# Abstract

Recently, an innovative hybrid structure has been developed as an alternative lateral-load resisting system at The University of British Columbia. The hybrid structure incorporates Cross Laminated Timber (CLT) shear panels as an infill in steel moment resisting frames (SMRFs). In order to increase the applicability of the proposed system, in this thesis, a direct displacement based design methodology has been developed and analytically validated.

Initially, a nonlinear time history analysis (NLTHA) was carried out to study the lateral behaviour of the proposed hybrid structure. For this purpose, a total of 162 different hybrid buildings were modeled and analyzed in OpenSees by using twenty earthquake ground motions (2% probability exceedance in 50 years). Post-earthquake performance indicators (Maximum Interstory Drift (MISD) and Residual Interstory Drift (RISD)) were obtained from the analyses. To assist the post-seismic safety assessment of the hybrid buildings, surrogate models for MISD and RISD were developed using Response Surface Methodology and Artificial Neural Network (ANN). By using the ANN surrogate models as fitness functions for the Genetic Algorithm, optimal modeling parameters of the hybrid system were obtained.

Secondly, to represent the energy dissipative capacity of the hybrid system, an equivalent viscous damping (EVD) equation was developed. To formulate the EVD equation, 243 single-storey single-bay CLT infilled SMRF models were developed and subjected to monotonic static and semi-static cyclic analysis. The EVD of each model was calculated from the hysteretic responses based on Jacobsen's area based approach and later calibrated using NLTHA.

Finally, an iterative direct displacement based design method was developed for the proposed hybrid structure. A detailed description of the proposed methodology is presented with a numerical example. In order to verify the proposed method, hybrid buildings with 3-, 6-, and 9- storey heights were designed. A calibrated EVD-ductility relationship was used to obtain the energy dissipation of the equivalent SDOF system for all case study buildings. Nonlinear time history analysis using twenty ground motion records was used to validate the performance of the proposed design methodology. The results indicate that the proposed design method effectively controls the displacements resulting from the seismic excitation of the hybrid structure.