



April 28, 2008

TO: PARTIES INTERESTED IN EVALUATION REPORTS ON STAY-IN-PLACE INSULATING CONCRETE FORM (ICF) SYSTEMS FOR STRUCTURAL-GRID CONCRETE WALLS

SUBJECT: Proposed Acceptance Criteria for Stay-in-place Insulating Concrete Form (ICF) Systems for Structural-grid Concrete Walls, Subject AC401-0508-R1 (PB/KS)

Hearing Information:

Friday, May 30, 2008

8:00 a.m.

Sheraton Gateway Suites Chicago O'Hare Airport

6501 North Mannheim Road

Rosemont, Illinois 60018

(847) 699-6300

Dear Madam or Sir:

The enclosed proposed acceptance criteria was submitted by a current ICC-ES report applicant. Staff has not had an opportunity to conduct a review of the criteria. However, since the criteria is of interest to several current ICC-ES report holders, staff feels the criteria should be made available for review by interested parties and the ICC-ES Evaluation Committee at the hearing noted above. The discussion on the staff memo, regarding seismic issues, which is also on the agenda for this hearing, may provide some input regarding the approach described in this criteria. The ICC-ES staff will review the criteria and comments from interested parties and will note the results in a staff memo that will be posted on the ICC-ES web site prior to the hearing.

You are cordially invited to submit written comments on agenda items, or to attend the Evaluation Committee hearing and present verbal comments. If you wish to contribute to the hearing, please note the following:

1. Written comments that are received by the Los Angeles business/regional office by **May 14, 2008**, will be forwarded to the committee prior to the hearing, and will be posted on the ICC-ES web site shortly after the comment deadline.
2. Written comments received up to ten days before the meeting, and staff memos responding to comments, will be posted to the web site on **May 23, 2008**.
3. ICC-ES is no longer providing printed copies at the meeting of proposed acceptance criteria, staff memos or public comments. These documents will be available on a limited number of CDs at the meeting, for uploading to computers; and ICC-ES will

make arrangements with the hotel business center to have hard copies available for photocopying.

4. Written comments that miss the deadline noted in item (1), above, will only be available at the meeting if you provide 35 copies, collated, stapled, and three-hole punched, either at the meeting itself or to the Los Angeles business/regional office by **May 23, 2008**.
5. If you plan to speak for more than 15 minutes, or offer a visual presentation lasting longer, you should notify ICC-ES staff as far as possible in advance. There will be a computer, projector, and screen available at the meeting for anyone wishing to make a visual presentation, and presentations in most cases will need to be in PowerPoint format. Also, ICC-ES will need to be provided with your presentation at least a half-hour before the start of the relevant meeting session (morning or afternoon) on either a CD or a flash card.
6. If you have any special needs related to a presentation, you should contact ICC-ES staff well in advance of the meeting.
7. Any visual aids for viewing at committee meetings (charts, overhead transparencies, slides, videos, electronic presentations, etc.) will be permitted only if a copy is provided to ICC-ES, before the presentation, in a medium that can be retained with other records of the meeting.
8. Any materials submitted for committee consideration are considered nonconfidential and available for public discussion, as noted in Section 2.7 of the ICC-ES Rules of Procedure for the Evaluation Committee.
9. Prior to the meeting, you should refrain from trying to communicate directly with committee members about agenda items, either verbally or in writing. Committee members reserve the right to refuse such communications.

Your cooperation with these guidelines is much appreciated, as is your interest in the deliberations of the Evaluation Committee. If you have any questions, please contact the undersigned at (800) 423-6587, extension 3306. You may also reach us by e-mail at es@icc-es.org.

Yours very truly,

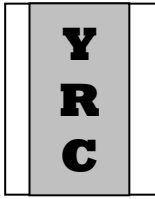


Peter Bahlo, P.E.
Senior Staff Engineer

PB/gh

Enclosures

cc: Evaluation Committee



Yland Research & Consulting LLC

5319 University Drive, #405, Irvine, CA 92612
Tel: 949 733 3580, Fax: 949 733 3611
Email: YlandResearch@aol.com

Via email

March 19, 2008

Peter Bahlo, P.E.
Senior Staff Engineer
ICC Evaluation Service, Inc.
Los Angeles Business/Regional Office
5360 Workman Mill Road
Whittier, CA 90601
pbahlo@icc-es.org

800-423-6587 x 3306

Re: Trilogy Materials, Ltd - Draft AC "362"

Dear Mr Bahlo

Please find attached a copy of a draft acceptance criteria entitled, "*Proposed Acceptance Criteria for Stay-in-place Cement-Based, Foam-Plastic Insulating Concrete Forms (ICFs) for Constructing Post-and-Beam Structural Concrete Walls.*" This draft is a joint effort on behalf of Trilogy Materials, Ltd by Nader Namdar of Namdar Engineering and myself. Trilogy Materials, Ltd. is desirous of having this AC on the agenda for the upcoming ICC-ES hearings to be held in Chicago May 28 – 30, 2008.

AC 362 – new criteria – structural only tests

This criteria is the result of the meeting on March 6th in ICC-ES offices, where we discussed how best to incorporate reversed cyclic testing and benchmark testing into an acceptance criteria. Accordingly, we are recommending removal of structural testing from AC 361 – leaving it to deal with ICF Cement-based Foam-plastic forms, fire/life-safety and building envelope issues and adding the new AC"362" to deal with structural tests.

Monotonic Tests

Two categories of tests are included in the new AC: Monotonic and Comparative. Monotonic tests would be per ASTM E 72 and include: (1) Flexural, (2) Compression-only, (3) Flexural-compression (Slender Walls), (4) Shear walls, and, (5) lintels. At least two configurations of each, five samples per configuration.

Comparative Tests

Page 2 of 2 – Trilogy Materials, Ltd, Draft AC

Two types of walls would be included in the comparative tests: (1) Slender Walls under monotonic loading, and (2) Shear Walls under reversed cyclic loading. Both types of walls would be

compared to solid reinforced concrete benchmark walls having the same height and width, concrete mix design, reinforcement grade/size/spacing and loading conditions. The solid benchmark walls would be of two different thicknesses selected to bracket the estimated equivalent solid wall thickness of the ICF grid walls. If the test results of the ICF walls fall in between the data points of the benchmark walls, then the equivalent solid wall thickness value could be refined using interpolation. In addition, a comparison of the behavior of ICF shear walls to similar solid reinforced concrete walls under reversed cyclic loading will give an indication of the lateral force resisting capabilities of the post-and-beam structural grid ICF system.

Test Method for Reversed Cyclic Loading

ACI 318-08 Commentary R 21.1 references “2003 NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures,” Building Seismic Safety Council, Washington, DC, (FEMA 450-CD), 2003. We have based the reversed cyclic testing concept in the proposed acceptance criteria upon the *Acceptance Criteria for Special Precast Structural Walls Based on Validation Testing* contained in Section 9.6 of this document. Attached for your reference is a copy of Chapter 9 and front materials, as well as a copy of the modifications included in the proposed acceptance criteria.

ICF-Specific Test Protocol

We are currently working on adapting the above criteria for ICFs. We are proposing more test specimens and there are some other precast-specific items that may not apply to ICFs.

Should you have any questions, or require additional information, please do not hesitate to contact us.

YLAND RESEARCH & CONSULTING, LLC

[signed]

Carla Yland, PhD
President

cc: Ron Hicks, Trilogy Materials, Ltd
Nadar Namdar, Namdar Engineering

Attachments:

1. Draft AC, “Proposed Acceptance Criteria for Stay-in-place Cement-Based, Foam-Plastic Insulating Concrete Forms (ICFs) for Constructing Post-and-Beam Structural Concrete Walls.”
2. FEMA 450 Chapter 9 with front matter
3. Modified excerpt from FEMA 450, Section 9.6.



ICC EVALUATION SERVICE, INC., RULES OF PROCEDURE FOR THE EVALUATION COMMITTEE

1.0 PURPOSE

The purpose of the Evaluation Committee is to monitor the work of ICC-ES, in issuing evaluation reports; to evaluate and approve acceptance criteria on which evaluation reports may be based; and to sponsor related changes in the applicable codes.

2.0 MEETINGS

2.1 The Evaluation Committee shall schedule meetings that are open to the public in discharging its duties under Section 1, subject to Section 3.

2.2 All scheduled meetings shall be publicly announced.

2.3 Two-thirds ($\frac{2}{3}$) of the voting Evaluation Committee members shall constitute a quorum. A majority vote of members present is required on any action.

2.4 In the absence of the nonvoting chairman-moderator, Evaluation Committee members present shall elect an alternate chairman from the committee for that meeting. The alternate chairman shall be counted as a voting committee member for purposes of maintaining a committee quorum and to cast a tie-breaking vote of the committee.

2.5 Minutes of the meetings shall be kept.

2.6 An electronic audio record of meetings shall be made by ICC-ES; no other audio, video, electronic or stenographic recordings of the meetings will be permitted. Visual aids (including, but not limited to, charts, overhead transparencies, slides, videos, or presentation software) viewed at meetings shall be permitted only if the presenter provides ICC-ES before presentation with a copy of the visual aid in a medium which can be retained by ICC-ES with its record of the meeting and which can also be provided to interested parties requesting a copy. A copy of the ICC-ES recording of the meeting and such visual aids, if any, will be available to interested parties upon written request made to ICC-ES together with a payment as required by ICC-ES to cover costs of preparation and duplication of the copy. These materials will be available beginning five days after the conclusion of the meeting but will no longer be available after one year from the conclusion of the meeting.

2.7 Parties interested in the deliberations of the committee should refrain from communicating, whether in writing or verbally, with committee members regarding agenda items. All written communications and submissions regarding agenda items should be delivered to ICC-ES. All such written communications and submissions shall be considered nonconfidential and available for discussion in open session of an Evaluation Committee meeting, and shall be delivered at least ten days before the scheduled Evaluation Committee meeting if they are to be forwarded to the committee. Materials delivered to ICC-ES at least ten

days before the scheduled meeting will be posted on the ICC-ES web site (www.icc-es.org) prior to the meeting. After this time, parties wishing to submit materials for consideration by the Evaluation Committee must deliver a sufficient number of copies as directed by ICC-ES. Consideration of materials not received by ICC-ES at least ten days before the meeting is at the discretion of the Evaluation Committee. Following the meeting, ICC-ES will make all materials considered by the Evaluation Committee available on the web site for a maximum period of one year following the meeting. The committee reserves the right to refuse recognition of communications which do not comply with the provisions of this section.

3.0 CLOSED SESSIONS

Evaluation Committee meetings shall be open except that the chairman may call for a closed session to seek advice of counsel.

4.0 ACCEPTANCE CRITERIA

4.1 Acceptance criteria are established by the committee to provide a basis for issuing ICC-ES evaluation reports on products and systems under codes referenced in Section 2.0 of the Rules of Procedure for Evaluation Reports. They also clarify conditions of acceptance for products and systems specifically regulated by the codes.

Acceptance criteria may involve a product, material, method of construction, or service. Consideration of any acceptance criteria must be in conjunction with a current and valid application for an ICC-ES evaluation report, an existing ICC-ES evaluation report, or as otherwise determined by the Evaluation Committee.

4.2 Procedure:

4.2.1 Proposed acceptance criteria shall be developed by the ICC-ES staff and discussed in open session with the Evaluation Committee during a scheduled meeting, except as permitted in Section 5.0 of these rules.

4.2.2 Proposed acceptance criteria shall be available to interested parties at least 30 days before discussion at the committee meeting.

4.2.3 The committee shall be informed of all pertinent written communications received by ICC-ES.

4.2.4 Attendees at Evaluation Committee meetings shall have the opportunity to speak on acceptance criteria listed on the meeting agenda, to provide information to committee members.

4.3 Approval of acceptance criteria shall be as specified in Section 2.3 of these rules.

4.4 Actions of the Evaluation Committee may be

appealed in accordance with the ICC-ES Rules of Procedure for Appeal of Acceptance Criteria or the ICC-ES Rules of Procedure for Appeals of Evaluation Committee Technical Decisions.

5.0 COMMITTEE BALLOTING FOR ACCEPTANCE CRITERIA

5.1 Acceptance criteria may be issued without a public hearing following a 30-day public comment period and a majority vote for approval by the Evaluation Committee when, in the opinion of ICC-ES staff, one or more of the following conditions have been met:

1. The subject is nonstructural, does not involve life safety, and is addressed in nationally recognized standards or generally accepted industry standards.
2. The subject is a revision to an existing acceptance criteria that requires a formal action by the Evaluation Committee, and public comments raised were resolved by staff with commenters fully informed.
3. Other acceptance criteria and/or the code provide precedence for the revised criteria.

5.2 Negative votes must be based upon one or more of the following, for the ballots to be considered valid and require resolution:

- a. *Lack of clarity:* There is insufficient explanation of the scope of the acceptance criteria or insufficient description of the intended use of the product or system; or the acceptance criteria is so unclear as to be unacceptable. (The areas where greater clarity is required must be specifically identified.)
- b. *Insufficiency:* The criteria is insufficient for proper evaluation of the product or system. (The provisions of the criteria that are in question must be specifically identified.)
- c. *The subject of the acceptance criteria is not within the scope of the applicable codes:* A report issued by ICC-ES is intended to provide a basis for approval under the codes. If the subject of the acceptance criteria is not regulated by the codes, there is no basis for issuing a report, or a criteria. (Specifics must be provided concerning the inapplicability of the code.)

d. *The subject of the acceptance criteria needs to be discussed in a public hearings.* The committee member requests additional input from other committee members, staff or industry.

5.3 An Evaluation Committee member, in voting on an acceptance criteria, may only cast the following ballots:

- Approved
- Approved with Comments
- Negative: Do Not Proceed

6.0 COMMITTEE COMMUNICATION

Direct communication between committee members, and between committee members and an applicant or concerned party, with regard to the processing of a particular acceptance criteria or evaluation report shall take place only in a public hearing of the Evaluation Committee. Accordingly:

6.1 Committee members receiving an electronic ballot should respond only to the sender (staff). Committee members who wish to discuss a particular matter with other committee members, before reaching a decision, should ballot accordingly and bring the matter to the attention of ICC-ES staff, so the issue can be placed on the agenda of a future committee meeting.

6.2 Committee members who are contacted by an applicant or concerned party on a particular matter that will be brought to the committee will refrain from private communication and will encourage the applicant or concerned party to forward their concerns through the ICC-ES staff in writing, and/or make their concerns known by addressing the committee at a public hearing, so that their concerns can receive the attention of all committee members. ■

Effective March 18, 2008



PROPOSED ACCEPTANCE CRITERIA FOR STAY-IN-PLACE INSULATING CONCRETE FORM (ICF) SYSTEMS FOR STRUCTURAL-GRID CONCRETE WALLS

AC401

Proposed April 2008

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 STAY-IN-PLACE INSULATING CONCRETE FORM (ICF) SYSTEM FOR STRUCTURAL-GRID CONCRETE WALLS

1 1.0 INTRODUCTION

2 **1.1 Purpose:** The purpose of this acceptance criteria is to establish requirements for
3 recognition in an ICC Evaluation Service, Inc. (ICC-ES), evaluation report, under the 2006
4 *International Building Code*[®] (IBC) of stay-in-place, cement based, foam-plastic insulating
5 concrete forms (ICFs) that are assembled on the building site for constructing post-and beam
6 and grid structural concrete walls. The reason for this criteria is the absence of reference
7 standards in the IBC that can be used to establish code compliance for stay-in-place, cement-
8 based, foam-plastic ICFs that are used to construct post-and-beam structural concrete
9 elements. The bases of recognition are IBC Section 104.11 and ACI 318 Section 1.4.

10 **1.2 Scope:** This acceptance criteria is applicable to factory-manufactured, cement-
11 based, foam-plastic ICFs that are assembled on the building site to create a grid of horizontal
12 and vertical cylindrical cavities that is filled with concrete and steel reinforcement. The stay-in-
13 place assembly of cement-based, foam plastic ICFs, which is the concrete forming system,
14 serves as the insulation material for the finished building and provides a surface for the
15 attachment of exterior and interior wall coverings.

16 For purposes of these criteria, the grid of horizontal and vertical structural
17 concrete members is defined as the concrete core of structural concrete wall that is designed to
18 resist the most critical effects resulting from the load combinations given in Section 1605 of the
19 IBC. The structural capacities of the cement-based, foam-plastic ICF wall assembly shall be
20 based on the post-and-beam or the structural grid of structural concrete wall only. Cement-
21 based, foam-plastic ICFs capacities will be ignored and are outside the scope of this criteria.
22 The cement-based, foam plastic ICF material is limited structurally to transferring out-of plane

23 loads, such as transverse loads, wind seismic, or lateral earth pressures, to the structural grid
24 concrete wall.

25 This criteria applies to cement-based, foam-plastic ICFs used in construction of load-
26 bearing and nonload-bearing structural concrete beams, lintels, above-and below-grade
27 foundation walls, and retaining walls. Use of the cement-based, foam plastic ICFs under the
28 IRC is applicable where an engineered design is submitted to the code official in accordance
29 with IRC Section R301.1.3. Applicant is responsible for identifying other criteria that may be
30 applicable for fire/life-safety and building envelopes.

31 **1.3 Codes and Referenced Standards:**

32 **1.3.1** 2006 *International Building Code*[®] (IBC), International Code Council.

33 **1.3.2** 2006 *International Residential Code*[®] (IRC), International Code Council.

34 **1.3.3** ACI 318-05, Building Code Requirements for Structural Concrete,
35 American Concrete Institute.

36 **1.3.4** ACI 318-08, Building Code Requirements for Structural Concrete,
37 American Concrete Institute.

38 **1.3.5** Minimum Design Loads for Buildings and Other Structures, ASCE/SEI 7-
39 05, American Society of Civil Engineers.

40 **1.3.6** 2003 NEHRP Recommended Provisions for Seismic Regulations for New
41 Buildings and Other Structures, Building Seismic Safety Council (FEMA 450-CD.)

42 **1.3.7** ACI 523-1R-92, Guide for Cast-in-Place Low Density Concrete, American
43 Concrete Institute.

44 **1.3.8** ASTM A 615/A 615M-04a, Specification for Deformed and Plain Billet-
45 steel Bars for Concrete Reinforcement, ASTM International.

46 **1.3.9** ASTM A 706/A 706M-04a, Specification for Low-alloy Steel Deformed
47 and Plain Bars for Concrete Reinforcement, ASTM International.

48 **1.3.10** ASTM C 31/31M-98, Practice for Making and Curing Concrete Test
49 Specimens in the Field, ASTM International.

50 **1.3.11** ASTM C 39/C 39M-05e1, Standard Test Method for Compressive
51 Strength of Cylindrical Concrete Specimens, ASTM International.

52 **1.3.12** ASTM C 143/C 143M-05a, Standard Test Method for Slump of Hydraulic-
53 Cement Concrete, ASTM International.

54 **1.3.13** ASTM C 172-04, Practice for Sampling Freshly Mixed Concrete, ASTM
55 International.

56 **1.3.14** ASTM C 173/C173M-07, Standard Test Method for Air Content of
57 Freshly Mixed Concrete by the Volumetric Method, ASTM International.

58 **1.3.15** ASTM C 203-05a, Standard Test Methods for Breaking Load and
59 Flexural Properties of Block-Type Thermal Insulation, ASTM International.

60 **1.3.16** ASTM C 272-01(2007), Standard Test Method for Water Absorption of
61 Core Materials for Structural Sandwich Constructions, ASTM International.

62 **1.3.17** ASTM C 496/C496M-04e1, Standard Test Method for Splitting Tensile
63 Strength of Cylindrical Concrete Specimens, ASTM International.

64 **1.3.18** ASTM C 557-03, Specification for Adhesives for Fastening
65 Gypsum Wallboard to Wood Framing, ASTM International.

66 **1.3.19** ASTM C 567-05a, Standard Test Method for Determining Density of
67 Structural Lightweight Concrete, ASTM International.

68 **1.3.20** ASTM E 72-02 Standard Test Method of Conduction Strength Tests of
69 Panels for Building Constructions, ASTM International.

70 **1.4 Definitions:**

71 **1.4.1 Cement-based Foam-plastic Insulation:** Cement-based foam-plastic
72 insulation is a mixture of hydraulic cement, water, air, admixtures, and expanded polystyrene
73 foam plastic to form a hardened material that, when oven-dried, has a unit weight of 50 pcf (400
74 kg/m³) or less.

75 **1.4.2 Cement-based Foam-plastic ICFs:** Cement-based foam-plastic ICFs
76 (insulating concrete forms) are block like elements molded from cement-based foam-plastic
77 insulation, which, when assembled on the building site, create a stay-in-place concrete forming
78 system for constructing cast-in-place structural concrete walls, beams, lintels, above-and below-
79 grade foundation walls, and retaining walls.

80 **1.4.3 Post-and-Beam ICF Wall:** A post-and-beam ICF wall is a structural grid
81 of horizontal and vertical cylindrical cavities (cores), which is created within the final assemblage
82 of cement-based, foam-plastic ICFs, and filled with reinforced concrete designed to be the load-
83 resisting component of the ICF wall assembly. The horizontal and vertical cylindrical cores of a
84 post-and-beam ICF wall, for purposes of this acceptance criteria, shall have a minimum 6-inch
85 (152.4 mm) in diameter and thickness, and a maximum 16-ince-on-center (406.4 mm) spacing.
86 Post-and-beam ICF walls having horizontal and vertical cylindrical cores spaced greater than 16
87 inches (406.4 mm) on center, or having horizontal and vertical cylindrical cores less than 6
88 inches (152.4 mm) in diameter and thickness, shall be considered nonstructural and shall be
89 limited to interior nonload-bearing wall applications, provided this ICF wall assembly

90 configuration has adequate strength to resist the loads to which it is subjected in accordance
91 with IBC load requirements.

92 **2.0 BASIC INFORMATION**

93 **2.1 General:** The following information shall be submitted:

94 **2.1.1 Description of the Cement-based Foam-plastic ICFs:** Complete
95 descriptive information concerning the cement-based, foam-plastic ICFs, including
96 configurations, material specifications, manufacturing process, and fully dimensioned drawings
97 with tolerances.

98 **2.1.2 Field Preparation:** A description of the methods of field preparation of
99 the cement-based, foam-plastic ICFs for installation.

100 **2.2 Testing Laboratories:** Testing laboratories shall comply with Section 2.0 of the
101 ICC-ES Acceptance Criteria for Test Reports (AC85) and Section 4.2 of the ICC-ES Rules of
102 Procedure for Evaluation Reports.

103 **2.3 Test Reports:** Test reports shall comply with AC85 and shall include a
104 description of the cement-based, foam-plastic ICFs, including sufficient information to verify
105 compliance of the tested products with the product specifications in the manufacturer's quality
106 control documentation. Test reports shall be as the following:

107 1. Reports of coupon tests that include the actual yield and tensile
108 strength of the rebar used in the concrete wall load tests conducted under this
109 criteria. (See Section 3.3.1.)

110 2. Concrete mix design and results of compression tests of concrete
111 used in sample post-and-beam wall testing.

112 **2.4 Product Sampling:** Sampling of cement-based, foam-plastic ICFs for
113 qualifying tests under this criteria shall comply with Section 3.1 of AC85. Products shall be
114 sampled from each manufacturing facility for which recognition is sought.

115 **3.0 TEST AND PERFORMANCE REQUIREMENTS**

116 **3.1 Cement-based, Foam-plastic ICF Material Properties:**

117 **3.1.1 Density:** The density of the cement-based, foam-plastic ICF material
118 shall be established in accordance with Section 4.1.1

119 **3.1.2 Compressive Strength:** The compressive strength of the cement-
120 based, foam-plastic ICF material shall be established in accordance with Section 4.1.2.

121 **3.1.3 Flexural strength:** The flexural strength of the cement-based, foam
122 plastic ICF material to withstand hydrostatic pressure generated during and after pouring of
123 concrete for the post-and-beam grid shall be established in accordance with Section 4.1.3.2.
124 The allowable transverse load on the ICF system shall be the average peak test load divided by
125 a safety factor of 3, and shall be further reduced to reflect the ICF surface area having a width
126 and length equal to the center-to-center spacing of the vertical and horizontal concrete core
127 elements, respectively.

128 **3.1.4 Recycled or Recovered EPS Materials:** The introduction of recycled or
129 recovered EPS material into ICC-ES-recognized, cement-based, foam-plastic ICFs requires
130 justification that the finished forms with the recycled or recovered content meet the requirements
131 of this acceptance criteria. The evaluation report applicant shall indicate which of the following
132 scenarios best describe the cement-based foam-plastic ICFs that will be manufactured:

133 1. ICFs manufactured only with EPS foam plastic formulated with
134 flame retardants (recycled, virgin, or a mixture thereof) at a specified maximum amount in the
135 design mix of the cement-based foam-plastic material.

136 2. ICFs manufactured with a specified maximum amount of EPS
137 foam plastic in the design mix of the cement-based foam-plastic material, but where the
138 presence or absence of fire retardants in the EPS foam is uncontrolled or unknown (for
139 example, when recycled EPS is used that comes from multiple or unknown sources).

140 **3.2 Concrete Properties:**

141 **3.2.1 Compressive Strength:** Concrete poured-in-place and field-cured in the
142 ICFs to create the post-and-beam grid in sample wall specimens used for strength testing under
143 this criteria shall be tested for compressive strength. The minimum specified compressive
144 strength of concrete shall be 2,500 psi (17.2 MPa).

145 **3.2.2 Modulus of Elasticity:** Concrete poured-in-place and field cured in the
146 ICFs to create the post-and-beam grid in sample wall specimens used for strength testing under
147 this criteria shall be tested for modulus of elasticity. Test results shall be used to confirm the
148 use of the general expression for E_c specified in Section 8.5.1 of ACI 318 for concrete poured-
149 in-place and cured in the cement-based, foam-plastic ICFs.

150 **3.2.3 Split-cylinder Tensile Strength:** The average splitting tensile strength,
151 f_{ct} , of the concrete poured-in-place and field-cured in the cement-based, foam-plastic ICFs.

152 **3.2.4 Concrete Sample Testing:** Concrete that is placed in each test module
153 shall be tested for slump and compression. Slump shall be a minimum of 9" to a maximum of
154 11". Also, sufficient concrete samples shall be taken to ensure sets of three samples can be
155 compression tested at 7 days, 28 days and day of wall test. These data shall be submitted with
156 the results obtained on Section 4.0

157 **3.2.5 Density:** The equilibrium and oven-dry densities of freshly mixed
158 concrete used to create the post-and-beam grid in sample walls for testing under this criteria
159 shall be determined.

160 **3.2.6 Air content:** The air content of freshly mixed concrete used to create the
161 post-and-beam grid in sample walls for testing under this criteria shall be determined. .

162 **3.3 Reinforcement (Rebar) Properties:**

163 **3.3.1 Reinforcing Steel:** Reinforcing steel used in sample walls for testing
164 under this criteria shall meet the requirements of ASTM A 615 or A 706. The minimum yield
165 strength of reinforcing steel shall be 40,000 psi (Grade 40) (276 MPa). Actual yield strength of
166 steel reinforcements shall be obtained by testing coupons taken from the same steel
167 reinforcement batch as used in the wall test specimens. Two tests, conforming to the ASTM
168 specifications cited in Section 3.5 of ACI 318, shall be made for each reinforcement type and
169 size.

170 **3.3.2 Reinforcement Installation Details:** Reinforcement may be placed
171 untied in the proper location in the ICF forms and horizontal reinforcement may rest directly on
172 the bottom of the horizontal voids.

173 **3.3.3 Lap Splices:** Vertical and horizontal wall reinforcements shall be the
174 longest lengths practical. Lap splices for the reinforcement must comply with requirements of
175 Section 1923 of the IBC.

176 **3.4 Structural Design:** The method of designing structural concrete post-and-beam
177 walls and elements shall be derived from a general rational model for predicting the complete
178 load-deformation response of reinforced concrete wall elements subjected to applied loads.
179 Such walls shall be designed taking into account the effects of openings formed by the ICF
180 units.

181 Before commencing tests according to Section 4.1, a test plan shall be developed and
182 submitted to ICC-ES for the ICF wall systems. The design procedure may be based on the
183 provisions of ACI 318 including modifications substantiated by the validation test data

184 **4.0 TEST METHODS**

185 **4.1 Structural Tests:** Structural testing of structural concrete post-and-beam
186 (structural grid) ICF walls shall be in accordance with this section. A sufficient number of test
187 specimens shall be constructed from the same batch of concrete to conduct the structural load
188 tests specified in Sections 4.2.1. through 4.2.4. Two different sets of wall configurations or wall
189 heights, or both, shall be tested for each load application.

190 At the time of structural load tests, actual compressive strength of concrete of the
191 sample wall specimens shall be obtained . In addition, the on-site slump of the sample concrete
192 shall be determined in accordance with ASTM C 143, establishing the maximum recommended
193 slump to be reported in the evaluation report

194 The physical properties of the rebar used in the test assemblies shall be determined in
195 accordance with ACI Chapters 7 and 12.

196 The test specimen wall surface shall be painted with white paint prior to testing in order
197 to observe and photograph formation of cracking of the walls. Painting of the ICF forms
198 facilitates recording and photographing specimen response at significant stages of the loading
199 process, including qualitative observations of concrete crack formation, growth, and propagation
200 during displacement history.

201 After completion of testing, a sample of each configuration of walls shall be stripped of
202 the ICF forming material to observe and photograph concrete consolidation and evidence of
203 bleeding and settlement. The appearance of poorly consolidated concrete within post-and-beam
204 wall specimens shall be recorded and shall be cause for excluding the specimen from test
205 reports.

206 Additionally, if the installation instructions recommend that the walls be constructed
207 using several lifts or layers of concrete to ensure maximization of the structural integrity of the

208 concrete, i.e., complete filling of horizontal and vertical cores with properly consolidated
209 concrete, locations of cold joints where one concrete lift meets another shall be recorded.

210 Sample post-and-beam ICF walls shall be tested in the vertical position, and shall be
211 cast using a separate concrete support foundation or with pinned-end conditions if approved in
212 the qualification test plan submitted prior to testing. The geometry and actual compressive
213 strength of the concrete support member shall be adequate to ensure they do not influence the
214 behavior of the wall specimens. For shear tests, the actual shear and axial loads shall be
215 applied at the top of the wall and the wall will distribute these loads to the supporting foundation.

216 In addition to the standard reporting and certification of tests results, the test report shall
217 also include descriptions of the following: (a) preparation of the sample wall specimen; (b) the
218 test setup, including fully dimensioned diagrams and photographs; (c) specimen response at
219 significant stages of the testing process, including qualitative observations of crack formation,
220 growth, and propagation during displacement history; and (d) the failure modes. Load-
221 displacement curves shall be included in the test report for each wall specimen. The curves
222 shall be plotted in a scale conducive to understanding and comparing the behavior of the walls.
223 Also, the test report shall include drawings showing measured dimensions of vertical and
224 horizontal cores size and location within the post-and-beam specimens, and measured location
225 of vertical steel reinforcement within the vertical cores.

226 **4.1.1 Monotonic Testing:** For monotonic testing, tests shall be conducted in
227 accordance with requirements of ASTM E 72. Flexure, Compression, Combined Flexure-
228 compression, and Shear walls shall be tested as listed in Sections 4.2.1 through 4.2.4. Lintels
229 shall be tests as required in Section 4.2.5. Two different configurations of each type of wall and
230 lintel; and five specimens of each configuration shall be tested.

231 **4.1.2 Comparative Testing:** The purpose of comparative testing is to
232 determine the behavior of structural grid ICF walls compared to solid reinforced concrete walls

233 under the same loading conditions. Comparative testing shall be conducted on Slender Walls
234 (as defined in 2006 IBC Section 1914.8 and ACI 318 Section 19.14.8; and on Shear Walls.

235 **4.2 Monotonic Tests**

236 **4.2.1 Wall Compression Tests:** Wall compression tests shall be
237 conducted in accordance with the compressive load test procedure of ASTM E 72,
238 including application of the load in load increments, except the load application rate
239 shall be such that the compressive stress in the vertical concrete elements increases at
240 a rate of between 20 and 50 psi of the vertical core cross-sectional core area (137 and 345 kPa)
241 per second. The load shall be applied to the specimen with a minimum eccentricity from the
242 center of the vertical concrete elements equal to one-sixth of the width of the concrete core. The
243 test setup shall be capable of accommodating rotation of the test specimen at the top of the wall
244 due to out-of-plane deflection, with the load applied throughout the duration of the test with the
245 required eccentricity. The specimens shall be instrumented in a manner that the axial
246 deformation over the entire height of the system is measured, which will typically result in the
247 deformations being measured between a location on the of the top of the wall and a location on
248 the representative concrete footing at the bottom of the wall.

249 **4.2.2 Wall Flexural Tests:** Wall flexural tests shall be conducted
250 in accordance with the transverse load test procedure of ASTM E 72 using the third-
251 point load application method. Each wall specimen shall span in the direction of the
252 vertical reinforcing steel.

253 **4.2.3 Wall Flexural-compression (Slender Wall) Tests:** Wall flexural-
254 compression tests shall be conducted in accordance with the general guidelines of ASTM E 72,
255 and ACI 318 Section 14.8 and IBC Section 1914.8..

256 **4.2.4 Wall Shear Tests (In-plane Shear):** Wall racking shear load

257 tests shall be conducted in accordance with ASTM E 72. Rigid body motion due to uplift is
258 permitted to be prevented by using external hold-down devices.

259 **4.2.5 Lintel/Beam Tests:** Lintel/beam tests shall be conducted in
260 accordance with the general guidelines of ASTM E 72 using the third-point load
261 application method. Two different configurations of lintel samples with a minimum span of 12-
262 feet shall be tested.

263 **4.3 Comparative Testing**

264 **4.3.1 General:** The purpose of comparative testing is to examine the behavior of
265 post-and-beam structural grid ICF walls compared to solid reinforced concrete walls under the
266 same loading conditions. Comparative testing shall be conducted by monotonic testing of
267 Slender Walls (as defined in 2006 IBC Section 1914.8 and ACI 318 Section 19.14.8), and by
268 reversed cyclic testing of Shear Walls^{1,2}

269 Intent is to provide an empirical basis for:: (1) an equivalent solid wall thickness
270 of post-and-beam (structural grid) ICF walls, and (2) equivalent reversed cyclic behavior of the
271 post-and-beam ICF walls compared to solid reinforced concrete wall. A Qualification Test Plan
272 must be submitted prior to testing.

273 **4.3.2 Slender Walls – Monotonic Tests**

274 **4.3.2.1 ICF Walls:** A minimum of two different configurations of wall
275 panels for combined flexural and axial loads (Slender Walls) must be tested under monotonic
276 loading conditions (See Section 4.2.3) per ASTM E 72.. . Five sample specimens of each ICF
277 wall configuration must be used. The wall panels shall have a minimum height of $h_w=16'-0''$ and
278 shall qualify as a slender wall in accordance with IBC 2006 . The panel length must be a
279 minimum of $L_w=4'-0''$. The tested walls shall have lateral (out-of-plane) loading applied at third
280 points of the span combined with a minimum eccentric load, e_c , of 6 inches. Pinned end
281 conditions apply.

282 **4.3.2.2 Benchmark Walls:** For each configuration of ICF slender
283 wall,, benchmark walls of solid reinforced concrete - and of the same height and width as the
284 ICF walls - shall be tested. A minimum of two different thicknesses of benchmark shall be
285 selected for each configuration. Each benchmark solid reinforced concrete test module shall
286 have three samples. Purpose is to compare the behavior of structural grid ICF Slender Walls to
287 solid concrete walls under combined out-of-plane and eccentric axial loads. If the load
288 deflection curve for ICF walls falls between the benchmark test data, interpolation is permitted
289 for purposes of determining equivalent solid wall thickness for the ICF structural grid walls.

290 **4.3.3 Shear Walls – Reversed Cyclic Tests^{1,2}:**

291 **4.3.3.1 ICF Walls:** A minimum of three configurations of wall panels
292 must be tested for in-plane shear under reversed cyclic loading conditions. Five sample
293 specimens of each structural grid ICF wall configuration must be used. Two of the wall
294 configurations s shall have a maximum $h_w/h_w=0.40$. The third configuration can have a
295 $h_w/h_w=0.5$. Shear walls of the same configuration as a tested monotonically per Section 4.2.4
296 may be tested under reversed cyclic testing per the Acceptance Criteria for Special Precast
297 Structural Walls Based on Validation Testing^{1,2} – modified for post-and-beam (structural grid)
298 walls.

299 **4.3.3.2 Benchmark Walls:** For each configuration of ICF shear wall, a
300 minimum of two sets of benchmark walls of solid reinforced concrete are to be tested.
301 Benchmark walls are to be of the same height and width as the ICF shear walls. A minimum of
302 two different thicknesses of benchmark walls shall be selected for each configuration. Each
303 benchmark module shall have three samples. Purpose is to compare the behavior of structural
304 grid ICF Shear Walls to solid concrete walls under reversed cyclic loading conditions. .If the
305 load deflection curve for ICF walls falls between the benchmark test data, interpolation is
306 permitted for purposes of determining equivalent solid wall thickness for the ICF structural grid
307 walls. Tests to be displacement controlled.

308 **4.4 Analysis:** The minimum thickness from all the above procedures will be
309 selected and used for the ICF wall systems. For walls not tested which have a smaller diameter,
310 by interpolation and analytical calculation an equivalent thickness can be determined. The ICF
311 wall systems with an equivalent thickness will be considered as a structure with concrete
312 specials shear wall systems.

313 After selection of the equivalent thick for ICF wall systems, analysis calculation is to be
314 performed to check the strength of the wall (in bending, compression, shear and combined
315 bending with compression), global toughness, deflection, and drift.

316 **4.4.1 Safety Index Procedure (Strength Design of Concrete):**

317 Design Value \leq Average Maximum Strength $\times \exp (-0.75 B V)$

318 where:

319 B = Safety index = 3.5.

320 V = CVt \leq 0.10.

321 Vt = Coefficient of variation of the average maximum strength.

322 C = 2.0 - 0.1n.

323 n = Number of identical specimens. The value of n for this equation
324 may range from 5 to 10.

325 The average maximum strength and coefficient of variation of the maximum strength
326 shall be based on a minimum of five identical specimens.

327 The Safety Index Procedure requires independent quality control on the manufacture of
328 the product in accordance and special inspection of installation of the system in since design
329 stresses are directly dependent on the variability of the product.

330 For purposes of this criteria, the standard deviation shall be calculated in
331 accordance with the following formula:

$$332 \quad S_s = \sqrt{\frac{\sum (X_1 - \bar{X})^2}{(n - 1)}}$$

333 where

334 S_s = Sample standard deviation, psi

335 X_1 = Individual strength tests

336 \bar{x} = Average of n strength test results

337 n = Number of consecutive strength tests

338 4.5 Conditions of Acceptance

339 **4.5.1 Scope & General Requirements:** These provisions define minimum
340 acceptance criteria for new ICF structural walls, designed for regions of high seismic risk or for
341 structures assigned to high seismic performance or design categories, where acceptance is
342 based on experimental evidence and mathematical analysis

343 **4.5.2 Response:** ICF structural walls shall have a response that is at least
344 equivalent to the response of monolithic structural walls designed in accordance with Sections
345 21.2 and 21.7 of ACI 318.

346 **4.5.3 Applicable Requirements:** The test wall panels shall satisfy all
347 applicable requirements of these provisions and of ACI 318, except Section 21.7.

348 **4.5.4 Tests:** Tests on wall panels satisfy the conditions in FEMA 450 Sections
349 9.6.4 and 9.6.9.

350 **4.5.5 Design Procedure:** The prototype structure is designed using the design
351 procedure substantiated by the testing program.

352 **4.5.6 Equivalent Thickness:** The ICF walls is designed and analyzed using
353 equivalent thickness properties consistent with those determined in accordance with Section
354 results obtained from bench mark testing prototype structure meets the drift limits of these
355 provisions.

356 **4.5.7 Consideration:** The structure as a whole, based on the results of the
357 tests of Section 4.5.1.4 of this criteria and analysis, is demonstrated to have adequate global
358 toughness (the ability to retain its structural integrity and support its specified gravity loads)
359 through peak displacements equal to or exceeding the story-drift ratios specified in FEMA 450
360 Sections 9.6.7.4, 9.6.7.5 or 9.6.7.6, as appropriate and shall be considered as a concrete shear
361 wall system.

362 **4.6 Nonconforming Walls:** Walls panels for diameters less than 6" shall not be
363 used for structural load bearing and analysis method of Section 4.4 does not apply.

364 **Design Procedure – Excerpted from FEMA 450 – Modified for ICFs**

365 **9.6.4 Design procedure:** The test program specified in these provisions is intended to verify
366 an existing design procedure for special ICF structural walls for prequalifying a generic type of
367 special wall system for construction in general. The test program is for the purpose of creating
368 basic information on the strength and deformation properties of such systems for design
369 purposes. Thus, the test modules should fail during the testing. For a generic wall system to be
370 accepted based on these provisions, a rational design procedure will be developed after testing.
371 The design procedure is to be based on a rational consideration of material properties and force
372 transfer mechanisms. Because special wall systems are likely to respond inelastically during
373 design-level ground shaking, the design procedure must consider wall configuration, equilibrium
374 of forces, compatibility of deformations, the magnitudes of the lateral drifts, reversed cyclic
375 displacements, the relative values of each limiting engineering design criteria (shear, flexure
376 and axial load) and use appropriate constitutive laws for materials that include considerations of
377 effects of cracking, loading reversals and inelasticity.

378 The effective initial stiffness of the structural walls is important for calculating the fundamental
379 period of the prototype structure. The procedure used to determine the effective initial stiffness
380 of the walls is to be verified from the validation test results and be based on the equivalent
381 thickness obtained earlier.

382 **9.6.5 Test modules.**

383 9.6.5.7. Details of the connection of walls to the foundation are critical, particularly for shear
384 wall designs. The deformations that occur at the base of the wall due to plastic hinging or
385 extension of the reinforcing bars crossing the wall to foundation interface, (Figure C9.6.2.2.2(d)),
386 are in part determined by details of the anchorage and the bonding of those reinforcements on
387 either side of the interface.

388 **9.6.6 Testing Agency.** In accordance with the spirit of the requirements of Sec.1.3.5 and 1.4
389 of ACI 318, it is important that testing be carried out by a recognized independent testing
390 agency, approved by the agency having jurisdiction and that the testing and reporting be
391 supervised by a registered design professional familiar with the proposed design procedure and
392 experienced in testing and seismic structural design.

393 **9.6.7 Test method.** The test sequence is expressed in terms of drift ratio, and the initial ratio is
394 related to the likely range of linear elastic response for the module. That approach, rather than
395 testing at specific drift ratios of 0.005, 0.010, etc., is specified because, for modules involving
396 these walls the concrete is likely within the range of elastic behavior.

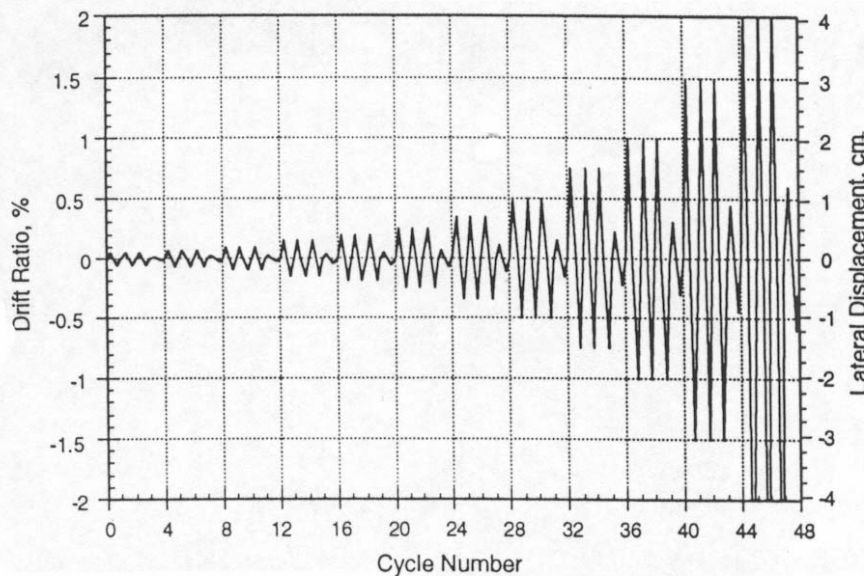


Fig. C9.6.7 Example of specified test sequence.

408 ¹ Based upon "2003 NEHRP Recommended Provisions for Seismic Regulations for New
409 Buildings and Other Structures," Building Seismic Safety Council, Washington, DC,
410 (FEMA 450-CD), 2003. – Chapter 9, Acceptance Criteria

411 ² Innovatative Task Group 5, American Concrete Institute, American Concrete Institute.■