

International Association of Plumbing and Mechanical Officials

Evaluation Criteria for the Testing and Analysis of Steel Sheet Sheathing for Wood and Cold Formed Steel Light Framed Structure Shear Walls

EC 003-2012

Division: 05 - METALS

Section: 05160 – Metal Framing Systems

Evaluation Criteria Scope:

1. Evaluation Criteria scope: This EC provides a basis for testing and evaluating uncorrugated steel sheathing for use in light frame shear walls of cold-formed steel and wood framing to be recognized in an IAPMO ES Evaluation Report. The sheathing may consist of alternate steel sheet thickness, composite steel systems, alternate fasteners and/or fastening patterns, and may incorporate alternate means and methods of assembly. The steel sheets may be applied on single-sided and double-sided shear wall assemblies. The design of the vertical elements is not a part of the scope of this EC. The cold-formed steel or wood framing used in the tested assembly shall conform to standard design practices and be engineered in accordance with the applicable sections of the model codes; including Section 2211 and Chapter 23 of both the IBC and CBC. The steel sheathing is to be attached directly to standard cold-formed steel sections or wood framing. The steel-sheathing panels are not to include alternate and proprietary framing members, however the sheathing assembly may include finish materials provided the steel sheet is applied directly to the vertical members. The tested sheathing is intended for use in all seismic design categories and may be applied in a seismic or wind lateral force-resisting system of light-framed construction.

1.1. Conditions of use for this Criteria:

1.1.1. The evaluation report shall identify one of Section 5 field identification options.

1.1.2. When the approved product is installed in jurisdictions governed by the IBC and CBC, periodic inspections shall be in accordance with the code requirements for the applicable type (wood or cold-formed steel) of light-framed construction.

1.1.3. Tested products may be used to resist seismic and wind loads. For seismic design, the limitations for the respective light frame shear wall bearing wall system as defined in ASCE/SEI 7, Table 12.2-1, shall apply.

1.1.4. Repair of Damaged Panels: All structural panels laminated to gypsum sheathing must be installed with the gypsum panels dry. After installation of panels follow manufacturer's procedure referenced in evaluation report to repair any damaged gypsum board.

1.1.5. The final test report shall indicate if the product has been specifically tested in conjunction with fire-treated lumber and shall be limited to the manufacturer and product tested. Alternatively, the final report may indicate that the product was not tested in conjunction with fire-treated lumber and shall indicate that the Building Official and Design Professional of Record shall incorporate the appropriate reduction recommended by the manufacturer.

1.1.6. Included in the allowable load tables are the product model number, height, seismic

& wind allowable in-plane shear, drift; boundary requirements, including screw quantities and foundation anchorage where applicable, and any other information that is pertinent to attain the product listed capacities.

1.1.7. The allowable load tables in the evaluation report will not include a 1.33 increase intended for transient loading. The evaluation report shall state that the 1.33 increase for transient load shall not be applied to allowable shear loads for these products.

1.2. Limitations of use for this Criteria:

1.2.1. The approved products shall be limited to use within height limits and seismic categories (IBC & CBC) permitted for the equivalent seismic performance coefficients and factors systems listed in ASCE / SEI 7, Table 12.2-1, for the respective light frame shear wall bearing wall system.

1.2.2. The evaluation report shall indicate that the use of this product in IBC Section 2308 conventional construction is outside the scope of the evaluation report.

1.2.3. The evaluation report shall clearly indicate that the product application is limited to use in light-framed wood and cold-formed steel construction complying with the code.

1.2.4. Holes in Sheathing: Holes that exceed 10 percent of the panel length, or 5 percent of the panel height, or are within 16 inches of a corner must be tested and the allowable quantities, locations, and sizes reported. The final report shall address proper hole cutting with special attention given to corners of rectangular holes. Attachment of Panels to Framing: Panels attached to framing members shall be dry.

1.2.5. Panels must be fastened to the framing with the steel sheet facing framing member. Sheets may lap on individual framing stud with joint space between sheets of 0" to 1/8". No over lap on sheets at vertical or horizontal joints is allowed. Each sheet must be attached to framing members with independent fasteners along each edge of each sheet as well as in the field. Fastener spacing will be determined by the Engineer of Record.

1.3. Compliance with the following codes and standards:

1.3.1. 2012 *International Building Code*[®] (IBC), International Code Council (ICC).

1.3.2. 2012 *International Residential Code*[®] (IRC), International Code Council (ICC).

1.3.3. 2010 California Building Code[®] (CBC)

1.3.4. 2009 *International Building Code*[®] (IBC), International Code Council (ICC).

1.3.5. 2009 *International Residential Code*[®] (IRC), International Code Council (ICC).

1.3.6. 2005 National Design Specification[®] (NDS[®]) (including the 2005 supplements) for Wood Construction, American Forest & Paper Association

1.3.7. AISI S100-07/SI-10 North American Specification for the Design of Cold-Formed Steel Structural Members (AISI-NAS), with Supplement 1 dated 2010.

1.3.8. AISI S213-07/SI-10 North American Standard for Cold-Formed Steel Framing – Lateral Design, American Iron and Steel Institute, with Supplement 1 dated 2010.

- 1.3.9. ASCE/SEI 7-10, Minimum Design Loads for Building and Other Structures, American Society of Civil Engineers.
- 1.3.10. ASCE/SEI 7-05, Minimum Design Loads for Building and Other Structures, American Society of Civil Engineers.
- 1.3.11. ASTM E 2126-10, Standard Test Methods of Cyclic (Reversed) Load Test of Shear Resistance of Vertical Elements of the Lateral Force Resisting Systems for Buildings, Method A in Section 8.3, ASTM International.
- 1.3.12. ASTM A370-03a Standard Test Method for Steel Sheets, ASTM International.
- 1.3.13. Steel Stud Manufacturers Association (SSMA)SM Product Technical Information, 2001

1.4. Property evaluated:

Structural

2. Uses:

Steel sheet sheathing for wood and cold formed steel light framed structure shear walls may be used as item A.13 in Table 12.2-1 of ASCE 7-05 and item A.15 and A.16 in Table 12.2-1 of ASCE 7-10.

2.1. Evaluation Basis: This Evaluation of the submittal is intended to provide guidelines for the testing and assignment of design capacities of steel sheet sheathing products used in shear walls and to establish code compliance through the proper characterization of element behavior within the scope of item A.13 in Table 12.2-1 of ASCE 7-05 and item A.15 and A.16 in Table 12.2-1 of ASCE 7-10, in accordance with the provisions of IBC Section 104.11, IRC Section R104.11, and CBC Section 104.11.

3. General product Category Description:

Shear Wall Assembly: The shear wall shall be limited to the sheathing, fasteners, connectors, and framing members intended for recognition in the evaluation report.

3.1. Materials:

3.1.1. Framing Members: The cold formed steel-framing members used in the tests shall comply with Chapter 2211 of both the IBC and CBC. The wood framing members used in the tests shall comply with Chapter 23 of both the IBC and CBC. Vertical elements, boundary elements and associated framing members not a part of the scope of this criteria shall be consistent with the referenced material chapter of the model code as well as standard design and construction practices.

3.1.2. Fasteners: The standards and specifications applicable to the fasteners shall be disclosed and the minimum structural properties of the fasteners shall be specified. Fasteners shall be fully described, including fastener type, size, length, location, penetration, and edge distance. Standards pertaining to the fasteners shall be disclosed in the report. Wall assemblies shall be constructed with fasteners having approved values. Where no values are recognized by the applicable code, the fasteners shall be listed in a current IAPMO ES evaluation report.

3.1.3. Steel Sheets: The sheet steel shall comply with the standard specified for the product for which recognition is sought.

3.1.4. Non-structural Sheathing: Where the steel sheet is part of a composite material or assembly, the non-structural sheathing shall comply with the standard specified for the product for which recognition is sought.

3.1.5. Steel-Sheathing: A sheathing assembly consisting of flat uncorrugated steel sheets. The steel sheet may be included as part of a composite assembly.

4. Requirements

4.0.1 Testing Laboratories: Testing laboratories shall meet the requirements for compliance with the International Accreditation Service (IAS) ISO/IEC Standards 17025 or accredited independent agency recognized by the International Laboratory Accreditation Cooperation Mutual Recognition Arrangement or ANSI. Testing at a non-accredited laboratory may be permitted by IAPMO ES, provided the testing is conducted under the supervision of an accredited laboratory and the supervising laboratory issues the test report as specified in IAPMO ES-011.

4.0.2 Test Reports: Test reports shall be submitted to IAPMO ES for approval. The resulting test failure mode shall be specified in the test report.

4.0.3 Product Sampling: Sampling of the shear wall components for tests under this criteria shall be approved by IAPMO ES.

4.1. Performance Requirements

4.1.1. Performance requirements

4.1.1.1. Shear design values for the wall assemblies may be based on the average of the test values if variation limits set forth in Section 4.1.3.3 are satisfied. Otherwise, the lowest of the test values shall be used.

4.1.1.2. Load values for both Allowable Stress Design (ASD) and Load and Resistance Factor Design (LRFD) shall be based on the first cycle backbone (envelope) curve. The actual design capacities shall be determined as outlined in Section 4.1.1.4.

4.1.1.3. The seismic design coefficients and factors listed in ASCE/SEI 7, Table 12.2-1 for light-frame shear wall bearing wall systems shall apply to the use of design loads under both the IBC and CBC, subject to all the limitations contained herein. Additionally, an analysis comparing test results to those obtained from similar code-based assemblies of both steel sheet and wood structural panel shear walls shall be submitted to IAPMO ES. The analysis shall compare the envelope of measured strength versus peak strength and the tested sheathing product shall fit favorably within the envelope of behavior resulting from code-based assemblies of similar aspect ratio and of similar light-frame construction, reference Figure 1 and 2.

4.1.1.4. 2012, 2009 IBC, and 2010 CBC Design Strength

4.1.1.4.1. Allowable Stress Design (ASD): The available ASD strength of a shear wall assembly shall be taken as the lesser of the allowable strength based on lateral displacement and the peak strength of the wall assembly as defined below:

4.1.1.4.1.1. Lateral Displacement: The available ASD seismic and wind strength shall be determined on the basis of the provisions in ASCE/SEI 7, Sections 12.2.1 and 12.8.6, as referenced in both the IBC and CBC Section 1613.1, as follows:

- 4.1.1.4.1.1.1. The maximum inelastic response displacement Δ_m shall be limited to the smaller of the code-specified allowable seismic story drift Δ_a in accordance with Table 12.12-1 of ASCE/SEI 7 and the lateral displacement Δ_{VPEAK} corresponding to the peak strength of the shear wall assembly.
- 4.1.1.4.1.1.2. Using the C_d value in accordance with Section 4.1.1.3 of this criteria, and an importance factor I equal to 1.0 regardless of the importance factor used in the design of the overall structure, the available Strength Level Design (Load and Resistance Factor Design—LRFD) response displacement, Δ_s , shall be calculated in accordance with ASCE/SEI 7, Section 12.8.6, as $\Delta_s = \Delta_m / C_d$.
- 4.1.1.4.1.1.3. Using the first-cycle backbone curve defined in Section 4.1.1.2, the shear wall strength V_s corresponding to Δ_s shall be determined. V_s defines the available LRFD strength of the wall assembly.
- 4.1.1.4.1.1.4. In accordance with the seismic load combinations in ASCE/SEI 7, Section 2.4.1, the drift-based available ASD strength of the shear wall assembly V_{ASD} shall be determined as 0.7 times the available LRFD strength V_s .
- 4.1.1.4.1.1.5. The lateral displacement $\Delta_{V_{ASD}}$ corresponding to the available ASD strength V_{ASD} shall be derived from the first-cycle backbone curve and $\Delta_{V_{ASD}}$ shall be included in the evaluation report.
- 4.1.1.4.1.2. Peak Strength: Using the first-cycle backbone curve defined in Section 4.1.1.2, the available seismic and wind ASD strengths shall be determined as the peak strength V_{PEAK} of the wall assembly divided by a factor of safety of 2.5 for seismic design and 2.0 for wind design. The lateral displacement $\Delta_{V_{ASD}}$ corresponding to each (seismic and wind) available ASD strength V_{ASD} shall be derived from the first-cycle backbone curve and $\Delta_{V_{ASD}}$ shall be included in the evaluation report.
- 4.1.1.4.2. Load and Resistance Factor Design (LRFD): The available LRFD (Strength Level Design) strength shall be determined as the lesser of the strengths based on lateral displacement and the peak strength of the shear wall assembly as defined below:
- 4.1.1.4.2.1. Lateral Displacement: The available LRFD seismic and wind strength shall be determined as the strength V_s in accordance with Section 4.1.1.4.1.1.3 of this criteria. The lateral displacement Δ_s corresponding to V_s (Section 4.1.1.4.1.1.3 of this criteria) shall be included in the evaluation report.
- 4.1.1.4.2.2. Peak Strength: Using the first-cycle backbone curve defined in Section 4.1.1.2, the available seismic and wind LRFD strength shall be determined as the peak strength V_{PEAK} of the wall assembly multiplied by a resistance factor $\phi = 0.55$ for seismic design and $\phi = 0.60$ for wind design. The lateral displacement Δ_s corresponding to each (seismic and wind) available LRFD strength V_s shall be derived from the first-cycle backbone curve and Δ_s shall

be included in the evaluation report.

4.1.2. Limiting values for performance requirements

- 4.1.2.1. Aspect Ratio: The tested wall assemblies shall have dimensions and height to width (H:W) aspect ratios consistent with the intended use. The tested aspect ratio shall be the maximum recognized in the evaluation report for each model tested. Tests shall be performed at a maximum aspect ratio of 2¼:1. Alternatively, values may be reported using a smaller tested aspect ratio provided the ratio is not smaller than 1:1.
- 4.1.2.2. Panel Sizes: The minimum panel width and maximum panel height shall be tested and be consistent with the approval being sought. All splice conditions shall be reported.
- 4.1.2.3. Boundary Conditions: All forces transferred to the tested sheathing shall be through the designated fasteners. The tested sheathing shall not be allowed to bear upon the base or other members of the test assembly. All boundary conditions shall be documented. Splices in track or horizontal elements shall be reported.
- 4.1.2.4. Boundary Elements: All boundary elements shall be calculated and shown to be in conformance with the appropriate material chapter of the model code. All framing members and boundary elements shall be reported and shall be shown to not control the failure of the test.

4.1.3. Test Methods to verify performance requirements

- 4.1.3.1. Steel Sheet: The base-steel thickness (uncoated) of the sheet steel used in the sheet steel panels shall be measured and reported. Base-steel thickness is the thickness of the steel exclusive of any coating, such as galvanization. The yield strength and ultimate tensile strength of the sheet steel shall be measured. The measured strengths shall meet the minimum specified strengths for the particular steel grade when tested in accordance with ASTM A370.
- 4.1.3.2. Test Setup:
 - 4.1.3.2.1. The bottom track/plate of the wall assembly shall be attached to a fixed base in such a manner that in-plane displacement of the sheathing is not restricted.
 - 4.1.3.2.2. The bottom track/plate of the wall assembly shall be adequately connected to the fixed base so as to exceed the expected shear transfer requirements.
 - 4.1.3.2.3. Hold-downs and boundary elements shall be installed at each end of the wall assembly. The capacity of the hold-downs shall exceed the anticipated peak strength of the wall assembly.
 - 4.1.3.2.4. A loading plate connected to the wall assembly top plate shall be used to distribute the applied load along the top of the wall. The loading plate shall be attached to the wall assembly in such a manner that in-plane displacement of the sheathing is not restricted.
 - 4.1.3.2.5. Each test assembly shall be instrumented to measure the following displacements at the locations indicated:
 - 4.1.3.2.5.1. Lateral in-plane displacement at the top of wall.
 - 4.1.3.2.5.2. Uplift and compression displacement at each end of wall.
 - 4.1.3.2.5.3. Base slip.
 - 4.1.3.2.5.4. Applied racking loads shall be measured. Hold-down load measurement is optional.

4.1.3.2.6. Test equipment shall be capable of recording racking loads and displacements at a minimum rate of 50 readings per cycle.

4.1.3.3. Test Procedure:

4.1.3.3.1. Racking shear loads shall be applied to the top of the wall assembly, displacing the top of the wall in accordance with the displacement schedule described in Section 4.1.3.3.2.

4.1.3.3.2. Cyclic Load Test Protocol

4.1.3.3.3. In-plane Cyclic Shear Load Tests: To comply with this criteria, in-plane cyclic shear tests in accordance with Section 1.3.11 are required.

4.1.3.3.4. Termination of Loading History: The loading history defined in Section 4.1.3.3.3 of this criteria shall be continued until the resistance of the wall assembly decreases to 50 percent of the peak assembly strength.

4.1.4. Number of required Test specimens: A minimum of three identical wall assemblies of a given construction shall be tested. The average of the three test results may be used if each of the three values is within 15 percent of the average, otherwise, the lowest of the three test values shall be used. Alternatively, the average of five or more identical tests may be used, regardless of variations.

4.2 Quality Assurance Requirements

4.2.1 IAPMO ES approved inspections of manufacturing facilities are required for this product.

4.2.2 Quality documentation complying with the IAPMO ES Minimum Requirements for Listee's Quality Assurance System (IAPMO ES-010) shall be submitted.

5. Field Identification of Evaluated products The evaluation report shall identify one of the following two options for field identification of evaluated products:

Option I) A permanent label bearing the name and address of the manufacturers, the model number, IAPMO ES Mark of Conformity, and this evaluation report number (Evaluation Report XXXX) identifies the products listed in this report.

Option II) A die-stamp label bearing the name and address of the manufacturers, the model number, IAPMO ES Mark of Conformity, and this evaluation report number (Evaluation Report XXXX) identifies the products listed in this report.

IAPMO-ES EC-003 Qualification of Test Data

Shear walls with design values derived from tests in accordance with IAPMO-ES EC-003 are permitted to be used as alternatives to the conventional wood and cold-formed steel (c-fs) frame shear walls – as described in ASCE/SEI 7-05 and -10, Table 12.2-1 – provided, in addition to meeting the analysis criteria prescribed in IAPMO-ES EC-003, the applicable test data falls within or exceeds the performance indicated by the bounds of existing test data for the code approved walls. Figures 1 and 2 illustrate the range of behavior exhibited by light frame shear walls with aspect ratios between 1:1 and 4:1 – predominantly 1:1 and 2:1.

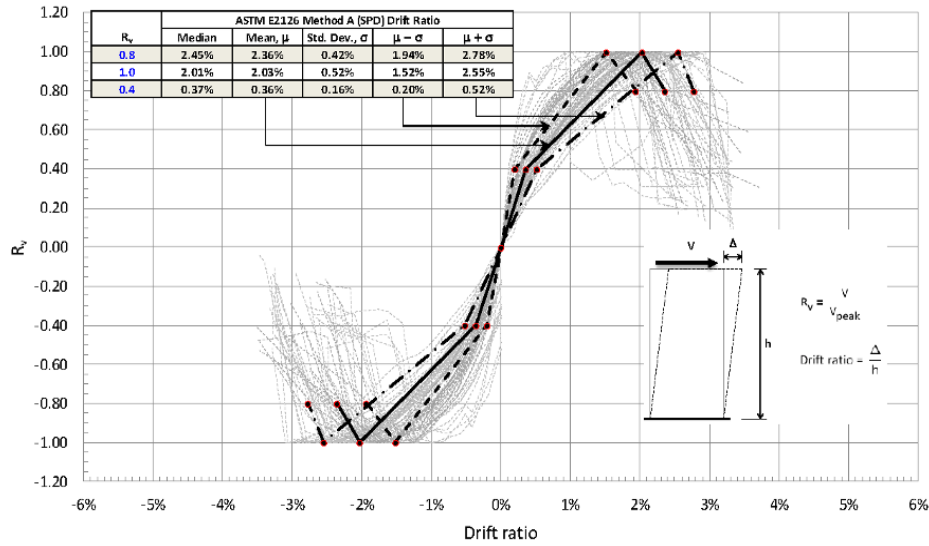


Figure 1. Performance data using ASTM E2126 Method A – c-fs framing data

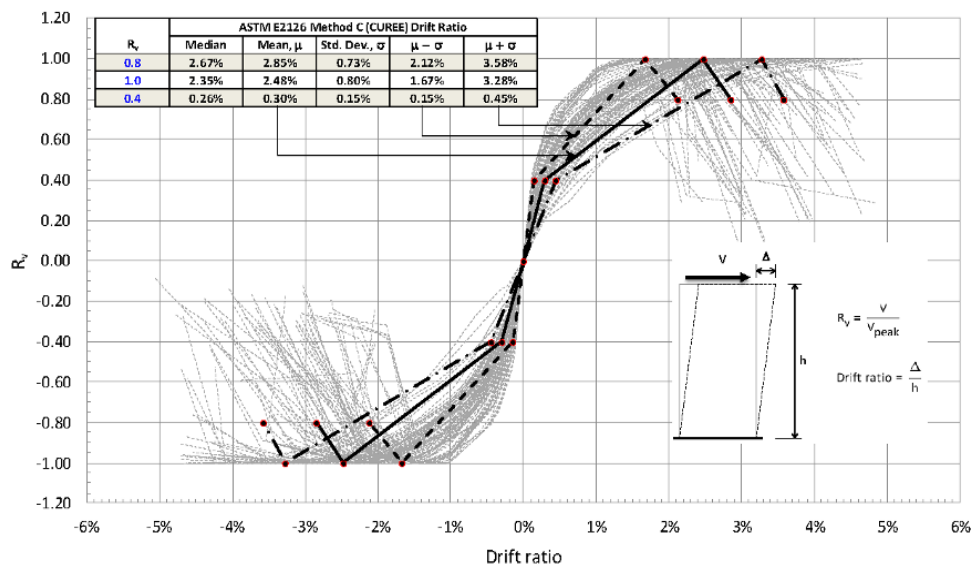


Figure 2. Performance data using ASTM E2126 Method C – c-fs and wood framing data