

**UNIVERSITI TEKNOLOGI MARA**

**DIMENSIONAL SHRINKAGE,  
STABILITY AND STRENGTH  
PROPERTIES OF OIL PALM  
LUMBER IN RELATION  
TO SAWING PATTERN AND RESIN  
IMPREGNATION TREATMENTS**

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Thesis submitted in fulfilment  
of the requirements for the degree of  
**Doctor of Philosophy**

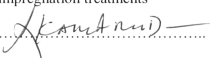
**Faculty of Applied Sciences**

**June 2015**

## AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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## ABSTRACT

This study focused on the dimensional shrinkage, stability and strength properties of oil palm lumber in relation to sawing pattern and resin impregnation treatments. A total of 26 oil palm trees of high yielding *tenera* variety were obtained from Sungei Kahang Estate, which is located between latitude N 2°12'24" to N 2°12'55" and longitudes E 103°30'59" to E 103°31'05". The geographical position of oil palm tree in east and west directions was determined and its position was marked onto the trunk before felling. For basic properties, test samples in pith to periphery zone at different tree heights were analysed by using various analytical techniques. All tests were conducted according to standard test procedures. Based on results, basic properties-related parameters that include vascular bundle, moisture content (MC) and basic density of oil palm lumber were highly dependent on the distance in radial plane with tree heights. For dimensional shrinkage, oil palm billets were sawn into lumber scantlings of different nominal sizes using four types of sawing pattern, namely sawing patterns of type A (SP-A), type B (SP-B), type C (SP-C) and type D (SP-D). After drying, the lumber shrinkage in radial, tangential and its cross-sectional area were measured using a mathematical technique of numeral integrations. In general dimensional shrinkage of oil palm lumber from the SP-D sawing pattern was the lowest, followed by the SP-A sawing pattern, while those lumbers sawn using both the SP-B and SP-C sawing patterns were highest (too distorted). With regards the resin treatment, oil palm billets were sawn into lumber scantlings using the SP-D sawing pattern, and dried to  $10 \pm 2\%$  MC. After drying, dried lumber was impregnated with a phenol formaldehyde (PF) resin using a vacuum infusion system, and followed by a densification process. With the introduction of grooves and channels, the resin flow was dispersed homogenously within the lumber matrix. The dimensional stability of densified resin-treated lumber was determined by measuring its antiswelling efficiency (ASE) while three-point bending procedures were employed for flexural strength properties. A positive ASE value indicated that the PF resin had penetrated into the cell wall and subsequently cross-linked, leading to bulking along interstitial spaces of parenchyma cells. The flexural strength of densified resin-treated lumber was significantly stronger than those lumbers devoid of PF resin, which in turn, was related to their basic properties-related parameters. These results collectively should provide some insight to the understanding of factors that influence the physical and mechanical properties of oil palm trunk, which when combined with a corresponding changes in material handling and processing may point the way forward to a satisfactory conversion and efficient utilisation for sawn lumber productions. Apart from sawn lumber products, information on variation in physical and mechanical properties as a function of the bole position along its radial plane with tree heights could assist to segregate billets from different sections of oil palm trunk for biocomposites such as plywood.

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## **CHAPTER ONE**

### **INTRODUCTION**

This thesis deals with the drying shrinkage, stability and strength properties of oil palm lumber (OPL) in relation to sawing pattern and resin impregnation treatments, and its primary focus is on the reporting of the results of scientific investigation. However, it is also an attempt to consolidate a great deal of technical and non-technical information, rendering it in a form that is accessible and understandable to scientists and non-scientists, alike. As such, it is an attempt to convey an understanding.

#### **1.1 RECOGNITION OF THE PROBLEM**

While requirements of solid-wood and biocomposites as physical products have been growing over the past ten years, great changes have been occurring in the forestry sector, wood-based industry and timber trade, which have important implications for timber utilisation. Consequently, awareness of the society towards impacts of human activities on the environment is increasing and environmental considerations of the need to offset their full carbon (C) and C footprints (CFP) are changing the way in which the materials are being utilised (FAO, 2009). Hence, forest exploitation is facing numerous challenges whether it is for economic or ecological reasons. For instance, many of these demands are driven by decisions of businesses to enhance their profit image, the governments to demonstrate their environmental commitment, the individuals to communicate their civil, and the leadership to be forward-looking by moving their countries goals towards achieving a low C economy (UNEP, 2011).

The momentum has been building up since 1997 following the establishment of the Kyoto Protocol (KP) to the United Nations Framework Convention on Climate Change signed by representatives of some 192 countries that agreed on the new binding limits of greenhouse gas (GHG) emissions based on the global warming potential (GWP) in the industrialized countries of the world (UNFCCC, 2002). The GWP is generally perceived as the aggregate measure of the contribution to the greenhouse effect of some gasses through their conversion into carbon dioxide (CO<sub>2</sub>) equivalent. It is defined as an index, based on radiative properties of greenhouse gasses, measuring the radiative forcing following a pulse emission of a unit mass of a GHG in the present day atmosphere integrated over a chosen time horizon (commonly 20, 100 or 500 years),