# THE CAPABILITY OF *GIGANTOCHLOA SCORTECHINII* BAMBOO AS SOUND ABSORBER

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**SCHOOL OF CIVIL ENGINEERING**
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# THE CAPABILITY OF *GIGANTOCHLOA SCORTECHINII* BAMBOO AS SOUND ABSORBER

By

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| NFC | Natural Fiber Composite |
| SAC | Sound Absorption Coefficient |
| CPE | Chlorinated Polyethylene |
| BJA | Bamboo Jungle Adventure |
| SEM | Scanning Electronic Microscope |

# ABSTRAK

Bunyi, secara ringkasnya, adalah bunyi yang tidak diingini. Bunyi ialah sejenis tenaga yang dikeluarkan oleh medium yang bergetar dan memberikan sensasi pendengaran apabila ia sampai ke telinga melalui saraf. Penyelidikan ini memberikan gambaran dan penerangan tentang sifat fizikal bahan seperti saiz gentian, kehadiran resin dan penggunaan celah udara di belakang spesimen pada kapasiti gentian buluh untuk menyerap bunyi. Sampel dibuat daripada gentian buluh *Gigantochloa Scortechinii* mentah dengan diameter dan lapisan celah udara yang berbeza di belakang sampel untuk melihat kesannya terhadap ciri penyerapan bunyi. Imej morfologi sampel dianalisis menggunakan Scanning Electronic Microscope (SEM) dan Tiub Impedans berdasarkan ISO 10534-2:1998. Ia mendedahkan bahawa penyerapan bunyi gentian buluh dengan kehadiran resin epoksi didapati mempunyai prestasi yang lebih baik berbanding sampel tanpa resin. Saiz gentian 850 µm diameter gentian buluh mencapai pekali penyerapan bunyi 0.47 pada frekuensi 700 Hz iaitu di bawah 0.5 yang menunjukkan prestasi yang lemah. Peningkatan jurang udara tidak menjejaskan prestasi sampel buluh. Daripada kajian, prestasi buluh dikategorikan berdasarkan julat pekali serapan bunyi iaitu di bawah 0.5 menunjukkan prestasi yang lemah manakala di atas 0.5 dianggap mempunyai prestasi yang lebih baik. Oleh itu, penyerapan bunyi buluh *Gigantochloa Scortechini* telah diuji secara eksperimen dan terbukti efektif.

# ABSTRACT

Noise, to put it simply, is unwanted sound. Sound is a kind of energy that is released by a vibrating medium and provides the sensation of hearing when it reaches the ear via nerves. This research provides an overview and description of the physical properties of materials such as fiber size, the presence of resin and the use of an air gap behind the specimen on the bamboo fiber capacity to absorb sound. The samples were fabricated from raw *Gigantochloa Scortechinii* bamboo fibers with different fiber diameter and air gap layer behind the samples to observe their effects on sound absorption characteristic. The morphology images of the samples were analyzed using Scanning Electronic Microscope (SEM) and Impedance Tube based on ISO 10534-2:1998. Results from the experimental tests show that bamboo fiber has good acoustic properties at high frequencies and can be used as an alternative replacement to conventional product. It reveals that the sound absorption of bamboo fibers with presence of epoxy resin was found has a better performance compared to the samples without resin. The fiber size of 850 µm bamboo fiber diameter achieves sound absorption coefficient of 0.47 at a frequency 700 Hz which is below 0.5 which is shows a poor performance. The increasing of the air gap does not affect the performance of the bamboo sample. From the study, the performance of the bamboo was categorized based on the range of sound absorption coefficient which is below 0.5 was performed a poor performance while above 0.5 is consider has a better performance. Thus, the sound absorption of *Gigantochloa Scortechinii* bamboo was experimentally tested and proven to be effective.

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

Bamboo has been classified as a green building material, which is in line with the sustainability trend. Recently, the used of bamboo as one of the primary structural materials in design or building are decreasing. The bamboo has a good alternative to the more widely used construction materials in this setting, such as concrete blocks, natural stones, and burned bricks. It is necessary to emphasize the value of bamboo as a low-cost, beautiful, and eco-friendly construction material to increase its acceptance in the housing industry. Because bamboo is not toxic and is very strong when it breaks, it can be used to build low-cost, environmentally friendly homes and projects that don't cost a lot of money (Habibi, 2019).

Noise that is transmitted through the air is commonly known as airborne sound and can be transmitted through the vibrations of a medium of mass, which is identified as structural sound and is caused by mechanical movements. Airborne sound mainly originates from exterior space, such as traffic sirens, tires, and roadways, as well as sounds from the surroundings or environment. These forms of undesired noise, both airborne and structural, must be regulated to reduce noise within the car and provide passenger comfort (Islam & Mominul Alam, 2018).

The acoustical materials for both insulation and absorption, are now utilized in diverse applications, such as furniture components, machine tool applications, wall partitions, vehicle components, and building barriers. Bio-composite substances are preferred because they use natural fibers that are eco-friendly, visually impressive, and lightweight, as well as having a high specific strength, low thermal expansion, and high modulus. While the bulk of these materials are still prototypes, some of them are now available commercially. Cork and recycled rubber layers offer passable sound insulation, whereas layers made of bamboo, kenaf, and coco fibers effectively absorb sound (Karlinasari et al., 2021).

The prospect of employing these natural materials for acoustic therapy has been examined by several researchers. When it comes to sound absorption, most natural materials serve as porous absorbers. Porousness is unquestionably one of the factors that determines a fibrous material's absorption capabilities (Taiwo et al., 2019). The density and thickness of the fibers are also important considerations. The high-frequency acoustic properties of porous sound absorbing materials are excellent, while low-frequency absorption coefficients are poor. Wave propagation and impedance factors, such as air density, wave number, flow resistivity, and sound frequency, influence the porosity of a substance.

One of the most important factors that affects absorption performance is the size of the absorbent material. The amount of absorption is not always proportional to size, and it depends on the type of materials used and the installation procedure. Therefore, this study is intended to investigate the performance of size of the bamboos in sound absorption.

## 1.2 Problem Statement

The building sector is often blamed for a variety of environmental issues. Because they mostly use concrete in the form of blocks and other structural parts, the most common building technologies used in almost every project use a lot of energy and produce a lot of carbon dioxide.

Certain building materials, like steel, are more challenging to manufacture as a non-renewable resource and contribute more to overall material consumption. Production of steel is high cost because of the mining industry, which consumes high energy and power. Steel, cement, and glass manufacturing all need a high temperature, which can only be achieved with large amounts of fossil-based energy. It helps the environment if buildings are built with bamboo instead of steel.

Bamboo, on the other hand, is a fantastic example of a sustainable construction material that can be used in various ways., including flooring, structural support, and even scaffolding, in the hunt for green-building solutions. Bamboo's usage in building construction should be extended due to its benefits, which include a fast-growing plant, increased tensile strength, and a lightweight material that is affordable to freight and easy to assemble.

The number of people in cities that affected by noise pollution is increasing because of the development of transportation, infrastructure, and residential areas. Due to the near vicinity to a variety of continuous noise emitting sources, such as construction, transportation (rail, road, and air), industry, public works and neighborhood-related noise, noise pollution is widespread and more frequent in dense urban regions. It has been estimated that automobile traffic accounts for more than 70% of unpleasant sound in metropolitan Australia. Excessive noise may harm people's health and well-being by restricting cognitive function, aggravating mental illness, reducing productivity at work, and potentially bringing on cardiovascular disease. Roadway canyons' hard surfaces act as sound reflectors, adding to the overall urban ambient noise level (Bond et al., 2020).

As a result, improved sound absorption materials must be utilized to guarantee that the environment and human health are not harmed. Natural fibers also have a lot of potential as sound-absorbing materials since they are less harmful to the environment than synthetic fibers. Bamboo fiber's acoustic properties may help to mitigate the development's detrimental environmental impact.

## 1.3 Objectives

The aim of the study is to access the potential of *Gigantochloa Scortechinii* as sound absorbing material. The observations involve measuring the fiber size, the presence of epoxy resin, air gap behind the specimen, and sound absorption coefficient of the bamboo. The objectives of this research are:

1. To characterize fiber diameter sizes of *Gigantochloa Scortechinii* specimen.
2. To study the acoustic performance of the *Gigantochloa Scortechinii* fiber as sound absorber based on the mechanical properties of the bamboo.
3. To correlate in term of statistic the relationship of sound absorption coefficient and bamboo fiber size.

## 1.4 Scope of Work

This study focuses on determining the sound absorption level of bamboo to promote and market it as a building material. The use of bamboo as a natural material is presented with a selection of diameter sizes to act as a sound absorber. As noise pollution has become a serious concern in our everyday lives, sound absorption materials have been widely used to overcome these issues. Also, bamboo characteristic will be determined using the appropriate protocol and standards.

## 1.5 Dissertation Outline

The following is a general description of each of the chapters.

**Chapter 1: Introduction –** General overview of the research consists of the background of the study, the problem statement of the research, the research objectives, the scope of work, and the dissertation work.

**Chapter 2: Literature Review -** This chapter provide a fundamental understanding based on research papers and publications by scientists and professionals. Also, this chapter identify the factors that affects absorption performance.

**Chapter 3: Methodology -** This chapter describes the flow of preparation bamboo specimen and experiment involve obtaining the data related to this research.

**Chapter 4: Results & Discussion –** This chapters cover the results obtained from the data analyses. Based on the vulnerability functionalities, the generated findings will be extensively examined in this chapter.

**Chapter 5: Conclusions –** This chapter concludes and summarize the research including a recommendation to the future and a study in this field.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

The regulation of room acoustics, industrial noise control, studio acoustics, and automobile acoustics are just a few of the crucial functions that acoustic material plays in acoustic engineering. To combat the unfavorable effects of sound reflection by hard, stiff, and internal surfaces and aid to minimize the levels of reverberant noise, sound absorptive materials are typically utilized. They are utilized as interior lining for apartments, cars, planes, ducts, enclosures for noise-generating equipment, and appliance insulation.

Study on the potential of natural fibers for the past research are discussed in this chapter that relate to the noise pollution sources, health effects on noise pollution, noise pollution occur in construction and mitigation measures to reduce noise. Furthermore, the factor that affect the performance of sound absorption such as the effect of fiber size, thickness, density, the flow resistivity, porosity and tortuosity, compression, and air gap are discussed in this chapter.

## 2.2 Natural Fiber as Sound Absorber

Natural fibers have grown in popularity because of their promising qualities, which include high strength-to-weight ratios, low densities, low costs, acceptable mechanical properties, environmental friendliness, ease of manufacture, and availability. However, when compared to synthetic fibers, natural fibers have inferior qualities such as excessive water absorption, weak bonding, low durability, and poor mechanical and thermal properties, which restrict their industrial uses. Fiber treatment, nano-filler addition, and hybridization are just a few of the technologies that have been created to get around these limitations. In recent years, similar procedures have been used to create natural fiber composite (NFC) materials, which has increased their use for structural, household, aerospace, sports, automotive, and other industrial applications (Mulenga et al., 2021).

### 2.3 Acoustic Properties of Fibrous Materials and Composites

Kerni (2020) wrote that the capacity to adapt and improving the qualities of composite materials has proven crucial to the industrial sector. People are trying to compete with some traditional materials by making them better at things like strong damping, corrosion resistance, high specific strength, and flexural modulus, which are all good qualities. Natural fiber composites have gained popularity as a reinforcing phase in composite materials owing to their distinctive qualities such as environmentally friendly, low densities and high impact resistance.

The total quantity of sound energy absorbed by the materials may be used to compute the sound absorption coefficient (SAC). SAC range is from 0 to 1, with 1 indicating the maximum absorption and 0 indicating no absorption at all as shown in Table 2.1. Low-frequency sound waves, such as 500 Hz, are much harder to absorb than high-frequency sound waves. The movement of sound waves through a medium without absorption or frequency loss is known as transmission (Kadam & Nayak, 2016). The proportion of energy that enters the system without being reflected or absorbed is known as the transmission coefficient (t). The transmission loss can be expressed as 10log(t) dB. As they hit surfaces, some of the sound waves are absorbed. The rest of them are reflected when they do this (Kang et al., 2021).

Table 2.1: Sound absorption coefficient classes (SAC) (Kang et al., 2021)

| Range | SAC Class |
|---|---|
| 0.90, 0.95, 1.00 | A |
| 0.80, 0.85 | B |
| 0.60, 0.65, 0.70, 0.75 | C |
| 0.30, 0.35, 0.40, 0.50, 0.55 | D |
| 0.15, 0.20, 0.25 | E |
| 0.00, 0.05, 0.10 | F |

The performance of sound absorption is divided into six classes which is A, B, C, D, E, and F, based on the sound absorption coefficient in Table 2.1. Class F denotes the lowest sound absorption coefficient, while Class A refers to the class with the highest sound absorption coefficient that is most effective.

### 2.4 Factor that Affects Acoustic Properties

Sound absorbers are materials that can absorb a substantial amount of sound energy. Because of friction with the pore walls and heat exchange, sound waves travelling through a porous material are absorbed and lose some of their energy. Fiber size, temperature, porosity, and flow resistance, as well as density, thickness, compression, and design or location, all influence the acoustic properties of composites and fibrous materials.

#### 2.4.1 Effect of Fiber Size

The length or diameter of a fiber can be used to describe a change in its size. One of the most important features is regarded to be fiber size influencing acoustic characteristics. Haron et al., (2020) investigated the possibility of using the leaf fibers of Napier grass as an acoustic absorber for sound. It has been discovered that bulk samples with a 5 mm fiber size perform better acoustically than samples with a 20 mm fiber size. Additionally, a hot-pressed sample with 20 mm fibers has superior acoustic performance than a hot-pressed sample with 5 mm fibers. The effect of fiber diameter and density on samples of NAF absorbers with the same 10 mm thickness on the SAC is depicted in Figure 2.1.

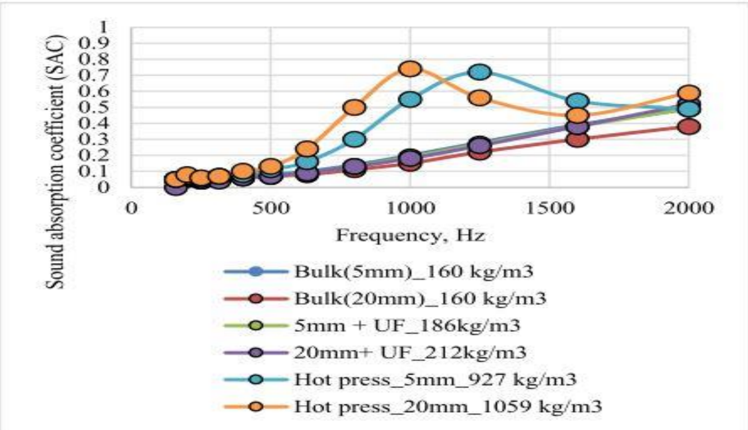


Figure 2.1: Effect of size of fibers and density on sound absorption of 10 mm thickness samples (Haron, 2020)

Xiang et al., (2013) examined the kapok fiber's acoustic properties. The results showed that long fibers had a somewhat higher SAC than short fibers. In addition, random fiber orientation has a greater SAC than oriented fibers. V. investigated how fiber orientation affected the acoustic properties of glass epoxy laminates. Changing the orientation, which also changes the total porosity, has a big effect on how the sound works.

Bakri et al., (2016) conducted study on the banana fiber-based epoxy composites' sound absorption coefficient. According to the study, reducing fiber diameter raises flow resistivity, which raises SAC, as seen in Figure 2.2. Hasina Mamtaz et al. (2017) examined the acoustic characteristics of several composites made from natural fibers and having a thickness of 1.8 cm. They also learned that a crucial element in enhancing sound absorption is fiber diameter. By lowering fiber diameter, SAC rises.

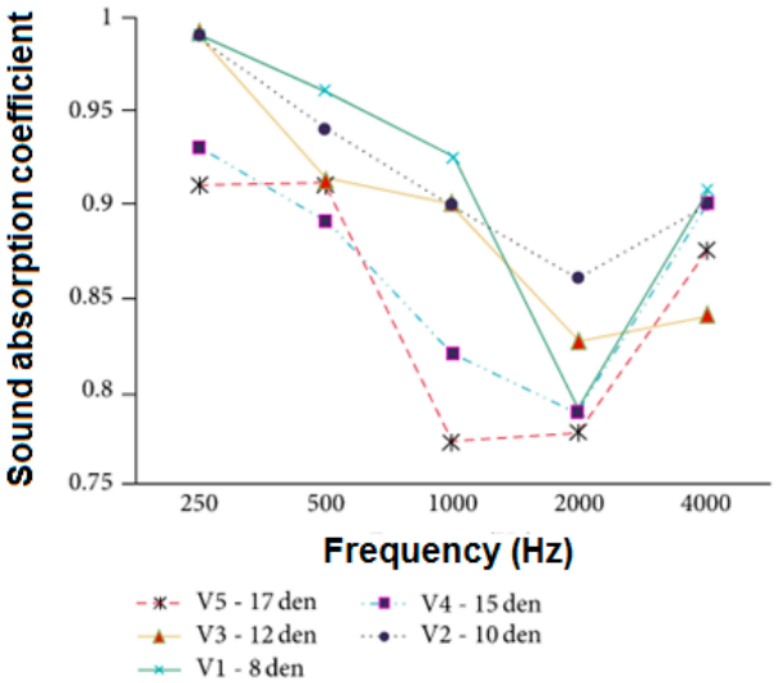


Figure 2.2: Effect of fiber diameter on sound absorption coefficient of composites (Bakri et al., 2017)

The acoustic characteristics of polydisperse fiber networks were studied by Luu et al., (2017). For modelling, they employed effective fiber diameter. Bi-dispersed fiber matrix and polydisperse fiber matrix were the two types of polydisperse fiber matrix that were explored during reconstruction. The sound absorption coefficient is significantly affected by fiber diameter, according to the findings. Reduced fiber diameter resulted in a significant increase in sound absorption coefficient.

### 2.4.2 Effect of Thickness

One of the most critical parameters that influences sound absorption performance is sample thickness. Several additional properties, such as density and porosity, are affected by variations in thickness. According to Putra et al., (2018) The sound absorption coefficient level and frequency bandwidth shift toward lower frequencies when the sound absorber thickness is increased while maintaining the same bulk density. Figure 2.3 shows a comparison of Pineapple Leaf Fiber samples of different weights and thicknesses, with the bulk density being kept at 11 kg/m$^3$ for all of them.

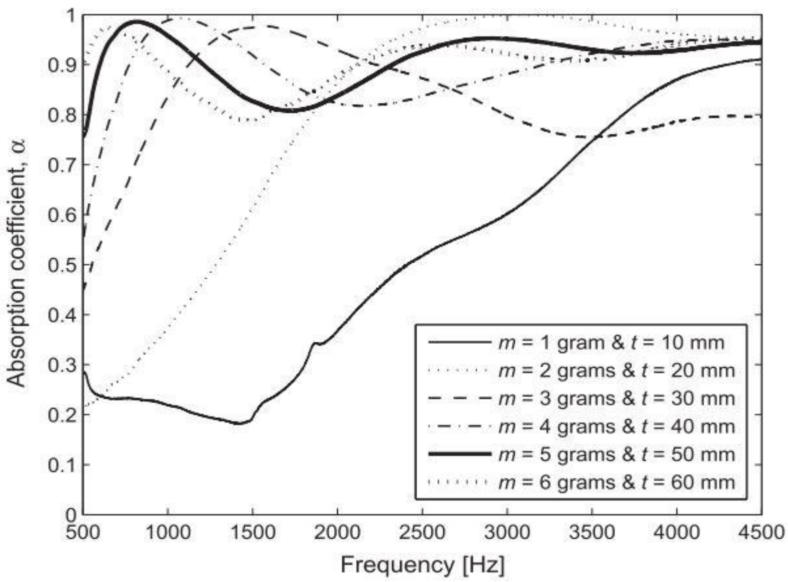


Figure 2.3: The sound absorption characteristics of Pineapple Leaf Fibre with various masses, m and thickness, t with constant bulk density, $\rho_{bulk}$ = 117 kg/m3 (Putra et al., 2018)

Jiang et al., (2020) reported that increasing the thickness of the seven-hole polyester fiber and chlorinated polyethylene composite resulted in a considerable increase in sound absorption coefficient. The acoustic characteristics of a seven-hole hollow-polyester-fiber-based chlorinated polyethylene (CPE) composite was examined. The investigation employed polyester fiber with a fineness of 10Dtex and a length of 60 mm. A fiber volume percentage of 65:35 and a reinforcement/matrix with three distinct thickness levels of 1, 2, and 3 mm were employed during composite manufacturing. As shown in Figure 2.4, increasing the thickness of a sample increases the sound absorption coefficient, which means that it can better block out noise. And Figure 2.5 represents the influence of thickness on the sound absorption coefficient. Increasing the thickness of composites resulted in a better sound absorption coefficient.

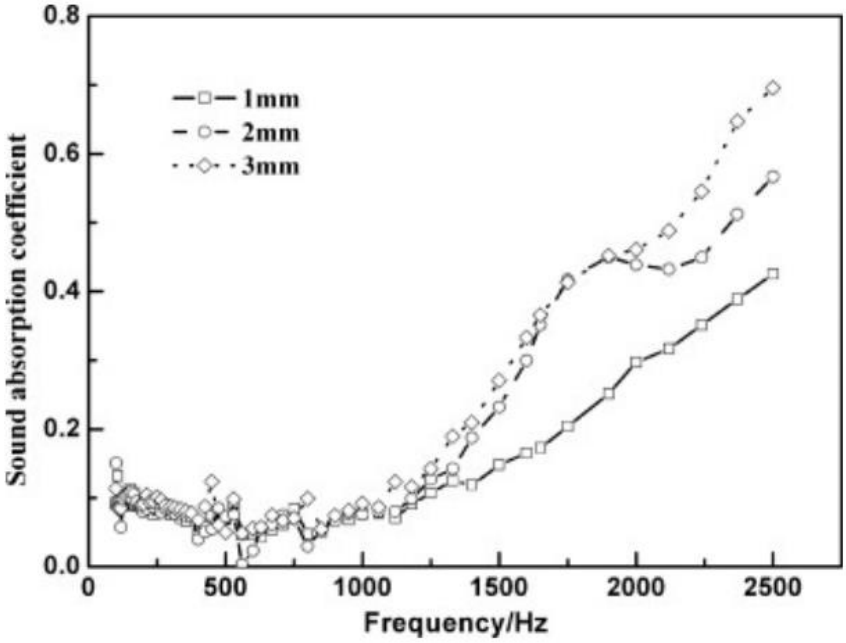


Figure 2.4: The effect of thickness on sound absorption coefficient (Jiang et al., 2020)

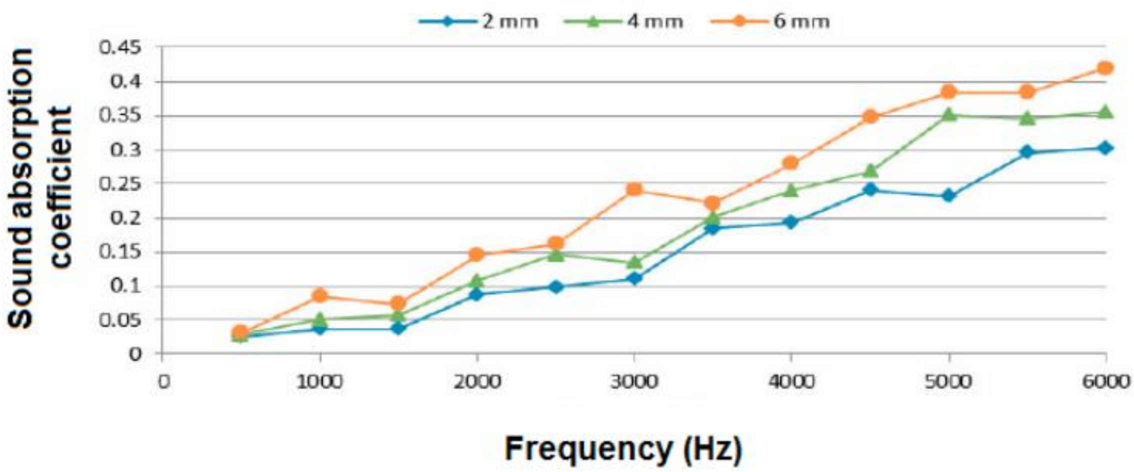


Figure 2.5: Influence of thickness of composites on sound absorption coefficients (Jiang et al., 2020)