RESEARCH in Progress

Coalition for Advanced Wood Structures
a university, industry, government partnership

Design and Understanding of Force Transfer around Openings

Shear walls and diaphragms are the primary lateral-load-resisting elements in wood-frame construction. Such buildings have performed relatively well in earthquakes and hurricanes from the life safety perspective. However, property losses from natural disaster can be high. For example, in the January 17, 1994, Northridge earthquake in the Los Angeles metropolitan region, property losses were attributed predominately to damages in wood-frame housing, accounting for over half of the $40 billion property damage and approximately 48,000 uninhabitable buildings. Better understanding and improvement of these lateral-load-resistive systems are needed to further enhance wood-frame construction as a competitive solution in wide applications, including residential buildings and engineered mid-rise construction.

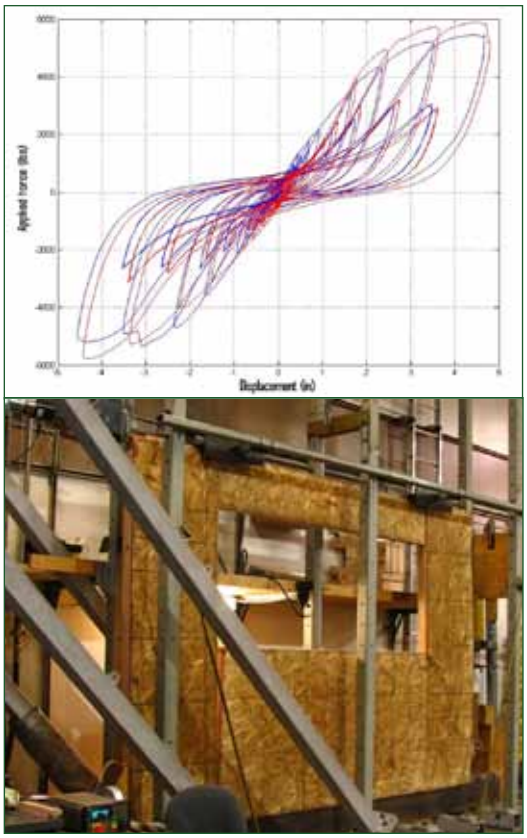

Figure 1. Experimental testing for understanding force transfer around openings.

Background

Design methods for shear wall with openings are becoming important as more buildings are engineered to reduce cost and increase efficiency. International Building Code stipulates design methods for two classes of shear wall with openings: (1) frame and connections around openings designed for force transfer around openings and (2) frame and connections around openings not designed for force transfer around openings. For force transfer design, the code provides guidelines on limitations of the aspect ratio of the overall wall and each wall pier at the side of the opening. However, it stipulates only that design for force transfer shall be based on a rational analysis. Different methodologies can result in significantly different solutions, leading to confusion in the design community. Furthermore, limitations of these methods and how close they are to reality are not clear. Failure modes in shear walls with openings depend on the arrangement of the sheathing element and can be quite complicated, including buckling of the sheathing panels. In some cases, whether the "rational" design methods can account for the complicated failure mode is unclear, because the load path may alter at high load levels.

Objective

The objective of this project is the development of rational design methods that can account for the complicated failure mode as the load paths alter at higher force levels that go beyond code-specified limitations.

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Figure 2. Structures for which an understanding of force transfer is needed.

Approach

To better understand and design for the complicated force behavior around openings, three work phases will be implemented:

- Phase 1—Review existing force transfer around opening design methodologies
- Phase 2—Conduct full-scale shear wall tests with a minimum of 10 configurations
- Phase 3—Develop a mathematical and/or computer model for force transfer around openings

Expected Outcomes

- New design methodologies or improved rational analysis methods that can be robustly applied to a wide range of cases
- A model to assist in the design of force transfer around openings

Timeline

Evaluation of the current force transfer around opening design methodologies will be completed by fall 2009. Preliminary tests of five wall configurations have been conducted, but the full test matrix, which will include a minimum of 10 configurations, will be established by fall 2009. Testing will continue in spring 2010. Information from the review of design methodologies will help establish the entire test matrix. Modeling and design method development will commence in spring 2010 and be completed by late summer 2010.

Cooperators

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