

ACCEPTANCE CRITERIA FOR SHEAR REINFORCEMENT DEVICES IN STRUCTURAL CONCRETE

AC170

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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.

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

ICC-ES may consider alternate criteria, provided the report applicant submits valid data demonstrating that the alternate criteria are at least equivalent to the criteria 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.

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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, LLC (ICC-ES), evaluation report under the 2009 *International Building Code*[®], the 2006 *International Building Code*[®] (IBC) and the 1997 *Uniform Building Code*[™] (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*[®] (2009 IBC) International Code Council.

1.3.2 2006 *International Building Code*[®] (2006 IBC), International Code Council.

1.3.3 1997 *Uniform Building Code*[™] (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 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

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

where nomenclature for A_v , s , V_u , V_c , f_{yt} and d are referenced in Chapter 2 of ACI 318 and Section 1911.0 of

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the UBC. Strength reduction factor ϕ 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/mm²) 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 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. 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 $(A_s)(f_{yt})$, where nomenclature for A_s and f_{yt} is referenced in Chapter 2 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, the UBC and the following expression:

$$V_n = V_c + V_s$$

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

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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.■