ACCEPTANCE CRITERIA FOR SANDWICH PANELS

AC04

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PREFACE

Evaluation reports issued by ICC Evaluation Service, Inc. (ICC-ES), are based upon performance features of the International family of codes and other widely adopted code families, including the Uniform Codes, the BOCA National Codes, and the SBCCI Standard Codes. Section 104.11 of the *International Building Code*® reads as follows:

> The provisions of this code are not intended to prevent the installation of any materials or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

Similar provisions are contained in the Uniform Codes, the National Codes, and the Standard Codes.

This acceptance criteria has been issued to provide all interested parties with guidelines for demonstrating compliance with performance features of the applicable code(s) referenced in the acceptance criteria. The criteria was developed and adopted following public hearings conducted by the ICC-ES Evaluation Committee, and is effective on the date shown above. All reports issued or reissued on or after the effective date must comply with this criteria, while reports issued prior to this date may be in compliance with this criteria or with the previous edition. If the criteria is an updated version from the previous edition, a solid vertical line (**I**) in the margin within the criteria indicates a technical change, addition, or deletion from the previous edition. A deletion indicator (**➜**) is provided in the margin where a paragraph has been deleted if the deletion involved a technical change. This criteria may be further revised as the need dictates.

ICC-ES may consider alternate criteria, provided the report applicant submits valid data demonstrating that the alternate criteria are at least equivalent to the criteria set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. Notwithstanding that a product, material, or type or method of construction meets the requirements of the criteria set forth in this document, or that it can be demonstrated that valid alternate criteria are equivalent to the criteria in this document and otherwise demonstrate compliance with the performance features of the codes, ICC-ES retains the right to refuse to issue or renew an evaluation report, if the product, material, or type or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or if malfunctioning is apt to cause unreasonable property damage or personal injury or sickness relative to the benefits to be achieved by the use of the product, material, or type or method of construction.

ACCEPTANCE CRITERIA FOR SANDWICH PANELS

1.0 INTRODUCTION

The purpose of this criteria is to provide a procedure for recognition of sandwich panels in ICC Evaluation Service, Inc., (ICC-ES) evaluation reports under the 2003 *International Building Code*® (IBC), the 2003 *International Residential Code*® (IRC), the BOCA® *National Building Code*/1999 (BNBC), the 1999 *Standard Building Code*© (SBC) and the 1997 *Uniform Building Code*™ (UBC). Bases of recognition are IBC Section 104.11, IRC Section R104.11, BNBC Section 106.4, SBC Section 103.7 and UBC Section 104.2.8. This criteria is general in nature and is applicable to all sandwich panels except where other current ICC-ES acceptance criteria are applicable to specific configurations or compositions of panels.

1.1 Panel Justification Options:

1.1.1 Panels may be justified by load tests as described in Section 4. Justification by this method limits their use to sizes and materials used in the tests. Allowable loads determined may be used for shorter spans or heights but extrapolation is not permitted.

1.1.2 Panels may be justified by a rational analysis based on allowable stresses developed as described in Section 5.

1.2 Testing Laboratories, Reports of Tests and Sampling of Specimens:

1.2.1 Testing Laboratories: Testing laboratories shall comply with the ICC-ES Acceptance Criteria for Test Reports (AC85) and Section 4.2 of the ICC-ES Rules of Procedure for Evaluation Reports.

1.2.2 Test Reports: Test reports shall comply with AC85.

1.2.3 Specimens shall be representative of standard manufacture in conformance with the minimum requirements of the quality control manual addressed in Section 8 of this criteria. The specimens shall be sampled in accordance with Section 3.1 of AC85.

1.3 Factors of Safety:

1.3.1 Factors of safety are set forth in subsequent sections and are based on the materials involved, test procedure, panel deformation and variation of results.

1.3.2 Allowable values developed under Section 1.3.1 are not subject to increase due to duration of loading unless specifically allowed. This includes wind and seismic loads.

1.3.3 Where loading conditions result in several modes of superimposed stressing, the sum of the ratios of actual loads over allowable loads shall not exceed one. Transverse wind loads on a bearing wall is one example requiring this consideration.

1.4 Supplementary Information: Supplementary information may be included in the evaluation report, provided it is justified and relates to the IBC, IRC, BNBC, SBC, or UBC. This includes sound transmission insulation as specified in IBC Section 1207, IRC Appendix K, BNBC Section 1214.0 and Division II of UBC Appendix Chapter 12, and thermal transmission data. Recognition of fire-resistive assemblies requires reports of tests in compliance with Chapter 7 of the IBC, BNBC, SBC and UBC, and IRC Chapter 3.

1.5 Referenced Documents: Where standards are referenced in this criteria, the standards shall be applied consistently with the code (IBC, IRC, BNBC, SBC, or UBC) upon which compliance of the sandwich panels is based. Editions of the standards applicable to each code are summarized in Table 1.

1.5.1 American Society for Testing and Materials (ASTM):

1.5.1.1 ASTM C 271, Test Method for Density of Core Materials for Structural Sandwich Constructions.

1.5.1.2 ASTM C 272, Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions.

1.5.1.3 ASTM C 297, Method for Tension Test of Flat Sandwich Constructions in Flatwise Plane.

1.5.1.4 ASTM C 365, Test Methods for Flatwise Compressive Strength of Sandwich Cores.

1.5.1.5 ASTM C 393, Method for Flexural Test of Flat Sandwich Constructions.

1.5.1.6 ASTM C 481, Test Method for Laboratory Aging of Sandwich Constructions.

1.5.1.7 ASTM D 1037, Method for Evaluating the Properties of Wood-Base Fiber and Particle Panel Materials.

1.5.1.8 ASTM D 2559, Specification for Adhesives for Structural Laminated Wood Products for Use Under Exterior (Wet Use) Exposure Conditions.

1.5.1.9 ASTM E 72, Method of Conducting Strength Tests of Panels for Building Construction.

1.5.1.10 ASTM E 84, Test Method for Surface Burning Characteristics of Building Materials.

1.5.1.11 ASTM E 661, Test Method for Performance of Wood and Wood-Based Floor and Roof Sheathing Under Concentrated Static and Impact Loads.

1.5.1.12 ASTM E 2126, Test Methods for Cyclic (Reversed) Load Test for Shear Resistance of Framed Walls for Buildings.

1.5.2 2003 *International Building Code*® (IBC), International Code Council.

1.5.3 2003 *International Residential Code*™ (IRC), International Code Council.

1.5.4 BOCA® *National Building Code*/1999 (BNBC).

1.5.5 1999 *Standard Building Code*© (SBC).

1.5.6 1997 *Uniform Building Code*™ (UBC).

2.0 PANEL DESCRIPTION

The panel description is to include the following information:

2.1 Dimensions: Thickness, width and length for each panel type.

2.2 Panel-facing Material:

2.2.1 The material shall be acceptable under a current ICC-ES evaluation report, a recognized product standard the

IBC, IRC, BNBC, SBC, or UBC, or be justified to the satisfaction of the ICC-ES. The material shall be clearly identified to determine compliance.

2.2.2 Exterior panel facings that remain exposed on weather-exposed surfaces, as defined in UBC Section 224, IBC Section 2502 and IRC Section R703, shall be justified to the satisfaction of ICC-ES for this use.

2.2.3 Panel facings subject to axial or racking shear loads shall have approved values for fasteners. Where no values are recognized by the ICC-ES, fastener tests shall be conducted for both shear and fastener pull-through at the minimum edge distances contemplated. Allowable values for fasteners may control allowable panel loads, when they are more restrictive than the panel test values. Specimens shall be conditioned and, where skins are subject to wetting, shall be additionally tested in that manner. Sections 41 through 67 of ASTM D 1037 serve as a guide for test procedures, which shall have ICC-ES concurrence prior to testing.

2.2.4 Panel facings exposed to the building interior shall have flame-spread and smoke-density ratings as specified in IBC Section 803.1, IRC Section R319 BNBC Section 803.2, SBC Section 803.2, and UBC Section 802.2. Plastic materials shall be approved plastics as set forth in IBC Sections 2602.1 and 2606.4 for use under the IBC or IRC; BNBC Sections 2601.2 and 2604.1 for use under the BNBC; SBC Section 202 for use under the SBC; and UBC Section 217 for use under the UBC. When these characteristics are affected by the core material of the panel, the combined section shall be tested when deemed necessary by the ICC-ES.

2.2.5 Wood-based sheathing facings of sandwich panels shall be protected against decay and termites in accordance with IBC Sections 2304.11.2.2 and 2304.11.2.5, IRC Sections R319 and R320, BNBC Section 2311.4.2, SBC Section 2304, and UBC Section 2306.8, as applicable.

2.3 Panel Cores:

2.3.1 Honeycomb specifications are to include a detailed description or illustration noting the thickness, cell size, kraft paper weight or metal thickness, direction of the paper or metal ribbon, percent impregnation of materials, etc.

2.3.2 Foam plastic specifications are to include the density, thickness, whether it is preformed slab, frothed or expanded, foam manufacturer and the type, catalog number, etc. The position of the panel during the frothing or pouring operation is to be specified.

2.3.3 Other core materials with specifications and descriptions will be considered.

2.3.4 When the core material does not completely fill the portion between panel facings, voids shall be detailed or properly described. Voids formed by honeycomb cells are not regulated by this subsection. The method used to maintain voids during foaming or bonding shall be described.

2.3.5 Core materials classified as noncombustible shall be justified under IBC Section 703.4, IRC Section R202, BNBC Section 704.4, SBC Section 202, and UBC Section 215, as applicable. Combustible core materials, except foam plastic, shall have a minimum Class III flame-spread classification not exceeding 200 and smoke-density rating not exceeding 450 when tested under ASTM E 84 for use under the IBC, IRC, BNBC, and SBC; and UBC Standard 8-1 for use under the UBC; in the thickness intended for use. Foam plastic cores shall comply with IBC Sections 2602.1 and 2603 and IRC Section R314 and the ICC-ES Acceptance Criteria for Foam Plastic Insulation (AC12).

2.4 Adhesives: Any adhesives used shall comply with ASTM D 2559 or the ICC-ES Acceptance Criteria for Sandwich Panel Adhesives (AC05). Adhesive specifications are to include the type, class, thickness of application, number of coats and assembly instructions, etc. Panel cores that are factory poured or frothed between panel facings and self adhere to panel facings shall comply with appropriate sections of the ICC-ES Acceptance Criteria for Sandwich Panel Adhesives (AC05).

Exception: Cores that self-adhere to panel facings of panels limited to use as nonbearing walls or roofs with a maximum allowable uniform live load of 20 psf (958 Pa) do not need to be tested in accordance with AC05 provided the panel manufacturer certifies the core's adhesive bond durability based on satisfactory field performance.

2.5 Panel Plates and Splines: Wood plates, splines, studs, blocking, etc., are to have wood species, grades, preservative treatments and maximum moisture contents at time of panel manufacture specified. Lumber shall be stress graded or stress-rated material. Lumber bonded to panel facings with adhesives shall have a moisture content not in excess of that recommended by the adhesive manufacturer, between 7 and 16 percent, or not exceeding a difference of 5 percent between the two materials bonded, whichever is more restrictive. Complete cross-sectional properties of the members are required.

2.6 Connections: Connections shall be detailed or adequately described. Fasteners shall be properly specified, including size, length and location.

2.7 Door and Window Openings: Details for door and window openings shall be provided to clarify the manner of supporting axial, transverse and/or racking shear loads. This includes the method of resisting wind loads at door and window jambs.

3.0 MISCELLANEOUS PANEL INFORMATION

3.1 Substitutions: No substitution of materials is allowed unless permitted by ICC-ES.

3.2 Field-cutting of Panels: Field-cutting of wall openings is not allowed unless specific openings or design parameters are permitted by ICC-ES.

3.3 Load Tests on Entire Structures: Test loads and manner of application to full structures shall be specified by the ICC-ES when design parameters for the full structure cannot be readily determined by accepted engineering principles.

3.4 Wall Panel Facings: Wall panel facings shall have sufficient strength to resist concentrated loads and prevent damage on the core material under loads to which they may be subjected.

3.5 Plumbing Installation Restrictions: Plumbing and waste lines may extend at right angles through the wall panels but are not permitted vertically within the core. Lines shall not interrupt splines or panel plates unless specifically permitted by ICC-ES.

3.6 Electrical Installation Restrictions: Electrical outlet boxes and raceways may be installed in the panels during fabrication at predetermined locations only. Electrical systems are limited to a single 1-inch (25.4 mm) maximum (outside diameter) vertical raceway at a minimum of 4 feet (1219 mm) on center, which is shop-installed with no more than three outlet box openings 4 inches by 4 inches (102 mm by 102 mm) in size. Two $^1/_2$-inch (12.7 mm) vertical raceways may be substituted for the single 1-inch (25.4 mm) raceway, provided they are maintained parallel and within 2 inches (51 mm) of each other.

3.6.1 Voids other than those specified in Section 3.6 will be permitted for field or shop installation of electrical wiring, provided the voids were in the panels tested. See Section 3.2 for field cut openings.

3.6.2 Where electrical raceways interrupt or reduce the cross section of wall plates, a method of strengthening the plate at that point for both lateral and plate axial loads shall be developed, detailed and submitted for evaluation.

3.7 Flashing: Flashing and other weatherproofing details are required for panel joints, wall openings, etc.

4.0 PANEL LOAD TEST OPTION

4.1 Purpose: In lieu of determining structural and mechanical properties of panel components for rational design purposes under Section 5, load tests may be conducted to determine reasonable ultimate values to which factors of safety are applied. Tests unrelated to the intended use of the panels are unnecessary. As an example, only tests under Section 4.3, Wall Panels Transverse Load Tests, are needed for panels used on exterior, nonbearing, nonshear curtain walls.

4.2 General:

4.2.1 The tests are to be conducted as set forth in Section 1.2.

4.2.2 Three tests of each type are required with none of the results varying more than 15 percent from the average of the three, unless the lowest test value is used. The average result based on a minimum of five tests may be used regardless of the variations. The results of two tests may be used when the higher value does not exceed the lower value by more than 5 percent and the lower value is used with the required factors of safety.

4.2.3 Where tests are not conducted to failure, the highest load achieved for each test will be assumed as ultimate.

4.2.4 Factors of safety are dependent on the consistency of materials, the range of test results and the load deformation characteristics of the panel. Generally a minimum factor of safety of three is applied to the ultimate load based on the average of three tests. Lower factors of safety may be assigned to panels or systems employing steel or aluminum having consistent physical properties.

For patio cover roof panels limited to recognition under IBC Appendix Chapter I, or IRC Appendix Chapter H, or Division III of UBC Appendix Chapter 31, and consisting of metal facings and foam plastic cores, either factory-adhered or foamed-in-place, the following factors of safety are applicable to uniform transverse loads:

F.S. = 2.0, ultimate load determined by bending (facing buckling) failure for allowable live loads up to 20 psf (958 Pa) and wind loads.

F.S. = 2.5, ultimate load determined by bending (facing buckling) failure for allowable snow loads.

F.S. = 2.5, ultimate reaction at failure for all loading conditions.

F.S. = 3.0, ultimate load at shear failure for all loading conditions.

4.2.5 Allowable loads will be limited by established fastener values except as noted in Section 4.4.2 or deflection limitations if lower than values from panel loading tests.

4.2.6 Splines or stiffeners, when utilized along the edges of the panel tests, shall be only that portion of the typical construction relative to the panel being tested and not supplemented by adjacent panel spline areas.

4.2.7 Unless otherwise noted in this criteria, load tests shall be conducted with panel support conditions as specified in ASTM E 72. The effects of field installation conditions of panels shall be evaluated to determine if the panel's support conditions adversely affect the panel's performance.

4.3 Wall Panel Transverse Load Tests:

4.3.1 With the design load imposed, exterior wall panel deflections shall not exceed the deflection limits of IBC Table 1604.3 for use under the IBC or IRC, or exceed L/180 for use under the BNBC, SBC, and UBC. Positive and negative pressure conditions shall be considered. Wall panels with different facing materials on opposite faces shall be tested for loads acting both inwardly and outwardly where there is a question of the most critical direction.

4.3.2 With a 5-pound-per-square-foot (239 Pa) horizontal loading imposed, interior wall panel deflections shall not exceed L/120 of the span for flexible facing material such as metal, plywood, particleboard and gypsum wallboard. A deflection limitation of L/240 of the span is required for brittle facing materials such as plaster.

4.3.3 All wall panels shall be loaded in increments to failure with deflections taken to obtain deflection and set characteristics. Application of load and duration of load application shall be in accordance with Sections 4.2 and 4.3 of ASTM E 72. Where preloading is applied, the loading, deflection and recovery shall be noted. The amount of preloading shall not exceed 10 percent of the final allowable load unless permitted by the ICC-ES.

4.3.4 As an alternate to limiting the allowable loads for shorter spans to loads determined from one test series as described in Section 1.1.1, additional full-scale testing shall include the maximum and minimum panel spans intended for recognition. No extrapolation beyond these spans or corresponding loads will be permitted.

4.3.5 Variations in facing thickness will require additional full-scale testing. Thicknesses tested shall "envelope" the range desired with interpolation of results between tested values.

4.3.6 Variation in panel strength and stiffness due to the effects of the pour direction of poured/foamed-in-place foam plastic cores will require additional full-scale testing.

4.3.7 Multiple-span full-scale testing will be required if recognition of multiple spans is desired.

4.3.8 The "bag method," vacuum chamber or a uniform loading of known unit weights shall be used.

4.3.9 Transverse load tests on panels having window or door openings are required unless subject to rational analysis. Load application shall be done in a manner that reflects field loading conditions.

4.3.10 Deflection readings are to be taken at mid-span, within 3 inches (76 mm) of each edge and at the center of the panel width. For panel widths less than 24 inches (610 mm), the edge readings shall be taken at a distance from each panel edge not more than ten percent of the panel's width. Panels tested over a double span are to have the same three deflection readings taken at the expected maximum deflection point based on analysis.

4.4 Wall Panel Axial Load Tests:

4.4.1 Load-bearing wall panels shall support an axial loading applied with an eccentricity of one-sixth the panel thickness to the interior or towards the weaker facing material of an interior panel. The test setup shall be capable of accommodating rotation of the test specimen at the top of the wall due to out-of-plane deflection with the load applied throughout the duration of the test with the required eccentricity.

4.4.2 The allowable axial load is determined from the axial load at a net axial deformation of 0.125 inch (3.18 mm) or the ultimate load divided by a factor of safety determined in accordance with Section 4.2.4, whichever is lower. In addition, loads transferred by fasteners shall not exceed established fastener values.

4.4.3 The test panel shall have wall sill and cap plate details with connections matching the proposed field installation. Axial loads shall be applied uniformly or at the anticipated spacing of the floor or roof framing.

4.4.4 For panels that are field installed without bearing on the full panel thickness, the bottom edges of the panel facing material shall be held at least $^3/_4$ inch (19.1 mm) above the base of the sill plate to ensure no direct bearing of the facings against test equipment framing. Panels may be inverted during testing if desired to meet the above loading requirements. If, due to deflection, the $^3/_4$-inch (19.1 mm) panel base clearance is dissipated, the load at this point shall be specified.

4.4.5 Lintel sections shall meet the deflection criteria of IBC Section 1604.3.6 for use under the IBC and IRC, and BNBC Section 1604.5, SBC Section 1610, and UBC Section 1613, as applicable.

4.4.6 All wall panels shall be loaded in increments to failure with deflections taken to obtain deflection and set characteristics. Application of load and duration of load application shall be in accordance with Sections 4.2 and 4.3 of ASTM E 72. Where preloading is applied, the loading, deflection and recovery shall be noted. The amount of preloading shall not exceed 10 percent of the final allowable load unless permitted by the ICC-ES.

4.5 Wall Panel Racking Shear Tests:

4.5.1 Racking shear tests in accordance with ASTM E 72, as amended by this criteria, are required for shear walls that resist wind and seismic loads. For use under the IBC, shearwalls of sandwich panels are limited to Seismic Design Categories A, B and C.

Exception: When tested in accordance with the requirements set forth in Appendix A, shearwalls of sandwich panels are permitted to be used in all IBC Seismic Design Categories. Appendix B provides an example of the application of Appendix A.

4.5.2 The allowable shear load is determined from the racking load at which a net horizontal deflection of $^1/_2$ inch (12.7 mm) occurs, the ultimate load divided by a factor of safety determined in accordance with Section 4.2.4, or the allowable fastener loads, whichever is the lower. The test panel shall be constructed and installed as intended in the field, including connections. Reference is also made to Section 4.2.6 of this criteria.

Hold-down rods may be used provided allowable net horizontal deflections are reduced to $^1/_8$ inch (3.18 mm).

4.5.3 The "stop" detailed in the ASTM E 72 procedure for installation against the toe of the test panel shall be located in such a manner that reactive forces are imposed against the end of the sill plate and clear of the panel spline and facing material.

4.5.4 The bottom edges of the panel facing material shall be held at least $^3/_4$ inch (19.1 mm) above the base of the sill plate to ensure against direct vertical bearing or frictional shear resistance of the facings against test equipment framing. The testing laboratory shall indicate the load at which the $^3/_4$-inch (19.1 mm) panel base clearance from the test frame is dissipated.

4.5.5 The panel top horizontal timber suggested for the test panel in the ASTM E 72 sketch shall not be used. The racking shear load should be applied directly against the typical wall panel top plate member or members that duplicate actual field construction unless otherwise permitted.

4.5.6 All wall panels shall be loaded in increments to failure with deflections taken to obtain deflection and set characteristics. Where preloading is applied, the loading, deflection and recovery shall be noted. The amount of preloading shall not exceed 10 percent of the final allowable load unless permitted by the ICC-ES.

4.6 Roof and Floor Panels:

4.6.1 Uniform Loads:

4.6.1.1 Allowable loads for roof and floor panels shall be based on the following:

4.6.1.1.1 Allowable loads determined under Sections 4.2.2 through 4.2.7.

4.6.1.1.2 Except for patio cover roof panels with metal facings, panels shall comply with the deflection requirements in IBC Table 1604.3 for use under the IBC and IRC, and BNBC Section 1604.5, SBC Section 1610, and UBC Table 16-D, as applicable. Additionally, roof panels used under the UBC, other than patio cover roof panels with metal facings, shall be limited to a maximum deflection of the span divided by 180 when subjected to roof live load or snow load, whichever governs. Patio cover roof panels with metal facings shall be limited to a total gravity load deflection of the span divided by 120. Patio cover roof

panels with metal facings shall be limited to a total wind uplift load deflection of the span divided by 60.

4.6.1.1.3 For roof panels, water accumulation or water ponding shall be addressed in accordance with IBC Section 1611.2 under the IBC and IRC, BNBC Section 1607.5, footnote 3 to SBC Table 1610.1, and UBC Section 1611.7, as applicable.

4.6.1.2 Deflection readings are to be taken at mid-span, within three inches (76 mm) of each edge and at the center of the panel width. For panel widths less than 24 inches (610 mm), the edge readings shall be taken at a distance from each panel edge not more than ten percent of the panel's width. Panels tested over a double span are to have the same three deflection readings taken at the expected maximum deflection point based on analysis.

4.6.1.3 Roof panels having different facing materials on the same panel are to be tested so each facing material will be in compression and tension. Floor panels or panels tested on a two-span condition need not be tested in both directions.

4.6.1.4 The "bag method," vacuum chamber or a uniform loading of known unit weights shall be used for transverse tests.

4.6.1.5 Application of load and duration of load application shall be in accordance with Sections 4.2 and 4.3 of ASTM E 72.

4.6.2 Concentrated Load Tests:

4.6.2.1 Facings of roof and floor panels shall be capable of supporting, without failure, a 300-pound (1334 N) concentrated load applied to a 3-inch-diameter (76 mm) disc. A minimum of three tests shall be conducted for each facing and core combination. Tests shall be conducted in accordance with ASTM E 661.

4.6.2.2 Concentrated load tests for floor panels are necessary for loads specified in IBC Section 1607.4 for use under the IBC or IRC, BNBC Section 1606.3, SBC Section 1604.3, and UBC Section 1607.3.3, as applicable.

4.6.2.2.1 Allowable loads for floor panels are determined under Sections 4.2.2 to 4.2.7. Panels shall comply with the deflection requirements in IBC Table 1604.3 for use under the IBC or IRC, and BNBC Section 1604.5, SBC Section 1610, and UBC Table 16-D, as applicable.

4.6.2.2.2 Deflection readings are taken at mid-span at each edge and the panel center. Panels tested over a double span shall have the same three deflection readings taken at the expected maximum deflection point based on analysis.

4.7 Density–Water Absorption Tests—Foamed Plastic Core Material:

4.7.1 The density and water absorption characteristics of foamed-in-place cores are to be determined from the load test panels after completion of tests. The test procedure in ASTM C 272 is to be utilized with the following revisions:

4.7.2 The conditioning temperature in Section 4.1.1 of ASTM C 272 is to be increased to 158°F. ± 5°F (70°C ± 2.8°C), in lieu of the specified 122°F (50°C).

4.7.3 Representative specimens shall be taken from panels that have been adequately cured. The report shall specify curing procedures. Panels indicating obvious discrepancies in load test results due to insufficient curing shall not be used.

4.7.4 Six specimens shall be taken from a representative panel of each set subjected to the transverse loading test.

4.7.5 The density–water absorption specimens are to be obtained as follows, assuming a 4-by-8-foot (1219 by 2438 mm) panel. The previously tested full-size solid panels are cut across the 4-foot (1219 mm) dimension 4 to 8 inches (102 to 203 mm) from each end and then longitudinally down the middle of the remaining center portion. Three-inch-square (76 mm) samples are cut from each outside quarter point of the end sections and one sample cut from each of the two remaining center portions, totaling six samples from each panel. The samples are to be cut a minimum of 1 inch (25.4 mm) away from any splines. A sketch is to be included in the laboratory report locating and numbering the position of each specimen.

4.7.6 The 3-inch-square (76 mm) samples are cut to maintain the entire panel thickness, including facings. The volumetric dimensions are measured "as received" and after removal of facings in accordance with Section 3 of ASTM C 272. The density and water absorption tests are conducted in accordance with ASTM C 272 with the facings removed. Care shall be taken to assure that a minimal core material is removed. Dimensions are taken after the first oven curing and after each conditioning of the absorption tests. After the final oven drying, the specimen dimensions are recorded.

4.7.7 The two-hour immersion linear measurement required by ASTM C 272 may be omitted.

4.7.8 Foam density variations for the different sample locations may not vary by more than 25 percent from any other samples taken from the same panel based on the lower value of the two being compared.

4.7.9 Subsequent density–water absorption tests in conjunction with quality control shall follow the same test procedure as used initially to assure the validity of comparing results.

4.8 Density Tests—Preformed Foamed Plastic Core Material: Panels having preformed foam cores bonded in place with an adhesive are to have density tests conducted in accordance with ASTM C 271. Two samples are to be cut from one of each set of panels subjected to the axial, transverse loading and racking shear tests, respectively. The samples are to have the facing material removed, together with any adhesive impregnated core material prior to the density determination. The average density values are to be based on a minimum of six samples. Panels with window and door openings are to have their cores treated in a similar manner.

4.9 Tests for Other Than Foam Plastic Cores: Density, shear and other tests for other than foamed plastic cores shall be determined by the ICC-ES.

4.10 Coefficient of Expansion for Core and Facings: Substantial differences in coefficient of expansion between core and facing materials require justification that this will not be detrimental to the panel integrity. Testing under ASTM C 393 after aging under Cycle B, ASTM C 481 shall be considered sufficient to determine this quality. Heated dry

air shall be increased to 182° F. + 2° F. (83.3°C + 1.14°C) in Cycle B.

4.11 Temperature Differentials on Panel Facings: Substantial differences in temperature between facings of a panel with high coefficients of expansion require justification that this will not be detrimental to the panel integrity.

5.0 PANEL ANALYSIS OPTION

5.1 Purpose: To provide flexibility in panel size with minimal uniform transverse and axial load testing of full-scale panels, the characteristics and allowable stresses for each material used in the panels may be determined to permit a rational analysis. Supplemental uniform transverse and axial load tests on actual panels in accordance with Section 5.6 will be necessary only to verify design assumptions and criteria.

5.2 Facing Material: Each facing material, unless allowable working stresses are established in the IBC, IRC, BNBC, SBC, or UBC are acceptable to ICC-ES is to have the following characteristics determined by representative tests (waiver of any of the characteristics shall be with the concurrence of ICC-ES):

5.2.1 Modulus of elasticity (bending).

5.2.2 Tension parallel to surface.

5.2.3 Tension perpendicular to surface.

5.2.4 Modulus of rupture.

5.2.5 Compression parallel to surface.

5.2.6 Shear parallel to surface.

5.2.7 Density.

5.2.8 Shear modulus.

5.2.9 Fastener values in shear and, where applicable, nail- or screw-head pull-through for each facing material as set forth in Section 2.2.3.

5.3 Core Materials: Panel cores shall have the following characteristics established:

5.3.1 Modulus of elasticity (bending).

5.3.2 Tension perpendicular to surface.

5.3.3 Compression perpendicular to surface.

5.3.4 Shear parallel to surface.

5.3.5 Shear modulus (in each direction for honeycomb and foam materials).

5.3.6 Density for foam plastic and related products, core size, weight and degree of impregnation for paper honeycomb or the standard identification specification for aluminum or light-gauge steel honeycomb.

5.4 Material Tests: Tests to determine the facing and core characteristics are as follows:

5.4.1 Tension—ASTM C 297 for core material, and ASTM D 1037, Sections 21 to 33, for facing material.

5.4.2 Compression—ASTM D 1037, Sections 34 to 40, Procedure B, for facing materials.

5.4.3 Shear and Shear Modulus—ASTM C 273 for core and facing material by tension tests.

5.4.4 Modulus of Rupture—ASTM C 393 for evaluation of facing materials in sandwich construction.

5.4.5 Density—Section 4.7 for frothed or poured-in-place foams, and ASTM C 271 for slab-type foams bonded in place in the panels.

5.4.6 Modulus of Elasticity—ASTM C 393, for facing materials in sandwich construction.

5.4.7 Fastener Values—ASTM D 1037, Sections 41 to 67.

5.4.8 Compression—ASTM C 365, Method "B," for core material.

5.5 Adhesives: Adhesives are to comply with ASTM D 2559 or the ICC-ES Acceptance Criteria for Sandwich Panel Adhesives (AC05).

5.6 Confirmatory Testing: Uniform transverse and axial load tests in accordance with Sections 4.2, 4.3, 4.4 and 4.6.1 shall be conducted on full-scale panels to confirm the design procedures. Axial load tests are not required for nonload-bearing panels. Density and water absorption tests in conformance with Section 4.7 are required for foamed plastics.

5.7 Racking Shear Tests: Racking shear tests in accordance with Sections 4.2 and 4.5 are required for shear walls that resist wind and seismic forces. Density and water absorption tests on six specimens from one panel in conformance with Section 4.7 are required for foamed plastics.

5.8 Concentrated Load Tests: Concentrated load tests of floor and roof panels shall be conducted in accordance with Section 4.6.2.

5.9 Coefficient of Expansion for Core and Facings: Coefficient of expansion of core and facing materials shall be investigated as noted in Sections 4.10 and 4.11.

6.0 ADDITIONAL FABRICATOR QUALIFICATION PROCEDURES

The following procedures are necessary for recognition of supplementary fabricating facilities.

6.1 A qualified representative of a recognized testing agency shall select at least three panels at random of each panel type. The panels are to be permanently identified by the laboratory personnel and shipped to the testing laboratory facility.

6.2 Each of the three panels selected shall be subjected to a transverse load test in accordance with Section 4.3 or Section 4.6.1. The individual test results and the average of the test results shall be no lower than 85 and 90 percent, respectively, of the average original plant transverse test results.

6.3 For foamed-in-place cores, one panel is to be selected for each panel type and six density-water absorption specimens cut from the panel and tested in accordance with Sections 4.7 and 4.8. The density–water absorption test average shall be no lower than 90 percent of the original plant test average nor shall any specimen vary more than 25 percent in density from any other sample taken from the same panel, based on the lowest value.

6.4 The preformed core panel density shall agree with the original core density.

7.0 PANEL IDENTIFICATION

Panels shall bear the company name and address, evaluation report number and other information deemed necessary by the ICC-ES. The identification shall be visible after the panels are erected. Exterior panels shall have the exterior face clearly identified. Panels with foam plastic cores used on noncombustible exterior walls under IBC Section 2603.5, BNBC Section 2603.6, SBC Section 2603.6, or UBC Section 2602.5.2.2 shall be labeled in accordance with IBC Section 2603.5.6, BNBC Section 2603.6.7, SBC Section 2603.6.6, or Item 6 of UBC Section 2602.5.2.2, respectively.

8.0 QUALITY CONTROL

8.1 The products shall be manufactured under an approved quality control program with inspections by an inspection agency accredited by the International Accreditation Service (IAS) or as otherwise acceptable to ICC-ES.

Exception: Quality control inspections by an ICC-ES accredited quality control agency are not required for nonbearing, noncombustible interior panels complying with requirements of IBC Section 1607.13, BNBC Section 1606.9, SBC Section 1604.5, and UBC Section 1611.5 , as applicable, provided recognition is limited to a maximum of 5 pounds per square foot (239 Pa) design load applied perpendicular to the panels.

8.2 A quality control manual complying with the ICC-ES Acceptance Criteria for Quality Control Manuals (AC10) shall be submitted.

9.0 CHANGES IN MATERIAL SOURCES

When deemed necessary by ICC-ES, the following procedures are necessary for continued recognition if the source for the panel component materials changes:

9.1 A qualified representative of an ICC-ES accredited testing agency shall select at least six panels, at random, of each panel type. Additional panels need to be selected if the panels are used as load-bearing or shear walls.

9.2 Two groups of three selected panels shall be subjected to transverse load tests in accordance with Section 4.3 or 4.6.1. One group of three specimens shall be tested with a long span to test for moment capacity and stiffness. The second group of three specimens shall be tested with a short span to test for shear capacity. The individual test results and the average of the test results of each group shall be no lower than 85 and 90 percent, respectively, of the average of the original production transverse test results.

9.3 Where the panels are used as load-bearing walls, three panels shall be subjected to axial load tests in accordance with Section 4.4. The individual test results and the average of the test results shall be no lower than 85 and 90 percent, respectively, of the average of the original production axial load test results.

9.4 Where the panels are used as shear walls, racking shear tests of three assemblies of panels shall be conducted in accordance with Section 4.5. The individual test results and average of the test results shall be no lower than 85 and 90 percent, respectively, of the average of the original production racking shear test results.

9.5 Density and water absorption tests in conformance with Section 4.7 are required for foam plastics.

9.6 Alternative panel facing materials, cores and adhesives shall comply with Sections 2.2, 2.3 and 2.4, respectively.

9.7 The sandwich panel quality control manual shall be revised to specify the alternative material source.■

TABLE 1—CROSS REFERENCE OF STANDARDS EDITIONS

STANDARD	2003 IBC	2003 IRC	1999 BNBC	1999 SBC	1997 UBC
ASTM C 271	-61 (1980)	-61 (1980)	-61 (1980)	-61 (1980)	-61 (1980)
ASTM C 272	-53 (1980)	-53 (1980)	-53 (1980)	-53 (1980)	-53 (1980)
ASTM C 297	-61 (1980)	-61 (1980)	-61 (1980)	-61 (1980)	-61 (1980)
ASTM C 365	-57 (1980)	-57 (1980)	-57 (1980)	-57 (1980)	-57 (1980)
ASTM C 393	-62 (1980)	-62 (1980)	-62 (1980)	-62 (1980)	-62 (1980)
ASTM C 481	-62 (1980)	-62 (1980)	-62 (1980)	-62 (1980)	-62 (1980)
ASTM D 1037	-78	-78	-78	-78	-78
ASTM D 2559	-92	-92	-92	-92	-92
ASTM E 72	-98	-98	-98	-80	-80
ASTM E 84	-01	-01	-98$^{\varepsilon 1}$	-95	UBC Std. 8-1
ASTM E 661	-88	-88	-88	-88	-88

APPENDIX A—OPTIONAL CYCLIC-LOAD TEST REQUIREMENTS FOR SIP SANDWICH PANELS

A.1.0 INTRODUCTION

A.1.1 Purpose: The purpose of this appendix is to establish requirements for permitting the use of structural insulated panels (SIPs) in Seismic Design Categories D, E, and F of the 2003 *International Building Code*® (IBC). This task is achieved by comparing the performance of an established seismic force resisting system (i.e, wood framed walls with wood-based structural panels mechanically fastened to wood framing members) to the performance of a SIP assembly when both types of wall assemblies are subjected to repeated reversed loading. The performance requirements assure that the tested SIP details, which are intended to represent field conditions, perform similar to the established benchmark.

A.1.2 Scope:

A.1.2.1 This appendix is limited to SIPs as defined in Section A.1.3.5. Other types of sandwich panels are beyond the scope of Appendix A. Extrapolation of test results to other SIP assemblies is not permitted. Interpolation of test results is permitted if the mechanical fastening schedule is the only variable that is under consideration.

A.1.2.2 This appendix is not intended to determine the available strengths; the response modification coefficient, R; the system over-strength factor, Ω_o; or the deflection amplification factor, C_d, for a SIP assembly; rather, it is an empirical approach that investigates whether SIP shearwall assemblies, with and without sealants, perform similarly, in terms of cyclic performance, to light-frame shearwalls with wood-based structural panels.

A.1.3 Definitions: The definitions in this appendix may be unique and are intended to apply to this appendix only.

A.1.3.1 Adhesive: In addition to meeting requirements of Section 2.4 of AC04, adhesives shall be limited to laminating the foam core to the oriented strand board (OSB) or plywood structural facers.

A.1.3.2 Backbone Curve: The locus of extremities of the load-displacement hysteresis loops. It represents the peak loads from the first cycle of each phase of the cyclic loading.

A.1.3.3 Benchmark Light-Framed Shearwall Assembly: Benchmark light-framed shearwall assemblies shall be fabricated with wood framing complying with IBC Section 2303.1.1. The test report shall include the following information concerning the wood framing members: moisture content at time of fabrication and testing, if more than 24 hours passes between these operations (ASTM D 4442, Method A or B; or ASTM D4444, Method A or B); and specific gravity of the lumber (ASTM D 2395, Method A). The number and size of nails connecting wood framing members shall be as set forth in IBC Table 2304.9.1.

Both sides of benchmark light-framed shearwall assemblies shall be sheathed with wood-based structural panels identical to the panels used to fabricate the SIP shearwall test assemblies. The wood-based structural panels shall be sampled from the same source that is used to fabricate the SIP shearwall test assemblies. The benchmark light-framed shearwall assemblies shall have identical fastener size and type for sheathing attachment as the SIP shearwall test assemblies. The perimeter of the wall sheathing panels shall be attached with the same total number of fasteners as used in the perimeter of the SIP panels.

Additionally, the benchmark light-framed shearwall vertical boundary details (i.e., vertical wood member at shearwall boundary), and tie-down details for overturning restraint shall be the same as those used in the SIP shearwall test assemblies. Sealants shall not be used for the light-framed shearwall assemblies. Deviations between the benchmark light-framed-shearwall test assembly and the SIP shearwall test assembly shall be described in the test report, and may include photographs or figures to facilitate understanding of the deviations.

A.1.3.4 Sealant: A sealant that is used at the interface between SIP and the wall perimeter members as well as the SIP-to-SIP interfaces. The sealant is typically used to minimize air movement through completed structure. The specification for the sealant used in the SIP shearwall assembly per Section A.1.3.6 shall be documented.

A.1.3.5 Structural Insulated Panels (SIPs): SIPs are factory-laminated sandwich panels consisting of solid-core insulation adhesively attached to structural skins of wood-based structural-use panels, complying with PS2, such as oriented strand board (OSB) or plywood. Plywood may comply with either PS1 or PS2.

The structural wood-based skins shall be attached with mechanical fasteners to wood members at the perimeter of the SIP shearwall. Splines used to connect the vertical edges of SIP panels (SIP-to-SIP interconnection) may be wood, wood-based, or metal-based. Mechanical fasteners shall be used to attach the SIP's structural skins to the splines.

A.1.3.6 SIP Shearwall Assembly (with Sealants): A SIP shearwall assembly is a wall assembly consisting of two or more structural insulated panels assembled using the report applicant's end use recommendations. The end use recommendations include, but are not limited to, fastener size and type, fastener schedule, method for SIP-to-SIP interconnection, wall boundary details, tie down details for overturning restraint, and application of sealants.

A.1.3.7 SIP Shearwall Assembly (without Sealants): Same as SIP Shearwall Assembly with sealant, except the sealant is excluded.

A.2.0 TEST REQUIREMENTS

A.2.1 Cyclic Testing of SIP Wall Assemblies: SIP shearwall assemblies shall be cyclically tested in accordance with the *Standard Method of Cyclic (Reversed) Test for Shear Resistance of Framed Walls for Buildings,* by the Structural Engineers

Association of Southern California (SEAOSC), dated August 1, 1996 (revised January 20, 1997), with the following modifications to the SEAOSC document:

A.2.1.1 Sections 1.3 and 5.2 of SEAOSC are deleted.

A.2.1.2 Section 5.3 of SEAOSC is supplemented by the following statement: Minimum wall assembly size shall be 8 feet (2438 mm) tall by 8 feet (2438 mm) wide.

A.2.1.3 Add the following to Section 6.1 of SEAOSC: Differences of the SIP shearwall boundary conditions when installed in the test frame, if consistent with report applicant's end use recommendations, and the benchmark light-frame-shearwall assemblies shall be permitted. These differences shall be described and detailed in the test reported. The edges of the wood-based structural skins at the top and bottom of the benchmark light-framed shearwall assemblies shall not bear on the loading head or test frame.

A.2.1.4 Section 7.1 of SEAOSC is replaced by the following statement: Three tests of each type are required. To apply the average result, none of the results shall vary by more than 15 percent from the average of the three. Otherwise, the lowest test value is used. The average results based on a minimum of five tests may also be used, regardless of the variation.

A.2.1.5 Section 8.1 of SEAOSC is nonmandatory.

A.2.2 Cyclic Testing of Benchmark Light Framed Shearwall Assemblies: Benchmark light-framed shearwalls assemblies shall be cyclically tested in accordance with Section A.2.1 of this appendix. The cyclic protocol shall be identical to that used for the SIP shearwall assembly.

A.3.0 PERFORMANCE REQUIREMENTS

A.3.1 Backbone Curve Analysis: The representative backbone curve for the SIP shearwall assemblies or benchmark light-framed shearwalls shall be the average of the positive and negative portions of all individual backbone curves of the tested SIP shearwall assemblies or benchmark light-framed shearwalls, respectively.

A.3.1.1 Peak Strength Load Criterion: The peak strength load for the SIP shearwall assemblies shall not be less than 90 percent of that for the benchmark light-framed shearwalls.

A.3.1.2 Stiffness Criterion: The SIP shearwall assembly stiffness, which is defined as the slope of the line passing through the origin and a point on the backbone curve where the load equals one-third of the peak strength load, shall not be less than 85 percent of that for the benchmark light-framed shearwalls.

A.3.1.3 Load at Allowable Story Drift Criterion: The load at the maximum allowable story drift per IBC Table 1617.3.1 (i.e., 2.5 percent wall height) for the SIP shearwall assemblies shall not be less than 85 percent of that for the benchmark light-framed shearwalls.

A.3.2 Analysis of Cumulative Energy Dissipated: Total cumulative energy dissipated shall be measured as the total area bounded by the hysteresis loops for each cycle of the test protocol. The cumulative energy dissipated by the SIP shearwall assemblies shall not be less than 85 percent of that for the benchmark light-framed shearwalls.

A.4.0 EVALUATION REPORT RECOGNITION

Where compliance with Appendix A has been established, the evaluation report shall include a description of the SIP panels, installation requirements to construct a shearwall similar to the SIP shearwalls complying with Appendix A, periodic special inspection requirements in accordance with IBC Section 1707.3, product identification, and the following "Conditions of Use":

- "Panels described in this evaluation report are permitted to be used as shearwalls in buildings located in Seismic Design Categories A through F."
- Where the SIP panel is used as a shearwall in buildings located in Seismic Design Categories D, E, or F, and is combined with other shear-resisting systems, applied loads shall be proportioned based on relative stiffness.

APPENDIX B—EXAMPLE DATA ANALYSIS PER APPENDIX A

Assume SIP assemblies were cyclically tested in accordance with Section A.2.1, and the benchmark light- framed walls were cyclically tested in accordance with Section A.2.2 of this criteria.

The backbone curves shown in Figure B.1 are used for the analysis per Section A.3.1. The curves labeled "Assembly – A" and "Assembly – B" are backbone curves for SIP shearwall assemblies using two distinctly different construction techniques. The line labeled as "Benchmark" is the backbone curve for the benchmark light-framed shearwalls. The three analysis criteria are examined as follows:

1. Ultimate Load Criterion (Section A.3.1.1): Assemblies A and B exceed the benchmark.
2. Stiffness Criterion (Section A.3.1.2): The stiffness of each type of SIP shearwall (Type–A and Type–B) is analyzed at the load corresponding to one third of the peak strength load of the benchmark light-framed shearwall assemblies. The stiffness for Assemblies A and B exceeds the benchmark.
3. Deflection at Allowable Story Drift Criterion (Section A.3.1.3): For this example, the wall height is assumed to be 96 inches and the allowable story drift per IBC Table 1617.3 is assumed to be 0.025 h_{sx}, thus resulting in an allowable story drift of 2.4 inches. Assembly B fails to meet the criterion, while Assembly A exceeds the benchmark.

The cumulative energy dissipation curves shown in Figure B.2 for the SIP shearwall assemblies and the benchmark light-framed shearwall assemblies, are used for the analysis per Section A.3.2. By inspection, Assembly B is less than 85 percent of the benchmark total cumulative energy, and as a result, fails to meet the energy dissipation criterion. Whereas, Assembly A exceeds the benchmark.

Conclusion: The evaluation report shall permit the use of SIP shearwalls, which are identical in construction to those in the Assembly A test population, to Seismic Design Categories A through F. Whereas, the evaluation report shall limit the use of SIP shearwalls, which are identical in construction to those in the Assembly B test population, to Seismic Design Categories A, B, and C.

APPENDIX B – EXAMPLE DATA ANALYSIS PER APPENDIX (Continued)

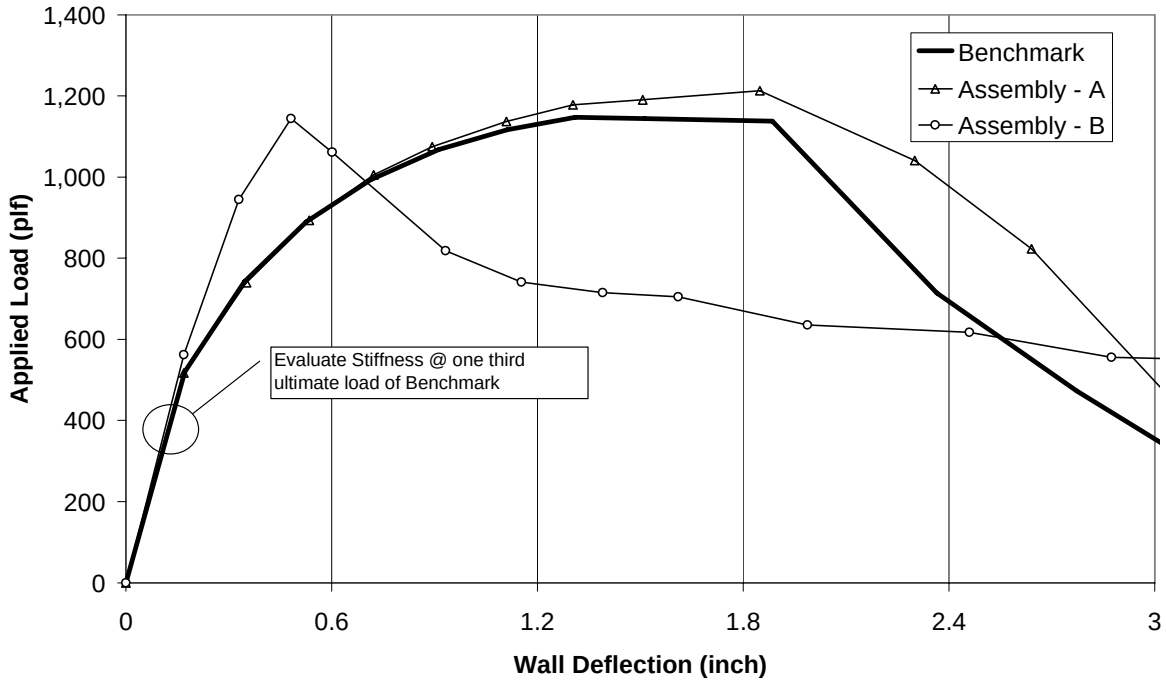

FIGURE B.1—BACKBONE CURVES

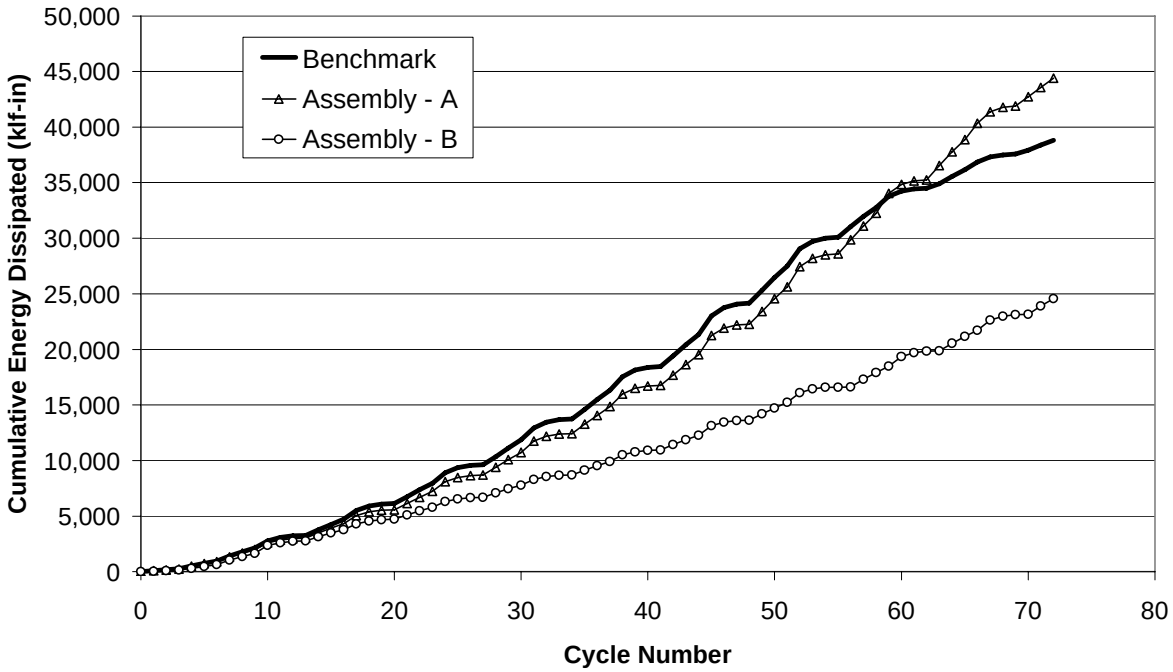

FIGURE B.2—CUMULATIVE ENERGY DISSIPATED