



THE EFFECT OF TIMBER MOISTURE CONTENT ON EPOXY BONDED-IN CONNECTION

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FH 2018 64

**THE EFFECT OF TIMBER MOISTURE CONTENT ON EPOXY BONDED-IN
CONNECTION**

By

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**A Project Report Submitted in Partial Fulfilment of the Requirement for
the Degree of Bachelor of Wood Science Technology in the**

**Faculty of Forestry
Universiti Putra Malaysia**

2018

DEDICATION

This thesis is dedicated to:

My parents,

Masbor Bin Kamdani

Rahmah Binti Hasan

Wife and son,

Nor Hazimah Binti Harun

Hasannudin Bin Muainnudin

My supervisor,

Dr Adlin Sabrina Binti Muhammad Roseley

Family and friends

ABSTRACT

Connections of timber structures using concealed bonded-in rods offer a solution to the efficient joining methods. However, the importance of certain basic joint characteristics, and the influence of moisture content are not yet fully understood. This paper describes a comprehensive experimental and numerical investigation into the fundamental material and joint geometry characteristics of rods bonded in to timber. The treatment type and level of moisture content both considered, along with test configuration that included rod and timber species. It was found that epoxy adhesives out-performed all other types investigated, and pull-out strengths can be significantly improved by indicating suitable moisture content and treatment. Moisture content at higher level sample exhibited higher pull-out strength. This indicates that the shear strength values of the tested specimens were affected by the moisture content and same result when tested with different type of treatment. There is a strong correlation between the moisture content of the wood, type of treatment and mean shear strength. Failure mode in moisture content and type of treatment is related to the anatomical properties of the wood that influences the wettability of adhesive used.

ABSTRAK

Sambungan struktur kayu yang dihubungkan dengan rod secara tersembunyi memberi penyelesaian kepada kaedah penyambungan yang lebih kukuh. Walau bagaimanapun, kepentingan ciri-ciri asas penyambungan dan faktor yang mempengaruhi kandungan kelembapan belum difahami sepenuhnya. Kajian ini menerangkan tentang penyiasatan eksperimen secara komprehensif dan kajian statistic terhadap bahan ujikaji dan ciri geometri bersama rod yang terikat pada kayu. Pembolehubah yang dipertimbangkan adalah jenis rawatan dan tahap kandungan kelembapan bersama dengan konfigurasi ujian yang termasuk spesies kayu dan rod. Kajian mendapati bahawa pelekat epoksi terbukti berkesan dilakukan semua jenis ujikaji yang disiasat, dan kekuatan tarik keluar dapat dijelaskan secara terperinci dengan menunjukkan kandungan dan rawatan kelembapan yang sesuai. Kandungan kelembapan pada sampel tahap tinggi menunjukkan kekuatan tarik yang lebih tinggi. Ini menunjukkan bahawa nilai kekuatan ricih spesimen yang diuji telah terjejas oleh kandungan kelembapan dan hasil yang sama apabila diuji dengan jenis rawatan yang berlainan. Terdapat korelasi perhubungan yang kuat antara kandungan lembapan kayu, jenis rawatan dan purata kekuatan ricih. Mod kegagalan dalam kandungan lembapan dan jenis rawatan berkaitan dengan sifat-sifat anatomi kayu yang dipengaruhi oleh faktor kelembapan pelekat yang digunakan.



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ACKNOWLEDGMENTS

The author wishes to express her deepest appreciation to his supervisor, Dr Adlin Sabrina Binti Muhammad Roseley for her guidance, trust, constructive criticisms, suggestions and her patience on the author throughout research period. Thank you for all knowledge that had been shared with the author from the beginning till the end of this research.

Special acknowledgment toward staff of faculty Mr. Mohd Rizal Abd Rahman and staff of faculty of engineering Mr. Muhammad Wildan Ilyas Mohamed Ghazali and Mr. Mohd Saiful Azuar Md. Isa for their help in guidance, support and kindly providing the facilities to the author and group member along this research.

Finally, the author wishes to express his most sincere appreciation toward his beloved family, and his friends for their love, encouragement during this research.

APPROVAL SHEET

I certify that this research project report entitled **“THE EFFECT OF TIMBER MOISTURE CONTENT ON EPOXY BONDED-IN CONNECTION”** by Muainnudin Bin Masbor has been examined and approved as a partial fulfilment of the requirement for the degree of Bachelor of Wood Science Technology in the Faculty of Forestry, university Putra Malaysia.

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Date: December 2017

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LIST OF ABBREVIATIONS

MC	Moisture Content
FRP	Fibre-reinforced plastic
EMC	Equilibrium moisture content
PRF	Polyurethane resorcinol formaldehyde
PU	Polyurethane
UF	Urea-formaldehyde

CHAPTER 1

INTRODUCTION

1.1 Background

In the past decade, many researches have focused on application method of joining especially in timber connections. Over 20 years, bonded-in have been used as a method of connecting timbers. Bonded-in technology provides rapid and reliable solutions for the connection, reinforcement and repair of timber structures. From the research had been made, it describes about how fibre-reinforced plastic pultruded rods are bonded into over-sized holes or slots in timber, using room-temperature cure epoxy adhesives, to achieve coherent timber to-composite interfaces (Ansell & Smedley, 2007). The necessary reinforcement of timber structures creates sustainability and important from economic, environmental, historical and social perspectives. In the latest research findings relating to the reinforcement of timber structures, current and new design approaches. Reinforcement were used because of deterioration due to a lack of maintenance, accidental damage, and requirements to increase seismic resistance or extend the use of structures approaching the end of design. The function of the reinforcement is to repair a weakened structure or increase the load bearing capacity of an intact structure (Harte & Crew, 2015).

Currently, timber structures were restored and repaired by using a combination of epoxy adhesives and secondary adherends such as fibre reinforced plastics (FRPs) or metallics. Steel plates, rods or bolts were bonded into timber with high strength adhesives to produce concealed timber connections for timber

repairs and reinforcement. These bonded-in connections produce strong and stiff connections for timber (Zakiah *et al.*,2010) Timber repair works typically involve various combinations of epoxy resins, with specific properties based on situation for repair with the combination with either metallic or non-metallic connection components in the form of plates or bars. The resin-bonded methods of repair were developed since 1970s and typical examples include the restoration of beam-ends and column-ends, repairs and the upgrading of beams. The resins may be used either in the form of a structural adhesive or as a volume grout for replaces damaged sections of timber. The advantage of resin method is it minimizes the removal of original material and able to be carried out in-situ. Resins can be used in the form of structural adhesives to bond new pieces of timber for existing timber such as in adding laminations, or for bonding metallic with non-metallic plates or rods to existing timber. The research that have been done found that epoxy adhesives out-performed with all types of connection and significantly pull-out strengths improved through careful selection and optimisation of the joint geometry (Broughton & Hutchinson,2001a). Epoxy is considered most suitable for bonding of FRP materials and steels. Their advantage in gap-filling showing requires low clamping pressure. The uses epoxy resin in bonding of wood is limited because product costing and durability of bond formed. In one study that had been done, bond formed between wood and epoxy resin is not enough to reach the strength of timber in the research (Raftery *et al.*, 2009, Broughton and Hutchinson, 2001a).

It is understandable that without an appropriate moisture content of the timber, poor adhesive mixture and incorrect curing temperature, would subsequently lead to weakening of the bond. The aim of this study is to investigate the effect of moisture content of tropical timber (Mengkulang) and the bonding properties of epoxy bonded-in rods joints. The previous research was conducted only on oak and ash wood.

1.2 Problem Statement

The feasibility of using green timber has been established in timber construction since this would tremendously reduce the cost and time needed for seasoning. Specific connection details and requirements were established due to the complexity of the condition of green timber. The technology of timber joints has tremendously improved with the usage of various connection materials such as wood, metallic or non-metallic rods. Steel or FRP rods are commonly used in bonded-in joints in which rods were inserted in pre-drilled holes filled with adhesives. The quality of the bonding however, depends on the curing time and the curing environment (e.g. temperature and moisture content). The cell structure in timber which contains cellulose, fluids and resins may also affect the bonding quality. The understanding on the effect of moisture content of green timber bonding has not been fully established. This eventually impedes the greater use of epoxy bonded connection in timber structure.

The effect of timber moisture content on epoxy bonding properties have been investigated previous using oak and ash wood. Any study on Malaysian

tropical timber has yet to be produced. Tropical timber is mostly hardwood and each species is unique. This study is about the effectiveness of epoxy bonded-in joints using Mengkulang timber of various moisture contents. The strength of the bond will be evaluated via using a single ended pull-out test.

1.3 Objectives

General objectives: To study the effect of timber moisture content on bonding performance of epoxy bonded-in rods joints.

Specific Objectives:

- i. To evaluate the relationship between the moisture content of tropical timber and pull out strength.
- ii. To determine the effect of accelerated ageing test on the shear strength of timber connections.

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