RESEARCH in Progress

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

Assessment of FEMA P695 on Seismic Design of Light-Frame Wood Residential Construction

Seismic design of buildings is based on a combination of empirical knowledge and engineering analysis. The experience accumulated from seismic events and large-scale tests provides confidence in engineering models and serves to establish acceptable levels of risk for code compliance (Figure 1). With the ongoing development of new building systems, accumulated experience and testing is lacking to establish acceptable risk levels for these systems. To address this need, the Federal Emergency Management Agency (FEMA) developed FEMA P695 (ATC-63), a methodology for quantifying building system performance and response parameters for use in seismic design.

Figrue 1. Seismic damage of light-frame wood apartment structure.

Background

Current seismic building design philosophy is focused on the life safety objective at the Maximum Considered Earthquake (MCE) ground motion level. An MCE event is expected to cause inelastic deformations in the seismic-force-resisting system, but the structure will remain stable with a low probability of collapse. These inelastic deformations provide a mechanism for the structure to control seismic forces in order to enable economical earthquake-resistant systems.

The building codes implement this design philosophy through the format of seismic performance factors (SPFs) that modify the forces and deformations calculated using simplified elastic models. These modified forces and deformations are intended to represent the nonlinear response of a building system (Figure 2). The SPFs include the response modification (R), overstrength (Ω_0), and deflection amplification (C_d) factors. SPFs are largely based on judgment, with the number of systems considered having been expanded from a relatively small number of systems with well-known response capabilities to more than 80 systems, many of which have not been tested either in the laboratory or in earthquakes.

The construction industry's drive for innovation leads to new building systems, novel design solutions, and improvements to existing systems. Because the SPFs are assigned to specific systems and associated detailing, new systems require assignment of new, or re-assessment of existing, SPFs. The lack of a standardized approach for developing these factors created a barrier to innovation and was one reason FEMA funded and published P695 "Quantification of Building Seismic Performance Factors," a methodology for determining SPFs. Within P695 was an example developed around light-frame wood systems.

Objective

This study is designed to expand and refine the FEMA P695 analysis of light-frame wood systems by conducting sensitivity studies to understand the effect of key assumptions made in the P695 simulations and the

Advanced Housing Research Center
Forest Products Laboratory Madison, Wisconsin

USDA
Forest Products Laboratory

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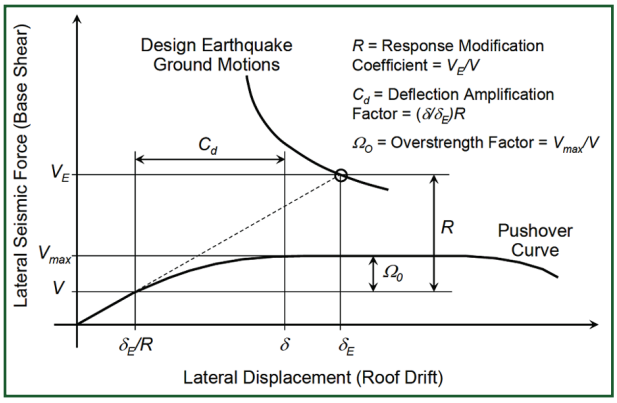

Figure 2. Illustration of seismic performance factors used in seismic design.

hysteretic parameters of the wood light-frame system. We will investigate several key assumptions and parameters:

- Analysis software
- Hysteretic formulations
- Wider variety of building configurations
- Lower seismic design categories
- Higher levels of viscous damping
- Soft-story configurations
- Sensitivity studies of key input parameter

Approach

To better understand the FEMA P695 methodology on seismic design of light-frame wood residential construction, we will take the following approach:

1. Calibrate the analytical models and tools using FEMA P695 Example Applications of Wood Light Frame Systems
2. Identify a broader set of residential Wood Light-Frame Archetype Configurations
3. Develop a nonlinear model for shear wall for use in Seismic Analysis of Woodframe Structures (SAWS) and open source seismic software (OpenSEES)
4. Parameterize hysteretic models to available shear wall test data
5. Model and analyze structural responses of index archetypes using monotonic pushover and incremental dynamic analysis
6. Perform parametric analysis of shear wall parameters to determine their effect on the collapse probability and SPFs

Expected Outcomes

- Better understanding of the application and key parameters of the FEMA P695 methodology to light-frame residential structures
- Suggested implementation guidance of the FEMA P695 process for lower-rise, light-frame wood structures
- Improved understanding of the performance of light-frame structures under seismic loadings

Timeline

Analytical models will developed from fall 2009 through early 2010. Interpretation of modeling results and modification of the analysis parameter will commence summer 2010 and be completed by winter 2010.

Cooperators

National Association of Home Builders (NAHB) Research Center
U.S. Forest Service, Forest Products Laboratory

Contact Information

Vladimir Kochkin
NAHB Research Center
Upper Marlboro, Maryland
(301) 430-6249; vkochkin@nahbrc.com

Douglas R. Rammer
U.S. Forest Service, Forest Products Laboratory
Madison, Wisconsin
(608) 231-9200; drammer@fs.fed.us