

Utilization of Cross-Laminated Timber as a Soft Story Retrofit within the NEES-Soft Shake Table Test

As early as 1970, the structural engineering and building safety community recognized that a large number of two-, three-, and even some four-story wood-frame buildings designed with the first floor used either for parking or commercial space were built with a readily identifiable structural system deficiency referred to as a “soft story.”

Background

Many older multistory wood-frame buildings (built prior to 1970s) are susceptible to collapse at the first story during earthquake events. Most of these older multistory wood-frame buildings have large openings and few walls at the ground level. These buildings are prone to collapse during major earthquake events and are known as “soft story” buildings. This behavior can result in destruction of property and, in some cases, loss of life, as was observed after the Loma Prieta (Fig. 1) and Northridge earthquakes (Fig. 2).

A 2008 study by the San Francisco Department of Building Inspection and the Applied Technology Council concluded that 43% to 80% of multistory wood-frame buildings will be deemed unsafe after a magnitude 7.2 earthquake and that a quarter of these buildings are expected to collapse. In 2013, the City of Los Angeles identified more than 29,000 wood-frame structures that might have soft story issues. The significance of this problem has highlighted the need for cost-effective retrofit options for soft story wood-frame structures.

The NEES–Soft Project, focused on seismic risk reduction for soft story wood-frame buildings project and funded by the National Science Foundation, is a



Figure 1. Soft story collapse of multifamily wood-frame structure during 1989 Loma Prieta earthquake.

collaboration of five universities and industry with objectives of enabling performance-based seismic retrofit for at-risk soft story wood-frame buildings and experimentally validating the FEMA P-807 retrofit procedures.

One possible retrofit option being developed within this project utilizes a new wood product called cross-laminated timber (CLT). CLT is a wood technology for structural applications that was developed in Europe over 15 years ago and is beginning to make its way into the North American market as a green building alternative. CLT is a multilayer wood panel made of lumber that results in increased stiffness and strength (Fig. 3), making it an ideal candidate for the retrofit of soft story wood-frame structures if basic seismic performance information can be generated.

Partnering with the ongoing NEES–Soft Project will generate this performance information and determine if CLT is a viable seismic retrofit option (Fig. 4).



Figure 2. Soft story collapse of structure during the 1984 Northridge earthquake.

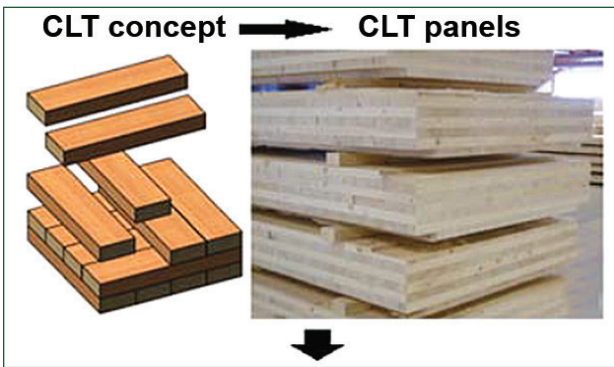


Figure 3. CLT concept and panels.

Objective

The objective is to develop CLT as a viable retrofit option for soft story upgrades in earthquake-prone regions in the United States.

Expected Outcomes

CLT experimental results generated in cooperation with the NEES-Soft Project will be used to

- validate current FEMA P-807 retrofit procedures,
- validate CLT use as a viable retrofit option for soft story wood-frame buildings, and
- increase the visibility of CLT as a viable and sustainable building product in seismic regions of the United States.



Figure 4. CLT repair option.

Timeline

Design criteria for CLT will be developed in the spring of 2013 for inclusion in full-scale shake table testing scheduled for the fall of 2013. A final report of findings will be available in late 2014.

Cooperators

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USDA Forest Service, Forest Products Laboratory
National Science Foundation NEES–Soft Project

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