UNIVERSITI TEKNOLOGI MARA

THERMAL CONDUCTIVITY OF SELECTED TROPICAL TIMBER USING HOT BOX METHOD

RAIHANA BINTI MOHAMAD HATA

Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science

Faculty of Civil Engineering

April 2019

ABSTRACT

In this study, thermal conductivity of selected tropical timber species was measured using Hot Box method. Each of the selected timber species represent hardwood and softwood as classified in Malaysian Standard MS 544 Part 2. Samples are categorized according to Strength Group (SG) and listed as SG1 to SG7. The higher the strength group, the higher its strength and density. For this research, Chengal, Balau, Kekatong, Kempas, Kembang Semangkok, Keranji, Merpauh, Perupok, Nyatoh, Rubberwood, Terap, Jelutong, Pulai and Sesendok were selected. Application and selection of timber for building are good for insulation as timber has lower thermal conductivity compared to concrete, steel and others building materials. Thus, data on thermal conductivity value for different timber species are useful for building design purposes. Therefore, the objectives of this research is first to determine the heat flux through selected timber species which the data then used to calculate the thermal conductivity and hence the correlation to its physical characteristic. The hot box method was selected since the test gave sufficient amount of data to analyse the thermal conductivity values. The hot box method also gave accurate data compared to other method. The Hot Box method of testing is based on steady state conditions. The testing was conducted up until the heat flux, air temperature and surface temperature value at hot and cold chamber become persistent. The thermal conductivity test was carried out based on BS EN ISO 8990:1996 and MS 1532:2002 standard. Prior to thermal conductivity test, density and specific gravity value were first measured. The moisture content measured using oven dried method. Heat flux value recorded for selected timber species ranged from 90.0 wm^{-2} to 139.3 wm^{-2} which is 35.4% different. The value of heat flux were then used to calculate thermal conductivity value. Based on calculations, the value of thermal conductivity are range from the highest is SG3 Kembang Semangkok 0.051 $Wm^{-1}K^{-1}$ and lowest is SG6 Terap 0.033$Wm^{-1}K^{-1}$ which the difference in 35.3%. Terap is the best timber species for building insulation purposes. The values of thermal conductivity were then compared with moisture content, density, specific gravity and temperature to see their relationship between these parameters. The relationship between density, specific gravity, moisture content, temperature to thermal conductivity shows a poor linear relationship R^2 of 0.09 and 0.14. As conclusion, timber with lowest moisture content, density and specific gravity is preferable for building insulation purposes.

ACKNOWLEDGEMENT

Alhamdulillah. My utmost grateful to Allah the almighty and gracious that has grant me this Master recognition. None of this hardship and efforts research journey would come to end if not with Allah permissions.

I would like to extend my gratitude to my most patient, lovely, supervisor Assoc. Prof Dr Rohana Hassan that has given me support, guidance and ideas throughout this Master journey. Thank you for being patient with me.

I also would like to express my gratitude to the staff of Civil Engineering Faculty and Acoustic Laboratory, Fakulti Seni Bina, UiTM Shah Alam.

Special thanks to my families, colleagues and friends who has been around helping and gave morale support throughout my ups and downs in this research journey. Most importantly, thank you very much to my parents, my husband Mohamed Salman, who has always been there whenever whatever that I needed and to my dear daughter Khadeejah, for always gave me strength to keep on do my best. This Master is truly dedicated to all of you. Thank you again.

Subhannah, Alhamdulillah, Allahuakbar.

TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.1 Background of Study

Temperature difference between indoor and outdoor of building cause heat to travel either from inside to outside of the building or vice versa. Heat can travel into a building from ceiling, windows, walls, floors and through air leakage. Heat can also move out from the building either from convection, conduction and ventilation. It is vital for every building to have a positive thermal balance to provide convenient temperature indoors. A positive thermal balance is achieved by reducing the thermal gain and overheating of building materials (Doulos et al., 2004). Each building material has different heat absorption characteristics (Md Din et al., 2012).

Heat represents the quantity of process of internal energy transmission. It can be transmitted from one material to another material (Huang & Tsai, 2014). The material components of buildings absorb heat and the accumulated heat is then deflected to the atmosphere. This means that building material play important roles in the heat gain and loss in a building (Alchapar et al., 2014). However, building comprises of various kind of materials. Each one of the materials has its own thermal characteristic. This thermal characteristic will define on how the material reacts with heat. The thermal characteristics are thermal conductivity, thermal resistivity, volumetric specific heat, thermal diffusivity, thermal absorption and many others.

Studies on thermal properties especially thermal conductivity on timber and timber products have started a long time ago. Thermal conductivity on timber has become a topic of interest due to the research findings and outcomes that are useful for our daily use. The research gap for this topic is very broad in term of the samples properties and the method used to determine the thermal conductivity. Published research reports on different timber species were based on the timber origin and also on engineered wood product materials. The methods used to determine the thermal conductivity are varied.

Presently, there are many published research studies on the effect of heat gain