MECHANICAL & PHYSICAL PROPERTIES OF HYBRID CROSS LAMINATED TIMBER (HCLT) FABRICATED USING SOLID WOOD & PLYWOOD

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By

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DEDICATION

For my beloved family:

Hj Mansoor Bin Hj Kadir

Hjh Mumin Binti Hj Madia

Also my siblings.

My supervisor:

Dr. Adlin Sabrina Binti Mohamad Roseley

To all my friends and Officers in FRIM & UPM

Thank you for helping me and your encouragements supports,

And the sacrifices that you have given.

Thank you for everything. May Allah Bless All of us.

ABSTRACT

Hybrid cross laminated timber (CLT) using the structural composite lumber (SCL) were developed in this study using Dark Red Meranti (solid timber) and plywood. The usage of plywood as cross and outer layers of hybrid CT was done to improve the mechanical and physical properties of the generic CLT. The objective of this study was to evaluate the mechanical and physical properties of HCLT fabricated with the combination of local species of lumber and plywood. Three samples of CLT with different configurations of layup were prepared with the same size dimension. These samples were then cut into dimension according to the BS EN408 standard for mechanical testing and BS EN391 standard for physical testing. As for the mechanical testing, 4-point bending tests were conducted and MOE & MOR values of the tested samples were determined. The delamination test was conducted to obtain the percentage of total and maximum delamination of the HCLT boards. It was found that the highest value of MOE and MOR was obtained from samples fabricated using solid wood. The property of HCLT using plywood material as outer layer has depicted a slight reduction of MOE and MOR values. The percentage of total and maximum delamination is lower when the outer layer of CLT was replaced by the plywood.

ABSTRAK

Kayu berlapis silang hibrid Hibrid (CLT) dengan menggunakan struktur kayu komposit telah dijalankan dalam kajian ini. Penggunaan papan lapis sebagai lapisan dalam dan lapisan luar CLT telah digunakan bertujuan untuk meningkatkan sifat mekanikal dan fizikal generik CLT. Objektif kajian ini adalah untuk menilai sifat mekanikal dan fizikal hibrid CLT dengan gabungan spesies lokal kayu dan papan lapis. Tiga sampel CLT dengan configurasi yang berbeza telah disediakan dengan saiz dimensi yang sama. Ketiga-tiga sampel ini kemudian dipotong mengikut dimensi yang ditetapkan melalui standard BS EN408 bagi ujian mekanikal dan BS EN391 bagi ujian fizikal. Bagi ujian mekanikal, ujian lenturan 4 titik dijalankan dan nilai MOE & MOR dicatakan. Manakala, bagi ujian delaminasi bagi ujian fizikal dijalankan dan peratusan jumlah delaminasi dan maksimum delaminsi bagi ketiga-tiga sampel direkodkan. Kajian mendapati bahawa nilai MOE & MOR menurun apabila menggunakan gabungan kayu dan papan lapis bagi hibrid CLT dan nilai peratusan jumlah dilaminasi dan peratusan maksimum delaminasi menurun apabila lapisan luar CLT digantikan dengan papan lapis.

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APPROVAL SHEET

I certify that this research project report entitled "Mechanical & Physical Properties of Hybrid Cross Laminated Timber (HCLT) Fabricated Using Solid Wood and Plywood" by Noorsyazwani Binti Mansoor has been examined and approved as a partial fulfillment of the requirements for the Degree of Bachelor of Wood Science and Technology in the Faculty of Forestry, Universiti Putra Malaysia.

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ANOVA	Analysis of Variance
ASTM	American of Standard Technology Method
CLT	Cross Laminated Timber
GPa	Giga Pascal
ft	Feet
g/mm^2	Gram per millimetre square
HCLT	Hybrid Cross Laminated Timber
kPa	Kilo Pascal
kg/m^3	Kilogram per metre cubic
LSL	Laminated Strand Lumber
LVL	Laminated Veneer Lumber
MDa	Maximum Delamination (a)
MDb	Maximum Delamination (b)
MOE	Modulus of Elasticity
MOR	Modulus of Rupture
MPa	Mega Pascal
N/mm^2	Newton per millimetre square

PRF	Phenol-Resorcinol Formaldehyde
RH	Relative Humidity
SCL	Structural Composite Lumber
SPF	Spruce-Pine-Fir
TD	Total Delamination

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Cross Laminated Timber (CLT) is a relatively new building system of interest in the North American construction and is helping to define a new class of timber products which is “mass” timber. CLT is an innovative wood product that was introduced in the early 1990s in Austria and Germany and it has been gaining a popularity in residential and also non-residential applications. The using of the CLT panels in buildings has increased in Europe for a past few years. The technology of CLT has many advantages such as easy in handling during the construction and it has a high level of prefabrication which can facilitate a rapid project completion.

The concept of hybrid CLT (HCLT) is demonstrated by replacing one or more layers of lumber with SCL. In this study, the SCL used is plywood. The replacement of layers of CLT panels with the SCL is to improve planar shear and bending properties of CLT. In this study, the configuration lay-up of CLT panels will be different as the layers of CLT will be replaced with plywood to evaluate the mechanical and physical properties of this HCLT.

1.2 Problem Statement and Justification

The generic CLT is prone to the planar shear failure and excessive deflection when subjected to out of plane loading with short spans. Planar stress is defined as shear stress leading to shear strains in a plane perpendicular to the grain direction of wood. To address this issues, many studies have been conducted including the measurement of planar shear properties of CLT, improvement of planar shear properties of CLT and evaluation of CLT configuration on the shear properties of CLT. The literature indicates that planar shear failure can be a limit factor for the strength of CLT subjected to out of plane loading. Based on the previous research, it was found that CLT specimens, for example SPF-SPF-SPF (Spruce-pine-fir) had higher planar shear properties than the HCLT fabricated with LVL, for example SPF-LVL-SPF (Wang et al., 2017).

1.3 Objectives

The objective of this research is to evaluate the mechanical and physical properties of HCLT fabricated with combination of local species of lumber and plywood. In order to achieve this specific purpose, the following specific objectives are required to be fulfilled.

1. To evaluate the mechanical and physical properties of hybrid CLT from solid wood and plywood.
2. To determine the failure mode of hybrid CLT from solid wood and plywood.

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