Comparing SIP Walls to Light Frame Wood Construction Under Seismic Loading

The primary construction method for evaluating equivalence under seismic loading is light frame wood shear wall construction. It serves as the foundational standard against which other framing systems are assessed. The International Residential Code (IRC) outlines 16 specific wall bracing techniques with different aspect ratios aimed at providing shear resistance. However, the IRC's prescriptive provisions are applicable only to sites in seismic design categories A, B, or C.

Aspect Ratios

An aspect ratio refers to the relationship between a wall segment's height and its length along the wall line. In the International Residential Code (IRC), the continuous sheathing bracing method, known as the CS-WSP method, allows for aspect ratios of up to 4:1 in specific framing scenarios. Section R610 of the IRC, which pertains to Structural Insulated Panel Wall Construction (SIPs), recognizes SIP walls as equivalent to continuous wood structural panel sheathing for determining required wall bracing. Consequently, the IRC permits the use of SIPs in seismic design categories A, B, and C with aspect ratios reaching up to 4:1.

Seismic Design Categories D, E, and F

The IRC does not cover the use of SIPs in seismic design categories D, E, and F. However, compliance with the International Building Code (IBC) allows for their use in these categories if demonstrated through test reports or a manufacturer's code evaluation report.

ASTM D7989, titled "Standard Practice for Demonstrating Equivalent In-Plane Lateral Seismic Performance to Wood-Frame Shear Walls Sheathed with Wood Structural Panels," was developed to establish the equivalency of wall systems like SIPs to light frame wood shear wall construction. Additionally, ICC-ES AC04, "Acceptance Criteria for Sandwich Panels," Appendix A outlines optional cyclic-load test requirements for SIP sandwich panels, also aimed at demonstrating this equivalency. Both ASTM D7989 and ICC-ES AC04 utilize the same criteria to showcase equivalent seismic performance with light frame shear walls sheathed with wood structural panels. Three specific criteria must be met to demonstrate this equivalency for use in seismic design categories D, E, and F.

The first criterion aims to establish comparable ductility capacity, calculated by dividing the ultimate deflection by the deflection at the allowable stress design (ASD) value. This capacity should be 11 or higher to meet the requirement.

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The second criterion assesses the similarity in ultimate failure deflection of the walls, known as drift capacity. It should be 0.028 times the height of the wall or greater. The third criterion focuses on achieving comparable load factors, termed overstrength capacity, obtained by dividing the peak strength by the design value. The overstrength capacity should fall within the range of 2.5 to 5.0.

The USDA Forest Products Laboratory (FPL) in Madison, WI conducted a study involving the testing of 54 SIP wall assemblies to assess their performance against the three seismic equivalency criteria. The study included SIP walls with aspect ratios of 1:1, 2:1, 3:1, and 4:1, as well as SIP wall assemblies with interconnected panels using block splines. Testing was carried out following the provisions of ASTM E2126-11, with all walls subjected to displacement at the top of the specimen according to the CUREE cyclic protocol (Method C, ASTM E2126-11). This protocol is widely recognized as the industry standard for seismic testing across all seismic design categories.

The study outcomes affirmed that SIP shear walls with aspect ratios of 1:1, 2:1, and 3:1, as well as SIP assemblies comprising five multiple panels, satisfied all three equivalency requirements outlined in ASTM D7989 and ICC-ES AC04. Detailed findings are available in FPL report FPL-RP-704. Additionally, APA --The Engineered Wood Association conducted a related study involving 29 full-size SIP walls of varied configurations, tested using the CUREE cyclic testing protocol. Results published in FPL report FPL-GTR-251, "Lateral Load Performance of SIP Walls with Full Bearing," validated that SIP wall assemblies with 2, 3, and 4 panels also met the equivalency criteria. These comprehensive findings demonstrate that SIPs exhibit performance on par with conventional light frame shear walls across all seismic design categories, as evidenced by a diverse range of SIP aspect ratios and assemblies tested. The FPL reports are accessible for download at no cost from the FPL website (fpl.fs.fed.us) and the SIPA website (www.sips.org).