ENGINEERING AND ACOUSTICAL PROPERTIES OF GYPSUM COMPOSITE MATERIALS CONTAINING PINEAPPLE LEAF FIBRES

TAIWO MARTINS ESAN

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy

School of Civil Engineering
Faculty of Engineering
Universiti Teknologi Malaysia

AUGUST 2022

DEDICATION

This thesis is dedicated to the almighty God, who created the universe for the opportunity to contribute to knowledge and humanity. It is also dedicated to my mother of blessed memory, who taught me all the good virtues of lives.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my supervisor Dr Khairulzan Yahya, for his guidance, support, patience, enthusiasm, and encouragement in completing my research project. Also, I would like to extend my sincere thanks to co-supervisor Assoc. Prof. Dr Zaiton Haron for her guidance and for providing necessary information regarding the project.

I would like to express a special thanks to my wife, Bukola Martins and children, Oluwatumininu and Oluwaferanmi Martins for their everlasting support and encouragement throughout this project. My thanks and appreciations also to all my friends and classmates in developing my project. I am also indebted to government of federal republic of Nigeria for funding my Ph.D. study.

My fellow postgraduate student should also be recognised for their support. My sincere appreciation also extends to all my colleagues who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. Finally, I wish to thank my parents, brother and sisters for being pillars of support all through my life.

Sincerely

Taiwo Martins Esan.

ABSTRACT

Gypsum is one of the most widely used interior building materials, notably as a finishing material. However, because to its brittle nature, as well as low compressive and flexural strength, there has been a reduction in interest in the prospective use of gypsum as an interior finish in buildings in recent years. In order to meet other mechanical and technical characteristics that are acceptable for use as interior building materials, gypsum must have high ductility characteristics and good sound energy absorption capabilities. Therefore, it is important to reduce these engineering issues using environmentally friendly and economic solutions through the use of natural fibres in the gypsum composite mixture. This study aims to characterize the engineering and acoustic properties of gypsum composites containing pineapple leaf fibres (PALF) with 5 mm and 15 mm in sizes. In determining the physical chemical and mechanical properties of gypsum-PALF composites, five different configurations containing PALF of 2%, 3%, 5%, 10%, and 20% based on the weight of the gypsum composition were prepared for both sizes of PALF. The composite specimens were tested under normal conditions after 7 and 28 days of curing. The microstructural characteristics of the composites were further examined using a Scanning Electron Microscope and an Energy Dispersive X-ray Spectroscopy (SEM/EDX), X-Ray Diffraction (XRD), and X-ray Fluorescence (XRF). The test results show that the materials reinforced with 2% PALF of 15mm in size provides composite materials with better mechanical properties of 3.70 MPa and 2.60 MPa, respectively for compressive and flexural strength. However, the compressive strength values are seen to decrease when more PALF content is mixed. The compressive strength increased up to 12.4% when 2% PALF was used in the gypsum composite. The flexural strength has increased up to 59% compared to ordinary gypsum when 2% PALF is added to the gypsum mixture. In comparison to materials reinforced with 5 mm fibre size, test results demonstrate that materials containing 15 mm PALF size provides a PALF-gypsum material with significantly better mechanical properties in terms of flexural strength. The optimum composition of the composite material was found to exist for a PALF content of 2% in the weight of the fibre size of 15 mm. Next, the study focused only on the optimal mix with 2% PALF of 15mm size tested for its sound absorption and sound loss capabilities. The series of specimens from the optimal mix are made based on market thicknesses of 9 mm, 12 mm, and 15 mm. The sound absorption and loss properties of the specimens were measured using an impedance tube instrument based on ASTM C384-04 in the frequency range between 60 Hz to 1600 Hz. As a result, it was found that there is an increase in sound absorption especially in the frequency range of 1000 Hz with a maximum value equal to 0.24. The average value of the sound absorption coefficient at 250 Hz, 500Hz, 1000 Hz and 1600 Hz or the noise reduction coefficient (NRC) shows an increase of 50% in the composite sample when compared to the gypsum sample without PALF. i.e., with a maximum value of 0.18. Sound transmission loss (SLT) also increases by 26% at a frequency of 1000 Hz. In general, adding 2% PALF to the gypsum results in greater level of STL. Based on the result of acoustical and mechanical test, it is concluded that the novel composite developed has the potential to be used to reduce agricultural waste, i.e., pineapple leaf waste. and energy savings from the use of non-natural fibres. Finally, design guidelines for gypsum-PALF composite materials in the future have also been proposed.

ABSTRAK

Gipsum adalah salah satu bahan binaan dalam bangunan yang paling banyak digunakan, terutamanya sebagai bahan kemasan. Walau bagaimanapun, kerana sifatnya yang rapuh, serta mempunyai kekuatan mampatan dan lentur yang rendah, maka terdapat pengurangan minat dalam penggunaan prospektif gipsum sebagai kemasan dalaman bangunan dalam beberapa tahun kebelakangan ini. Bagi memenuhi ciri mekanikal dan teknikal lain yang boleh diterima untuk digunakan sebagai bahan binaan dalaman, gipsum mesti mempunyai ciri-ciri kemuluran yang tinggi dan keupayaan penyerapan tenaga bunyi yang baik. Oleh itu, adalah penting untuk mengurangkan isu kejuruteraan ini menggunakan penyelesaian yang mesra alam dan ekonomi melalui penggunaan serat asli dalam campuran komposit gipsum. Kajian ini bertujuan untuk mencirikan sifat-sifat kejuruteraan dan akustik bagi komposit gypsum yang mengandungi serat daun nanas (PALF) berukuran 5 mm dan 15mm. Dalam menentukan sifat-sifat fizikal, kimia dan mekanikal komposit gypsum-PALF, lima konfigurasi berbeza mengandungi PALF sebanyak 2%, 3%, 5%, 10%, dan 20% berdasarkan berat komposisi gipsum telah disediakan bagi kedua-dua saiz PALF. Spesimen-spesimen komposit diuji di bawah keadaan normal selepas 7 dan 28 hari pengawetan. Ciri mikrostruktur komposit diuji menggunakan Mikroskop Elektron Pengimbasan dan Spektroskopi sinar-X Energy Dispersive (SEM / EDX), Difraksi Sinar-X (XRD), dan Fluoresensi sinar-X (XRF). Keputusan ujian menunjukkan bahawa bahan-bahan yang diperkukuh dengan 2% PALF bersaiz 15mm memberikan bahan komposit dengan sifat mekanikal yang lebih baik iaitu 3.70 MPa dan 2.60 MPa, masing-masing bagi kekuatan mampatan dan lenturan. Bagaimanapun, nilai kekuatan mampatan dilihat menurunkan apabila lebih banyak kandungan PALF dicampurkan. Kekuatan mampatan meningkat sehingga 12.4% apabila 2% PALF digunakan dalam komposit gipsum. Manakala kekuatan lenturan pula telah meningkat sehingga 59% berbanding gipsum biasa apabila 2% PALF dimasukkan ke dalam campuran gipsum. Berbanding dengan bahan yang diperkukuh dengan saiz gentian 5 mm, keputusan ujian menunjukkan bahawa bahan yang mengandungi saiz PALF 15 mm memberikan bahan PALF-gipsum dengan sifat mekanikal yang jauh lebih baik dari segi kekuatan lenturan. Komposisi optimum bahan komposit didapati wujud untuk kandungan PALF sebanyak 2% dalam berat saiz gentian 15 mm. Seterusnya, kajian menumpukan hanya campuran optimum dengan PALF 2% bersaiz 15mm diuji keupayaannya terhadap penyerapan bunyi dan kehilangan bunyi. Siri spesimen dari campuran optimum diperbuat berdasarkan ketebalan pasaran iaitu 9 mm, 12 mm, dan 15 mm. Sifat penyerapan dan kehilangan bunyi spesimen diukur dengan menggunakan instrumen tiub impedans berdasarkan ASTM C384-04 dalam julat frekuensi antara 60 Hz hingga 1600 Hz. Hasilnya, didapati terdapat peningkatan penyerapan bunyi terutamanya pada julat frekuensi 1000 Hz dengan nilai maksimum bersamaan 0.24. Nilai purata pekali penyerapan bunyi pada 250 Hz, 500Hz, 1000 Hz dan 1600 Hz atau pekali pengurangan bunyi (NRC) menunjukkan peningkatan sebanyak 50% dalam sampel komposit jika dibandingkan dengan sampel gipsum tanpa PALF iaitu dengan nilai maksimum 0.18. Kehilangan bunyi juga meningkat sebanyak 26% pada frekuensi 1000 Hz. Secara umum, menambah 2% PALF pada gipsum menghasilkan tahap kehilangan penghantaran bunyi (STL) yang lebih besar. Berdasarkan keputusan ujian akustik dan mekanikal ini, disimpulkan bahawa komposit novel yang dibangunkan berpotensi digunakan bagi mengurangkan bagi sisa pertanian iaitu sisa daun nanas dan penjimatan tenaga dari penggunaan serat bukan asli. Seterusnya, garis panduan reka bentuk bagi campuran bahan komposit gipsum-PALF pada masa hadapan juga telah dicadangkan.

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
BS	-	British Standard
EDX	-	Energy Dispersive X-ray
ITZ	-	Interface Transition Zone
NRC	-	Noise Reduction Coefficient
PALF	-	PALF
SAC	-	Sound Absorption Coefficient
SEM	-	Scanning Electron Microscopy
STL	-	Sound Transmission Loss
UTM	-	Universiti Teknologi Malaysia
XRD	-	X-Ray Diffraction
XRF	-	X-Ray Fluorescence

LIST OF SYMBOLS

p	-	Density
D, d	-	Diameter
ϕ	-	Porosity
f	-	Frequency
dB	-	Decibel
Hz	-	Hertz
mm	-	Millimetre
M	-	Meter
°C	-	Degree centigrade
R	-	Flow resistivity
α	-	Sound Absorption Coefficient
αopt	-	Optimum Sound Absorption Coefficient
μ	-	Micrometre
%	-	Percentage
f_c	-	Compressive Strength
fs	-	Flexural Strength
F	-	Maximum Load
A	-	Area of Specimen
W	-	Maximum Applied Load for the Specimen
Y	-	Span between the Center of the Support
B	-	Width of the Test Specimen
T	-	Mean Thickness of the Test Specimen
Hl	-	Frequency Response Function of the Impedance Tube
Hi	-	FRF Associated with the Incident Wave Components
Hr	-	FRF Associated with the Reflected Wave Components
k	-	Wave Number
l	-	Distance Between the Microphone and the Sample
S	-	Spacing Between the Microphone and the Sample
$CaCO_3$	-	Calcium Carbonate
CaO	-	Calcium Oxide

$CaSO_{4}.0.5H_{2}O$	-	Calcium Sulphate Hemihydrate
$CaSO_{4}.2H2O$	-	Calcium Sulphate Dehydrate
SO_3	-	Sulphur Trioxide
$CaSO_4$	-	Calcium Sulphate
MPa	-	Megapascal
W_a	-	Percentage Water Absorption
W_1	-	Mass of PALF after Absorption
W_2	-	Mass of PALF after Heating
M_c	-	Percentage of Moisture Content
W_I	-	Initial Mass
W_2	-	Dry Mass
P_b	-	Bulk Density of Sample
M_f	-	Mass of the Test Sample
V_c	-	Volume of the Test Sample
$V_{apparent}$	-	Volume of Weight without Porosity
V_t	-	Total Volume
$W_{in\ air}$	-	Weight of Sample in Air
ρ_{water}	-	Density of Water
f_l	-	Flow of Sample
d_a	-	Average Base Diameter
d_o	-	Original Base Diameter
W_d	-	Weight of Oven Dry Gypsum Sample in Air
W_{sat}	-	Weight of Saturated Surface Dry Gypsum Sample in Air
W_{sub}	-	Weight of Submerged Gypsum Samples in Water
m	-	Mass of the Test Specimen
V	-	Volume of the Test Specimen

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CHAPTER 1

INTRODUCTION

1.1 General

Gypsum is one of the oldest materials used by humans for construction purposes and is a binding material generally produced by heating and extracting some or all the crystallization water present in the structure of gypsum rock. Gypsum-based materials such as mortar, composites, and board are now widely used materials in the world, owing to their ease and speed of assembly, adaptability, cleanliness, excellent fire resistance, thermal properties, and sound insulation properties (Boccarusso *et al.,* 2020; Erbs *et al.,* 2018; Gencel *et al.,* 2016; Gutiérrez-González *et al.,* 2012; Jeong *et al.,* 2017; Skujans *et al.,* 2007; Toppi and Mazzarella, 2013).

Gypsum board, also known as drywall, plasterboard, or wallboard, is the most popular gypsum mineral product. Gypsum board is composed of a gypsum plaster core, typically bonded to a durable paper liner. Gypsum plasterboards are primarily used as a lining material in lightweight construction and are a cost-effective and reliable way to provide compact partitioning assemblies in residential and commercial buildings. To meet specified acoustic and structural specifications, the thickness of the gypsum board lining and the design of the framing can be flexibly modified. The use of this device is growing every day, and more research into its properties and behaviors is required.

Gypsum is made up of a "network of linked needle-like calcium sulfate dihydrate crystals" (Chen *et al.*, 2010). Gypsum crystals are uniformly sized and have a high porosity of up to 70%. Crystal porosity influences elastic modulus, tensile strength, and fracture toughness. The mechanical characteristics of gypsum are influenced to some extent by network structure, crystal size, and porosity. Individual crystal features and orientation are also suggested to influence mechanical properties (Chen *et al.*, 2010). Gypsum boards are naturally brittle; however, they have undesired mechanical qualities including low tensile and flexural strengths. When utilized, it shrinks and cracks, causing parts of the gypsum boards to fall.

Furthermore, gypsum boards act as sound insulation. They can reduce noise levels by 2 to 4 decibels (Ragab, 2015). Gypsum boards are utilized in buildings near the workshop, such as classrooms and offices, to reduce noise. Sound transmission management can be aided by certain construction methods and drywall building systems. Gypsum boards also have a high level of durability, which is why they are utilized for high-end walls and ceilings. Furthermore, the boards are very adaptable to various architectural designs and to all types of ornamentation (Ragab, 2015).

The idea of using fibres to reinforce brittle materials has a long history. Natural fibres have been utilized to reinforce fragile matrices (Mohammed *et al.,* 2015). Though minor strength gains can be achieved, the major goal of fibre inclusion in cementitious materials is to improve toughness and ductility. Fibres in the gypsum matrix can improve mechanical qualities including compressive and flexural strength, as well as toughness. This is due to the ability of fibres to bridge cracks due to features such as high tensile strength, length, and aspect ratio.

Pineapple leaf fibres (PALF) has gained a lot of attention as a result of advancements in their strength and toughness for civil engineering applications with a wide range of applications in the building industry, including PALF/polyester composites (Senthilkumar *et al.,* 2019), hybrid composites (Zin *et al.,* 2018), PALF/polypropylene composites (Arib *et al.,* 2006), and extracted PALF for sound absorption (Putra *et al.,* 2018; Yahya *et al.,* 2019). Furthermore, following the highly publicized findings of the health risks linked with synthetic fibres, it is rapidly being used as an alternative. As a result, PALF has a lot of potential as a reinforcing material and can also be used as a fibre source in gypsum composites.

1.2 Background of Study

Gypsum is the most common building material, and its use is on the rise all over the world. Higher ductility and energy absorption capacity are frequently required in the production of gypsum board, in addition to the usual applications. Plain gypsum board, on the other hand, has poor tensile strength, limited ductility, low crack resistance, and negligible energy absorption. Internal microcracks in gypsum board materials are naturally present, and their low tensile strength is due to the development of such microcracks, which eventually leads to brittle fracture of the gypsum material. As a result, increasing the toughness of the gypsum board will result in improved gypsum board performance. Previously, researchers attempted to improve the mechanical properties of gypsum by adding palm fibre, as seen in (Al-Rifaie and Al-Niami, 2016). The findings showed that increasing the palm fibre content had a negative effect on the composites' compressive strength, but that there was an improvement over fibreglass composites. In their analysis of mechanical properties and microstructure, Eve *et al.* (2002) discovered the effect of the aspect ratio and fibre concentration on the mechanical properties of polyamide fibre reinforced gypsum. Another recent research by Zhu *et al.* (2018) looked at how polyvinyl alcohol and polypropylene fibres influenced the physical and mechanical properties of gypsum-based composites. Iucolano *et al.* (2018a) found that using bio-degummed hemp as reinforcements increased the mechanical properties and thermal resistance of gypsum composites.

Other than mechanical properties, acoustic properties analysis are greatly considered in assessing the behavior and potential use of fibre in gypsum board production. As a result, sound absorption material design is becoming increasingly important on a global basis. A sound absorber is one of the most significant components in a building's noise control system for reducing sound energy. Uncontrolled noise can disrupt sleep and lead to various health problems. Hence, providing a system to control noise is of great significance in engineering practice.

In recent years, because of the need and demand for cost-effective and sustainable materials that are stronger, lighter, and more robust, gypsum-based composite materials have seen major advances. The energy required for the calcination of calcium sulphate hemihydrate ($CaSO_4.0.5H_2O$) is substantially lower than that necessary for the calcination of cement or lime, making it one of the most environmentally friendly binders. While lime is burned at over 1000℃ and cement at over 1400℃, the temperature at which gypsum is calcined does not surpass 200℃. Making gypsum an excellent material for utilization. Gypsum is also used in internal partitions, drywall, and façade panels because of its excellent thermal insulation, lightweight, low energy consumption, fire resistance, acoustic insulation, and quick healing time (Aghaee *et al.*, 2015; Garg and Pundir, 2014; Li *et al.*, 2003; Mohandesi *et al.*, 2012; Rahman *et al.*, 2007; Zhang *et al.*, 2011).

This prompt research into the manufacture of composite natural fibre materials to replace synthetic fibres with sustainable natural fibres, mainly from vegetables such as sisal, bagasse sugarcane, coir, and date palm fibres, which are otherwise waste products and contribute to contamination of the environment by creating problems with disposal. In addressing the problem of disposal, and cost-effectiveness, the use of these fibres as reinforcements provides advantages such as lightweight, low cost, high specific strength, ease of processing, increased energy recovery, low density, decreased equipment wear, renewability and biodegradability (Oladele *et al.*, 2016). These often outweigh the inconveniences of low fibre-matrix compatibility and heavy moisture absorption of these natural fibres (Ghali *et al.*, 2011).

On the other hands, PALF threads have historically been used in many countries' textile industries. PALF is used elsewhere to manufacture craft products, though attempts to use PALF in Malaysia have only begun, even though the country is one of the largest producers of pineapple in South East Asia (Mohamed *et al.*, 2009). PALF are suitable for a wide range of applications due to their mechanical properties (Satyanarayana *et al.*, 1990). In addition, pineapple leaves can be help alleviate the environmental burden, because the leaves are usually waste. Hence, the porous fibrous material of pineapple leaf can be used to reinforce and strengthen building materials.

This study is devoted to researching the engineering properties and acoustic performance of PALF-gypsum composite. Recently, demand for the use of eco-friendly materials for construction applications has made a tremendous contribution to the selection of this study objective. The research findings will be useful in the construction industry, where strong and lightweight materials are required in greater quantities. For this reason, PALF-gypsum composites have been developed and their engineering and acoustic properties have been investigated.

1.3 Problem Statement

Building energy conservation, green building, and environmental protection issues have steadily gained attention as modern society has progressed. Gypsum is widely used in construction, especially as a finishing material, and is one of the most popular indoor building materials. Gypsum boards are widely used for ceilings and partitioning in manufacturing, residential, and industrial buildings. Gypsum board is becoming increasingly popular due to its high sound insulation capability, green and non-pollutive material, speed of erection, and ease of installation (Ma *et al.*, 2020). Plain gypsum board, on the other hand, is brittle, with low flexural strength and weak sound absorption required in building for the interior. Because of this material's low flexural strength and weak ability to absorb sound, several researchers have focused their research in recent years on how to strengthen these properties by incorporating fibre as reinforcements. Fibre, which has a higher tensile strength than the gypsum matrix in most situations, appears to help increase the mechanical efficiency of the composite by distributing the applied stress load (Bilici *et al.*, 2019; Kuqo and Mai, 2021). Fibreglass and natural fibres have been used to solve this issue in previous studies (Eve *et al.*, 2002; Hernández-Olivares *et al.*, 1999; Iucolano *et al.*, 2018b). The mechanical properties of the gypsum board were improved by adding fibres. The fibres serve as reinforcements in the matrix, preventing crack spread while also enhancing tension distribution (Callister and Rethwisch, 2013). Another problem with using gypsum products is the amount of waste produced as a result of the gypsum's short setting time (Carvalho *et al.*, 2008; Camarini and Milito, 2011)

However, amid recent efforts, the advancement of composite materials faces various obstacles many of which remain unanswered, such as global warming and requires high energy and is thereby harmful to humans (Alhijazi *et al.*, 2020; Behdinan *et al.*, 2020; Huzaifah *et al.*, 2017; Mazzanti *et al.*, 2019; Sanjay *et al.*, 2018). As a result, green gypsum composites with lower global warming potential associated with carbon dioxide emissions from synthetic fibre production must be created, while maintaining desirable mechanical properties and taking into account acoustic properties.

Pineapple leaf waste is trashed in massive volumes across the world every year. A considerable amount of this material is disposed of in a landfill. Much research has been done over the last few decades to identify and assess innovative applications for development of sustainable construction materials. Several researchers in Malaysia have been reported to use pineapple leaves, including PALF/polyester composites (Senthilkumar *et al.*, 2019), hybrid composites (Zin *et al.*, 2018), PALF/polypropylene composites (Arib *et al.*, 2006), and extracted PALF for sound absorption (Putra *et al.*, 2018;Yahya *et al.*, 2019). As a result, PALF has a lot of potential as a reinforcing material and can also be used as a fibre source in composites. Today, the use of PALF to substitute other types of natural fibres in gypsum composites as an alternative reinforcement has not been implemented. More research is therefore required on PALF, which is renowned for its strong ability to absorb sound and also provides cleaner processing with less environmental impact. The reason for this study stems from the drawbacks of the manufacture of gypsum-based composite panels for soundproofing materials compared with other forms of natural fibres. As a result, reinforcing the gypsum matrix with natural fibre such as PALF is a feasible option where sound absorption and strength are the primary consideration.

1.4 Research Aim and Objectives

The aim of the research is to investigate the effect of PALF on engineering and acoustic properties of gypsum composite material. The objectives of this research are:

(a) To determine the physical, chemical and microstructure properties of PALF and gypsum.

(b) To investigate the physical and mechanical properties of PALF-gypsum composite materials with different sizes and percentages of PALF.

(c) To obtain the optimum percentage of PALF that fulfil the requirement of physical and mechanical properties of PALF-gypsum composite.

(d) To evaluate the acoustic properties of PALF-gypsum composite.

1.5 Scope of the Research

This study investigates the potential for using PALF to reinforce gypsum composite. The scope of work also includes investigating the physical, microstructural properties, mechanical properties, and acoustic properties of PALF-gypsum composite materials. Hence the mechanical properties of composite materials were tested in the laboratory by developing samples of PALF-gypsum with different percentages and sizes to include: five percentages and reference samples. The grind PALF was used in two sizes (5 mm and 15 mm). Replacement levels of PALF were 2%, 3%, 5%, 10%, and 20% from the weight of gypsum content. The characteristics of PALF and gypsum were tested. Density, porosity, water absorption, moisture contents are among them. It also covers the use of X-ray fluorescence (XRF) for determining the chemical compositions of PALF and gypsum, as well as morphological analysis.

The fresh and hardened states, as well as the microstructure characteristics of composite materials, were investigated. The research is carried out using 33 cube specimens (50 mm x 50 mm x 50 mm) for compressive strength properties tests and 33 specimens (40 mm x 40 mm x 160 mm) for flexural strength tests according to ASTM C348. The tests conducted to study the engineering properties of PALF-gypsum composites include compressive strength tests, flexural strength tests, moisture content test, water absorption test, porosity, density, workability, and setting time.

Specimen that fulfils the requirements of gypsum board was used to examine the acoustic properties of the composite material based on the physical and mechanical properties for the characterization of the sound absorption properties of the PALF-gypsum composite materials in varying thicknesses of 9 mm, 12 mm and 15 mm based on market thicknesses. The acoustic tests are conducted which include, Investigating the effect of thickness on sound absorption coefficient (α), comparing the α of plain with composite samples, determining the effect of thickness on sound transmission loss (STL), determining the relationship between α and non-acoustic properties (thickness) of PALF-gypsum composite and determining the relationship between STL and non-acoustic properties (thickness) of PALF-gypsum composites. The reaction and filling mechanism inside the PALF-gypsum composites are determined by conducting a microstructure study including X-ray diffraction (XRD), X-ray fluorescence (XRF), scanning electron microscopy, and an Energy Dispersive X-ray Spectroscopy (SEM/EDX).

1.6 Significance of the Study

In the highly competitive market of gypsum board systems, it is necessary for top producers to consistently develop new products by using new materials and innovative systems. Since natural fibres have been advocated for improving gypsum board performance, using PALF will reduce the quantity of waste generated from agricultural products while also improving the brittleness characteristics of gypsum. Furthermore, replacing an appropriate amount of natural fibre in the mix meant the mechanical, physical, and acoustic properties of gypsum mortar could be greatly improved. However, the outcome of the study provides more information on the performance of PALF in gypsum mortar. The effect of PALF on the engineering and acoustic properties of gypsum is also investigated. Therefore, the study tends to evaluate the engineering and acoustic properties of new products from PALF as an alternative to synthetic material in natural gypsum-based fibre composite materials.

Based on the environmental concerns of synthetic fibres for fibre-based gypsum composite panels, biological materials such as natural fibres are becoming the best alternative material to use as a reinforced fibre in gypsum composite panels. The introduction of the use of ecological materials for acoustic engineering applications is the main significance of this study that can help save nature and reduce carbon dioxide emissions. Using natural fibres like PALF as composites in the gypsum board will help reduce the negative impact of pineapple debris on the environment.

It will also help promote environmental awareness by reviving local agricultural waste and natural resources with less intensive emission of carbon dioxide. These materials have a lower density and a high level of porosity, which is essential for the absorption mechanism during the drying of the acoustic energy within the structure. In addition, it will help to increase agronomic activities and boost the economic sector in Malaysia and above all, the use of renewable materials will also be advantageous for engineers and industries.

This study is motivated by the need to expand knowledge about the use of natural fibres in the construction industry. Specifically, this study will focus on the physical, mechanical properties, and acoustic properties of PALF-gypsum composite. The developed material can contribute to the improvement of the acoustic properties of composite materials. The findings of the study are likely to inspire the introduction of new inventive approaches to manufacture gypsum boards for use in the building industry. The current research is a step toward developing a construction material that is inexpensive, long-lasting, and environmentally friendly.

1.7 Thesis Structure and Organization

This thesis is divided into seven chapters with the following structure:

Chapter 1: Briefly explains the study's background and problem statement. It also explains the study's purpose, objectives, scope, and significance.

Chapter 2: Provides an overview of gypsum materials in construction, as well as a review of prior laboratory studies, field tests, and analytical and numerical work on fibre reinforced gypsum composites.

Chapter 3: Describe the details experimental program, mix proportions, specimen preparation, and test methodologies used to achieve the objectives, which includes material selection, composite manufacturing methods, visual examination of the PALF-gypsum composite surface using SEM, as well as the acoustic, physical and mechanical properties of the composite.

Chapter 4: Presents the physical and microstructure results of the raw materials. Such as gypsum and PALF.

Chapter 5: Presenting the physical, mechanical, and microstructural properties of PALF-gypsum composite materials, as well as the findings of these properties.

Chapter 6: Presents the optimization of the composite mixture and acoustic properties result, which evaluates the STL and α properties.

Chapter 7: Presents the conclusions and explains the overview of the research findings, presents the contribution, and makes suggestions for the future production of the acoustic insulator PALF-gypsum composites in building materials.

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