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Design models for CLT shearwalls and assemblies based on connection properties

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Résumé:

The work presented in this report is a continuation of the FPInnovations' research project on determining the performance of the CLT as a structural system under lateral loads. As currently there are no standardized methods for determining the resistance of CLT shearwalls under lateral loads, the design approaches are left at discretion of the designers. The most common approach that is currently used in Europe and North America assumes that the resistance of CLT walls is a simple summary of the shear resistance of all connectors at the bottom of the wall. In this report some new analytical models for predicting of the design (factored) resistance of CLT walls under lateral loads were developed based on connection properties. These new models were than evaluated for their consistency along with the models that are currently used in North America and in Europe.

In total five different design models (approaches) were used in the study, the two existing models and three newly developed ones. All models were used to predict the factored lateral load resistances of various CLT wall configurations tested in 2010 at FPInnovations. The analyzed walls had different aspect ratios and segmentation, different vertical load levels, different connection layouts and different fasteners in the connections (ring nails, spiral nails and screws). The design values obtained using the various analytical models were compared with the maximum forces and yielding forces obtained from the experimental tests. Ratios between the ultimate loads obtained from experimental tests and design values obtained by the five analytical design models were used as a measure for the consistency of the models. Newly developed models that account for sliding-uplift interaction in the brackets (models D3-D5) showed higher level of consistency compared to existing ones. The analytical model D4 that accounts for sliding-uplift interaction according to a circular domain, is probably the best candidate for future development of design procedures for determining resistance of CLT walls under lateral loads. In case of coupled CLT walls, contribution of vertical load to the wall lateral resistance was found to be two times lower than in case of single wall element with the same geometry and vertical load. Special attention in the coupled walls design should be given to step joints between the adjacent wall panels. Over-design of the step joint can result in completely different wall behavior in terms of mechanical properties (strength, ductility, deformation capacity, etc.) that those predicted.

It should be noted that conclusions made in this report are made based on the comparison to the tested configurations only. Additional experimental data or results from numerical parametric analyses are needed to cover additional variations in wall parameters such as wall geometry and aspect ratio, layout of connectors (hold-downs, brackets), type and number of fasteners used in the connectors, and the amount of vertical load. The findings in this report, however, give a solid base for the development of seismic design procedure for CLT structures. Such procedure should also include capacity based design principles, which take into account statistical distributions of connections resistances.

Documents

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