NOVEL STEEL TUBE CONNECTION FOR HYBRID SYSTEMS

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KEYWORDS: Cross-Laminated Timber, Connections, Cyclic Tests, Seismic Performance

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.

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).

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
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).

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.

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Figure 3: Illustration of the connection

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

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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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