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February 8, 2010

**TO: PARTIES INTERESTED IN EVALUATION REPORTS ON SHEARWALLS OF LIGHT-FRAME CONSTRUCTION**

**SUBJECT: Proposed Acceptance Criteria for Fiber-Reinforced (FRP) Composite Systems Used to Form a Lateral Force-resisting System from Wood- or Cold-formed Steel Framed Shear Walls, Subject AC416-0210-R2 (BG/BNH)**

Dear Madam or Sir:

A new acceptance criteria, as presented in the attached criteria draft, is being posted on the ICC-ES web site to allow public comment.

AC416 was previously considered at the October 2009 ICC-ES Evaluation Committee hearing. This version was done with the objective of qualifying FRP composite systems for new construction under the *International Building Code*®. The committee placed the item on further study. The enclosed proposal has been significantly revised from the first version, to indicate that the primary purpose of the FRP composite system is to improve in-plane shear resistance of existing wood and cold-formed steel light frame walls, as permitted in the 2009 *International Existing Building Code*®. To address earthquake resistance, the qualification and design procedures are largely taken from ASCE/SEI 41-06, including Supplement No. 1, which has been accepted by building officials as an alternative method.

Here are some comments from the ICC-ES staff on the proposal:

1. **Section 1.2:** Should the systems be evaluated for out-of-plane loads as well as in-plane loads?
2. **Section 2.2.5:** For material properties, AC416 defers to the ICC-ES Acceptance Criteria for Concrete and Reinforced And Unreinforced Masonry Strengthening Using Externally Bonded Fiber-reinforced Polymer (FRP) Composite Systems (AC125). Concerning the extents of the material properties, which include bond or adhesion of the FRP composite material to concrete or masonry, the staff assumes all mandatory properties set forth in AC125 will be investigated in accepting the FRP composite material. In AC416, the substrates intended for rehabilitation may be wood- or gypsum-based, which may have degraded or have contaminants present. Therefore, AC416 should include specific provisions

for verifying of bond of the FRP composite material to the unique substrates for conditions beyond the scope of AC125.

3. **Section 3.3:** How are effects of aging of the wall materials, which may be subject to differences in construction techniques such as taping of joints, represented in the prototype assemblies shown in Table 1? Also, certain details such as fastener type and size should be described for the prototype assemblies.
4. **Section 3.4:** This section was revised to indicate that the reference deformation  $\Delta$  should be taken from monotonic tests in accordance with ASTM E 564. The staff questions whether preliminary cyclic tests conducted per ASTM E 2126 could also be used to estimate  $\Delta$ .
5. **Section 3.6.1:** A question is raised on the amount of data, such as the number of tests, that are needed to develop an idealized force-deformation pushover curve.
6. **Section 4.2:** Detailed information on rehabilitation, including repair of existing building elements and on-site testing, should be included in the evaluation report, and provisions addressing the need for such information should be included in AC416. The details should include substrate preparation, use of primers, climatic conditions, setting time, and installation of anchorage.
7. **Section 4.3:** This section refers to AC178 for inspection and testing during installation of the FRP composite system. AC178 pertains to FRP composite systems applied to concrete or masonry. More details may be needed, either in AC416 or AC178, to address use on framed walls.
8. **Section 5.0 c and d:** It is not clear how the m-factors to be added to Tables 2 and 3 are applied in design. For example, are the factors intended to be multipliers for the existing shear wall capacities as defined in ASCE/SEI 41?

You are cordially invited to submit written comments, within 30 days of the date of this letter. Please use the comment form on the web site attaching any letters to the form. An explanation of the alternate criteria process can be found on our web site at [http://www.icc-es.org/Criteria\\_Development/alternative\\_criteria\\_process.shtml](http://www.icc-es.org/Criteria_Development/alternative_criteria_process.shtml).

All comments received in the 30-day comment period will be considered in preparing a proposed criteria that may be considered at a future Evaluation Committee meeting. Comments received will be posted on the web site shortly after the close of the comment period.

Your cooperation is requested in forwarding to the Los Angeles business/regional office all material directed to the Evaluation Committee. Parties interested in the deliberations of the committee should refrain from communicating, whether in writing

or verbally, with committee members. The committee reserves the right to refuse communications that do not comply with this request.

Newly approved acceptance criteria may involve test methods or test protocols that are not currently included in the scope of testing services offered by accredited testing laboratories. As noted in the ICC-ES Rules of Procedure for Evaluation Reports, the scope of the laboratory's accreditation must include the type of testing that is to be reported to ICC-ES. We encourage accredited laboratories to expand their scopes of accreditation to include testing under newly approved acceptance criteria. Please note that testing laboratories must be accredited by the International Accreditation Service (IAS) or by another accreditation body that is a signatory to the International Laboratory Accreditation Cooperation Mutual Recognition Arrangement. For further information, please contact IAS at (562) 699-0541, extension 3309, or send an e-mail to [pmccullen@iasonline.org](mailto:pmccullen@iasonline.org).

Please submit all comments using the form on the web site. Attach any letters to the comment form. If you have any questions (not comments), please contact the undersigned at (800) 423-6587, extension 3260, or B.N. Horeczko, at extension 3289. You may also reach us by e-mail at [es@icc-es.org](mailto:es@icc-es.org).

Yours very truly,



Brian Gerber, S.E.  
Principal Structural Engineer

BG/dc:raf

Enclosure

cc: Evaluation Committee

**PROPOSED ACCEPTANCE CRITERIA FOR  
FIBER-REINFORCED POLYMER (FRP) COMPOSITE SYSTEMS  
USED TO FORM A LATERAL FORCE-RESISTING SYSTEM  
FROM WOOD- OR COLD-FORMED STEEL-FRAMED  
STRENGTHEN LIGHT-FRAME SHEARWALLS**

AC416

Proposed ~~September 2009~~ February 2010

## 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.

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 proposed in this document, and otherwise meet the applicable performance requirements of the codes. Notwithstanding that a product, material, or type or method of construction meets the requirements of the criteria proposed in this document, or that it can be demonstrated that valid alternate criteria are equivalent to the criteria in this document and otherwise meet the applicable performance requirements 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 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 are developed for use solely for purposes of issuing ICC-ES evaluation reports.*

**PROPOSED ACCEPTANCE CRITERIA FOR FIBER-REINFORCED POLYMER  
(FRP) COMPOSITE SYSTEMS USED TO FORM A LATERAL FORCE-  
RESISTING SYSTEM FROM WOOD- OR COLD-FORMED STEEL-FRAMED  
STRENGTHEN LIGHT-FRAME SHEARWALLS**

1 **1.0 INTRODUCTION**

2 **1.1 Purpose:** The purpose of this acceptance criteria is to establish  
3 requirements for fiber-reinforced polymer (FRP) composite systems, applied to  
4 existing sheathed wood- or cold-formed steel-framed walls ~~light-frame shearwalls~~  
5 ~~sheathed with gypsum or cement plaster panels~~, to be recognized in an ICC  
6 Evaluation Service, Inc. (ICC-ES), evaluation report under the ~~2006 and 2009~~  
7 *International Building Code*<sup>®</sup> (IBC), ~~the 2006 and~~ the 2009 *International Existing*  
8 *Building Code*<sup>®</sup> (IEBC), ~~and the 1997~~ *Uniform Building Code*<sup>®</sup> (UBC). The basis  
9 of recognition are IBC Section 104.11 and UBC Section 104.8.

10 The reason for the development of the criteria is to provide  
11 guidelines requirements for testing and assignment of modeling parameters and  
12 acceptance criteria of FRP-composite strength lateral force-resisting walls in  
13 existing construction ~~light-framed shearwall design strength and stiffness~~  
14 ~~capacities; and for assigning equivalent seismic design coefficients and factors~~  
15 where the codes do not provide the necessary requirements for the FRP  
16 composite systems.

17 **1.2 Scope:** This acceptance criteria applies to passive FRP composite  
18 systems used to form shear walls from existing wood- or cold-form steel-frame  
19 walls. ~~strengthen light-frame shearwalls with shear panels~~. Properties evaluated  
20 include the in-plane shear capacities of the complete wall assembly, including

21 panel detailing and connections to existing structures. The modeling parameters  
22 and acceptance criteria shall be determined in accordance with ASCE/SEI 41,  
23 Section 4.8. ~~Seismic design coefficients and factors shall be assigned based on~~  
24 ~~equivalency to light-framed walls with wood structural panels, as set forth (under~~  
25 ~~the IBC) in Items A and B of Table 12.2-1 of ASCE/SEI 7, or Item 1.1.a of Table~~  
26 ~~16-N of the UBC.~~

27 **1.3 Codes and Referenced Standards:**

28 **1.3.1** ~~2006 and 2009~~ *International Building Code*<sup>®</sup> (IBC), International  
29 Code Council.

30 **1.3.2** ~~2006 and 2009~~ *International Existing Building Code*<sup>®</sup> (IEBC),  
31 International Code Council.

32 **1.3.3** ~~1997~~ *Uniform Building Code*<sup>™</sup> (UBC)

33 **1.3.4** ~~ASCE/SEI 7-05, Minimum Design Loads for Buildings and Other~~  
34 ~~Structures, including Supplement No. 1 and Supplement No. 2, and excluding~~  
35 ~~Chapter 14 and Appendix 11A, American Society of Civil Engineers.~~

36 **1.3.4** ASCE/SEI 41-06, including Supplement No. 1, Seismic  
37 Rehabilitation of Existing Buildings, American Society of Civil Engineers.

38 1.3.5 AC10, Acceptance Criteria for Quality Documentation, ICC  
39 Evaluation Service, Inc.

40 1.3.6 AC125, Accepting Criteria for Concrete and Reinforced and  
41 Unreinforced Masonry Strengthening Using Externally Bonded Fiber-Reinforced  
42 Polymer (FRP) Composite Systems, ICC Evaluation Service, Inc.

43 1.3.7 AC178, Acceptance Criteria for Inspection and Verification of  
44 Concrete and Reinforced and Unreinforced Masonry Strengthening Using Fiber-  
45 Reinforced Polymer (FRP) Composite Systems, ICC Evaluation Service, Inc.

46 ~~1.3.6 AF&PA National Design Specification-2005, American Forest &~~  
47 ~~Paper Association.~~

48 ~~1.3.7 AF&PA/ASCE 16-95, Standard for Load and Resistance Factor~~  
49 ~~Design (LRFD) for Engineered Wood Construction, American Society of Civil~~  
50 ~~Engineers.~~

51 **1.3.3** ASTM E 2126-07, Standard Test Methods for Cyclic (Reversed)  
52 Load Test for Shear Resistance of Walls for Buildings, ASTM International.

53 **1.3.4** ASTM D 564-06 Standard Practice for Static Load Test for Shear  
54 Resistance of Framed Walls for Buildings, ASTM International. ~~ISO 16670: 2003,~~  
55 ~~Joints Made With Mechanical Fasteners-Quasi-Static Reversed Cyclic Test~~  
56 ~~Method, International Organization for Standardization.~~

57 **1.4 Definitions:**

58 **1.4.1 Anchoring Elements:** ~~To be determined.~~ Elements that transfer  
59 tension (uplift) forces to the structure below.

60 **1.4.2 Cold-formed Steel-frame Walls:** Walls constructed from cold-  
61 formed steel-frame studs and track with mechanically fastened sheathing panels.

62 **1.4.3** ~~1.4.2~~ **FRP Composite Material:** A combination of high-strength  
63 nonmetallic fibers and polymer matrix material.

64           **1.4.4** ~~1.4.3 Light-frame Shearwalls:~~ Walls consisting of repetitive wood  
65 or cold-formed steel framing members and mechanically fastened sheathing  
66 panels. **Wood-frame Walls:** Walls constructed from wood studs and plates with  
67 mechanically fastened sheathing panels.

68           **1.4.5** ~~1.4.4 FRP Composite System:~~ A configuration consisting of FRP  
69 composite material externally bonded to the sheathing panels and Anchoring  
70 Elements, connecting the FRP Composite material to the framing members.

71           **1.4.6** ~~1.4.5 Strengthened Shearwall:~~ Light-frame shearwall with the  
72 FRP composite system. **FRP-sheathed Shear Wall:** Wood- or Cold-formed  
73 steel-framed shear wall with the FRP composite system applied over existing  
74 wall substrate.

## 75 **2.0 BASIC INFORMATION**

76           **2.1 Description:** A detailed description of the strengthening system is  
77 needed, including the following items:

- 78           a. A description of the system, including product names,  
79           components, specifications and materials.
- 80           b. Means of identifying and packaging of the product or system.  
81           Identification shall include the product name, manufacturer's  
82           name and address, ICC-ES evaluation report number, name of  
83           the inspection agency, storage requirements, and shelf life and  
84           other information deemed necessary by ICC-ES. The

85 identification information for all materials shall be visible prior to  
86 installation.

87 c. Restrictions or limitations on use.

88 **2.2 Strengthened FRP-sheathed Shear wall Description:** The

89 strengthened shear wall description shall include the following information:

90 **2.2.1 Dimensions:** The width, height and length for each strengthened  
91 shear wall type.

92 **2.2.2 Archetypical Wall Construction:** The archetypical information on  
93 building components, including wall framing members and spacing, vertical chord  
94 elements, sill and top plate, sheathing material, sheathing fasteners and spacing,  
95 shall be obtained in accordance with Section 2.2.2 of ASCE/SEI 41 and shall be  
96 assigned a representative Archetypical Condition as identified in Table 1 of this  
97 acceptance criteria.

98 **2.2.3 Alterations to Pre-existing Wall:** Any alterations to the pre-  
99 existing wall construction prior to the installation of FRP strengthening  
100 components that may affect its strength and/or stiffness properties, i.e. sawcuts in  
101 pre-existing sheathing, modification to pre-existing sheathing at boundary, etc.

102 **2.2.4 ~~2.2.2~~ Anchoring Elements:** Anchoring elements shall be  
103 composed of the FRP composite materials or steel-based structural material that  
104 complies with the ASCE/SEI 41, IBC, ~~UBC~~ IEBC or this acceptance criteria.

105           **2.2.5 2.2.3 Shear-resisting Material:** The primary shear resisting  
106 elements of the light-frame shearwalls shall be externally bonded FRP composite  
107 material that complies with ??? AC125.

108           **2.2.6 2.2.4 Structural Field Connections:** Structural connections  
109 between the wall and the structure, made in the field at the time of installation,  
110 shall be consistent with the intent of this criteria and as necessary for installation  
111 of the walls. Design and installation requirements shall comply with the  
112 ASCE/SEI 41, IBC, IEBC, ~~or UBC~~, or an applicable evaluation report.

113           **2.2.7 2.2.5 Connections:** Strengthened shear wall connections shall be  
114 detailed or clearly described. Fasteners shall be properly specified, with the  
115 specifications including fastener type, size, length and location.

116           **2.3 Installation Instructions:** Instructions shall include the following  
117 items:

- 118           a. A description of the system, including product names,  
119           specifications of materials, and how the product or system will  
120           be used.
- 121           b. Procedures for establishing quality control in the field during and  
122           after installation.
- 123           c. Requirements for product handling and storage.
- 124           d. Connections/installations for the strengthened shearwall.
- 125           e. Structural field connection installation.
- 126           f. Curing requirements.

127           **2.4 Structural Design:** The structural applications of the system shall  
128 address the following items:

- 129           a. Clarification of recognition in accordance with the requirements  
130           in Chapter 8 of ASCE/SEI 41 ~~22~~ or Chapter 23 of the IBC or  
131           UBC, or as referenced in the ~~2009 IEBC~~ for shearwalls.  
132           b. A complete description of details.  
133           c. Details and examples of how the product or system is designed  
134           and analyzed, including equations, with procedures and  
135           properties needed for design and analysis as set forth in  
136           ASCE/SEI 41. The engineering analysis shall define failure  
137           modes or force and deflection limit states.

138           **2.5 Testing Laboratories:** Testing laboratories shall comply with  
139 ~~Section 2.0 of the ICC-ES Acceptance Criteria for Test Reports (AC85)~~ and  
140 Section 4.2 of the ICC-ES Rules of Procedure for evaluation reports.

141           **2.6 Test Reports:** Test reports shall comply with AC85.

142           **2.7 Product Sampling:** Components of the test assemblies shall be  
143 sampled in accordance with Section 3.1 or Section 3.2 of AC85, as applicable.

### 144 **3.0 TEST AND PERFORMANCE REQUIREMENTS**

145           **3.1 FRP Composite Material Requirements:** ~~TBD~~ The FRP  
146 Composite material shall be qualified in accordance with AC125.

147           **3.2 FRP Composite Anchoring Elements:** ~~TBD~~ The FRP Anchoring  
148 element materials shall be qualified in accordance with AC125.



PROPOSED ACCEPTANCE CRITERIA FOR FIBER-  
 REINFORCED POLYMER (FRP) COMPOSITE  
 SYSTEMS USED TO STRENGTHEN LIGHT-  
 FRAME SHEARWALLS FORM A LATERAL FORCE-  
 RESISTING SYSTEM FROM WOOD- OR COLD-FORMED  
 STEEL-FRAMED WALLS

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WALL TYPE	ARCHETYPICAL CONDITION	PROTOTYPE ASSEMBLY (REPRESENTING ARCHETYPICAL CONDITION)
Single Layer Horizontal Sheathing or Siding on Wood Studs	Sheathing: ¼ <u>inch</u> to ¾ <u>inch</u> thick wood sheathing or Siding Framing: 2x4 (Dimensional or Nominal) wood studs or larger @ 16 to 24- <del>ee</del> <u>inches on center</u> Connectors (Sheathing to Studs): 1¼ <u>inch long</u> min. Nails @ 2 to 12- <del>ee</del> <u>inches on center</u>	Sheathing: ¼ <u>inch</u> thick wood sheathing or Siding Framing: 2x4 (Nominal) wood studs @ 16- <del>ee</del> <u>inches on center</u> Connectors (Sheathing to Studs): 1¾ <u>inch long</u> Nails @ 12- <del>ee</del> <u>inches on center</u>
Stucco on Wood Studs	Sheathing: ¾ <u>inch</u> to 1 ½ <u>inch</u> thick stucco on ¼" to ½" wood lath or metal lath Framing: 2 <u>by</u> 4 (Dimensional or Nominal) wood studs or larger @ 16 to 24- <del>ee</del> <u>inches on center</u> Connectors (Sheathing to Studs): 1¼ <u>inch long</u> min. Nails from lath to each stud	Sheathing: ¾ <u>inch</u> thick stucco on ¼ <u>inch</u> wood lath Framing: 2 <u>by</u> 4 (Nominal) wood studs @ 16- <del>ee</del> <u>inches on center</u> Connectors (Sheathing to Studs): 1¾ <u>inch long</u> Nails from lath to each stud
Plaster on Metal Lath on Wood Studs	Sheathing: ¾ <u>inch</u> to 1¼ <u>inch</u> thick plaster on metal lath Framing: 2 <u>by</u> 4 (Dimensional or Nominal) wood studs or larger @ 16 to 24- <del>ee</del> <u>inches on center</u> Connectors (Sheathing to Studs): Nails or staples from lath to stud	Sheathing: ¾ <u>inch</u> thick plaster on metal lath Framing: 2 <u>by</u> 4 (Nominal) wood studs @ 16- <del>ee</del> <u>inches on center</u> Connectors (Sheathing to Studs): Nails or staples from lath to stud
½ <u>inch thick</u> Gypsum Wallboard on Metal Studs	Sheathing: ½ <u>inch</u> thick Gypsum board Framing: 4" <del>or larger</del> <u>Minimum 4 inch wide,</u> <u>Minimum No. 20</u> ga or thicker metal studs @ 16 to 24- <del>ee</del> <u>inches on center</u> Connectors (Sheathing to Studs): 1 <u>inch long</u> min. Screws @ 4 to 12- <del>ee</del> <u>inches on center</u> Sheathing Joints: Horizontal or Vertical, blocked or unblocked with any material at joints	Sheathing: ½ <u>inch</u> thick Gypsum board Framing: 4 <u>inch wide No. 20</u> ga metal studs @ 16- <del>ee</del> <u>inches on center</u> Connectors (Sheathing to Studs): 1¼ <u>inch long</u> Screws @ 12- <del>ee</del> <u>inches on center</u> Sheathing Joints: Horizontal, unblocked with tape and compound
¾ <u>inch thick</u> Gypsum Wallboard on Metal Studs	Sheathing: ¾ <u>inch</u> thick Gypsum board Framing: 4" <del>or larger</del> <u>Minimum 4 inch wide,</u> <u>Minimum No. 25</u> ga or thicker metal studs @ 16" to 24- <del>ee</del> <u>inches on center</u> Connectors (Sheathing to Studs): 1 <u>inch long</u> min. Screws @ 4" to 12- <del>ee</del> <u>inches on center</u> Sheathing Joints: Horizontal or Vertical, blocked or unblocked with any material at joints	Sheathing: ¾ <u>inch</u> thick Gypsum board Framing: 4 <u>inch wide No. 20</u> ga metal studs @ 16- <del>ee</del> <u>inches on center</u> Connectors (Sheathing to Studs): 1¼ <u>inch long</u> Screws @ 12- <del>ee</del> <u>inches on center</u> Sheathing Joints: Horizontal, unblocked with tape and compound
Plaster on Metal Lath on Steel Truss Studs	Sheathing: ¾ <u>inch</u> to 1¼ <u>inch</u> thick plaster on metal lath Framing: Steel Truss Studs @ 16 to 24- <del>ee</del> <u>inches on center</u> Connectors (Sheathing to Studs):	Sheathing: ¾ <u>inch</u> thick plaster on metal lath Framing: Steel Truss Studs @ 16- <del>ee</del> <u>inches on center</u> Connectors (Sheathing to Studs):

159            **3.3.1 Gypsum Boards:** ~~The gypsum board shall comply with one of the~~  
160 ~~gypsum material standards listed in Table 2506.2 of the IBC. Test reports~~  
161 ~~documenting compliance of the test specimens shall be submitted.~~

162            **3.3.2 Cement Plaster:** ~~Cement plaster and its installation shall comply~~  
163 ~~with IBC Section 2512 and ASTM C 926 and C 1063. Test reports documenting~~  
164 ~~compliance of the test specimens shall be submitted.~~

165            **3.4 Framing:** ~~The framing, consisting of either wood or cold-formed steel,~~  
166 ~~shall be described in the test report. The description of wood framing shall~~  
167 ~~include dimensions, species, grade and specific gravity. The description of steel~~  
168 ~~framing shall include dimensions, base metal thickness, physical properties, and~~  
169 ~~a detailed description of holes and notches. Wood framing members shall have~~  
170 ~~a width of at least a nominal 2 inches (50.8 mm). Cold-formed steel framing~~  
171 ~~members shall be a minimum of 1<sup>5</sup>/<sub>8</sub> inches by 3<sup>1</sup>/<sub>2</sub> inches (41.28 mm by 88.90~~  
172 ~~mm), with a <sup>3</sup>/<sub>8</sub>-inch (9.53 mm) return lip. The cold-form steel shall have a~~  
173 ~~minimum thickness of 0.0329 inch (0.84 mm). Grading standards and~~  
174 ~~specifications described in the applicable code shall apply to the sawn lumber~~  
175 ~~framing members and cold-formed steel framing members. Proprietary wood-~~  
176 ~~based framing members, such as structural composite lumber complying with the~~  
177 ~~ICC-ES Acceptance Criteria for Wood-based Studs (AC202), shall be recognized~~  
178 ~~in a current ICC-ES evaluation report.~~

179 ~~Data on the test specimens shall be reported in accordance with Sections~~  
180 ~~6.3.1 and 6.3.2 of ASTM E 2126. In addition, the tensile and yield strength of the~~  
181 ~~test specimens shall be reported based on tests in accordance with ASTM A 370.~~

182 **3.4 3.5 In-plane Cyclic Shear Panel Load Tests:** Cyclic shear tests  
183 shall be conducted in accordance with ASTM E 2126 Section 8.5, Method C  
184 (CUREE Basic Loading Protocol), with the following modifications:

- 185 a. Section 8.1 of ASTM E 2126 is replaced by the following  
186 statements: Three tests of each strengthened shearwall type are  
187 required. To apply the average result, none of the results shall vary  
188 by more than 15 percent from the average result for the three tests.  
189 Otherwise, the lowest test value shall be used. The average result  
190 based on a minimum of five tests may also be used, whatever the  
191 variations.
- 192 b. Section 8.3 of ASTM E 2126 is deleted.
- 193 c. Section 8.4 of ASTM E 2126 is deleted.
- 194 d. ~~Horizontal wall displacement during cyclic load testing need not~~  
195 ~~exceed the least of the following: (1) a displacement corresponding~~  
196 ~~to 80 percent post-peak strength; (2) a displacement corresponding~~  
197 ~~to the peak strength if the ratio of the displacement at peak strength~~  
198 ~~to the displacement at ASD design load is equal to or greater than~~  
199 ~~11; or (3) a displacement corresponding to 6 percent of the wall~~  
200 ~~height.~~ In Section 8.5.2, the sentence “The reference deformation

201  $\Delta$  shall be an estimate of the maximum displacement at which the  
202 load in a primary cycle has not yet dropped below  $0.8 P_{peak}$ ” shall  
203 be replaced with “The reference deformation  $\Delta$  shall be the  
204 maximum displacement at which the load in a primary cycle has not  
205 yet dropped below  $0.8 P_{peak}$  based on the results of the average of  
206 three monotonic in-plane shear tests performed in accordance with  
207 ASTM E 564.”

208 ~~**3.6 Cyclic Shear Anchorage Load Tests:** Cyclic load tests shall be~~  
209 ~~conducted in accordance with ISO 16670, with the following modifications:~~

210 **3.5** ~~**3.7 General:**~~

211 **3.5.1** ~~**3.7.1 Additional Test Requirements:**~~ The testing and reporting  
212 shall comply with Section 2.0 of this criteria. No substitution of materials is  
213 allowed unless permitted by ICC-ES.

214 **3.5.2** ~~**3.7.2 Test Setup:**~~ Cyclic shear tests in accordance with Section 3.5  
215 of this criteria shall be conducted on support conditions reflective of the intended  
216 use, i.e., rigid or flexible.

217 **3.5.2.1.** ~~**3.7.2.1 Foundation-on-grade**~~ **(Ground Floor):** Walls  
218 intended to be installed ~~in~~ on a foundation-on-grade condition shall be tested on  
219 a rigid base.

220 **3.5.2.2.** ~~**3.7.2.2 First-floor Raised Floor**~~ **and Upper Floors:** Walls  
221 intended to be installed on the first floor of a structure with a crawl space

222 foundation or on upper floors shall be tested by placing walls over the wall on a  
223 representative floor system constructed on a rigid base.

224 **3.5.2.3.** ~~**3.7.2.3 Second Floor:**~~ Walls intended to be installed over  
225 ~~the second floor of a structure shall be tested by placing the wall on a~~  
226 ~~representative floor system constructed over a representative wall system, all of~~  
227 ~~which shall be supported by a rigid base.~~

228 **3.5.2.4.** ~~**3.7.2.4 Representative Systems:**~~ A floor or wall system  
229 shall be considered representative if it is constructed in such a way that the  
230 stiffness and strength are similar to that which is expected to be encountered in  
231 typical usage.

232 ~~The use of less than full-height stud systems under the second-floor~~  
233 ~~platforms, and the use of floors constructed with short members, is acceptable.~~

234 Qualifying the wall performance for all floor framing alternatives is not required.

235 Secondary connections required to transfer shear and overturning through  
236 the floor system shall also be constructed with materials and methods typical for  
237 the end use. The representative floor/wall systems, as well as the materials and  
238 methods for shear and overturning continuity, shall be fully detailed in the test  
239 report. Additionally, the ICC-ES evaluation report shall specify these details or  
240 other equivalent details.

241 ~~**3.7.2.5 Initial Pretension of Overturning Restraint:**~~ If perpendicular to  
242 grain stress of wood-based material is involved in transferring overturning forces  
243 produced by the wall to the foundation, then the overturning restraint device

244 ~~pretension shall not exceed 500 pounds (2,225 N). If overturning restraint device~~  
245 ~~tension is not being monitored, then nuts securing the device against uplift shall~~  
246 ~~be tightened to a condition of finger tight plus a  $\frac{1}{3}$  turn.~~

247 **3.5.2.5. 3.7.2.6 Load Beam:** To the extent practicable, the load  
248 beam shall be minimized with regard to its mass, length, and stiffness. The load  
249 beam shall not contribute to the strength and stiffness of the tested assembly.

250 **3.5.2.6. 3.7.2.7 Gypsum or Cement Plaster Shear Panels:** When  
251 the primary shear-resisting element of the strengthened shear walls are gypsum  
252 or cement plaster shear panels with an FRP composite system overlay, neither  
253 the panels nor the FRP composite system shall bear on the top or bottom fixtures  
254 of the test frame.

255 **3.6 3.8 Shear Wall Panel Analysis: IBC or IEBC Allowable**  
256 **Strength:**

257 **3.6.1 Design Parameters and Acceptance Criteria:** Using the  
258 procedure outlined in Section 2.8.3 of ASCE/SEI 41 Supplement No. 1, an  
259 idealized force-deformation pushover curve shall be developed from the  
260 experimental data for each test. The pushover curve shall be used to develop a  
261 multi-segmented curve conforming to one of the types indicated in Figure 2-3 of  
262 ASCE/SEI 41 Supplement No. 1. The multilinear curves derived for all tests  
263 involving the subassembly shall be compared and an average multilinear  
264 representation of the subassembly behavior shall be derived based on these  
265 curves.

266            ~~**3.8.1 Allowable Stress Design:**~~ The Allowable Stress Design (ASD)  
267 strength for the test sample shall be the lesser of the ASD strength based on a  
268 drift limit or strength limit, determined as follows:

269            **3.6.1.1.        Stiffness:** The stiffness of the subassembly shall be  
270 determined in accordance with ASCE/SEI 41 Supplement No. 1, Section 2.8.3.3.

271            **3.6.1.2.        Force-controlled or Deformation-controlled:** The  
272 subassembly shall be classified as either force-controlled or deformation-  
273 controlled, in accordance with ASCE/SEI 41 Supplement No. 1, Section 2.8.3.4.

274            **3.6.1.3.        Strength Capacity:** The strength capacity for force-  
275 controlled actions shall be determined in accordance with ASCE/SEI 41  
276 Supplement No. 1.

277            **3.6.1.4.        Acceptance Criteria:** The acceptance criteria for  
278 deformation-controlled actions shall be determined using nonlinear procedures in  
279 accordance with ASCE/SEI 41 Supplement No. 1.

280            **3.6.1.5.        m-factors:** The *m*-factors used as acceptance criteria for  
281 deformation-controlled actions in linear procedures shall be determined in  
282 accordance with ASCE/SEI 41 Supplement No. 1, Section 2.8.3.7.

283            ~~**3.8.1.1 Drift Limit (Seismic):**~~ The ASD strength which satisfies the drift  
284 limit requirements of Section 12.8.6 of ASCE/SEI 7 as referenced in IBC Section  
285 1613.1, shall be computed as follows:

286            a. — Maximum inelastic response displacement,  $\delta_x$ , shall be defined as  
287            either the inelastic drift limit defined in Section 12.12.1 and Table

288 12.12-1 of ASCE/SEI 7, or the mean displacement at the Strength  
289 Limit State of the tested wall assemblies,)  $\Delta_{SLS}$ , whichever is  
290 smaller.

291 b. Using  $\delta_x$ , determined above and the assigned  $C_e$  factor taken from  
292 Section 5.2.1, the Strength Design (LRFD) level response  
293 displacement,  $\delta_{xe}$ , shall be calculated based on Eq. 12.8-15 of  
294 ASCE/SEI 7, with an importance factor,  $I$ , equal to 1.0.

295 c. From the first cycle envelope curve of the cyclic load testing  
296 constructed in accordance with ASTM E 2126, the force  
297 corresponding to  $\delta_{xe}$  shall be determined. This corresponds to a  
298 strength-level factored resistance.

299 d. The strength-level factored resistance shall be multiplied by 0.7 to  
300 determine an ASD level resistance for use with the load  
301 combinations noted in Section 1605.3 of the IBC.

302 e. The drift corresponding to the ASD resistance strength in item (d)  
303 shall be derived from the first cycle backbone envelope curve and  
304 included in the evaluation report.

305 **3.8.1.2 Drift Limit (Wind):** The ASD strength shall be equal to the load  
306 derived from the first cycle envelope curve at a deflection of  $H/180$ , where  $H$  is  
307 equal to the height of the tested assembly.

308 **3.8.1.3 Strength Limit (Wind and Seismic):** The ASD strength shall be  
309 derived by dividing the peak test loads, as determined by Section 3.5 of this

310 criteria, by a factor of safety of 2.5 for seismic forces and 2.0 for wind forces.

311 The drift corresponding to this allowable load capacity shall be derived from the  
312 first-cycle envelope curve.

313 **3.8.1.3 Load and Resistance Factor Design:** The values from the test  
314 may be used as the adjusted reference resistance ( $D'$ ) values when used in  
315 accordance with Section 14.3.3 of the NDS. The adjusted reference resistance  
316 ( $D'$ ) value is not permitted to exceed the ASD strength determined in accordance  
317 with Section 3.8.1.3 of this criteria by a factor of 1/0.7.

318 **3.9 Panel Analysis: UBC Allowable Loads:**

319 **3.9.1 Allowable Stress Design (ASD):** The ASD load for the test sample  
320 shall be the lesser of the allowable load based on drift limit or strength limit,  
321 determined as follows:

322 **3.9.1.1 Drift Limit (Seismic):** The ASD load which satisfies the drift limit  
323 requirements of UBC Section 1630.9.2 shall be computed as follows:

324 a. Maximum inelastic response displacement,  $\Delta_m$ , shall be defined as  
325 either the inelastic drift limit defined in UBC Section 1630.10.2, or  
326 the mean displacement at the Strength Limit State of the tested wall  
327 assemblies,  $\Delta_{SLS}$ , whichever is smaller.

328 b. Using  $\Delta_m$  determined above and the assigned R factor, the  
329 Strength Design level response displacement,  $\Delta_S$ , shall be  
330 calculated using UBC Equation 30-17.

- 331 c. ~~From the first-cycle envelope curve of the cyclic-load testing, the~~  
332 ~~force corresponding to  $\Delta_s$  shall be determined. This force~~  
333 ~~corresponds to a strength-level factored resistance.~~
- 334 d. ~~In accordance with Section 1612.3 of the UBC, this strength-level~~  
335 ~~factored resistance strength shall then be divided by a factor of 1.4~~  
336 ~~to determine the appropriate ASD level resistance.~~
- 337 e. ~~The drift corresponding to the ASD resistance strength in item (d)~~  
338 ~~shall be derived from the first-cycle envelope curve and included in~~  
339 ~~the evaluation report.~~

340 **~~3.9.1.2 Drift Limit (Wind):~~** ~~The ASD load shall be equal to the load~~  
341 ~~derived from the first-cycle envelope curve at a deflection of  $H/180$ , where  $H$  is~~  
342 ~~equal to the height of the tested assembly.~~

343 **~~3.9.1.3 Strength Limit (Wind and Seismic):~~** ~~The ASD load based on~~  
344 ~~the strength of the PSWP and WSRF shall be derived by dividing the peak test~~  
345 ~~load, as determined by Section 3.5 of this acceptance criteria, by a factor of~~  
346 ~~safety of 2.5 for seismic forces and 2.0 for wind forces. The drift corresponding~~  
347 ~~to this allowable load capacity shall be derived from the first-cycle envelope~~  
348 ~~curve.~~

349 **~~3.9.2 Load and Resistance Factor Design:~~** ~~The values from the~~  
350 ~~test may be used as the adjusted resistance ( $D'$ ) values when used in~~  
351 ~~accordance with ASCE 16. The design load determined using this approach is~~

352 not permitted to exceed the ASD load determined in accordance with Section

353 3.9.1 of this criteria multiplied by a factor of 1.4.

354 a. ~~Seismic Design Compatibility with a Code-defined~~

355 **Seismic-force Resisting System:**

356 ~~3.9.3~~ FRP composite strengthened shear panels may be used as  
357 components of a seismic-force resisting system consisting of light frame load-  
358 bearing walls and be assigned the following response modification coefficient,  $R$ ,  
359 system overstrength factor,  $\Omega_o$ , and deflection amplification factor,  $C_d$ , provided  
360 compliance with the evaluation parameters specified in Sections 3.10.2, 3.10.3,  
361 and 3.10.4 of this criteria is established.

362 **Under the IBC:**

363 Response Modification Coefficient:  $R = 6\frac{1}{2}$

364 System Overstrength Factor:  $\Omega_o = 3$

365 Deflection Amplification Factor:  $C_d = 4$

366 **UBC:**

367 Response Modification Coefficient:  $R = 5\frac{1}{2}$

368 System Overstrength Factor:  $\Omega_o = 2.8$

369 Deflection Amplification Factor: Not applicable

370 ~~3.9.3.1~~ The evaluation parameters specified in Sections 3.10.2,  
371 3.10.3, and 3.10.4 of this criteria are based on data derived from testing using  
372 ASTM E 2126 Method C. Test results from Method C shall not be combined for

373 purposes of determining compliance to evaluation parameters specified in

374 Sections 3.10.2, 3.10.3 and 3.10.4 of this criteria.

375 ~~3.9.3.2~~—The evaluation procedure set forth in Section 3.10 of this criteria

376 is intended for determining equivalency of a specified set of seismic design

377 coefficients and factors ( $R$ ,  $\Omega_0$ , and  $C_d$ ) only; it is not intended to negate the

378 provisions for ASD load value derivation in other sections of this criteria.

379 ~~3.9.4~~ The lower bound on the ratio of the displacement at the post-peak

380 load to the displacement at the assigned ASD design load, is determined by:

381 
$$\frac{\Delta_U}{\Delta_{ASD}} \geq 1.1$$

382 where:

383  $\Delta_{ASD}$  = The displacement at the ASD design load developed in Section  
384 3.8.1 (IBC) or Section 3.9.1 (UBC) of this criteria, as applicable.

385  $\Delta_U$  = The ultimate displacement taken from the backbone curve  
386 corresponding to an absolute load having no more than 20  
387 percent strength degradation of the post-peak load point as set  
388 forth in Sections 3.2.6 and 3.2.12 of ASTM E 2126.

389 ~~3.9.5~~ The minimum post-peak displacement shall be in accordance with  
390 the following:

391 
$$\Delta_U \geq 0.028H$$

392 where:

393  $H$  = The height of the prefabricated wall panel.

394  $\Delta_U$  = The ultimate displacement taken from the backbone curve  
395 corresponding to an absolute load having no more than 20  
396 percent strength degradation of the post-peak load point as set  
397 forth in Sections 3.2.6 and 3.2.12 of ASTM E 2126.

398 **3.9.6** The ratio of peak strength to the assigned ASD design load shall be  
399 in accordance with the following:

400 
$$2.5 \leq \frac{P_{peak}}{P_{ASD}} \leq 5.0$$

401 where:

402  $P_{peak}$  = The peak strength of the prefabricated wood shear panel.

403  $P_{ASD}$  = The assigned ASD design load developed in accordance with  
404 Section 3.7.1 or 3.8.1 of this criteria, as applicable.

405 The ratio of peak load capacity to ASD design capacity may exceed 5.0  
406 provided the evaluation report includes a requirement that collectors and their  
407 connections, bearing and anchorage of the panel, and the lateral load path to the  
408 panel are designed in accordance with the special load combinations of Section  
409 12.4.3 of ASCE/SEI 7, using  $E_m$ , where  $E_m$  is calculated using the test panel  
410 overstrength.

## 411 **4.0 QUALITY CONTROL**

### 412 **4.1 Manufacturing:**

413           **4.1.1** The products shall be manufactured under an approved quality  
414 control program with inspections by an inspection agency accredited by the  
415 International Accreditation Service (IAS) or otherwise acceptable to ICC-ES.

416           **4.1.2** Quality documentation complying with ~~the ICC-ES Acceptance~~  
417 ~~Criteria for Quality Documentation (AC10)~~ shall be submitted.

418           **4.2 Installation:** All FRP composite system installations shall be done by  
419 applicators approved by the evaluation report holder. Special inspection is required and  
420 shall comply with Section 1704 of the IBC or Section 1701 of the UBC, and other  
421 applicable sections of the applicable code. Duties of the special inspector shall be  
422 described and included in the evaluation report.

423           **4.3** Applicable requirements in AC178 shall be utilized

424 **5.0 EVALUATION REPORT SCOPE RECOGNITION**

425 The evaluation report shall include the following information:

- 426           a. Basic information required by Section 2.1 of this criteria, including product  
427 description, installation procedures, and packaging and identification.
- 428           b. ~~Available in-plane shear strength and stiffness~~ Stiffness values for each  
429 shear wall assembly, based on analysis of data in accordance with  
430 Section 3.8 of ~~with~~ this criteria.
- 431           c. Modeling Parameters and Numerical Acceptance Criteria for Nonlinear  
432 Procedures for each shear wall assembly at each performance level, in  
433 accordance with Section 3.6.1.4 of this criteria listed in the following  
434 format:

435  
436

**TABLE 2—Modeling Parameters and Numerical Acceptance Criteria for Nonlinear Procedures**

Description of Testing Assembly	Height/Width Ratio (h/b)	Modeling Parameters			Acceptance Criteria				
		$\frac{\Delta}{\Delta_y}$		Residual Strength Ratio	Acceptable Deformation Ratio $\Delta/\Delta_y$				
		Performance Level							
		Component Type							
		d	e	c	IO	Primary		Secondary	
						LS	CP	LS	CP

437  
438  
439

- d. Numerical Acceptance Factors for Linear Procedures for each shear wall assembly at each Performance Level in accordance with Section 3.6.1.5 of this criteria listed in the following format:

440

441

442  
443

**TABLE 3—Numerical Factors for Linear Procedures**

Description of Testing Assembly	Height/Width Ratio (h/b)	m-factors				
		IO	Primary		Secondary	
			LS	CP	LS	CP

444  
445  
446

- e. ~~e.~~ The FRP composite system used on weather exposed surfaces defined in Section 202 of the IBC or Section R703 of the IRC, shall be protected by a weather-resistant exterior wall envelope, or, under Section 224 of the UBC, shall be protected by a water-resistive barrier.

447

448

449

450

- f. ~~f.~~ Continuous special inspection for the application of the FRP composite system is required, as set forth in Section 4.2 of this criteria.

451

452

- ~~e.~~ This criteria will allow the use of the assemblies within height limits and seismic categories (IBC) and seismic zones (UBC) permitted for the

453

454

- equivalent *R* system listed in ASCE/SEI 7 Table 12.12-1 (IBC) and UBC

455

- Table 16-N, respectively. When the assemblies are installed in

- 456 jurisdictions governed by the IBC, periodic inspections in Seismic  
457 Categories C, D, E, or F shall be provided of the fastening and anchoring  
458 of the assembly within the lateral force-resisting system. Inspection shall  
459 include connections of the wall assemblies to drag struts and hold-downs,  
460 in accordance with IBC Section 1707.4, unless exempted by IBC Section  
461 1707.1.
- 462 g. f. Where recognition is sought for stacked multi-story applications,  
463 allowable design values, wall anchorage and detailing requirements, shall  
464 address the effects of cumulative overturning.
- 465 h. g. In addition to the requirements noted in this criteria, anchorage to  
466 concrete details (engineered design and details), in accordance with  
467 Section 1912 of the IBC or Section 1923 of the UBC, whichever is  
468 applicable, shall be submitted. The engineered details will be included in  
469 the evaluation report.
- 470 h. ~~The ASD strength values in the evaluation report will not include a 1.33~~  
471 ~~increase intended for multiple transient loading. The shear-resisting~~  
472 ~~assemblies covered by this acceptance criteria are typically subjected to~~  
473 ~~only one transient load at a time (seismic or wind). For tables that~~  
474 ~~establish the design loads for the UBC, there will be a footnote that~~  
475 ~~indicates the designer must determine if the shear-resisting assembly will~~  
476 ~~be subjected to concurrent, multiple transient loads that would trigger the~~

