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WOOD INFILL WALLS IN REINFORCED CONCRETE FRAME STRUCTURES: A WOOD/CONCRETE CONSTRUCTION NICHE

KEYWORDS: Wood infill wall; Wood concrete hybrid structure; Lateral load resisting system

OVERVIEW OF PROJECT

The focus of this study was to improve the use of wood/concrete hybrid systems in mid- to high-rise structures. Current research has focused on using heavy timber for these larger structures, however this study has been carried out to identify and pursue avenues that may enhance the use of lumber.

A spectrum of wood/concrete hybrid systems was reviewed and three niche areas were identified as potentially feasible for mid- to high-rise structures. The maximum potential number of storeys of light-frame wood structures with wood/concrete hybrid flooring was investigated, and the investigation was repeated for structures with concrete lateral-load-resisting systems. The third niche area, wood infill walls in reinforced concrete structures, was explored by considering whether the infill walls should be load-bearing and identifying other factors that currently restrict the use of this system in Canada.

An experimental investigation of the structural aspects of light-frame wood infill walls in reinforced concrete frame structures was conducted. Analysis of a prototype reinforced concrete frame established the critical deflection ranges for lateral sway and vertical racking displacements in a single storey at Serviceability and Ultimate Limit States. These in-plane racking limits were then adopted as design criteria for the full-scale reinforced concrete frame test apparatus shown in Figure 1. A system of Pressure Load Actuators applied out-of-plane pressures to the exposed wall surface that were consistent with the wind loads specified in the NBCC (2010). The connections were designed to isolate the infill wall from the in-plane sway and racking deflections but transfer horizontal reactions due to out-of-plane wind loading from the wood wall to the concrete frame.

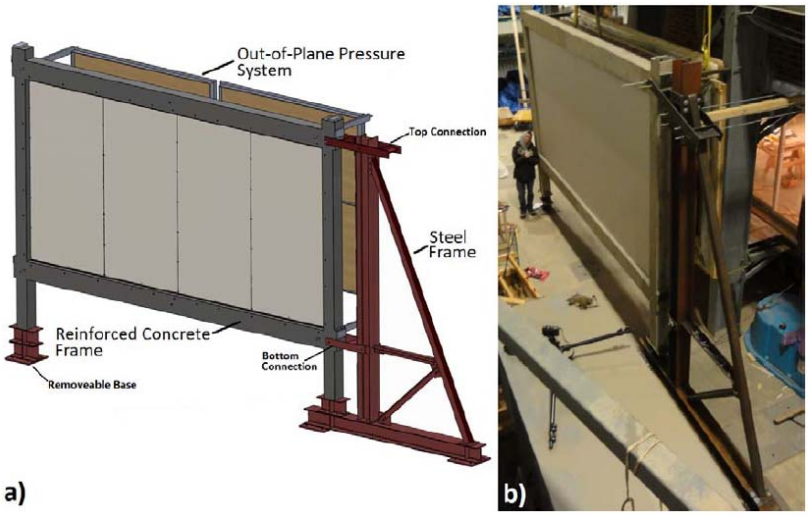

Figure 1 – Test Apparatus a) as design b) as constructed in the lab with a 2.4m x 4.8m (8' x 16') wood panel

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KEY RESULTS

Key conclusions from the feasibility investigation of light-frame wood/concrete hybrid construction niche areas are:

- The use of light-frame wood structures with wood/concrete floor systems is not feasible for structures with 7 or more storeys due to the limited axial capacity of wood stud walls.
- The use of light-frame wood structures with wood/concrete floor systems and a concrete lateral-load-resisting system is potentially feasible for structures up to 9 storeys.
- Light-frame wood infill walls in reinforced concrete structures are feasible in mid- to high-rise structures if sufficient gap is provided around the perimeter of the wall to ensure that the wall remains non-load-bearing and prevents material incompatibility issues.

Key conclusions concerning the test apparatus and wood infill wall specimen are:

- The statically loaded full-scale, single frame test apparatus accurately replicated the realistic horizontal sway and vertical racking deformations of a typical eight storeys reinforced concrete frame structure at SLS and ULS.
- The use of Pressure Load Actuators successfully applied realistic out-of-plane SLS wind pressures.
- The out-of-plane response was not significantly affected by horizontal sway deflections of ±7.2mm or vertical racking deflections of +9.6mm.
- Although a nominal 20mm gap was provided to isolate the wall from the surrounding frame, insulation foam sprayed in the gap facilitated load transfer between them. This may be due to the specific foam selected for this specimen.
- The connections performed adequately, however further development is suggested.

FUTURE WORK

The following future work is recommended:

- Further out-of-plane pressure tests should be performed under loading at ULS to determine adequate performance, and mode of failure, of the infill wall and connections. (Task completed by Jared Harnish in late 2012)
- It is suggested that the infill wall studs be increased to 2” x 6” (38mm x 140mm) lumber to reduce deflections at Serviceability Limit States and allow for more insulation in the wall cavity for additional thermal benefits.
- Repeat horizontal sway and vertical racking tests without an infill wall specimen to quantify the in-plane stiffness contributions of the infill wall.
- Initial tests at ULS showed that minor cracking may be occurring, which may need to be accounted for in further predictions using an elastic-cracked analysis.
- Repeated in-plane tests at SLS are suggested as cumulatively loading may impact the out-of-plane stiffness of the infill wall.
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