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Technical paper

Investigating the Meraka Hardwood Failure in Bolted Connections Parallel to the Timber Grain

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Abstract

The present study was performed to investigate the ductile failure mode of timber bolted connections, specifically in Meraka hardwood. This was done to initiate an effort in developing a comprehensive guideline in designing the timber bolted connections for the purpose of strengthening the wall-diaphragm connections of the Malaysia unreinforced masonry buildings. A series of experimental tests was conducted on the steel-wood-steel (SWS) with a single row connection type. A total of eight different bolted connection configurations or groups with ten replicates for each group was tested. The Meraka hardwood was selected in this study as it was found to be one of the most hardwood species that are commonly used in the construction of floor and roof diaphragms in the existing Malaysia unreinforced masonry buildings. From the experimental results obtained, the effectiveness of the Malaysian timber code of MS544 and European Yield Model (EYM) in predicting the bolted connection strength was verified. It was determined that the MS544 is too conservative in estimating the bolted connection strength with an average ratio of 0.38 compared to the test results. Thus, the use of the EYM is recommended to complement the timber code as the average ratio of 0.81 was identified in comparison to the test data.

Keywords: *Meraka wood, timber bolted, connections, strength prediction*

1. Introduction

In principle, there is an agreement within the international timber engineering community that the criteria in timber design standards for determining the capacity of bolted connections should be based on the recognized mechanical models that are capable of identifying each possible mode of failure [1]. The lowest capacity that governs performance of connection should be estimated from both failure modes of ductile/bearing and brittle/fracturing in wood. The following paragraphs describe the current design equations to predict the strength of bolted connections, parallel to the timber grain, for both Malaysian timber standard and European Yield Model.

Referring to the Malaysian timber standard of MS544: Part 5: 2001 in Section 11.2.3, the permissible load (Fadm) of a laterally loaded bolt system is given by:

$$F_{adm} = k_1 k_2 k_{16} k_{17} F \qquad \text{(Eq. 1)}$$

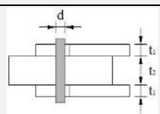
where

- k_1 = the factor for duration of load, refer to Table 4 of MS544: Part 5: 2001;
- k_2 = 1.0 for dry timber or 0.7 for wet timber;
- k_{16} = 1.25 for bolts that transfer load through metal side plates of adequate strength and the bolts are a close fit to the holes in these plates provided that b/d > 5 (where b denotes the effective timber thickness and d is the bolt diameter) or 1.0 otherwise;
- k_{17} = factor for multiple bolted joint, see Table 15 of MS544: Part 5: 2001;
- F = basic working load as derived in Section 11.2.2 of MS544: Part 5: 2001.

The values of the basic working load for a selection of bolt diameter and effective timber thickness can be taken from Table 12 of MS544: Part 5: 2001 considering for a single bolt bearing parallel to the timber grain acting in single shear. This shows that the timber code assumes the behaviour of connections to be ductile. A brittle failure is assumed to occur only in a connection that consisting of five or more fasteners, taken into account a value of $k_{17} < 1$.

The European Yield Model (EYM), which considers ductile failure modes of bolted connections, is associated with the Johansen's theory. This theory is based on the assumption that both timbers and dowels behave as rigid-plastic [2]. In other words, the timber is under embedding stresses due to the bearing action as in contact with the fastener, whereas the fastener is under bending action when the embedding stresses exceeded the fastener bending capacity. For a double shear connection, the resistances (R) per fastener per shear plane are given by four possible failure modes as shown in Table 1, which the lowest value calculated will govern the capacity of the connection.

Table 1: Possible failure mode and resistance for double shear joint [2]

Failure mode	Resistance, R, per fastener per shear plane
	$R = f_{h,1}\, t_1\, d$ (Eq. 2)