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August 1, 2010

**TO: PARTIES INTERESTED IN EVALUATION REPORTS ON SHEAR REINFORCEMENT DEVICES IN STRUCTURAL CONCRETE**

**SUBJECT: Proposed Revisions to the Acceptance Criteria for Shear Reinforcement Devices in Structural Concrete, Subject AC170-0810-R1 (ME/BG)**

Dear Madam or Sir:

The revisions proposed to the subject acceptance criteria, as presented in the enclosed criteria draft, are being posted on the ICC-ES web site to allow for public comment. If approved by the ICC-ES Evaluation Committee, these revisions may require re-evaluation of the test data for existing ICC-ES evaluation reports. The revisions include:

1. Updating the criteria to include references to the 2009 *International Building Code*<sup>®</sup> (2009 IBC).
2. Updating the criteria to include references to ACI 318-08 (Building Code Requirements for Structural Concrete), which is referenced by the 2009 IBC.
3. Revising the determination of  $A_v$  equation in Section 3.1, item No. 2, to use the proper strength reduction factors referenced by ACI 318-08.
4. Replacing the reference to AC01 in Sections 3.2.5 and 3.2.5.1 with ASTM E 488, because currently AC01 is limited to anchor tests in masonry structures, not concrete.
5. Updating the nomenclature throughout the criteria to reflect the latest versions as presented in ACI 318-08.
6. Replacing the  $V_n$  equation in Section 3.2.6.2 in accordance with the ACI 318-08.

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

All comments received in the 30-day comment period will be considered. During this same 30-day period, however, the draft criteria will be balloted to the Evaluation Committee. If the public comments raise major issues, generate controversy, or

require the criteria to be substantially rewritten, then ICC-ES staff may decide to rebalot the criteria; or place a revised draft on the web site for further public comment; or put the criteria on the agenda for a future Evaluation Committee meeting.

Correspondence received and a memo outlining staff's resolution of the comments in the correspondence will be posted on the web site shortly after the close of the comment period.

Your cooperation is requested in forwarding to the Los Angeles business/regional office all material directed to the Evaluation Committee. Parties interested in the deliberations of the committee should refrain from communicating, whether in writing or verbally, with committee members. The committee reserves the right to refuse communications that do not comply with this request.

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

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

Yours very truly,

A handwritten signature in black ink, appearing to read 'M. Ekenel', with a long horizontal flourish extending to the right.

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

ME/raf

Enclosure

cc: Evaluation Committee

# PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR SHEAR REINFORCEMENT DEVICES IN STRUCTURAL CONCRETE

AC170

Proposed August 2010

Previously approved July 2000, editorially revised June 2007

## 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 by ICC-ES for purpose of issuing ICC-ES evaluation reports.*

# PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR SHEAR REINFORCEMENT DEVICES IN STRUCTURAL CONCRETE

## 1.0 INTRODUCTION

**1.1 Purpose:** The purpose of this acceptance criteria is to establish requirements for shear reinforcement devices in structural concrete to be recognized in an ICC Evaluation Service, Inc. (ICC-ES), evaluation report under the 2009 International Building Code<sup>®</sup>, the 2006 International Building Code<sup>®</sup> (IBC) and the 1997 Uniform Building Code<sup>™</sup> (UBC). Bases of recognition are IBC Section 104.11 and UBC Section 104.2.8.

The reason for the development of this criteria was to provide testing and analytical procedures for evaluating shear reinforcement devices that are alternatives to those described in Section 11.4 of ACI 318-08 or Section 11.5 of ACI 318-05 and Section 1911.5.1 of the UBC.

**1.2 Scope:** The shear reinforcement consists of steel devices providing shear reinforcement in reinforced structural concrete slabs and beams. The shear reinforcement devices may be arranged as flat, perforated strips. The arrangements may be continuous and interconnected or individual units. The flat perforated strips can be preformed into a variety of shapes, typically into continuous U-shapes for slab shear reinforcement. The strips are either 0.031, 0.047 or 0.079 inch (0.79, 1.2 and 2.0 mm) thick. The scope of this criteria is limited to flat, perforated strip shear reinforcement devices, with punched holes along the center of their widths.

### 1.3 Codes and Reference Standards:

**1.3.1** 2009 International Building Code<sup>®</sup> (2009 IBC) International Code Council.

**1.3.2** 2006 International Building Code<sup>®</sup> (2006 IBC), International Code Council.

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

**1.3.4** ASTM A 370-97a, Test Methods and Definitions for Mechanical Testing of Steel Products, ASTM International.

**1.3.5** ASTM A 505-87, Standard Specification for Steel, Sheet and Strip, Alloy, Hot-rolled and Cold-rolled, General Requirements, ASTM International.

**1.3.6** ASTM E 8-98, Test Methods for Tension Testing of Metallic Materials, ASTM International.

**1.3.7** ACI 318-08, Building Code Requirements for Reinforced Concrete, American Concrete Institute (2009 IBC).

**1.3.8** ACI 318-05, Building Code Requirements for Reinforced Concrete, American Concrete Institute (2006 IBC).

**1.3.9** ASTM E 488-96, Standard Test Method for Strength of Anchors in Concrete and Masonry, ASTM International.

## 2.0 BASIC INFORMATION

### 2.1 General:

**2.1.1 Product Description:** Complete information, as applicable, concerning components, material specifications, and the manufacturing processes, shall be submitted.

The flat, perforated strip shall conform to ASTM A 505.

**2.1.2 Installation Instructions:** Dimensioned scale drawings and installation details, noting installation requirements and limitations, shall be submitted.

**2.1.3 Packaging and Identification:** A description of the method of packaging and identifying the device shall be submitted. Identification shall include the evaluation report number and notice of any product installation limitations.

**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:** Test reports shall comply with AC85.

**2.4 Product Sampling:** Sampling of the shear reinforcement device for tests under this criteria shall comply with Section 3.2 of AC85.

## 3.0 DESIGN AND TEST METHODS

**3.1 Design:** The shear reinforcement devices shall be designed in accordance with the accepted design ~~formula~~ equations as presented in, for the IBC, Sections 11.4.7 and 11.12 of ACI 318-08 or Sections 11.5.7 and 11.12 of ACI 318-05; and, for the UBC, UBC Sections 1911.5.6 and 1911.12.

The development strength of the flat, perforated strip shear reinforcement device, when processed with its punched holes along the center of its width, can be assessed in an identical manner to the manner for conventional reinforcing bars. Similar testing to that used to establish conventional reinforcing bar development strength can be used to show the shear reinforcement device development length in general compliance with ACI 318 Sections 12.5, 12.10 and 12.13 or UBC Sections 1912.5, 1912.10 and 1912.13. Unlike other punching shear devices, flat, perforated strip shear reinforcement devices shall be used as a direct replacement for conventional shear reinforcing bars and are designed with code-accepted design formulae and practice. The design procedure for the flat, perforated strip shear reinforcement device shall follow the procedure defined in ACI 318-08 Sections 11.1 and 11.11 or ACI 318-05 Sections 11.1 and 11.12 or UBC Sections 1911.1 and 1911.12. The design path is shown below:

1. Determination of  $V_c$ . For beams, ACI 318-08 Section 11.2 or ACI 318-05 Section 11.3 and UBC Section 1911.3 apply. For slabs, ACI 318-08 Section 11.11 or ACI 318-05 Section 11.12 and UBC Section 1911.12 apply.

2. Determination of  $A_v$  from 
$$\frac{A_v}{s} = \frac{(V_u - 0.85*V_c)}{0.85*F_y*d}$$

$$\frac{A_v}{s} = \frac{(V_u - \phi V_c)}{\phi f_{yt} d}$$

where nomenclature for  $A_v$ ,  $s$ ,  $V_u$ ,  $V_c$ ,  $F_y$ ,  $f_{yt}$  and  $d$  are referenced in ~~Section 11.0~~ Chapter 2 of ACI 318 and

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Section 1911.0 of the UBC. Strength reduction factor  $\phi$  shall be taken from Chapter 9 of ACI 318.

3. The area of the shear reinforcement device leg is the net area of the punched section.

**3.2 Test Methods:**

**3.2.1 Flat, Perforated Strip:** On the basis of similarity to properties of conventional shear reinforcement bars, the flat, perforated strip shear reinforcement device shall be assessed in an identical manner to the manner for reinforcing bar, and tested to verify the following criteria.

1. Ultimate tensile strength.
2. Yield strength.
3. Percent elongation.
4. Bend suitability.
5. Development length.

Tests 1, 2 and 3 shall be in accordance with ASTM E 8. Test 4 shall be in accordance with ASTM A 370. Test 5 is described in Section 3.2.6 of this criteria.

**3.2.2 Basic Material Tests:** Batches of steel conforming to ASTM A 505 shall be procured in coil form in various quantities and gages, and representative samples shall be taken for testing as follows:

0 to 5 tons (0 to 10,000 pounds weight) [0 to 4,536 kg]	3 samples of each gage to be tested
Over 5 tons (over 10,000 pounds weight) [over 4,536 kg]	5 samples of each gage to be tested

**3.2.3 Tensile and Elongation Test:**

**3.2.3.1 Procedure:** Samples shall be prepared from raw coil (unpunched stock) for tensile tests in accordance with ASTM E 8. The specimens shall be prepared to have a length of 8 inches (203.2 mm) and a reduced section of width 0.5 inch plus or minus 0.01 (12.7 mm plus or minus 0.254 mm) with a gage length of 2 inches (51 mm) for the purpose of determining the percentage of elongation after yielding.

**3.2.3.2 Conditions of Acceptance:** Minimum yield strength shall be 72,500 pounds per square inch (500 N/mm<sup>2</sup>) and the minimum elongation after fracture shall be 11 percent over a 2-inch (51 mm) gage length.

In the event of any specimen failing the above criteria, a further set of samples shall be taken and the tests repeated to validate results.

**3.2.4 Bend Tests:**

**3.2.4.1 Procedure:** Samples shall be prepared from raw coil (unpunched stock) for bend tests in accordance with ASTM A 370 (Figure 4) Section 14, where the specimens shall, at room temperature, be bent through 100 degrees (such that the angle between the horizontal and inclined legs is 80 degrees) within the reduced width of the specimen and with an internal radius on the bend of four times metal thickness.

**3.2.4.2 Conditions of Acceptance:** After bending, the section shall be inspected for signs of any significant cracking that would unduly affect the tensile strength of the specimens. Should any of the samples exhibit

significant cracking, further samples shall be prepared and tested.

**3.2.5 Shear Bond Tests:** To demonstrate the compatibility of shear reinforcement device with conventional reinforcement, anchorage tests in accordance with ASTM E 488 ~~the ICC-ES Acceptance Criteria for Expansion Anchors in Concrete and Masonry (AC04)~~ and beam tests in accordance with the criteria described in Section 3.2.7 shall be used to compare the equivalence of shear reinforcement device and of deformed reinforcement bars.

**3.2.6 Anchorage Test:**

**3.2.6.1 Procedure:** Five samples of shear reinforcement device shall be embedded in concrete anchor blocks and tested in accordance with Section 8 of ASTM E 488 Series 3, Table 2, in AC04. Five additional samples using conventional reinforcing bar shall be used as the control sample.

**3.2.6.2 Conditions of Acceptance:** The minimum anchorage shall be at least  $(A_s)(F_y f_{yt})$ , where nomenclature for  $A_s$  and  $F_y f_{yt}$  is referenced in Chapter 2 Section 11.0 of ACI 318 and Section 1911.0 of UBC. Deflection or slip shall be a maximum of 0.04 inch (1 mm).

**3.2.7 Beam Test:**

**3.2.7.1 Procedure:** Three beam test specimens plus two control specimens are required to replicate prior tests, described in references 1 to 3. The beams shall be 4 feet long (1200 mm) with cross-sectional area of nominally 6 inches by 10 inches (150 by 250 mm), and shall be reinforced with two No. 6 bars (20 M). Web reinforcement shall be designed to achieve the following objectives:

1. To demonstrate the full potential of shear reinforcement device to act as shear reinforcement.
2. To study the effect of confinement on the anchorage of shear reinforcement device.
3. To verify the effectiveness of continuous U-shaped shear reinforcement device running longitudinally.

Two additional beam specimens, one without shear reinforcement and one with conventional stirrup reinforcement, shall be used as control specimens.

The beams shall be simply supported at 4 inches (100 mm) from each end. A single point load shall be applied at 18 inches (450 mm) from one end to ensure that shear failure occurs on the side of the beam where strain gauges would be bonded on the shear reinforcement.

Vertical beam deflection shall be monitored using LVD transducers. The load rate shall be determined prior to testing. The strain gauges shall be connected to a computer system to record the strain at each location independently and provide separate plots for each. Compression testing of concrete cylinders shall be performed the day of the beam testing.

**3.2.7.2 Conditions of Acceptance:** The predicted capacities shall be established by using the equations in the Chapter 11 of ACI 318 and the UBC and the following expression:

$$V_n = (A_v f_y / s + b V_c) d$$

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$$V_D = V_c + V_s$$

where  $V_c$  is computed using ACI 318 Equation (11-5) and the UBC, and the nomenclature for  $V_n$ ,  $A_v$ ,  $f_y$ ,  $s$ ,  $b$ ,  $V_c$  and  $V_s$  is referenced in Chapter 2 Section 11.0 of ACI 318 and Section 1911.0 of UBC.

The results shall be tabulated with the ratio of the test load versus the predicted strength.

**4.0 QUALITY CONTROL**

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

**4.2** Third-party follow-up inspections are not required under this acceptance criteria.

**4.3 Special Inspection:** Special Inspection shall be required as follows:

**4.3.1 IBC:** Special inspections in accordance with IBC Sections 1704.4 and Table 1704.4 are required when the shear reinforcement device is installed. Duties of the special inspector include verifying field preparation of

materials, product identification and condition, installation of components, positioning, clearances and concrete cover

**4.3.2 UBC:** Special inspection is required as noted in UBC Section 1701.5 (4) for placement of shear reinforcement device.

**5.0 EVALUATION REPORT RECOGNITION**

**5.1** Special Inspection provisions shall be described in the evaluation report as noted in Section 4.3 of this criteria.

**5.2** The evaluation report shall require design provisions to be in accordance with Chapter 11 of ACI 318, including specific requirements of ACI 318-08, Section 11.11 or ACI 318-05, Section 11.12.

**5.3** The evaluation report shall provide basic Information required by Section 2.1, including product description, installation procedures, packaging and identification.■