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INVESTIGATING THE PERFORMANCE OF WOOD PORTAL FRAMES AS ALTERNATIVE BRACING SYSTEMS IN LIGHT-FRAME WOOD BUILDINGS

KEYWORDS: Wood portal frame; Lateral load resisting system

OVERVIEW OF PROJECT

The lateral resistance of light-frame wood buildings is generally provided by braced walls sheathed with panels or diagonal lumber boards. To ensure that buildings have adequate lateral load-carrying capacity to resist moderate-to-high wind and seismic loads, prescriptive requirements on the minimum length of braced walls, along with maximum spacing between braced walls, have been enacted in Part 9 of the 2010 National Building Code of Canada (NBCC). Acceptable materials, fastening requirements and framing details constituting a braced wall are also specified in the code.

Although most light-frame wood buildings are able to meet the minimum braced wall requirements, there are situations where the required length of braced walls may not be met due to space limitations imposed by architectural requirements. For example, one common feature is the large opening required for multi-car garages. Alternative bracing systems which do not limit open space need to be developed to provide equivalent lateral resistance to the minimum braced wall requirements in Part 9 of 2010 NBCC. Wood portal frame systems have been identified as a potential alternative to shear wall to meet some aspects of this construction demand.

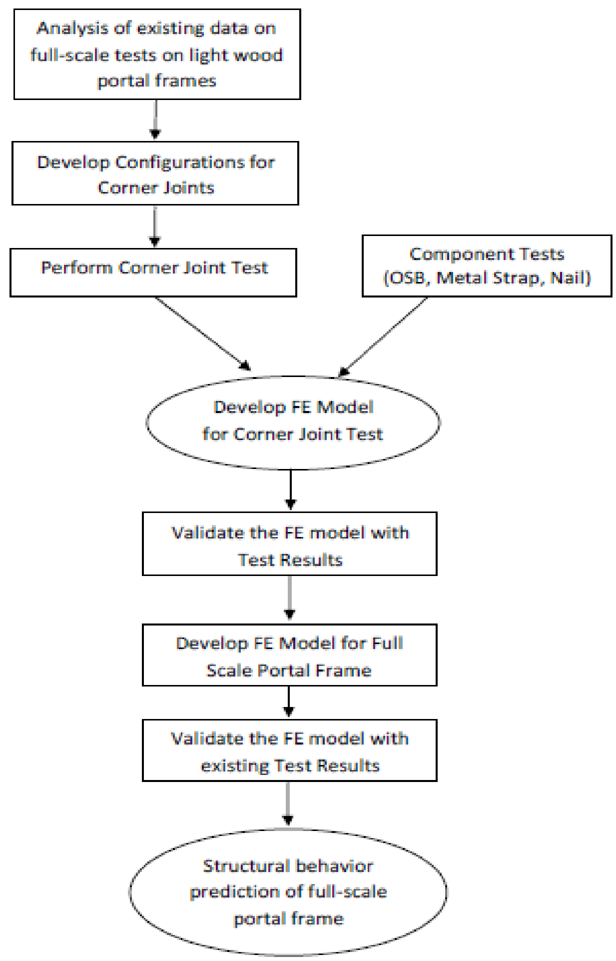

Figure 1 – Methodology of research project.

The overarching goal of the project was to develop wood portal frame bracing systems, which can be used as an alternative or in combination with light-frame wood shear walls. More specifically, the objectives of the project was to investigate the behavior of wood portal frame bracing systems using the mid-ply shear wall framing technique and develop detailed numerical finite element models that are capable of capturing the behavior of portal frame systems. The methodology (Figure 1) followed in this research project involved observation and analysis of existing data, conducting material as well as corner joint tests, developing a detailed finite element model and once the model

Researchers: Abdullah Al Mamun and Ghasan Doudak
Affliation: University of Ottawa
Contact email address: gdoudak@uottawa.ca

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had been verified at the element, sub-system and system levels, it was used to predict the performance of full-scale MIDPLY portal frame systems using corner construction details that were tested and deemed suitable.

KEY RESULTS

It can be concluded from the corner joint tests that, in general, the maximum moment resistance increased with the addition of the metal straps or exterior sheathing. A significant increase in capacity was observed when either the metal strap or the exterior sheathing was added. Combining the two, by adding the metal straps on top of the sheathing resulted only in a minor improvement in the performance. It was also shown that all double-sided sheathing increased the lateral capacity compared to those with single-sided sheathing. The test results also showed a significant increase in the moment capacity by replacing the SPF header with the LVL header.

The addition of the fibre-glass reinforced plastics (FRP) to the standard wall configuration resulted in a significant increase in the moment capacity. However, the addition of the FRP membrane had no significant effect on the stiffness properties of the corner joint.

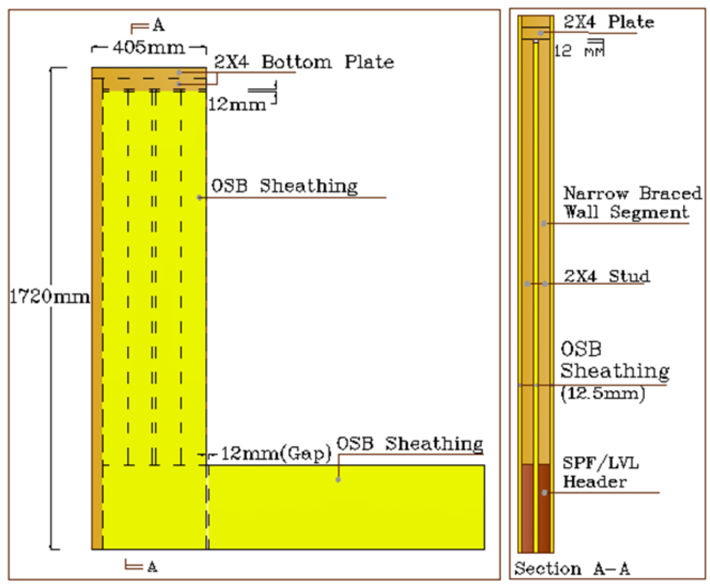

Figure 2 - MIDPLY corner joint details.

Finite element (FE) model was capable of predicting the behavior of corner joints. The FE model closely predicted the ultimate lateral capacity for all the configurations. On average, the maximum load was predicted within 6% for the MIDPLY corner configurations. The prediction of the initial stiffness was also reasonably good and within 10% of the measured values. The uncertainty in predicting the stiffness was expected since it was difficult to measure experimentally or to predict, with non-linearity present at early stages of loading. The FE model used to estimate the behavior of the full-scale portal frame constructed using the MIDPLY framing techniques showed a significant increase in the lateral load-carrying capacity when compared with the traditional portal frame, especially for the case with sheathing on one side. The lateral load-carrying capacity of the MIDPLY portal frame was not affected by whether the hold-down was installed at the end of the frame or at the end of the frame as well as the opening. It was predicted using the full-scale FE model that the lateral load-carrying capacity of the MIDPLY portal frame would increase with the addition of the metal straps on exterior faces. This was consistent with observations made on corner and full-scale tests on standard wall portal frames.

THESIS

Al Mamum, A. 2012. Investigating the performance of wood portal frames as alternative bracing systems in light-frame wood buildings. MASc thesis. University of Ottawa, Ottawa, ON.