ICC EVALUATION SERVICE

ICC Evaluation Service, LLC
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August 31, 2010

TO: **PARTIES INTERESTED IN EVALUATION REPORTS ON SEMI-CONTINUOUS FIBER-REINFORCED GRID CONNECTORS USED IN COMBINATION WITH RIGID INSULATION IN CONCRETE SANDWICH PANEL CONSTRUCTION**

SUBJECT: Proposed Acceptance Criteria for Semicontinuous Fiber-reinforced Grid Connectors Used in Combination with Rigid Insulation in Concrete Sandwich Panels, Subject AC422-1010-R3 (ME/RK)

Hearing Information:
Wednesday, October 6, 2010
8:00 a.m.
Sheraton Gateway Hotel Los Angeles
6101 West Century Boulevard
Los Angeles, California 90045
(888) 627-7104

Dear Madam or Sir:

A new acceptance criteria, as presented in the enclosed draft, is being posted on the ICC-ES web site and will be discussed at the October Evaluation Committee meeting in Los Angeles, California. A previous version of this criteria was discussed at the June 15, 2010, Evaluation Committee meeting in Birmingham, Alabama, but held for further study by the ICC-ES Evaluation Committee.

The main topics of contention at the meeting in Birmingham, Alabama, were the durability and performance of the bond between the insulation material and concrete due to both freeze-thaw exposure conditions and loading due to differential temperature cycling. Therefore, the proponent of this criteria proposed a new section (Section 4.4.3 of the enclosed revised criteria) which describes test procedures and conditions of acceptance for evaluation of the bond degradation due to freeze-thaw exposure conditions and loading due to differential temperature cycling. Staff seeks public input as to whether this new proposed section (Section 4.4.3) sufficiently addresses bond degradation due to freeze-thaw exposure conditions and loading due to differential temperature cycling, and whether the proposed conditions of acceptance are appropriate.

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 **September 17, 2010,** 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 **September 28, 2010**.

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 **September 28, 2010**.

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 question, please contact the

undersigned at (800) 423-6587, extension 3721, or Russ Krivchuk, P.E., at extension 3275. You may also reach us by e-mail at es@icc-es.org.

Yours very truly,

Mahmut Ekenel, Ph.D., P.E.
Staff Engineer

ME/RK/md

Enclosures

cc: Evaluation Committee

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ICC EVALUATION SERVICE, LLC,
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 ($^2/_3$) 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 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.

ICC EVALUATION SERVICE

www.icc-es.org | (800) 423-6587 | (562) 699-0543 *A Subsidiary of the International Code Council®*

PROPOSED ACCEPTANCE CRITERIA FOR SEMICONTINUOUS FIBER-REINFORCED GRID CONNECTORS USED IN COMBINATION WITH RIGID INSULATION IN CONCRETE SANDWICH PANEL CONSTRUCTION

AC422

Proposed August 2010

PREFACE

Evaluation reports issued by ICC Evaluation Service, LLC (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 by ICC-ES for purposes of issuing ICC-ES evaluation reports.

PROPOSED ACCEPTANCE CRITERIA FOR SEMICONTINUOUS FIBER-REINFORCED GRID CONNECTORS USED IN COMBINATION WITH RIGID INSULATION IN CONCRETE SANDWICH PANEL CONSTRUCTION

1.0 INTRODUCTION

1.1 Purpose: The purpose of this criteria is to provide a procedure for recognition of semicontinuous fiber-reinforced grid connectors in ICC Evaluation Service, LLC (ICC-ES), evaluation reports under the 2009 *International Building Code*® (IBC) and the 2009 *International Residential Code*® (IRC). Bases of recognition are IBC Section 104.11 and IRC Section R104.11.

The reason for development of this criteria is to establish guidelines for the evaluation of shear transfer capacities of semicontinuous fiber-reinforced grid connectors used in combination with rigid insulation in concrete sandwich panel construction, since the codes do not provide requirements for testing and determination of capacities of this product.

1.2 Scope: This acceptance criteria is applicable to semicontinuous fiber-reinforced grid connectors that are combined with rigid insulation to transfer shear stresses in insulated concrete sandwich panels.

The semicontinuous fiber-reinforced grid connectors addressed by this criteria, used in conjunction with rigid insulation, are used to provide structural composite action between the panel facers of reinforced concrete sandwich panels that are used as walls to resist wind pressure acting on the panel surface. This acceptance criteria also addresses connectors used to transfer shear forces between the concrete panel facers due to gravity loads on sandwich panels used as exterior bearing walls. The grid

connectors are factory-cast into the concrete facers of the sandwich panels. The typical shape of the semicontinuous grid connectors is shown in Figure 1.

The shear transfer capabilities of the fiber-reinforced grid connecters and rigid insulation addressed by this acceptance criteria are for shear transfer parallel to the length of the connector, with the grids installed in concrete sandwich panels and with the grid element semicontinuous along the panel length. The grid connectors are intended to transfer the shear flow induced by composite action between two concrete elements subjected to flexural bending in one or more directions. Grid connectors addressed by this criteria are to be used in sandwich panels designed according to ultimate strength design applications.

1.3 Codes and Referenced Standards:

1.3.1 2009 *International Building Code*® (2009 IBC), International Code Council.

1.3.2 2009 *International Residential Code*® (2009 IRC), International Code Council.

1.3.3 ACI 318-08 (2008), Building Code Requirements for Structural Concrete, American Concrete Institute.

1.3.4 ACI 211.1-91 (2002), Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete, American Concrete Institute.

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

1.3.6 ASTM C 33-03, Standard Specification for Concrete Aggregates, ASTM International.

1.3.7 ASTM C 39-03, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens, ASTM International.

1.3.8 ASTM C 165-07, Standard Test Method for Measuring Compressive Properties of Thermal Insulations, ASTM International.

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

1.3.10 ASTM C 303-07, Standard Test Method for Dimensions and Density of Preformed Block and Board-Type Thermal Insulation, ASTM International.

1.3.11 ASTM C 581-03, Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service, ASTM International.

1.3.12 ASTM D 1621-04a, Standard Test Method for Compressive Properties of Rigid Cellular Plastics, ASTM International.

1.3.13 ASTM D 2247-02, Standard Practice for Testing Water Resistance of Coatings in 100 percent Relative Humidity, ASTM International.

1.3.14 ASTM D 3039/3039M-07, Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials, ASTM International.

1.3.15 ASTM E 119-07, Standard Test Methods for Fire Tests of Building Construction and Materials, ASTM International.

1.3.16 ASTM E 488-96 (2003), Standard Test Method for Strength of Anchors in Concrete and Masonry Elements, ASTM International.

1.3.17 EB001 (2002), Design, Control of Concrete Mixtures, 14th edition, Portland Cement Association.

1.4 Definitions:

1.4.1 Semicontinuous Grid Connector: Connectors installed in segments such that the connectors are discontinuous along the length of the panel, with a maximum separation of 6 inches (152 mm) between the ends of the connector segments.

1.4.2 Connector Design Alternative: The combination of connector grid, insulation type, density and thickness, connector spacing, connector design (See Section 1.4.2.1), minimum embedment of the connector in the concrete, concrete type and minimum concrete strength that is being tested for recognition.

1.4.2.1 Connector Design: Connector design, determined by connector geometry and connector materials, identified by the grid manufacturer's catalog number or description.

1.4.2.2 t (Insulation Thickness): Thickness of insulation measured perpendicular to the concrete surfaces that encase the insulation.

1.4.2.3 Minimum Concrete Embedment: Minimum embedment of the connector into each of the two layers of concrete of sandwich panels.

1.4.2.4 Minimum Concrete Strength: The minimum concrete strength for which the connector design alternative is recognized.

1.4.2.5 q_n (Connector Shear Flow): The nominal shear in the semicontinuous connector per unit length of connector.

2.0 BASIC INFORMATION

2.1 Connectors: Description of the grid connectors shall be submitted and shall include the following:

a. Generic or trade name.

b. Manufacturer's catalog number.

c. Nominal connector dimensions and geometry.

d. Permitted manufacturing tolerances.

e. Materials.

f. Manufacturing procedure.

g. Manner of field identification.

h. Recommended installation procedures.

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

2.3 Test Reports:

2.3.1 Test reports shall comply with AC85, and reports of tests required by Section 4.0 shall include applicable information specified in Section 13 of ASTM E 488 and the following:

a. Mode of failure and location of connector fracture failures for each test specimen.

b. Photographs of test equipment and typical failure.

c. Report of connector sampling at manufacturer's facilities as required by Section 2.4 of this criteria.

2.3.2 Concrete Properties: The test reports shall describe the properties of the concrete used in the connector performance tests called for by Section 4.1.2, as set forth in Section 4.1 of this criteria.

2.4 Product Sampling: Grid connectors and insulation material used in tests shall be sampled in accordance with Section 3.1 of AC85. The manufacturing of the specimens for tests under Section 4.4 of this criteria shall be witnessed by the testing laboratory.

2.5 Data Analysis: The documentation containing analysis of data shall be sealed by a registered design professional.

2.6 Identification: Labels on grid connector packages shall include the name and address of the evaluation report applicant, size, product model or name, the applicable ICC-ES evaluation report number and the name or logo of the inspection agency, as applicable.

3.0 TEST AND PERFORMANCE REQUIREMENTS

3.1 Connector Material Suitability Requirements: The grid connectors shall be tested in accordance with Section 4.3, and must comply with the requirements specified in Section 4.3.

3.2 Connector Performance Tests: The connector performance tests shall be in accordance with Section 4.4, with the connector design properties q_n and G determined

in accordance with Section 3.3. The concrete used in the connector performance tests shall be tested in accordance with Section 4.1 to establish the concrete type and compressive strength requirements for end-use conditions. The insulation material of the connector performance test specimens shall be tested in accordance with Section 4.2 to establish the required physical properties of the insulation material to be specified for end-use conditions.

3.3 Connector Design Properties:

3.3.1 General: Connectors are intended for design based on ultimate strength design. Information obtained from Section 4.4 of this criteria shall be used to determine nominal shear flow, q_n, and shear modulus, *G,* for each connector design alternative.

3.3.2 Determination of Shear Design Strength: The nominal shear strength shall be calculated using the average ultimate load minus three standard deviations in accordance with the following procedures:

The nominal shear strength, q_n, shall be determined as follows:

$$q_{i,max} = \frac{V_{i,max}}{NL}$$

$$q_{a,max} = \frac{\Sigma q_{i,max}}{n}$$

$$q_n = q_{a,max} - 3\sigma$$

where

$V_{i,max}$ = the peak test load for each test specimen [pounds (kN)].

N = the number of pieces of equal length grid segments in the individual test specimen; minimum of four pieces of grid located concentric to the applied load, as shown in Figure 2.

L = the length of the grid segment and specimen [inches (mm)]; minimum of 84 inches (2100 mm), as shown in Figure 2.

q_n = the nominal shear flow [lbs/in. (kN/mm)].

$q_{a,max}$ = the mean shear flow of the specimens [lbs/in. (kN/mm)].

$q_{i,max}$ = shear flow for each test specimen [lbs/in. (kN/mm)].

σ = the standard deviation of the peak test loads of the test specimens.

n = the number of test specimens.

3.3.3 Determination of Shear Modulus: The shear modulus, *G*, shall be based on deformation measurements of the double shear specimens as shown in Figure 3, and shall be determined at 50 percent of the peak load level as shown in Figure 4.

The shear modulus of the connector, *G*, used to determine the shear component of the deflection of sandwich panels using the grid connector, shall be calculated based on the average nominal shear modulus minus three standard deviations in accordance with the following procedures:

$$G_i = \frac{0.5V_{i,max}}{A_{sa}} \cdot \frac{t}{\Delta_{i,v}} = \frac{0.5V_{i,max}}{2Lw} \cdot \frac{t}{\Delta_{i,v}}$$

$$G_a = \frac{\Sigma G_i}{n}$$

$$G = G_a - 3\sigma$$

where:

$V_{i,max}$ = the peak test load for each specimen [pounds (kN)].

G_i = shear modulus for each test specimen [lbs/in^2. (kN/mm^2)].

G_a = the mean shear modulus of the test specimens [lbs/in^2. (kN/mm^2)].

t = thickness of the rigid foam insulation [inch (mm)].

L = the length of the grid segment and specimen [inch (mm)]; minimum of 84 inches (2100 mm), as shown in Figure 2.

A_{sa} = the total contact surface area between the insulation material and both surfaces of the central concrete wythe [inch^2 (mm^2)].

w = the width of the specimen [inch (mm)]; minimum of 48 inches (1200 mm), as shown in Figure 2.

$\Delta_{i,V}$ = relative displacement between the central concrete core and the two outer concrete wythes of each specimen evaluated at 50 percent of the peak load level, as shown in Figure 3 [inch (mm)].

σ = standard deviation of the shear modulus of the five test specimens.

3.4 Design Parameters

3.4.1 Strength Reduction Factors: The following strength reduction factors are applicable for the design of the sandwich panel construction with grids:

(1) A strength reduction factor of 0.75 shall be used to determine the nominal design shear flow strength. An additional strength reduction of factor of 0.85 (Ψ_f) shall also be applied to improve the reliability of strength prediction:

$$\phi\psi_f q_n = 0.75 \times 0.85 \times q_n$$

(2) For the design of the sandwich panels for sustained loads, a strength reduction factor of 0.15 shall be used to determine the nominal design shear flow strength: $\phi q_n = 0.15 q_n$

3.4.2 Stiffness: Designing the deflections of sandwich panels using the construction method under consideration shall be based on the combination of flexural deformation and shear deformation. The total deformation shall be based on the following

$$\left(\delta_F \lambda_\Delta + \delta_S \xi\right) = \delta_{LongTerm}$$

where;

δ_F = the flexural deflection of the panel due to moment applied to the panels by sustained gravity loads

λ_Δ = long-term flexural deformation creep factor due to sustained loads as defined in Section 3.4.2.1

δ_S = the shear deflection of the panel due to shear in the panel due to the sustained gravity loads

ξ = Shear deformation creep factor due to sustained loads as defined in Section 3.4.2.2

3.4.2.1 Flexural Deformations: Long term load flexural deformation calculations shall follow any rational method. The long term load modification factor is defined as λ_Δ in accordance with ACI 318 Section 9.5.

3.4.2.2 Shear Deformations: Long term load shear deformation calculations shall follow a rational method. The long term modification factor is defined as ξ in accordance with ACI 318 Section 9.5.

3.5 Durability of Concrete Insulation Board Interface: The durability of the concrete to insulation board interface shall be evaluated for each combination of concrete, grid type and insulation board type in accordance with Section 4.4.3 of this criteria.

3.6 Fire Resistance (Optional): Recognition of connector use in fire-resistive construction shall be evaluated for load resistance during fire exposure. General guidelines for fire exposure testing are in ASTM E 119.

4.0 TEST METHODS AND ANALYSIS

4.1 Concrete: The concrete used in the connector performance tests must be evaluated in accordance with the following:

4.1.1 Concrete Mix

4.1.1.1 The type of concrete shall be same as the concrete that is intended to be used in the sandwich panel construction.

4.1.1.2 Concrete mix design shall follow recommendations for proportioning in EB001, ACI 211.1 or IBC Chapter 19 (ACI 318). Proportions may be varied to meet local requirements and to achieve desired nominal compressive strength. The reason for any variation shall be explained in the test report.

4.1.1.3 Coarse and fine aggregate in concrete shall comply with ASTM C 33 for normal-weight concrete. The aggregate description shall include the rock and mineral components, shape, hardness, maximum size, and grading specification.

4.1.1.4 Concrete test cylinders shall be prepared, stored and cured according to ASTM C 31 (field cure). Concrete cylinders shall be tested in accordance with ASTM C 39 and Section 4.1.2 of this criteria, to determine the strength of the concrete of the specimens of tests under Section 4.4.

4.1.1.5 Reinforcement may only be used to stabilize test members during transportation. Reinforcing elements in concrete test members shall be outside the potential failure region of each test connector or connector group. The testing laboratory shall verify location of reinforcing.

4.1.2 Concrete Strength Determination:

4.1.2.1 Concrete test members shall be aged a minimum of 21 days prior to the beginning of the connector performance tests.

4.1.2.2 For concrete less than 90 days old, two tests of two cylinders each, prepared according to Section 4.1.1 of this criteria, shall be performed at the beginning and ending of connector testing. The beginning test shall be concurrent with the initiation of connector performance testing. The beginning and ending strength results shall be averaged (four cylinders) to establish the strength of the test members during the connector performance test period.

4.1.2.3 For concrete aged 90 days or more, the compressive strength shall be the average of the results for a single test of three cylinders determined after at least 90 days and within 30 days of connector testing.

4.1.2.4 Reported concrete strength for any connector performance test series shall be determined from the tests in this section.

4.2 Insulation Material: Insulation material shall be recognized in a current ICC-ES evaluation report. The following properties of the insulation used in the connector performance test specimens shall be reported:

- Compressive strength (ASTM C 165).
- Flexural strength (ASTM C 203).
- Density (ASTM C 303).
- Compressive properties of rigid cellular plastics (ASTM D 1621), if applicable.

4.3 Material Suitability Requirements of Fiber-reinforced Grid Connectors

4.3.1 Tensile Properties: Ultimate tensile strength, ultimate tensile strain and tensile modulus of elasticity of the strand of the connector grid material shall be determined in accordance with ASTM D 3039. The specimens shall be cut from the manufactured grid connectors. Twenty specimens shall be tested. Specimen sets shall exhibit a coefficient of variation (COV) of 6 percent or less. Outliers are subject to further investigation according to ASTM E 178. If the COV exceeds 6 percent, the number of specimens shall be doubled. Gripping of the test specimens shall be such that it does not damage the specimen and cause premature failure of the specimen in

the gripping location. Tensile properties shall be reported by the testing laboratory and used for evaluation under Section 4.3.2.

4.3.2 Environmental Properties: The fiber-reinforced grid connector material's response to moisture, wet concrete environment, and aging shall be determined as follows:

4.3.2.1 Effects of Moisture and Aging: Testing shall be conducted in accordance with ASTM D 2247, Section 7. Tensile strength testing of the material, conducted in accordance with Section 4.3.1 of this criteria, shall be conducted after exposure of the material to 100 percent humidity at 100 ± 4°F (37 ± 2°C) for 1,000 and 3,000 hours. Twenty specimens shall be tested at each time increment.

4.3.2.2 Effects of Wet Concrete Environment and Aging: Testing shall be conducted in accordance with ASTM C 581, Section 7.2. Tensile strength testing of the material, conducted in accordance with Section 4.3.1 of this criteria, shall be determined after the material has been exposed to an alkali solution with a pH of 12 at 73 ± 3°F (23 ± 1.6°C) for 1,000 and 3,000 hours. Twenty specimens shall be tested at each time increment.

4.3.2.3 The conditions of acceptance for environmental properties evaluated under Sections 4.3.2.1 and 4.3.2.2 of this criteria are shown in Table 1.

4.4 Connector Performance Tests

4.4.1 General:

4.4.1.1 Each grid connector design alternative to be recognized shall be tested.

4.4.1.2 The grid connectors shall be installed into concrete of the test members in accordance with the grid manufacturer's recommendations. The manufacturing of the specimens for tests shall be witnessed by a representative of the testing laboratory. Pertinent data such as connector embedment, spacing, thickness of attached and receiving materials, manufacturing procedure, etc., shall be observed and reported by the testing laboratory representative.

4.4.1.3 The connectors are to be tested in multiple rows. Multiple rows shall be parallel and uniformly spaced. Except for end joints, the grid connector length shall be the same as the length of the concrete elements. The rigid insulation shall extend the full length and width of the concrete elements. The width of rigid insulation associated with each connector row shall be the recognized value.

4.4.1.4 Concrete embedment of the grid connectors shall be the minimum recommended by the grid connector manufacturer. Thickness of the concrete element shall be the minimum recommended by the grid connector manufacturer.

4.4.1.5 Test result values for concrete thicknesses that differ from the tested thicknesses can be interpolated from results of other thicknesses provided all other connector design alternatives are the same; however, extrapolation is not acceptable.

4.4.2 Connector Shear Tests: Shear tests shall be performed with push-through specimens consisting of three layers of concrete and two layers of rigid insulation with connectors as seen in Figure 2. The test shall consist of loading the center layer and supporting the outer two layers. Load shall be applied parallel to the

connector rows and concentric to the test specimen. Test specimens, supports, and loading shall all be symmetric about the center plane of the test specimen.

The test specimen shall contain at least two rows of semicontinuous grid connector material. The offset between end gaps of the semicontinuous grid connector rows shall be spaced no closer than 18 inches (457 mm) measured in the direction of *L* as shown in Figure 2. There shall be no more than one end gap per row of semicontinuous grid connector material. Test measurements shall include applied load and deflection of the center layer of concrete relative to the outer two layers. Five specimens shall be tested for each connector design alternative. The relative displacement at supports should be prevented using frictionless lateral support. Loading rate shall be 0.05 inch/minute (1.30 mm/minute).

4.4.3 Freeze-thaw and Temperature Cycle Tests:

4.4.3.1 Test Specimens: Freeze-thaw and temperature cycle tests shall be performed with push-through specimens' consisting of three layers of concrete and two layers of rigid insulation similar to what is shown in Figure 2. The specimen dimensions shall be *L* = 48 inches (609 mm), and *w* = 24 inches (609 mm) with two rows of grid connectors parallel to the dimension *L* spaced at dimension *s* apart similar to what is shown in Figure 2. The exterior concrete thickness is 2 inches (51 mm) and the interior layer thickness is 4 inches (102 mm). Insulation thickness is 2 inches (51 mm), minimum, and shall conform to Section 4.2 of this criteria. The panel edges shall be sealed to prevent direct infiltration of water and prevent direct exposure of the insulation material to the thermal chamber. A minimum three specimens shall be tested

as control specimens and a minimum of three specimens are required for cyclic-aged specimens.

4.4.3.2 Test procedure: Three specimens shall be placed in an environmental chamber and cycled fifteen times from -20°F (-29°C) to 140°F (60°C) to -20°F (-29°C). Each cycle end point is defined when the surface temperature of the exterior concrete layer is at the cycle end point temperature, either -20°F (-29°C) or 140°F (60°C), respectively. During each cooling portion of the cycle [from 140°F to -20°F(60°C to -29°C)] and prior to the first low-temperature exposure, the specimen shall be exposed to a continuous water spray until the surface of the panel reaches ambient water temperature [70°F (21°C)] or for one hour, whichever is longer. The environmental chamber temperature shall never exceed 150°F (66°C) during the heating phase or -32°F (-36°C) during the cooling phase. After fifteen environmental cycles, the samples shall be load-tested in a fashion similar to what is described in Sections 4.4.2 and 4.4.4. The test shall consist of loading the center layer and supporting the outer two layers. The load shall be applied parallel to the connector rows and concentric to the test specimen. Test specimens, supports, and loading shall all be symmetric about the center plane of the test specimen. Relative displacement at supports should be prevented using frictionless lateral support. The loading rate shall be 0.05 inch/minute (1.30 mm/minute). Test measurements shall include applied load and deflection of the center layer of concrete relative to the outer two layers. The shear modulus shall be calculated for each group of specimens as described in Section 3.3.3 of this criteria.

4.4.3.3 Conditions of Acceptance: The ratio of shear modulus of cyclic-aged specimens to the shear modulus of control specimens shall be equal to or greater than 90 percent.

4.4.4 Test Equipment: Test equipment for all loading shall be adequate to impose the anticipated ultimate loads and shall comply with Section 5.1.1 of ASTM E 488. If loading is not carried to failure, the highest load achieved shall be considered the ultimate load.

5.0 QUALITY CONTROL

5.1 The connector grids shall be manufactured under an approved quality program with inspections by an inspection agency accredited by the International Accreditation Service (IAS) or otherwise acceptable to ICC-ES. The quality program shall verify continued connector compliance with specifications in Section 2.1.

5.2 Quality documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted.

6.0 EVALUATION REPORT AND RECOGNITION

The evaluation report shall include the following:

6.1 Basic information required by Section 2.1 of this criteria, including product description, connector design alternative, installation procedures, packaging, identification and insulation type.

6.2 Nominal shear flow capacity, q_n, and shear modulus, G, for each connector design alternative, as determined by Section 3.3 of this criteria.

6.3 Strength reduction factors and panel deflection analysis requirements for use in design of sandwich panels shall be consistent with Section 3.4.

6.4 A statement that the grid connectors are not recognized for use in conjunction with fire-resistance-rated construction, if test reports in accordance with Section 3.6 are not submitted.

6.5 A statement that connectors are for use in concrete sandwich panels recognized in a current ICC-ES evaluation report.

6.6 A statement that qualification testing, as described in Section 4.4 of this criteria, is needed for each sandwich panel manufacturing facility. The testing must justify that the nominal shear flow capacity, and shear modulus of the grid connectors is applicable to the sandwich panels manufactured at that panel manufacturing facility.

6.7 A statement that use of connectors to resist seismic loads is outside the scope of the evaluation report.

6.8 A statement that short-term loads due to product manufacturing, transportation, and handling is outside the scope of the evaluation report.

6.9 A statement that lap splicing of semicontinuous fiber connectors is outside the scope of the evaluation report.

6.10 Statements that special inspection shall apply to the installation of the connectors. Special inspection shall conform to Section 1704 of the IBC.

6.11 Since an ICC-ES acceptance criteria for evaluating the performance of composite connectors in cracked concrete is unavailable at this time, the use of the

connectors is limited to use in uncracked concrete. Cracking occurs when $f_t > f_r$ due to service loads or deformations.

6.12 A statement that because an ICC-ES acceptance criteria for evaluating data to determine the performance of connectors subjected to fatigue or shock loading is unavailable at this time, the use of these connectors under these conditions is outside the scope of this report.

6.13 A statement that the minimum span of panels with fiber-reinforced grid connectors is limited to 7 feet (2100 mm.

TABLE 1—ENVIRONMENTAL DURABILITY TEST MATRIX

ENVIRONMENTAL DURABILITY TEST	RELEVANT SPECIFICATIONS	TEST CONDITIONS	TEST DURATION	MINIMUM NUMBER OF SPECIMENS	PERCENT RETENTION OF AVERAGE TENSILE STRENGTH	
					1,000 Hours	3,000 Hours
Water resistance	ASTM D 2247	100 percent, 100 ± 4°F	1,000 and 3,000 hours	20 for each duration	90	85
Alkali resistance	ASTM C 581	Immersion in alkali solution of pH = 12 at 73 ± 3°F	1,000 and 3,000 hours	20 for each duration		

For **SI:** 1°C = 5/9(t°F - 32).

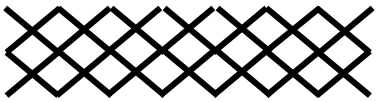
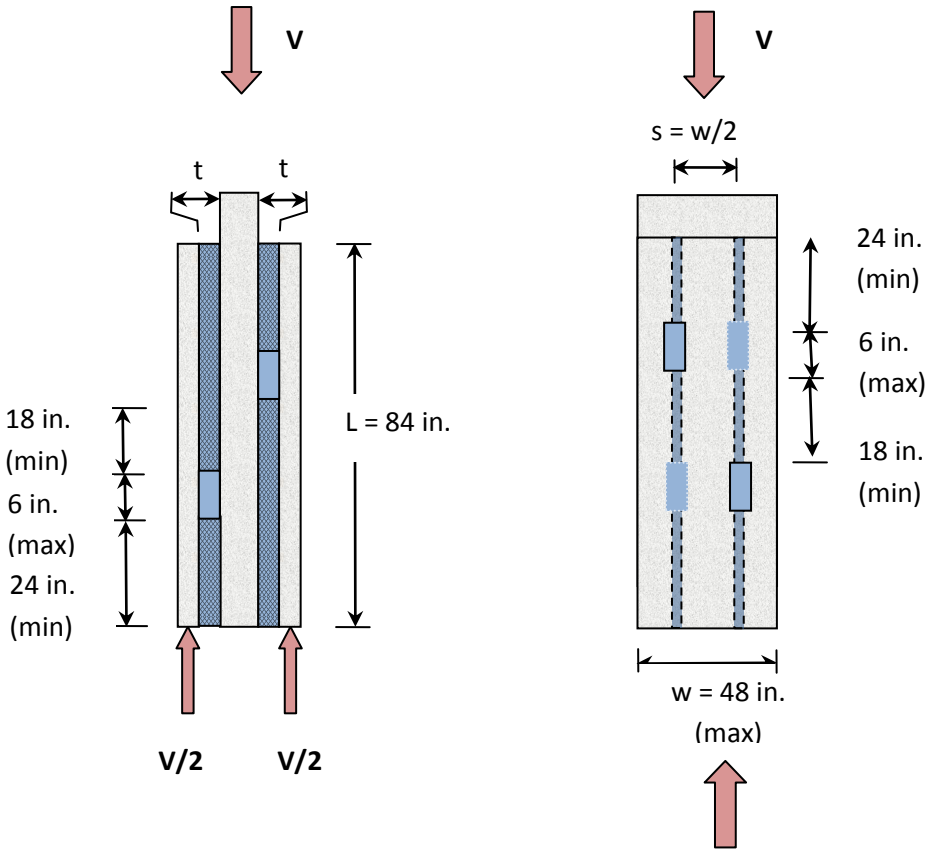


FIGURE 1—TYPICAL C-GRID CONNECTOR



For **SI:** 1 inch = 25.4 mm

FIGURE 2—TYPICAL DOUBLE-SHEAR SPECIMEN

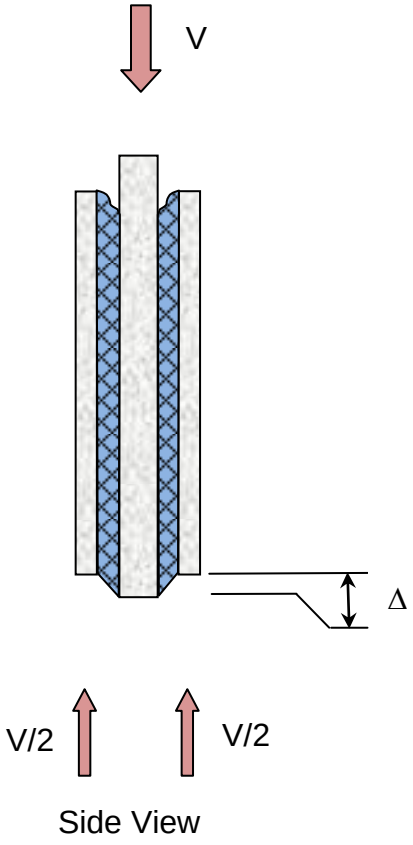


FIGURE 3—TYPICAL DOUBLE-SHEAR SPECIMEN UNDER LOAD

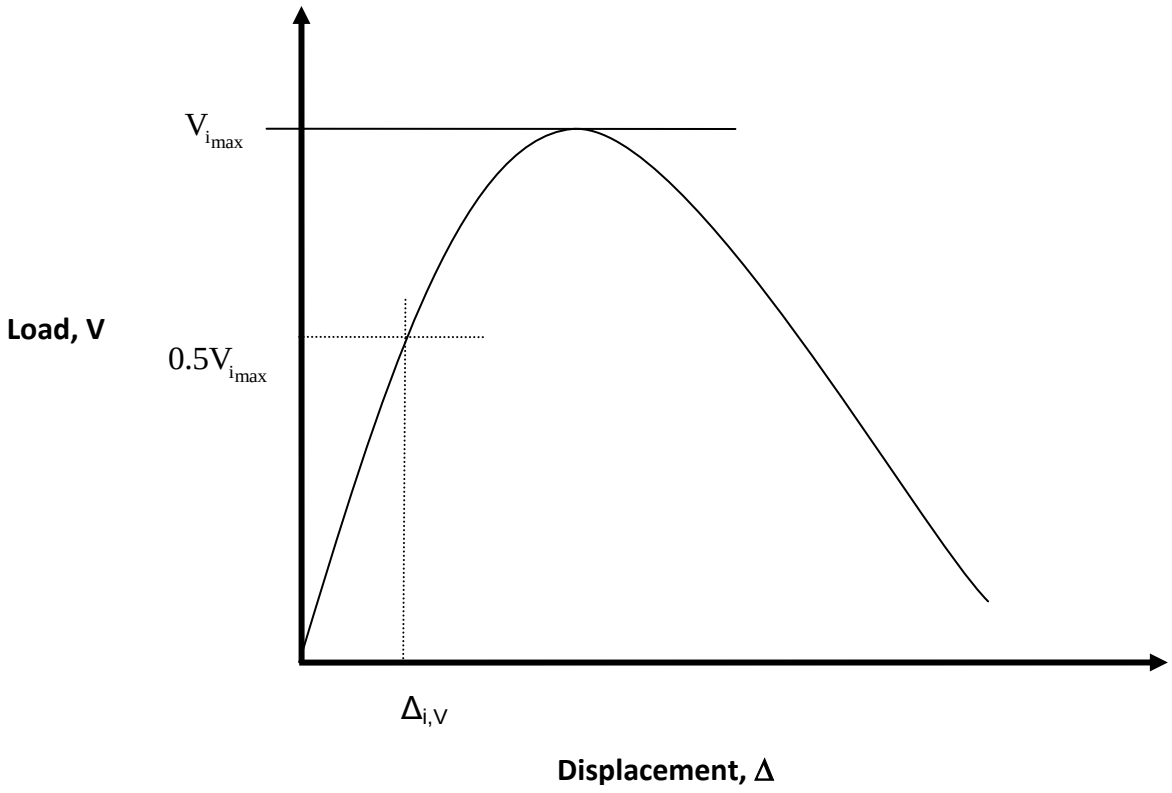


FIGURE 4—REPRESENTATIVE LOAD vs. DISPLACEMENT GRAPH