Establishing Seismic Equivalency for Proprietary Prefabricated Shear Panels

An Introduction to the Process

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In 2003 and before, the International Code Council Evaluation Service (ICC-ES) was asked by product manufacturers to accept their testing and analysis criteria for determining seismic design factors for their products. Some members of the structural engineering community strongly opposed this process because of the incongruity between the seismic-force-resisting system design methodology promulgated in building codes and the development of seismic design factors for individual products by manufacturers and ICC-ES.

The Federal Emergency Management Agency (FEMA) agreed with the structural engineering community and sponsored the Applied Technology Council's ATC-63 project, *Quantification of Building System Performance and Response*. The goal was to "create a methodology for determining Seismic Performance Factors (SPF's)" that, when properly implemented in the design process, would result in the equivalent earthquake performance of buildings having different structural systems (i.e., different lateral-force-resisting systems).

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More recently, ICC-ES had been working to develop a new acceptance criterion for cold-formed steel shear panels used in light-frame construction. Drafts of the proposed acceptance criteria, *AC322: Prefabricated, Cold-formed Steel Lateral Resisting Assemblies*, had been the subject of considerable debate at development hearings. Much of the controversy centered around two technical topics:

- How to develop seismic design factors for a proprietary prefabricated shear panel product used as a component within a larger system.
- How to evaluate the ability of a proprietary prefabricated shear panel to carry a combination of vertical and lateral load when the elements of the panel that carry the vertical load are degraded during a lateral load test.

ICC-ES coordinated a meeting of interested parties in San Francisco on May 9, 2007 to discuss these issues. Representatives were present from various proprietary prefabricated shear panel manufacturers, related trade associations, consulting engineering firms, academia, government, and ICC-ES. During the meeting, nearly all of the discussion centered around the development of seismic design factors. The second issue was not addressed.

With regard to the development of seismic design factors, it was established that:

- Proprietary prefabricated shear panels are typically used as a component within a building containing a code-defined lateral-force-resisting system, as well as other building elements, which – though not considered in the structural design of the building's seismic resistance – provide the building with stiffness, strength and energy dissipation capacity.
- The seismic design factors for defined systems that are presently contained in ASCE/SEI 7-05, which is referenced by the 2006 International Building Code (IBC), cannot be directly calculated based upon analysis and cyclic shear wall test data. The reason for this is that code-defined seismic design factors were developed over a period of many years based largely upon observed seismic performance of systems subjected to actual earthquake demands, limited test data, and comparison with other code-defined systems. However, because the seismic design factors were considered subjective, very detailed code provisions were developed to limit displacement and provide adequate strength and ductility for elements and subassemblies specific to each defined structural system.

Given the current lack of a definitive mathematical methodology to analyze cyclic shear wall test data for a proprietary product and to assign seismic design factors that are both consistent and compatible with code-defined lateral-force-resisting systems, it was decided that seismic design factors for proprietary prefabricated shear panels could be assigned on an "equivalency" basis.

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At the close of the May '07 meeting, a Task Group was formed to establish the methodology that should be employed to establish "equivalency" for the assignment of seismic design factors to proprietary prefabricated shear panels. The author was appointed to chair this Task Group.

Basis for Establishing Equivalency

For seismic-force-resisting systems not listed in ASCE/SEI 7-05 Table 12.2.1, ASCE/SEI 7-05 §12.2.1 allows for analytical and test data to be submitted that establish the dynamic characteristics and demonstrate the lateral force resistance and energy dissipation capacity to be equivalent to the structural system listed in Table 12.2.1 in terms of the values for the response modification factor, R, system over-strength factor, Ω_0, and deflection amplification factor, C_d.

To satisfy Section 12.2.1 of ASCE/SEI 7-05, a methodology defining the critical characteristics, using a database of existing industry-approved test data for the defined system, was used to set parameters for each characteristic.

The Task Group objective was to provide a practical means by which to judge whether or not a proprietary prefabricated shear panel performs in a manner consistent with a "benchmark" code-defined lateral-force-resisting system when subjected to high-intensity, cyclic loading similar to that produced by earthquake shaking. In other words, if the cyclic test behavior of a proprietary prefabricated shear panel is judged to be "equivalent" and consistent with the behavior of a lateral-force-resisting system defined in the IBC, then that panel may be used as a component within that system and share the same seismic design factors. This is acceptable for elements that can be "inserted" into the wood framed structure that must still meet all code provisions related to strength and ductility that support the use of the established "tabulated" seismic design factors.

The Task Group decided that equivalency should be based on the comparison of critical performance "parameters" from cyclic tests of the proprietary system against similar tests for the benchmark system defined by the code.

Methodology Acceptance

The Task Group's final results were presented to the ICC-ES Evaluation Committee at its October 10, 2007 meeting, and accepted as a means for manufacturers to determine seismic factors for products manufactured under compliance with AC-130 for Prefabricated Wood Shear Panels and AC-322 for Prefabricated, Cold-formed, Steel Lateral-force-resisting Vertical Assemblies.

The two articles that accompany this one (Waltz and Hamburger, page 13; Serrette, page 19) go into more depth regarding the final characteristics and parameters that were accepted. Waltz and Hamburger present the consensus view of the Task Group. Serrette presents an alternative view that was discussed extensively during the Task Group's deliberations, but ultimately was found to be unpersuasive by the majority and by the ICC-ES Evaluation Committee.

In addition, the Structural Engineers Association of California (SEAOC) Seismology Committee has reviewed the Task Group's results. While they would like to see the Task Group amend the proposed acceptance criteria to consider specific conditions associated with critical characteristics and parameters used to determine equivalency, they are in general agreement with the Task Group's efforts to date. One of SEAOC's main concerns was that the applicability of the current incarnation of the equivalency determination effort was limited only to shear panels in light frame construction.

The Task Group plans to continue refining its initial findings. Its members hope to enlarge the test database for structural panels on wood framing and add information for structural panels on light-gauge, cold-formed steel. In addition, the SEAOC issues mentioned above will be discussed and likely incorporated.

Conclusion

Material product manufacturers, other than wood, have been following the development of this equivalency methodology. While the equivalency methodology could be applied to other products providing lateral force resistance, the same level of scrutiny for establishing critical characteristics and parameters for comparison is required. The development of such an equivalency methodology should be executed by an equally diverse and qualified task group. A large set of recognized test data for the system, and a robust testing protocol for vetting results used for comparison, are further requirements for establishing equivalency.▪

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