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CLT – STEEL HYBRIDIZATION IN MID-RISE SYSTEMS AS A SEISMIC RESISTING SYSTEM

KEYWORDS: CLT-Steel hybrid Building System; Seismic Resisting System; CLT infill panels

OVERVIEW OF PROJECT

The NEWBuildS project T2-3-C4 looks at hybridizing the stiff and light timber material with steel to increase gravity and seismic load resistance. Timber (CLT) - steel hybrid systems as vertical seismic resisting system were studied. The goal of the project was to determine how various parameters affect the timber-steel hybrid system. The system examined was a steel moment frame with bays infilled with CLT panels. Three, six, and nine storey frames with varying infill configurations were analysed to determine the viability of heights to increase seismic force resistance compared to a plain wood system. CLT panels are used as infill in a steel moment frame. This system allows for the combination of high strength and ductility of steel with high stiffness and light weight of timber.

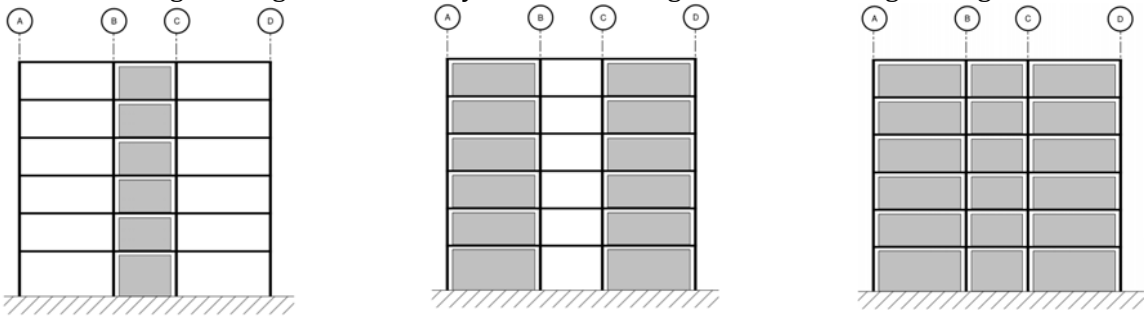

Figure 1: Wall Locations for Frame with Infill Wall Locations

Detailed non-linear models of the 2D infilled frame systems were created and parametric analyses were performed to determine the effect of the panels and the connection configuration, steel frame design, and panel configuration in a multi-bay system. Static pushover loading was applied alongside pseudo-static cyclic loading to allow a basis of comparison to future experimental tests. Dynamic analysis using ten ground motions linearly scaled to the uniform hazard spectra for Vancouver with a return period of 2% in 50 years, 10% in 50 years, and 50% in 50 years was conducted to examine the effect of infill panels on the inter-storey drift of the 3-, 6- and 9-storey buildings.

KEY RESULTS

The parametric analysis allowed the comparison of the yield and drift capacities for the various parameters. The addition of panels was found to increase the strength and stiffness of the system almost linearly with each panel. However, the addition of panels also resulted in a decrease in the drift at ultimate deformation, although the effect was less dramatic than the strength. A decrease in ductility with the additional panels was also noticed in the systems with high ductility steel frame, but less dramatically in the limited ductility frame. Overall, the results suggest that the addition of infill bays is less beneficial in ductile moment frames; CLT infill panels are better suited to lower ductility systems. The overstrength of the hybrid system was increased compared to the overstrength of the bare frames, but not significantly. Ultimately, a ductility factor of 3.0 is recommended for the infilled frame system (Figure 2), and an overstrength factor of 1.3 (Figure 3).

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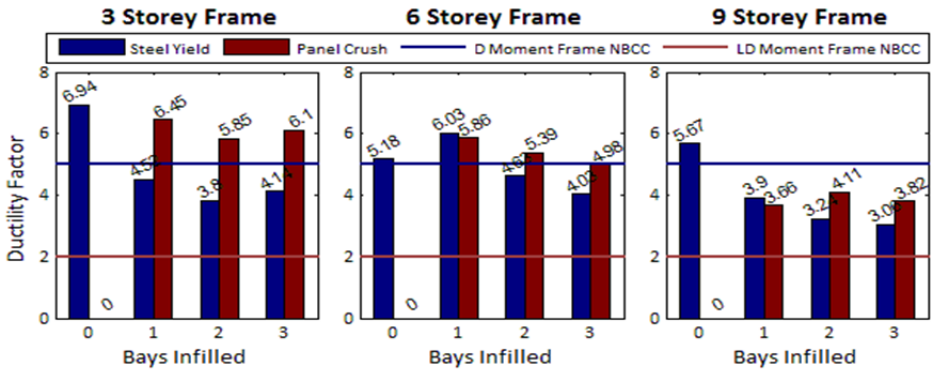

Figure 2: Ductility for various configurations

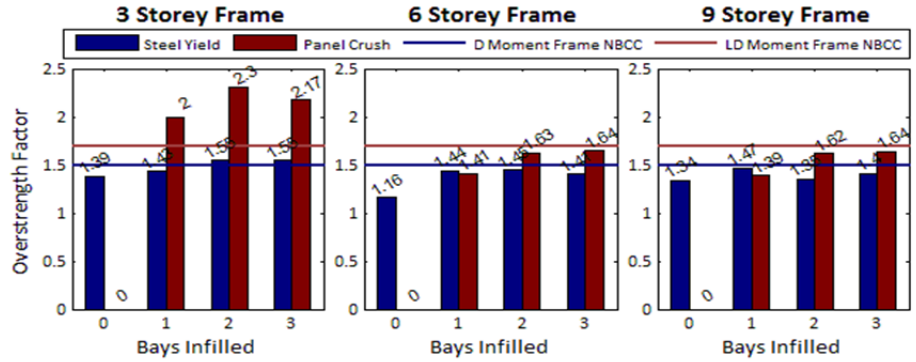

Figure 3: Overstrength for Various Configurations

Overall, the system shows significant promise for future construction. The addition of CLT infill walls to a steel moment frame shows a significant increase in strength and stiffness of the system and reduction in inter-storey drift. Further, there is a preliminary indication that the panel crushing allows for ductility values higher than that of a limited ductility moment frame.

Further research should include significant physical testing of the system discussed. It could include the following experimental research to investigate:

1. Smaller specimen of CLT to determine the diagonal crushing behavior of the panel.
2. Onset of crushing of a panel and its final failure mode.
3. Larger specimen of CLT in plane to determine at which load levels and specimen sizes the buckling effect becomes an issue for the panel capacity.
4. A complete single bay frame of the system loaded monotonically and cyclically to confirm the interaction between the two systems.

To further develop a full design methodology for CLT infill wall systems, further analytical research is also required including the development of more detailed material models for the brackets and panel crushing based on the experimental testing programs described above. Also, a full incremental dynamic analysis as described in FEMA P695 to determine the specific ductility and overstrength factors is required.

Finally, the concept of CLT infill walls in steel moment frames can be significantly expanded by researching other connection types. One possibility is to include multiple panels as infill within a single bay. The panels could be connected with energy dissipating connections. Strong connections with more ductility could be used between the panels and the frame, and the placement and size of the panels can be optimized to increase the efficiency of the system.