Faculty of Mechanical Engineering

INVESTIGATION ON THERMAL PERFORMANCE OF PROSPECTIVE GREEN MATERIALS AS BUILDING WALL INSULATION

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Report

Projek Sarjana Muda

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DECLARATION

I declare that this thesis entitled "Investigation on Thermal Performance of Prospective Green Materials as Building Wall Insulation" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :……

Name :……

Date :……

APPROVAL

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality as a partial fulfillment of bachelor degree of Mechanical Engineering.

Signature :……

Supervisor Name :……

Date :……

DEDICATION

To my beloved mother and father

ABSTRACT

The building construction industry is recently changing focus in using sustainable and green materials. With the abundance of the resources, it is beneficial to utilize the application and observing its potential as wall insulation materials. This study is hoped to provide some prospect in using green materials as wall insulation. Building insulation is defined as any object in a building, such as roof and wall are used as insulation for any purpose. Thermal insulator in buildings is an important factor to achieve thermal comfort for its occupants. By installing the insulator in a building, it will reduce the unwanted heat loss or gain and can also decrease the energy demands of heating and cooling systems. Besides that, the study tends to set as a benchmark study for further application of green materials in building construction. In this project, green waste materials is chosen to analysis and perform the heat transfer test. Green materials used in this study are coconut fibres, cellulose and sugar cane wastes. The objective of this study is to analysis the behaviour and thermal insulation of the selected green materials. The measurement is conducted by installing the green materials samples in mini house model and infrared camera is used to record the temperature gradient in the mini house model under different conditions. Thermal conductivity of each insulator is calculate to determine the thermal behaviour of these insulators.

ABSTRAK

Industri pembinaan bangunan baru-baru ini mengubah tumpuan dalam menggunakan bahan-bahan mampan dan hijau. Dengan adanya sumber yang banyak, aplikasi dan potensinya sebagai bahan penebat dinding telah dipehartikan. Kajian ini diharapkan dapat menyediakan beberapa prospek dalam menggunakan bahan hijau sebagai penebat dinding. Penebat bangunan ditakrifkan sebagai sebarang objek di dalam bangunan, seperti penebat di bumbung dan dinding untuk mencapai tujuan tertentu. Penebat haba dalam bangunan merupakan faktor penting untuk mencapai keselesaan terma bagi penghuninya. Dengan memasang penebat di bangunan, ia akan mengurangkan kehilangan atau kenaikan haba yang tidak diingini dan juga dapat mengurangkan permintaan terhadap tenaga pemanasan dan penyejukan. Di samping itu, kajian ini cenderung kepada penggunaan bahan hijau dalam pembinaan bangunan. Dalam projek ini, bahan buangan hijau dipilih untuk dianalisis dan melaksanakan ujian pemindahan haba. Bahan-bahan hijau yang digunakan dalam kajian ini adalah sisa-sisa kelapa, selulosa dan sisa tebu. Objektif kajian ini adalah untuk menganalisis tingkah balas dan penebat haba bahan-bahan hijau terpilih. Pengukuran dilakukan dengan memasang sampel bahan hijau dalam model rumah dan kamera inframerah digunakan untuk merekam kecerunan suhu dalam model rumah dalam keadaan yang berbeza. Kekonduksian haba bagi setiap penebat akan dikira untuk menentukan tahap kelakuan haba penebat tersebut.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF SYMBOLS

k	-	Thermal conductivity
ρ	-	Density
c	-	specific heat capacity
Q	-	Rate of heat conduction
ΔT	-	Temperature different
d / L	-	Material thickness
R	-	Thermal resistance of the material
K	-	Kelvin
℃	-	Degree Celsius
κ	-	Thermal diffusivity
C_p	-	Specific heat
m	-	meter
W	-	Watt
kg	-	kilogram
k_{ave}	-	Average thermal conductivity
T	-	Temperature
A	-	Surface area of heat transfer
Re	-	Reynolds Number

LIST OF ABBREVIATIONS

3I	-	3 cm insulation layer
7I	-	7 cm insulation layer
CBAGB	-	Chemical treated bagasse fibre
CBAGP	-	Heat treated bagasse fibre
CFI	-	Cellulose fibre insulation
ExSTNI	-	External Surface Temperature No Insulation
GR	-	Green roof
GFO	-	Green facade optimization
HHW	-	Household waste
InSTNI	-	Internal Surface Temperature No Insulation
LCA	-	Life cycle analysis
NHIW	-	Non-hazardous industrial waste
NI	-	No insulation
SEM	-	Scanning Electron Microscope
UHI	-	Urban heat island
WG	-	White gravel

CHAPTER 1

INTRODUCTION

1.1 Background of Problem

Building insulation is defined as any object in a building, such as roof and wall are used as insulation for any purpose (Asdrubali, 2015). Majority of insulation in buildings is for thermal insulation purpose in Malaysia. Thermal insulator in buildings is one of the most important factor to achieve thermal comfort for its occupants. By installing the insulator in a building, it will reduce the unwanted heat loss or heat gain and also decrease the energy demands for heating or cooling systems. Generally, insulation can just refer to the insulation materials applied to slow down the heat transfer process from the outer wall to the inner wall, such as cellulose, rock wool, glass wool, wood fibre, plant fibre, cement, polystyrene, urethane foam and plant straw. Figure 1.1 shows the example of extruded polystyrene foam as wall insulation in building.

Figure 1.1: Extruded polystyrene foam as building wall insulation (KIMMU, 2017).

In Malaysia, the problem faced is the hot weather, where the greatest source of heat energy is mainly from solar radiation. Through the windows and doors, solar radiation is able to enter the buildings directly and heat up the wall to a higher temperature than the ambient and increasing the heat transfer through the building envelope and cause the room become hot and uncomfortable (Baker, 2013). In order to stay in comfortable room, refrigerated air conditioning is employed to solve the hot situation, then it is particularly important to seal the building envelope. Due to the dehumidification of air infiltration inside the room, it can significantly cause the wastes of energy. In Malaysia, most of the building designs are based on effective cross ventilation instead of installed air conditioning system to provide convective cooling to the room. Building construction and correct way of insulated materials installation on the wall of the buildings will ensure low conduction of heat transfer. This requires attention from contractor and designer.

The lesser the natural air flow into the building, the more mechanical ventilation required to ensure the thermal comfort of the occupants. High humidity in a room can be significant issue related to lack of airflow, construction material failure, condensation and encouraging growth of microbial such as bacteria and mould. These problems are incorporated with actively or passively air exchange systems. The higher the density of a material, the better it will conduct heat. For example, air is low density medium, hence, air is a very poor heat conductor and therefore can be a good insulator. Principle of insulation is to reduce the heat transfer conductive by using air spaces between fibres, plastic bubbles or foam and building's wall cavities. This is beneficial in an actively heated or cooled building, but can be a liability in a passively cooled building.

In this project, green waste materials is chosen to analyse and perform the heat transfer test. Green material is defined as biodegradable waste material, such as grass, plants, tree trimmings and fibre waste that can be diverted from landfills for recycling (Peterson,

2017). Statistic shows that millions tons of green waste is disposed of in landfilled every year instead of being recycled or fully used. Beside shortens the life of landfills, landfilling green materials also contributes to Green House Gases emission. By applying green material in the building development, it may provide sustainable utilization of waste resources. Utilize of green material not only reduce the quantity of wastes, but also reduce the harmfulness to the environment. For example, in thermal energy storage system (TES) development in Pahang, Malaysia, in order to absorb the heat from outer wall to inner wall of a building, a form of green material is used as an insulator. The potential of heat absorber of the insulator is measured by its R-value. The greater the value of R-value, the better the heat insulation of the green material (Ali, 2013).

1.2 Problem Statement

The purpose of this study is to investigate the potential of waste or green materials as wall insulation for building. This study suits well with the current trend in building construction industry where the focus is on using environmental friendly and sustainable materials. This study will be conducted to find solutions to the following questions:

1. How is the thermal performance of green materials as wall insulation?
2. What are the effects of green materials as wall insulation on internal condition?
3. How efficient is the green materials as wall insulation compare to other types of wall insulation?

1.3 Objectives

The objectives of this project are:

1. To evaluate the thermal performance of green materials as wall insulation for residential housing.
2. To conduct a comparative analysis of the different green materials on how the interior and exterior of the house heats and cools.

1.4 Scope of Research

The scopes of this project are:

1. The experimental investigation will be conducted by using a mini house model.
2. The study will observe the temperature different between internal and external condition by installing different types of green materials.
3. For the temperature distribution during certain condition, the image will be recorded by using thermal infrared camera.
4. The heat transfer analysis will include the calculation of thermal conduction between the wall and green materials from outer surface to inner surface of the room.

1.5 Project Organization

Project organization is a structure that facilitates the coordination and implementation of the activities in the project. The main reason is to create a clear guideline and tidy structure when conduct the project (Diaz, 2007). Proper structured project organization can reduce confusion and uncertainty during project initiation phase is one of the main objectives of the project organization preparation. Proper design of project organization chart is essential to the project success. Figure 1.2 shows the project organization chart for Final Year Project.

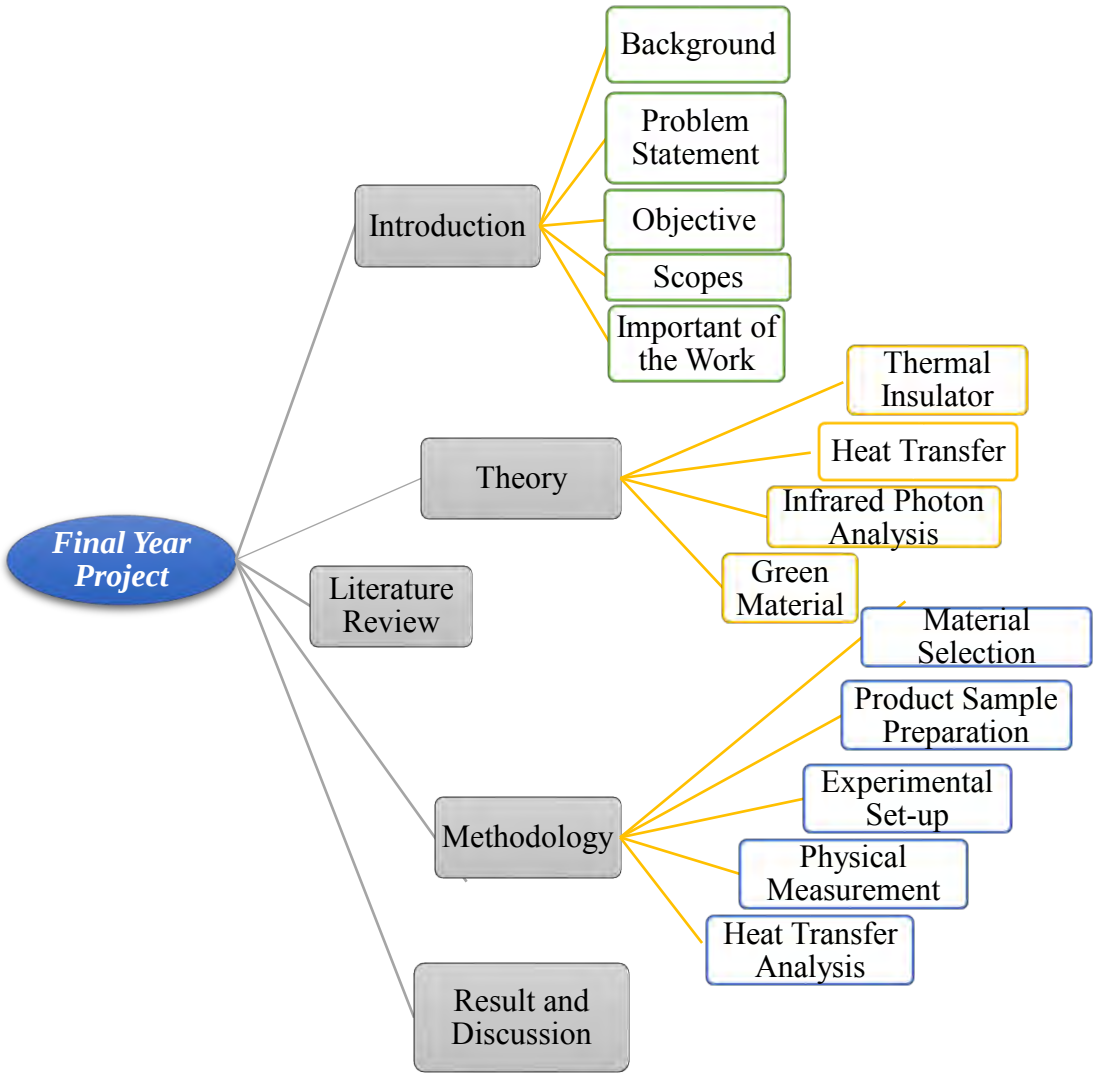

Figure 1.2: Project organization chart for Final Year Project.

1.6 Important of the Work

The building construction industry is recently changing focus in using sustainable and green materials. With the abundance of the source, it is beneficial to utilize the application and observing its potential as wall insulation materials. This study is hoped to provide some prospect in using green materials as wall insulation. Besides that, the study tends to set as a benchmark study for further application of green materials in building construction.