Assessing the Bolted Connection Strength of New Zealand Hardwood

A.R. Abdul Karim, P. Quenneville, N. M.Sa'don & J.M. Ingham

Department of Civil & Environmental Engineering, The University of Auckland, Auckland.

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ABSTRACT: From published literature, it was found that through-bolt connections were typically applied as a retrofit technique to most New Zealand unreinforced masonry (URM) buildings following the 1931 Hawke's Bay earthquake. As connection failure by tearing out part of the diaphragm joist was observed in past earthquakes due to lateral earthquake loading, the strength of the bolted connection in existing indigenous New Zealand timber joists needs to be assessed. The main objectives of this study were to evaluate the strength and to identify the possible failure modes of bolted connections in New Zealand hardwood. Bolted connection tests loaded parallel-to-grain were performed using recycled native New Zealand Matai and Rimu hardwoods because the timber diaphragms in URM buildings are typically constructed using such wood species. From the experimental study, it was observed that the timber bolted connection can fail in either ductile or brittle modes. The test results obtained were compared with the European Yield Model (EYM), the New Zealand timber code (NZS 3603:1993), and a proposed set of equations (Quenneville 2009) in order to evaluate the applicability of those equations in predicting bolted connection strength for New Zealand hardwood. It was found that the EYM equations provide better predictions than the NZS 3603:1993 when compared to the actual capacity. However, the EYM predictions are only good in estimating the strength of timber bolted connections that fail under ductile mode. For the connections that fail exhibiting the brittle mode, the proposed row shear equation by Quenneville was found to give better strength estimation.

1 INTRODUCTION

Unreinforced masonry (URM) buildings are typically the class of structures with the highest risk of failure during an earthquake, and the requirement to seismically upgrade these earthquake damage-prone buildings in New Zealand was mandated by The Building Act 2004 (DBH 2004). Importantly, these URM buildings form a significant percentage of New Zealand's building stock and represent the predominant national architectural heritage (Russell and Ingham 2008). Most URM buildings in New Zealand consist of solid URM bearing walls and flexible timber diaphragms (floor and roof), with the wall thickness configuration over the height of the building typically reduced by a single leaf at each storey height in order to support the diaphragm. The most common diaphragm seating method was to bear the joists and transverse beams on a single brick width without embedment.

No connections between URM walls and diaphragm were identified in URM buildings constructed before the 1931 Hawke's Bay earthquake and most out-of-plane wall failures were related to the absence of anchorage between the walls and diaphragms. Following the 1931 Hawke's Bay earthquake, most URM buildings were seismically retrofitted, which included the installation of wall-floor and wall-roof connections (Blaikie and Spurr 1992). Most wall-diaphragm connections that were installed as seismic retrofits were through-bolt anchors, used in conjunction with a steel bearing plate located on the exterior of the building and a bolted connection on the timber diaphragm joist. Typical wall-diaphragm connection details can be found in Abdul Karim et al. (2009). Figure 1 shows typical diaphragm details determined for existing New Zealand URM buildings.