Research in Progress

Forest Products Laboratory

Development of Seismic Performance Factors for Cross-Laminated Timber Shear Walls

Since its initial introduction in Europe more than two decades ago, cross-laminated timber (CLT) has been established as a new-generation product (UNFAO 2016). Recent construction projects in both Canada and the United States (Pei et al. 2016) and research efforts in Europe, North America, and Japan on CLT-based lateral force resisting systems (Pei et al. 2014) have demonstrated that CLT can be a viable alternative to steel and concrete in mid-rise construction, particularly in seismic regions.

However, CLT-based seismic force resisting systems are not included in current design codes and standards, meaning that any CLT seismic design can be conducted only through alternative methods. This approach is both costly and complicated, making CLT less competitive than other conventional structural systems such as light-frame wood and heavier materials such as steel and concrete.

The purpose of this Forest Products Laboratory partnership with Colorado State University is to determine seismic performance factors for CLT, thereby enabling CLT to be used efficiently and competitively throughout the United States.

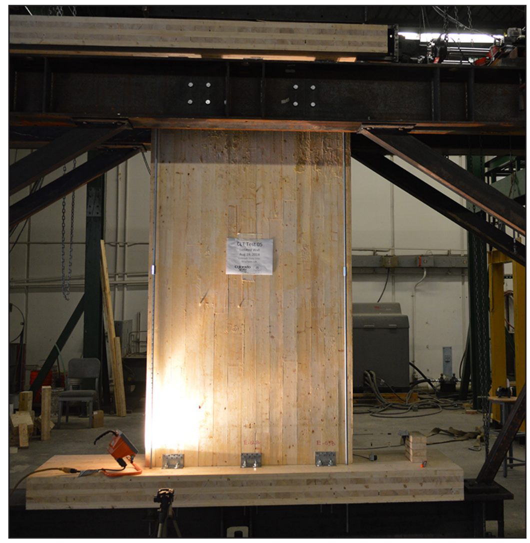

Figure 1. CLT shear wall testing with horizontal actuator in displacement control applying shear load and vertical actuator in load control applying gravity.

Background

CLT panels are constructed of several layers of lumber boards stacked orthogonally and glued together. They are usually constructed in odd number of layers that varies from three to seven, sometimes even more.

This innovative product offers a number of advantages, such as the potential for mass production, prefabrication, rapid construction, and sustainability as an environmentally friendly renewable construction product. Very good thermal insulation, acoustic performance, and fire ratings are some additional benefits of this system (CLT Handbook 2013; Ceccotti 2008).

Objective

The main objective of this project is to develop an understanding of the cyclic and seismic behavior of the proposed CLT shear wall systems. This includes (1) testing at the component and assembly level (Fig. 1), (2) developing the design methodology and calibrating it based on test data, (3) developing and calibrating the numerical model, (4) designing a suite of archetypes that are representative of the design space, and (5) performing extensive analysis to identify the seismic performance factors. In addition, the project team will work with the American Forest & Paper Association (AF&PA) to propose these factors for inclusion in current design standards.

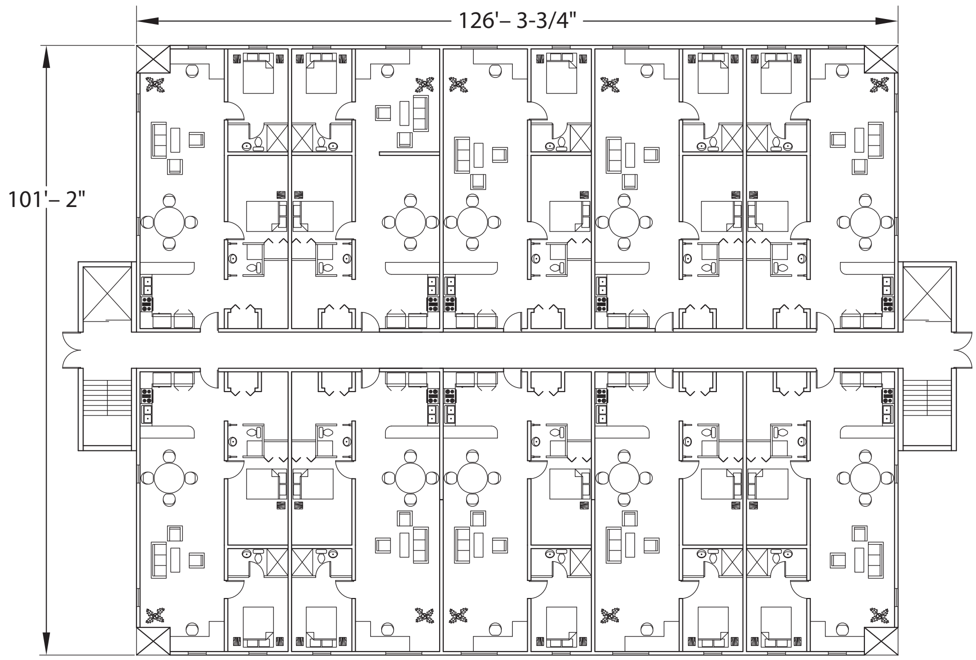

Figure 2. CLT index building.

Approach

The study utilizes the FEMA P695 methodology (FEMA 2009), which provides a systematic approach consisting of nonlinear static and dynamic analyses. The procedure also takes into account uncertainties inherent in test data and modelling methods. The methodology is applied to a number of archetypes extracted from index buildings that are representative of the CLT design space. Figure 2 shows one such index building from which several archetypes will be extracted and analyzed.

Expected Outcomes

At the completion of this research project, the proposal for seismic performance factors will be submitted to the peer review panel. This research will result in the following:

- Evaluation of seismic performance factors, including response modification factor (R-factor), system over strength factor, and deflection amplification factor for seismic design in the United States
- Design methodology based on the 2015 *National Design Specification for Wood Construction*, including appendix E, ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures*, and applicable building code that can be used by engineers nationwide
- Component tests data that are reported in accordance with the standards and are widely available to the engineering community, allowing application of P795 methodology to facilitate potential use for alternative fasteners and connectors by manufacturers

Timeline

The last phase of the project began in early 2017. The project is expected to be completed by the end of 2017, with reporting in early 2018.

Cooperators

Colorado State University
USDA Forest Service, Forest Products Laboratory
American Wood Council
Colorado School of Mines
FPInnovations (Canada)

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References cited available upon request.