NOVEL STEEL TUBE CONNECTION FOR HYBRID SYSTEMS

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ABSTRACT

Amidst the traditional dominance of wood-frame construction approaches for residential buildings, innovative hybrid structures (e.g., timber-concrete and timber-steel methods) are achieving greater popularity. In such hybrids, materials with different properties are combined to utilize the best of each and overcome their individual limitations. In particular, timber-steel hybridized buildings are very promising with several advantages such as short construction times and heightened overall resilience to seismic events. A major focus of research and innovation for timber-steel construction is on the connection between the individual elements made of steel and wood. Figure 1 illustrates a proposed building with steel frame structure and cross-laminated timber (CLT) infill walls. In this application, the conventional CLT connection method uses a metal bracket that is nailed or screwed to the face of the panel. This commonly used connection is simple, strong, and fairly inexpensive, but there are some disadvantages. The bracket is attached on only one side of the wall, thereby creating an imbalance in the load path (Figure 2a). As well, the brackets often irreparably damage the wood during seismic events.

Figure 1: Timber-steel hybrid building with steel frame and timber infill walls

Previous tests following cyclic loading protocols with such brackets showed acceptable ductile behavior [1][2]. However, the destruction to the CLT panel was extensive, which in practice would prevent reattachment at the same location when retrofitting a building after a seismic event (Figure 2b).

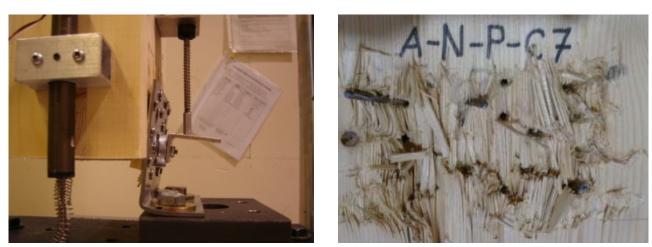

***Figure 2:** (a) off-centred fastened bracket, (b) damaged CLT panel after cyclic loading protocol*

In this paper, a new connection will be presented that addresses the problems of load imbalance and panel damage. Expanded tube fasteners in combination with densified wood were developed and studied by Leijten [3]. It was found that a hollow tube type connection provides

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significant ductility without relying on deformation of the wood panel, because the force is focused on the tube, which deforms as it dissipates the energy. Similar tube type connections were tested by Murty *et al*. in combination with laminated veneer lumber and laminated strand lumber [4]. The damage to the wooden base material was significantly reduced while ductility was maintained at a reasonable level.

The proposed tube connection used for CLT infill walls is bigger than the tube connection used in previous research. The connection to the CLT wall panel consists of a steel tube, a bolt, and a nut. The steel tube is inserted from the face of the wall panel. The bolt is screwed perpendicular to the axis of the tube through the base steel beam, and is held in place with the nut (Figure 3 and ***Figure 4***).

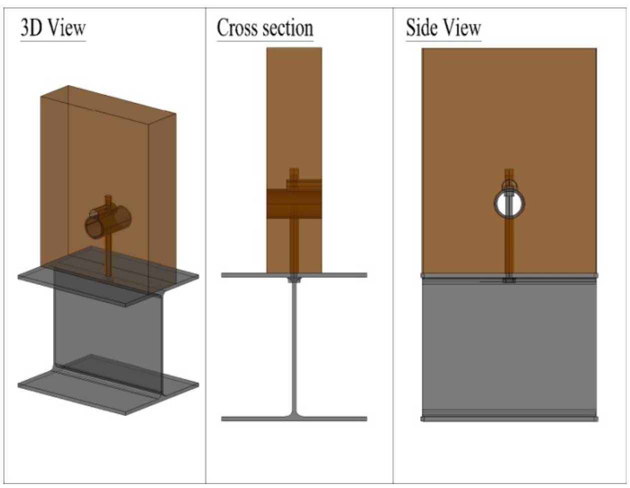

Figure 3: *Illustration of the connection*

Figure 4: *Plastic deformation of the tube under monotonic loading protocol*

This tube type connection takes advantage of the ability of the tube to localize and absorb energy by deforming the steel while providing strength to the connection. Additionally, this system provides easy access to the connection allowing the deformed or damaged parts to be replaced after a seismic event.

This research focuses on identifying limitations and defining optimal states for the major influencing factors for the performance of this connection method, such as tube diameter, tube thickness and edge distance to avoid damage to the CLT panel. The monotonic tests performed to date with a 50.5 mm (2 inch) steel tube showed great potential for the application as a timber-steel connector. The initial stiffness is very high, and the plasticity is continuously above a regular bracket type connection while providing equivalent displacement until maximum load at 33 kN. (Figure 5). The goal of this research will be to explore the properties and characteristics of the connection to improve the post-peak load performance under both monotonic and cyclic loading protocols.

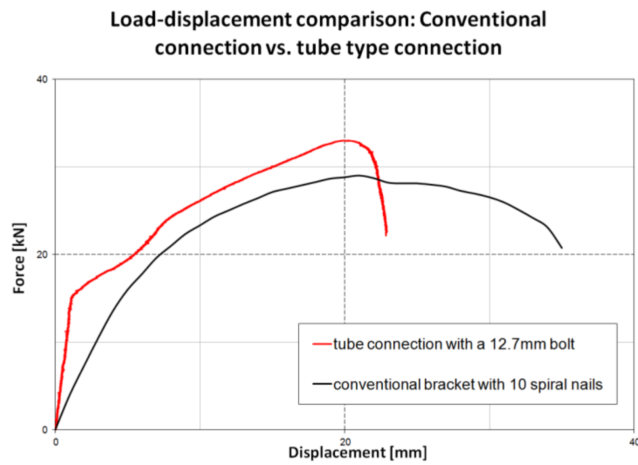

Figure 5: *Load-displacement curve of a tube connection and a regular bracket connection*

The outcome of the test series will be compared to the bracket type connection widely used for CLT walls. The obtained test results will be analyzed to develop a characterizing model for the connection to support further research and ultimate application of tube type connections.

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