

UNIVERSITI TEKNOLOGI MARA

**PHYSICAL, CHEMICAL AND
MECHANICAL
CHARACTERIZATION OF HEAT
TREATED MALAYSIAN
HARDWOOD TIMBERS**

NUR ILYA FARHANA BT MD NOH

Thesis submitted in fulfillment of the
requirements for the degree of
Doctor of Philosophy
(Civil Engineering)

Faculty of Civil Engineering

April 2018

ABSTRACT

As timber with natural durability and excellence properties is limited and high in price, there is a need to make use of the timber with low durability and properties. In order to use this kind of timber, the timber needs to be treated to improve its properties and durability. The well-known treatment used worldwide is by using chemical preservative; however, this kind of treatment is bad to the environment. Therefore, there is a need to find an alternative way to replace this treatment with an environmentally friendly way of treatment. Heat treatment is one of the treatments which may equip the timber with new properties without using any chemical or preservative but heat, where the heat is used to achieve new material properties rather than to dry the wood. Heat treatment generally causes an apparent decrease in wood mechanical properties due to the material losses in cell wall, hemicellulose degradation and the modification of long chain molecules. Therefore, this study investigated the effect of heat treatment on the physical, chemical and mechanical properties of four different species of Malaysian hardwood timbers; Pauh Kijang (SG3), Kapur (SG4), Keruing (SG5) and Light Red Meranti (SG6) after having been treated by heat. The size of the timber beam for each species is 50mm x 90mm x 1800mm. The total number of samples for each species is 90, with 15 numbers of samples allocated for control, kiln dried and four levels of heat treatment. There are four different levels of temperatures, namely 150°C, 170°C, 190°C and 210°C, which were applied on the timber beam samples within 1 hour. Control and kiln dried samples were used as comparisons to each test conducted to identify the changes that occur on the timber properties after heating. This study found that all of the properties for each species of timbers used were affected by heat. The moisture content and density were decreased as temperature increased, except for Pauh Kijang at 190°C. The reduction in density is due to the loss of mass, which is partly effected by the degradation of hemicellulose and α -cellulose. The colour turned darker as the temperatures increased for these four species of heat treated timber, which had been analyzed by CIE-Lab system. The Modulus of Elasticity (MOE) and the bending strength, Modulus of Rupture (MOR) of these four species of Malaysian hardwood timber showed a positive increment after being treated at temperature levels of 150°C, 170°C and 190°C but decreased at 210°C. The improvement in MOE and MOR are seen due to the densification of wood as the lignin content increased at higher temperatures. At 190°C, the MOR and MOE values of all species are still higher than the MOE and MOR of the control and kiln dried samples. This shows that 190°C is the suitable temperature. It was also found that the heat treatment has improved the strength of lower density timber significantly.

ACKNOWLEDGEMENT

Assalamualaikum and Alhamdulillah. First and above all, I praise Allah, the Almighty and the most Merciful for providing me this opportunity and granting me the capability, strength and health to proceed this journey completely.

This thesis appears in its current form due to the assistance and guidance of several people. I would therefore like to offer my sincere thanks to all of them.

I would like to express my special appreciation and thanks to my main supervisor Professor Dr. Hajah Zakiah Ahmad, who have been a tremendous mentor for me. I would like to thank her for encouraging me to complete my study, for her patience, motivation, and immense knowledge. Her guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my Ph.D study. Besides my main supervisor, I would like to thank my co-supervisor, Dr Mohd Hisbany Mohd Hashim for his advice, opinion and support during this research.

My sincere thanks also goes to the technician of Civil Engineering Faculty Laboratory, staff of Faculty of Dentistry, and also Institute for Infrastructure Engineering and Sustainability Management (IIESM), who provided me an opportunity to join their team as student, and who gave access to the laboratory and research facilities. Without their precious support and guidance it would not be possible to conduct this research. I also appreciate the financial support of the Ministry of Higher Education (MOHE), during my Ph.D study, and also to Universiti Teknologi Mara (UITM).

A special thanks to my parents, Hj Md Noh Bin Bidin and and my family. Words cannot express how grateful I am for all of the sacrifices, patience, love, advice, and prayer given to me. Thank you for the incredible support. Thanks to all my close friends and postgraduate students community for the suggestions and positive advices. Besides that, I also would like to thank for who directly or indirectly helped me during my journey to complete this research. Thank you to me, myself for being strong. Thank you.

TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
TABLE OF CONTENT	vii
LIST OF TABLE	viii
LIST OF FIGURE	ix
LIST OF ABBREVIATIONS	xv
CHAPTER ONE: INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	3
1.3 Research Questions	4
1.4 Research Hypothesis	5
1.5 Research Objectives	5
1.6 Scope of Research	6
1.7 Significance of Research	8
1.8 Limitation of Research	10
1.9 Chapter Summary	11
CHAPTER TWO: LITERATURE REVIEW	12
2.1 Introduction	12
2.2 Timbers as Structural Materials	13
2.3 Factors Affecting the Properties of Timber	15
2.3.1 Movement Stability	15
2.3.2 Moisture Content	17
2.3.3 Density	18
2.3.4 Chemical Components of Wood	18
2.4 Heat Treatment	19
2.5 Gap of Research	29
CHAPTER THREE: RESEARCH METHODOLOGY	32
3.1 Introduction	32
3.2 Experimental Design	32
3.3 Methodology	33

CHAPTER ONE

INTRODUCTION

1.1 Background

Malaysia is considered as one of developing country in the world and is aiming to be a developed country in year 2020. To achieve this goal, Malaysia has to gain success in many sectors. Construction industry is one of the key sectors in Malaysia. However, there are a lot of challenges need to be faced by this developing country in effort to make a good achievement in construction industry (Elkhalifa, 2011). Commonly, problems that may arise in construction industry are related to materials issues including materials production, supply and management.

There are different types of construction materials in construction industry such as cements, steel, timber, bricks, polyvinyl chloride (PVC), polyethylene, glass, ceramic tiles and stones (Turkey, 2012). Timber is one of the oldest building materials been used to build man's shelters. In construction industry, timbers are useful to build a structure such as building, bridge, boats, and the other civil engineering works (Al-nagadi, 2012). However, there is a limit on timber usage based on its properties and characteristics. This limit has defined timbers as a material that not under all conditions is an appropriate building materials (Patel, 2011). In general, the usage limit of timber can be defined from its biological durability. For above ground uses, a timber species rated with moderately durable or better can be used, and those species that rated as very durable or better are suitable for above ground and for ground contact use.

Most of timber species with natural durability such as Kekatong and Resak are expensive and being supply from natural forest resources and not plantation area. Due to this problem, the use of timber with good properties has been decreasing and an alternative to encounter this problem has been find out which is by using timber species comes from the low strength group (SG) of timber (Hall & Beder, 2005). However, this timber needs to be modified or treated to help improve its characteristics and properties. Timber will be improvised in term of its physical, chemical and mechanical properties if been properly treated (Porteous and Kermani, 2007).The timber usually will be treated or modified by using preservative or