EFFECT OF FABRIC COVERS ON IMPROVING SOUND ABSORPTION

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This report is submitted in fulfillment of the requirement for the degree of Bachelor of Mechanical Engineering (Structure & Materials)

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DECLARATION

I declare that this project report entitled “Effect of fabric covers on improving sound absorption” is the result of my own work except as cited in the references

Signature	:	....
Name	:	....
Date	:	....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Materials).

Signature :. ....

Name of Supervisor : ....

Date : ....

DEDICATION

This project is dedicated to my beloved mother and father, my supervisor, Associate Professor Dr. Azma Putra, and all my friends for the support during the completion this project.

ABSTRACT

Nowadays, the increasing request for quietness in building and auditoriums has inspired the use and development of the quality of sound absorption material. Textile material such as woven, nonwoven and knitted fabrics is one of the porous materials and has a great ability for sound absorption application. The researchers keep study about the absorptive materials using natural materials but not widely make the research about the acoustics textile. Fabrics usually used to cover the absorptive materials and sometimes using as a decoration but they do not know that each type of fabrics has their own acoustics characteristics. In order to expand the research about the characteristics of acoustics textile, three type of fabrics is used to become a fabric covers on the absorptive materials to find its effects on improving the sound absorption. The three types of fabrics are cotton fabric, plain fabric and satin fabric. This measurement of sound absorption coefficient is conducted by using the impedance tube according to ISO 10534-2. These three types of fabrics are put on the micro-perforated panel (MPP) and three types of natural fibers. The application of air gap enhances the sound absorption coefficient and shifted the peak to the lower frequency region. MPP with the satin fabric cover showed a good sound absorption performance compare with cotton and plain fabric. For the natural fiber, sound absorption performance of coir fiber increased drastically and showed a good absorption performance when put the fabric cover on it where the sound absorption coefficient achieved 0.5 and above in average frequency above 2500 Hz.

ABSTRAK

Pada masa kini,permintaan yang semakin meningkat untuk ketenangan di dalam bangunan dan auditorium telah memberi aspirasi kepada penggunaan dan pembangunan kualiti bahan yang menyerap bunyi. Bahan tekstil seperti tenunan, bukan tenunan dan kain rajutan adalah salah satu daripada bahan-bahan berliang dan mempunyai keupayaan yang besar untuk aplikasi penyerapan bunyi. Para penyelidik tetap meneruskan kajian tentang bahan-bahan penyerapan dengan menggunakan bahan-bahan semula jadi tetapi tidak banyak membuat penyelidikan mengenai tekstil akustik. Fabrik biasanya digunakan untuk menutup bahan-bahan penyerapan dan kadang-kadang ia juga digunakan sebagai hiasan tetapi mereka tidak tahu bahawa setiap jenis fabrik mempunyai ciri-ciri akustik yang tersendiri. Dalam usaha untuk mengembangkan penyelidikan tentang ciri-ciri akustik tekstil, tiga jenis kain digunakan untuk menjadi kain yang meliputi pada bahan-bahan penyerapan untuk mencari kesannya dalam meningkatkan penyerapan bunyi. Tiga jenis kain tersebut adalah kain kapas, kain plain dan kain satin. Pengukuran untuk mengukur pnyerapan bunyi dilakukan dengan menggunakan tiub galangan mengikut standard ISO 10534-2. Ketiga-tiga jenis fabrik ini diletakkan pada panel mikro berlubang (MPP) dan tiga jenis gentian asli. Penggunaan ruang udara di dalam tiub tersebut dapat meningkatkan pekali penyerapan bunyi dan mengalihkan puncak ke bahagian frekuensi yang lebih rendah. MPP dengan penutup kain satin mennjukkan prestasi penyerapan bunyi yang baik berbanding dengan kain kapas dan kain plain. Untuk serat semula jadi, prestasi penyerapan serat sabut meningkat secara mendadak dan menunjukkan prestasi yang baik apabila lapisan penutup kain di atasnya di mana pekali penyerapan bunyi mencapai 0.5 dan ke atas dalam kekerapan purata frekuensi di atas 2500 Hz.

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LIST OF ABBREVIATIONS

MPP	Micro Perforated Panel
GA	Geometrical Acoustic
RC	Reverberant Chamber
FFT	Fast Fourier Transform

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CHAPTER 1

INTRODUCTION

1.1 Background

Materials that reduce the energy of sound wave by the phenomenon of absorption are called sound absorptive materials. These materials are commonly used to reduce the amplitude of the reflected waves of sound. Nowadays, the increasing request for quietness in building and auditoriums has inspired the use and development of the quality of sound absorption material (Shahani et al., 2014). Among the acoustic absorptive materials, porous material is widely used and numerous achievements have been made in recent years (Xiang et al., 2013).

There are many types of porous materials which can usually classify as porous foam and fibrous medium (Ayub et al., 2011). These materials generally composed of porous synthetic materials such as glass wool, rock wool, polyester or polyurethane. Textile material such as nonwoven, woven and knitted fabrics also one of the porous materials and it has great ability for sound absorption application. Three categories can be can characterized in the acoustic properties of textiles which is absorption , propagation, and scattering and the properties can be expressed by flow resistance, transmission loss, absorption coefficient and scattering coefficient (Nayak, 2016).

The researchers keep study on progressing to reduce the usage of synthetics materials by replace it with natural material which more green and friendly to environment. Many research works have been done on finding the performance of sound absorption materials using the natural fibers. Some of the natural fibers that they use are coir fibers (Nor et al., 2010), oil palm fibers (Or et al., 2017), kenaf fibers (Ying et al., 2015, bamboo fibers (Koizumi et al., 2002), sugarcane fibers (Putra et al., 2013) and hemp fibers (Berardi and Iannace, 2015). These natural fibers have a great ability of sound absorption and can be applied for building or auditorium. Figure 1.1 shows the example of natural fibers.

Figure 1.1: The example of natural fibers (Berardi and Iannace, 2017).

This research discusses about the effect of the fabrics cover on the natural fibers in order to improve the sound absorption. Different type of fabrics is used to identify the best fabric material that can be used to apply on the fiber as well as can improve the sound absorption. The fabrics are placed at the front and the back of the natural fibers and then compared it with the fiber that not attached with fabrics. This experiment is conducted by using impedance tube with the proper standard ISO 10534-2:2001.

1.2 Problem Statement

Acoustic materials are widely known for its application for sound absorber especially for the sound quality in the building. Nowadays, natural fibers have been chosen to use as the sound absorptive materials in building or auditorium. For the auditorium, the fibers are applied on the wall of the building and at the same time the fibers needed to be covered. The fibers usually undergo some process to make it panel shape to make it easier to put on the wall. By doing this, the fiber panel needs to cover by using fabrics so that it may look nicer but had a greater ability of sound absorption.

The acoustic textiles are not often used in the industry because of the lack of the research about the acoustic textiles characteristics. Usually, the acoustic textile is used in the building such as hall or sound studio and can be used as a fabric wrapped panel. The fabrics also can be used as a cover for acoustical panels such as fiber panel because it has higher ability of sound absorption. The usage of the fabric also important to give a better quality of sounds absorption and also can be a decoration purposes. The type of the fabrics that can be used to cover the fiber panel is still lack in research. It is because each type of fabric has its own sound absorption characteristics that can affect the quality of sound in the building. For this research, three types of fabrics are choosing to expand the research about the acoustic textile to reduce noise in the building.

1.3 Objective

For this project, a few objectives can be determined as follows:

1. To measure the sound absorption coefficient by using different types of fabric covers on micro perforated panel (MPP).
2. To measure the sound absorption coefficient on three types of natural fibers by applying different types of fabric cover.

1.4 Scope of Project

This project focuses on the effects of fabric cover on improving the sound absorption. In this research, three type of fabric material is used which is Cotton (rough), Japanese Plain and Satin. The experiment is conducted on impedance tube by using micro perforated panel and three types of natural fiber, kenaf fiber, oil palm fiber and coir fiber. Other type of micro perforated panel material and fabric material are not covered in this research.

CHAPTER 2

LITERATURE REVIEW

2.1 Sound Absorption Materials

Materials that reduce the energy of sound wave by the phenomenon of absorption are called sound absorptive materials (Kumar, 2011). Figure 2.1 shows the example of the phenomenon of sound absorption material. They are often used to moderate the acoustic environment of a closed volume by way of decreasing the amplitude of the reflected waves. Absorbing materials are usually resistive in nature, either porous, fibrous or reactive resonator (Bell et al., 1994). Mineral wools, fibrous glass and foams are the sample of resistive materials while the example of the resonator is such as sintered metal and hollow core blocks. A resonator is a passive standard for noise reduction by converting into a vibration. The resonator absorbs sound by making the vibration to produce heat loss due to the sound pressure differences (Liu and Hu, 2010). Most of the product material is provide some degree of absorption at the same frequencies and when the material thickness is increase, the performance at low frequencies also increase.

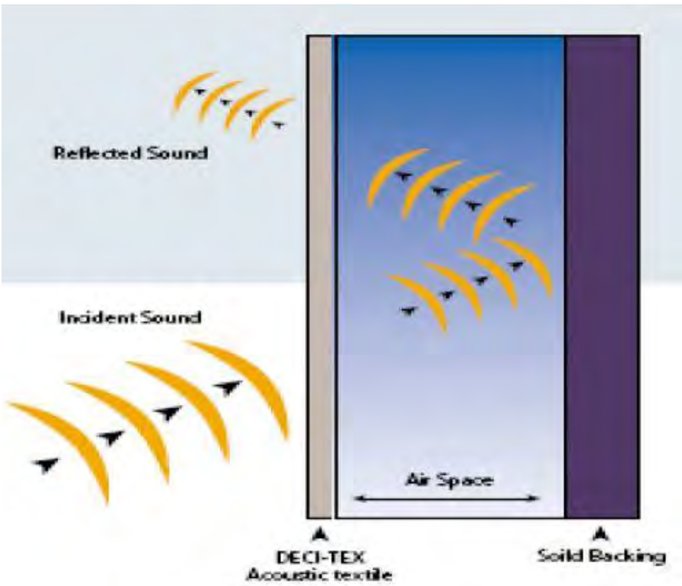

Figure 2.1: The example of the phenomenon of sound absorption material (Kumar, 2011)

Porous materials usually used as sound absorbers and it application are often assembled with a resistive layer. Chevillotte (2011) has stated that, the resistive layer can be used to increase acoustic properties of the porous material and usually it used for the protection or decoration. From this research, there are three type of numerical simulations that carried out which is influence of perforation diameter, influence of perforation rate and influence of downstream layer. Two multilayer textile + air and textile + glass wool are carried out in this experiment by using impedance tube. The results can be shows that the sound absorption selectivity is increasing when the perforation rate decreases. This is because the considered multilayer tends to act as a Helmholtz resonator. Figure 2.2 shows the example of multilayer made up of a downstream porous media and resistive layer.

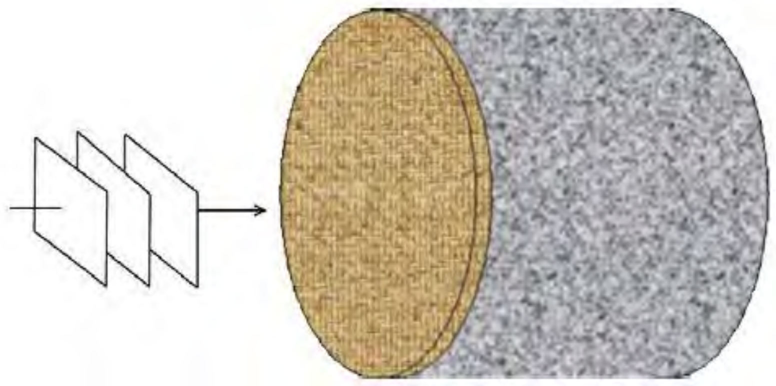

Figure 2.2: The example of multilayer made up of a downstream porous media and resistive layer (Chevillotte, 2011).

2.2 Sound Acoustics of Textile

Textiles are used in many application including the acoustics such as in automotive insulation, panels for workstations and halls. The used of textiles for noise reduction is based on two categorise which is low costs production and small specific gravity. Textiles materials have their own acoustics properties. Generally, acoustic materials are separated in two categories of porous sound absorbers which are (Kumar, 2011):

- Bulky, high loft textiles which basically act as rigid, porous sound absorber.
- Light weight, compact woven and nonwoven textiles that act as porous screen.

Textile materials is made up from fibres that can be either natural fibres or man-made. There are two types of fibres which are fibres of unlimited length that called filaments and fibres of much smaller length that called staple fibres (Sinclair, 2015). Normally, the filaments are combined and twisted to produce yarns while the staple fibres are rolled to create yarns. Yarns are usually woven or knitted into fabrics. A piece of fabric contains a huge number of fibres. Morton & Hearle (2008) stated that a small piece of fabric contain over 100 million fibres.

Fabric is the processed and assembled of the yarns. There are many ways by processing yarns to make a fabric such as woven, nonwoven and knitting. The fabrics processing in different way produces a variation in texture, appearance, drape as well as it performance characteristics such as strength and durability (Sinclair, 2015). In textile fibres, there are three types of fibre groups which are natural fibres, regenerated fibres and synthetic fibres. Regenerated and synthetic fibres are known as man-made (manufactured) fibres. Figure 2.3 shows that the variety type of textile fibres.

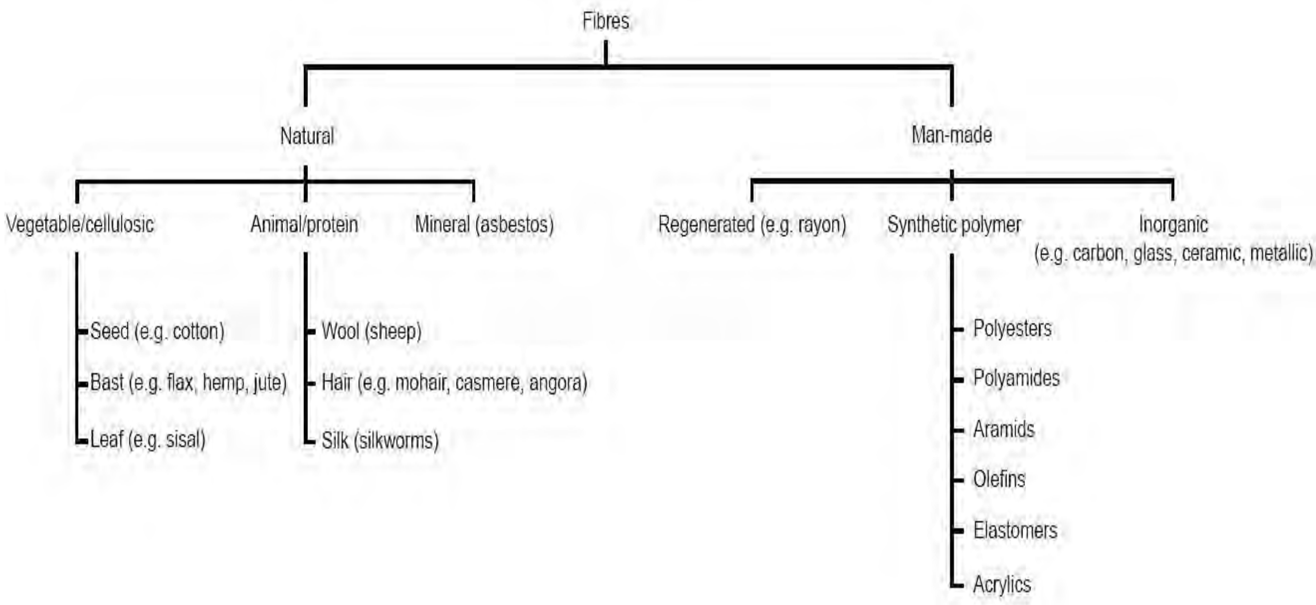

Figure 2.3: Types of textile fibres (Sinclair, 2015)

Natural fibres made of wool from sheep or cotton from the cotton plant while the regenerated fibres are made from natural polymers and it cannot use it in the form of original but can be regenerate to make fibres. For the synthetic fibres, it made of from polymerising that convert from smaller molecules into larger in an industrial process.

2.3 Sound Absorbing in Woven Fabrics

Woven fabrics can be used as a component of noise reduction assemblies made of textile materials and also as decorative cover of noise absorber that made of rock wool. Shoshani and Rosenhouse (1990) conduct the investigated about the relationship between the noise absorption coefficients of a cover made of woven fabric and its intrinsic parameters. The parameters considered were fibre content, yarn count, cover factor, air gap behind the fabric and the frequency of the impinging sound wave. There are 28 woven fabrics that conducted in the experiment varying with the parameters and the results shows that the intrinsic parameters of the woven fabric have a very little effect on absorption coefficient in the low frequency but has major impact at the highest frequency. Figure 2.4 shows the example of woven fabrics.

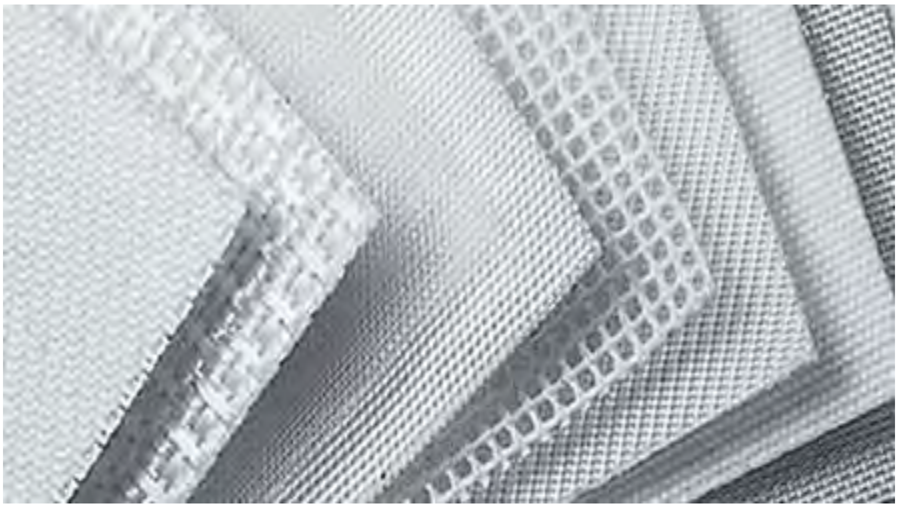

Figure 2.4: Example of woven fabrics (Raaz, 2014)

Nowadays, more and more building and hall are built that are both economical and environmentally friendly by using new materials and method. Lightweight constructions such as materials that made from textiles are needed in modern day constructions requirements (Baier, 2010). In the case study by Ricciardi and Lenti (2010), they conducted the analysis of acoustical performance of an auditorium in Italy, the historical S. Giorgio Palace in Genoa. The palace need to restoration but can only use woven materials for floor and curtains. Two different types of material which is carpet and felts were used in order to improve absorption at low frequencies in a multilayer system. Six sample of carpet were selected and has different for composition, thickness and mass per unit area.

Table 2.1 shows the description of the analysed sample of carpet. The results show that the absorption coefficient is increase with the frequency with 0.1 at 400 Hz up to 0.5 to 0.8 at 4200 Hz. The best sample among the six samples is the sample with made of 100% wool and having the highest thickness of 12 mm.

Table 2.1: The description of the analysed sample of carpet (Ricciardi and Lenti, 2010)

Test Sample	Composition	Total Thickness (mm)	Mass per unit area (g/m^2) of Fibre + Support	Colour
A	100% Wool	12	3934	Brown
B	100% Wool	8	2925	Dark Blue Plain
C	80% Wool 20% Polymide	14	2752	Brown & Green
D	80% Wool 20% Polymide	12	3809	Purple Veined
E	80% Wool 20% Polymide	10	3296	Ochre Plain
F	100% Polymide	12	2548	Electric Blue with Yellow Picture

Alonso and Martellotta (2015) investigated on how sound absorbing materials such as curtain which is hung freely in space can be analyse and modelled in geometrical acoustic (GA) software. This analysis is conducted in the scaled model measurement to replace with the real building room. The problem is to establishing the best way to model textile materials hung free in space. Four types of materials were use with different weight and thickness and were measured in reverberant chamber (RC). Figure 2.5 shows the detailed view of the different samples of textiles under investigation. Two samples were selected for the subsequent analysis after the measuring of all the materials in their acoustic properties including sound absorption, transmission coefficients and flow resistance. The GA software simulation was use to optimized the sound absorption coefficients in order to adjustment and matching of reverberation times. As the results show the measurement of absorption coefficient between the GA simulation and RC only showed small differences.

Figure 2.5: The detailed view of the different samples of textiles under investigation (Alonso and Martellotta, 2015).

2.4 Sound Absorbing in Nonwoven Fabrics

Porous materials such as nonwoven fibre are widely used as sound absorptive materials. By using nonwoven fabric as porous absorber, it is technically and economically one of the most extensive means among the variation techniques that used for the sound absorption (Moghaddam et al., 2015). According to Wang and Torng (2001), the sound absorption materials are widely used because of their fibrous structures due to the porosity, cost and low mass are capable of sound absorption. Compare to the woven and knitted fabric, nonwoven fabrics do not have an organized geometrical structure. Nonwoven fabrics are not easily recognized because they are commonly hidden even though it is used in various areas (Yilmaz and Deniz, 2009). There are some example of nonwoven application area such as in automotive, clothing, construction, home and healthcare.

The reduction of the sound insulation performance is generally due to the gaps, slits and openings for natural ventilation that usually occur around doors and windows. According to Shimizu and Koizumi (2015), by installing the nonwoven fabrics as a breathable material in the gaps, it can be improved the sound insulation performance and also improved the amount of ventilation as the total equivalent clearance area. In their study, they used the nonwoven fabrics as the sound absorbing materials so that it can maintain the air ventilation. Figure 2.6 shows the enlarged image of the nonwoven fabric. The measurement of the air permeability of the nonwoven fabrics through the gaps, the experiment was conducted by using the two chambers with the use of fan in order to varying the amount of ventilation. The sample is measured in differences of sound pressure level between the gaps and also in differences gap in height. The results can be seen that