Proceedings of the Ninth Pacific Conference on Earthquake Engineering
Building an Earthquake-Resilient Society
14-16 April, 2011, Auckland, New Zealand

Wall-Diaphragm Connection Assessment Guidelines for URM Buildings

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ABSTRACT: The connections between walls and diaphragm in unreinforced masonry (URM) buildings typically consist of two major parts. The first part is the wall anchorages and the second part is the diaphragm connections. From the NZNSEE (1995) and FEMA (2006) guidelines, the connection strength values given by both guidelines are apparently related only with the possible failures of the masonry wall anchorages, and no procedures are currently available to identify the strength values related to failure of the timber bolted connections. This latter failure mode is important to consider as the minimum strength value that will govern the wall-diaphragm connection capacity can be acquired from the diaphragm connections. To counter this limitation, this study recommends a set of design equations to assess the strength of the timber bolted connections. By using these equations, in addition to the default connection strength values provided by the guidelines, the expected strength level of wall-diaphragm connections can be accurately assessed.

1 INTRODUCTION

Referring to the guidelines published by the New Zealand National Society for Earthquake Engineering (NZNSEE, 1995) and Federal Emergency Management Agency (FEMA, 2006), it can be seen that the wall-diaphragm connections in unreinforced masonry (URM) buildings primarily consist of two major parts. The first part is the wall anchorages, either in the form of through-bolt with external bearing plate to anchor the walls or dowel that drilled into the masonry walls. The second part is the diaphragm connections, typically bolted connections to the timber members of the diaphragms (i.e floor joists or roof rafters). From a review of both guidelines, none of the wall-diaphragm connection details provide guidelines on the steel cleat to timber connection. Important design parameters such as end distance and spacing of the bolts, which significantly affect the timber connection strength, are not provided in detail. The connection strength values given by both guidelines are apparently related only with the possible failures of the masonry wall anchorages, and no procedures available to identify the strength values related with the failures of the timber bolted connections. This later failure mode is important to consider as the minimum strength value that will govern the wall-diaphragm connection capacity can be acquired from the diaphragm connections. Further, the current 2006 NZSEE guidelines were identified to provide only a revision on the connection strength values for wall anchorages.

From a review of published works, no attempt was found to assess the bolted connections applied to the existing timber members of the floor and roof diaphragms in unreinforced masonry buildings. The strength of timber bolted connections is very important to investigate since the brittle failure of the diaphragm connections (i.e. tearing out part of the diaphragm joist) observed in past earthquakes (Blaikie and Spurr 1992). From the published research studies on the timber bolted connections (Quenneville and Mohammad, 2000; Mohammad and Quenneville, 2001; Quenneville et al., 2006; Quenneville and Jensen, 2008), many brittle failure modes were identified such as row shear-out, group tear-out, and splitting. Referring to the current standard for timber structures of New Zealand (NZS 3603: 1993), the design of bolted connections was developed based on a ductile failure. The use of this standard can lead to an inaccurate strength assessment of timber bolted connections in unreinforced masonry buildings. Thus, the bolted connection tests of existing timber in the buildings