Abstract

The combination of timber and steel for residential hybrid buildings is an unconventional approach to date. The challenge of a hybrid structure is the link between the individual materials. The focus of this research is the connection between steel frame and the infill wall. Over 100 conventional bracket-type connections with various combinations of bracket and fasteners with cross-laminated timber were tested, investigated and assessed for damage under seismic loading protocols for a hybrid application. An energy-based formulation according to Krätzig was applied to calculate the development of the damage index, and the resulting index was validated with visual observation.

Six of the connections were modeled in OpenSees. For the modeling, a CUREE-10 parameter model was chosen to reproduce the test curves. The load-displacement results from both test and model were analyzed; the first method according to ASTM standards, where the envelope curve of the hysteretic results are considered and plotted in an equivalent energy elastic-plastic curve (EEEP). The second analyzing method used, was Krätzig's damage accumulation model. Throughout all six combinations and both loading directions (parallel- and perpendicular-to-the-grain) a major difference was found in the analyzing methods. The EEEP curve roughly approximates the performance but with the damage accumulation method showed that analysis of the subsequent cycles is required to better reflect the empirical performance of the connections. To avoid the extensive destruction of a bracket type connection after completion of seismic loadings, a new approach was chosen. It was found that a tube connection can obtain comparably similar strength results as a conventional bracket connection. The computed mechanical properties of bracket-type and tube-type connections were compared and evaluated. The new tube connection showed great potential for future timber-steel hybrid structures and their connecting challenge. A total of 27 connection assemblies were tested under quasi-static monotonic and reversed cyclic loads. The tube connections showed two major differences when compared to traditional bracket connections: i) the completely linear elastic behaviour at the beginning, and ii) the continued load increase after yielding. Both phenomena are founded in the geometry of that connector effectively making the novel connector a very promising alternative.