ABSTRACT

In low-rise multi-storey light wood frame buildings (LWFBs) (up to four-storey), the elevator shaft and stairwell cores made of reinforced concrete/masonry materials are usually designed separately from the wood frame. As the releasing of storey limit from four to six of residential LWFBs in the Province of British Columba since 2009, combination design consideration becomes an alternative way to utilize the lateral resistance of stiff cores. The uncertainty on seismic performance of these hybrid buildings has prompted the need to investigate the structural behavior of hybrid wood structures under earthquake load, especially on the estimation of seismic response parameters and load distributions between sub-systems.

In this study, a procedure of quantifying the seismic force modification factors of hybrid building systems that consisting of a relatively ductile light wood frame structure and a less ductile stiff core connected by a ductile connection system was proposed. According to this procedure, sixty-seven hybrid buildings with various combinations of sub-system properties were analyzed under San Fernando earthquake by two-dimensional (2-d) numerical modeling approach with ABAQUS software. The concept of super-element was used to modeling the wood and stiff core shear walls and inter-connections of sub-systems that incorporates the Bouc-Wen-Baber-Noori (BWBN) model to describe the hysteresis performance under lateral loads. The predictive capacity of this 2-d modeling approach was verified using the test data of two-storey hybrid wood-masonry wall and connection tests conducted in this study. The results show that the deformation incompatibility of the two sub-systems can be partially accommodated by the bolted connection systems developed in this study. An R value (seismic force modification factor) larger than the lower value of the two sub-systems can be assigned to design of the hybrid buildings.

Base on the numerical modeling analyses results of the sixty-seven buildings, empirical equations of estimation of seismic response parameters (seismic force modification factor and fundamental period) of hybrid buildings and load distributions between sub-systems were proposed. Two more earthquakes, Loma Prieta and Northridge-01, were used to verify the relationship explored by these equations. The results show that the relationship between system properties of wood-hybrid buildings and sub-system properties of components derived under San Fernando earthquake is also applicable for other earthquakes.