Force modification factors for cross laminated timber buildings

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Abstract:

European experience shows that Cross-Laminated Timber (CLT) can be competitive in mid-rise and high-rise buildings. Although this system has not been used to the same extent so far in North America, it can be viable wood structural solution for the shift towards sustainable densification of urban and suburban centers. For these reasons FPInnovations has undertaken a multi-disciplinary project on determining the performance of a typical CLT construction, including quantifying the seismic resistance and force modification factors for CLT buildings in Canada and the US.

In this report, a performance-based seismic design (PBSD) of a CLT building was conducted and the seismic response of the CLT building was compared to that of a wood-frame structure tested during the NEESWood project. A suitable force modification factors (R-factors) for CLT mid-rise buildings with different fasteners were recommended for seismic design in Canada and the US. The six-storey NEESWood Capstone building was redesigned as a CLT building using the PBSD procedure developed during the NEESWood project. The results from the quasi-static tests on CLT walls performed at FPInnovations were used as input information for modeling of the main load resisting elements of the structure, the CLT walls. Once the satisfactory design of the CLT mid-rise structure was established through PBSD, a force-based design was developed with varying R-factors and that design was compared to the PBSD result. In this way, suitable R-factors were calibrated so that they can yield equivalent seismic performance of the CLT building when designed using the traditional force-based design methods.

Based on the results of this study it is recommended that a value of Rd=2.5 and Ro=1.5 can be assigned for structures with symmetrical floor plans according to NBCC. In the US an R=4.5 can be used for symmetrical CLT structures designed according to ASCE7. These values can be assigned provided that the design values for CLT walls considered (and implemented in the material design standards) are similar to the values determined in this study using the kinematics model developed that includes the influence of the hold-downs in the CLT wall resistance. Design of the CLT building with those R-factors using the equivalent static procedures in the US and Canada will result in the CLT building having similar seismic performance to that of the tested wood-frame NEESWood building, which had only minor non-structural damage during a rare earthquake event.

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