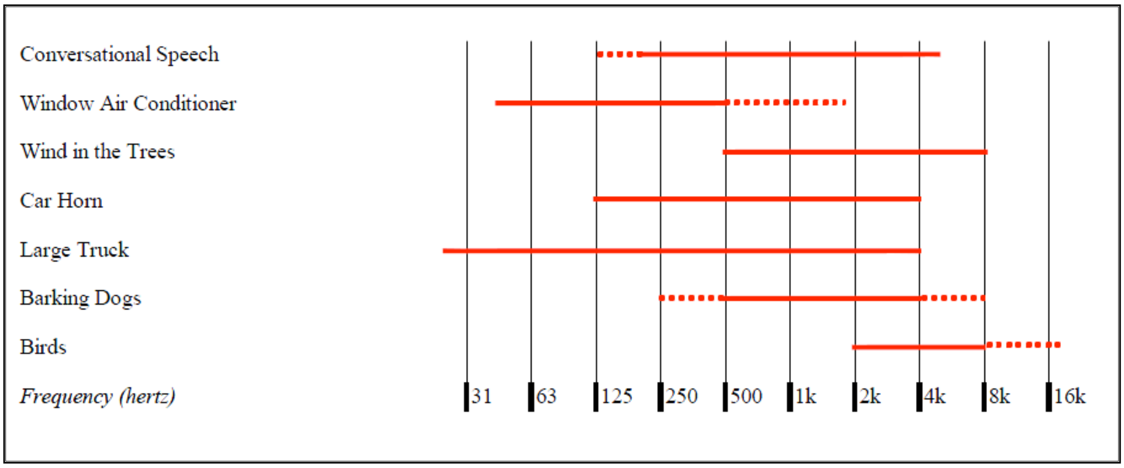

Figure 1.1: Frequency range of typical sound sources.

Noise is defined as excessive or any unwanted sound considered by human ear [1, 4, 5] which can possibly cause annoyance or hearing loss [2]. Figure 1.1 shows the frequency range of the typical sound sources in our daily life. Noise can be related to three different elements namely the source, the receiver and the transmission path [5] that can be seen at Figure 1.2. Transmission path commonly comprise of air or any structural material.

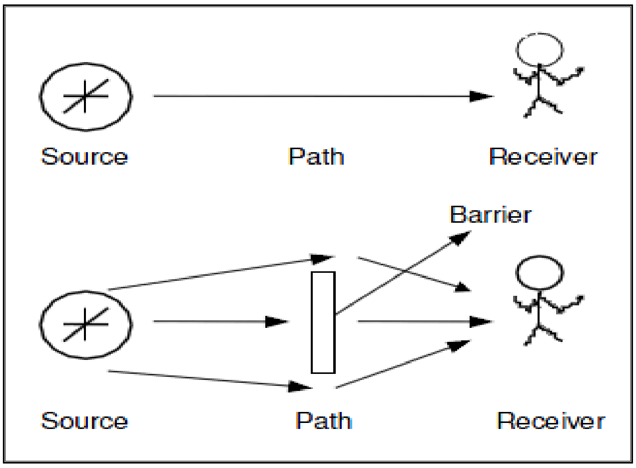

Figure 1.2: Inter-relationship between the elements of noise.

Additionally, noise may be continuous or discontinuous with high or low frequency as long as it is undesired for normal hearing. Design solution for noise is done by recognizing characteristics of main element that play a major role and also the sound transmission path.

1.1.1 Sound Absorption

Every material has its own ability to absorb sound energy. Material that has low absorption ability tends to reflect most of the acoustical energy and vice versa. Sound absorption is a capability of a material to convert sound energy into other energy. This energy is usually converted to heat energy [6]. The property of a material absorbing ability is called sound absorption coefficient at a particular frequency range.

Absorption material in building usually used Noise Reduction Coefficient (NRC) with the average sound absorption coefficient range of 250 Hz to 2 kHz with NRC of 1.0 as perfectly absorptive and NRC of 0.0 as perfectly reflective for its scale [3].

1.1.2 Sound Insulation

Sound insulation can be differentiating in two manners: airborne sound insulation and impact sound insulation [7]. Airborne sound is generated from a source such as loudspeakers and transmitted through the air. Pressure from the sound will cause a vibration in material instead travelling in them. New vibration will be set up in the next corresponding air to continue transmission of the sound [8]. Impact sound or also known as the structure borne sound is caused by direct vibration to the material by object, for example footsteps. These vibrations transferred to the air next to it including structure that connected with the material [8]. As it is important to insulate both of the sound sources, there is a concern to build a reducing partition between spaces, inside or outside depending on the acoustic requirement.

Figure 1.3: Airborne sound (a) an impact sound insulation (b) between two rooms.

1.2 NATURAL FIRBE

Fibres are continuous filaments or a discrete elongated material that belong to a hair-like class. It can be spun into filaments, thread or rope. Fibre can be classified into two main groups, which are natural fibre and man-made fibre [9]. The two main groups can then be further subdivided into smaller parts. In general, natural fibres can be subdivided as to their origin such as plants, animals, or minerals, whereas man-made fibres can be subdivided to synthetic and natural polymers [10]. Producing a product such as door, parcel shelves or interior sunroof shield required natural fibre to be combined with polypropylene, polyester, or polyurethane [11].

Fibres that used firstly by man were natural fibres such as cotton, silk, flax, hemp and sisal. The first man-made fibre was probably glass. Figure 2.1 describe the major fibre that still in used until now [10].

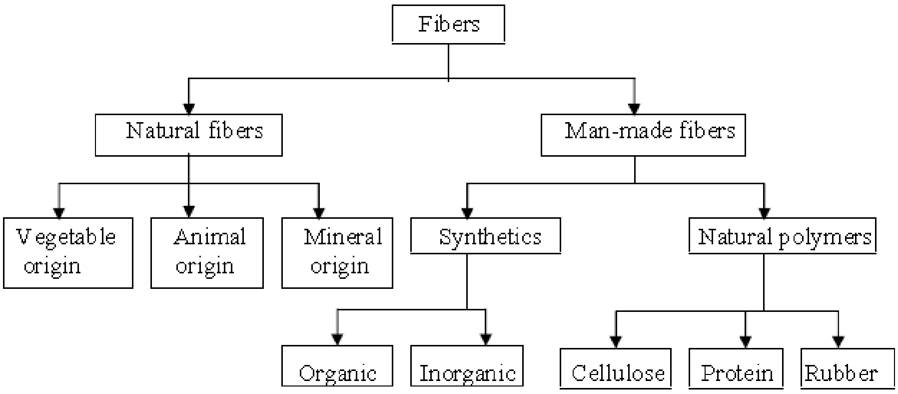

Figure 1.4: Classification of fibre.

Natural fibre can be directly translated from its word as produced through agriculture. It is a composite materials constructed by the environment. Fibre consists usually are rigid, crystalline cellulose microfibril-reinforced amorphous lignin and hemicellulose matrix. Almost all of plant has a composition of cellulose, hemicellulose, lignin, waxes and some water soluble compounds. From this entire component, only three become the major which is cellulose, hemicellulose and lignin [10].

Natural fibres from vegetable fibres are obtained from the various parts of the plants. Three categories are made to classify the fibre according to the part which it have been extracted. The categories are bast or stem fibre (jute, sugarcane, banana), leaf fibres (sisal, pineapple) and fruit fibres (cotton, coir, oil palm) [12, 13].

Fibres tend to have a finite length associated with them, ranging from about 5 cm to 20 cm. The hair of sheep (wool) or cotton filament that has a length in this range that it has to be aligned together into a continuous strand called yarn or thread to form it into fabric. To do so, a spinning machine is required. When it turns to fabrics, all the filaments are held together by van der Waals' type of force. Filament branches help to provide the woven fabric with greater bulk and porosity. Natural fibres have a maximum density about 1.5 g cm^3 but may vary especially if the fibre contain hollow inside it [14].

The major chemical component of a living tree is water. But on a dry weight basis, all plant cell walls consists mainly of sugar-based polymer (carbohydrates) that are combined with lignin lesser amounts of extractives, protein, starch and inorganics [10]. Chemical components on plants are different depends on geographic locations, ages, climate and soil conditions where all the components are distributed throughout the cell wall that composed of primary and secondary wall layers. Main components in plant fibre such as; cellulose, hemicellulose, and lignin and minor components such as pectin, waxes and water soluble substances contribute to the overall properties of the fibres.

There are several advantages and disadvantages of natural fibres that described on Table 1.1 below.

Table 1.1: Advantages and disadvantages of natural fibre.

Advantages	Disadvantages
• Producing this material has a low cost that important to poor country. • Recycling is possible. • Higher specific strength and stiffness with low specific weight. • Production used less energy.	• Changing in price due to supply uncertainties. • Lower durability. • Absorb moisture causing defect for product in service. • Low impact strength.

1.3 PROBLEM STATEMENT

Noise control is gaining more attention as it is one of the important factors to improve the environment. Noise can cause disruption to one’s health when noise exposure levels are exceeding the limits of hearing. Several methods are combined to control noises which are sound source control, sound to listener route control and control of the listener. The common method to control the sound path is to use acoustic absorbing material [15].

These days, sound absorbing components are commonly used in the building construction industry which consists of synthetic materials. Synthetic materials are substance that produce by chemical process rather than formed naturally. Current sound absorption materials for acoustic treatment used in the building construction industry consist of glass or mineral-fibre materials [15]. For a long time now, these materials become more dominance in the commercial market. However, fibre shedding from glass or mineral-fibre materials caused health risk related to human lungs and eyes [15]. It is eminent to make research on the alternative material in the way of eco-friendly and less harmful to environment. However, not many research done to discover new material with sound absorption application.

Malaysia has an extensive agricultural waste such as coir fibre (Cocos nucifera), rice fibre (Oryza sativa) and oil palm frond fibre (Elaeis guinnesis). The fibre is usually burned or turned into agricultural by-products. Furthermore, those fibres are suitable as a substitute for acoustic absorption purpose [15]. Study was made on the coir fibre showed that the coir fibre is very useful to be used on the structural and non-structural application. Those studies, was initiated to implement analytical techniques for illuminating the acoustical characteristics of coir fibre absorber panel. This recent study is also a part of that initiate to explore the possible approaches for enhancing the absorption coefficient [16].

Researches and studies about sound absorbers or insulation are rapidly developing to achieve the maximum effect of sound attenuation. The most recent method is the employment of a microperforated panel (MPP) as a hygienic absorber replacing the abrasive, synthetic acoustic porous materials. This project is proposed to couple the microperforated panel (MPP) and the fibrous material to be a potential sound absorber and noise barrier structure. Additional fibres in the microperforated panel (MPP) are expected to enhance its acoustic performance. This will be measured with several potential waste fibres, such as coir and palm fibres, using the impedance tube.

1.4 OBJECTIVE

This project is aimed to investigate the sound insulation performance of a hybrid fibre-microperforated system in terms of the sound transmission loss.

1.5 SCOPE

This final year project only focused the fundamental of acoustics, which only the performance is being investigated. Measurements are taken to show the best acoustics performance of the fibre. The studies of material strength for the material used in the project were not performed. The project also intends to propose a suitable fibrous material to be couple with the microperforated panel (MPP). Fibres involved are limited to sugarcane and coir fibre.

CHAPTER 2

LITERATURE REVIEW

2.1 AIRBORNE AND STRUCTURE - BORNE SOUND

The original source of noise is usually identified prior to installation of insulation or absorption materials, but sometimes it is difficult to determine how sound travel from the source to a receiver. Due to the difficulty in determining sound propagation, it is important to understand the airborne and structure-borne that involve in the system [16].

Airborne sound is one of the ways noise may be generated by acoustic transmission path. This type of sound spread directly from its source and propagate through the air. When transmitted through a barrier, it tent to act in the same behaviour as a radio frequency signal. It happens when a high energy Sound Pressure Level (SPL) produces and excite the air within a room [17]. An example of airborne sound that includes in this category can be taken as sound of traffic passing, sound of music from the next room or noise from flying aircraft [6]. Although insulation installed in a room, airborne sound still can escape through small openings such as small holes, seams and cracks. Transmitted sound may be spread across the room and can travel in great distance.

Transmission loss for this type of sound is measure of the amount a material can block or reduce transmission of sound into nearby area. Every materials can block, attenuate or both to a certain level. Heavy and water-resistant materials are more effective to have these characteristic than a light and porous materials. Existing technology allow structures such as gypsum board and lightweight steel framing to be assemble together and used as sound insulation in buildings. However, to combine both materials and gained maximum acoustical performance, flexibility is needed without adding mass and weight of the combine materials [6].

Structure-borne sound or also known as gradient noise is different in medium for propagation from airborne sound. Still, both of the sounds are related closely to each other since structure-borne sound can propagate through seams or crack inside a materials and eventually turn to airborne sound in order to be heard by human ears. Structure-borne sound travels across solid materials usually parallel to the direction of the sound source or crated from impact exert on the material such as footsteps, falling object on the floor or knock at the door. Similar to airborne sound, structure-borne sound also can propagate for a long distance but only can feel as vibrations in a structure [17].

2.2 SOUND TRANSMISSION LOSS

Generated noise prevented by constructing barrier at the propagation path between the sound source and receiver. This is the concept of sound isolation. In an ideal system, noise is completely isolated by the barrier constructed.

However, in practice the sound may actually pass through the material where the reducing amount depends on the properties of material and acoustic properties of the receiver [16, 17]. Barrier that depends on the types of material will have various transmission loss as a function of frequency [16].

Striking sound at the surface of barrier will be reflected to the direction of sound source or absorbed into the barrier which the absorb part will turn into heat [18] and detectable in the next receiving room or enclosure. Energy from sound wave will exerts a fluctuating pressure to barrier affecting the wall to vibrate like a diaphragm and further radiate sound to the receiving side of the barrier [16]. Heavier barrier has less vibration and in the sound attenuation [17].