ICC EVALUATION SERVICE

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

ACCEPTANCE CRITERIA FOR THREADED HIGH-STRENGTH STEEL BARS FOR CONCRETE REINFORCEMENT

AC237

Approved June 2009

Effective July 1, 2009

Previously approved October 2006, October 2003

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.

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 set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. Notwithstanding that a product, material, or type or method of construction meets the requirements of the criteria set forth in this document, or that it can be demonstrated that valid alternate criteria are equivalent to the criteria in this document and otherwise demonstrate compliance with the performance features 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 if 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.

ACCEPTANCE CRITERIA FOR THREADED HIGH-STRENGTH STEEL BARS FOR CONCRETE REINFORCEMENT (AC237)

1.0 INTRODUCTION

1.1 Purpose: The purpose of this criteria is to establish procedures for threaded high-strength steel bars to be recognized in an ICC Evaluation Service, Inc. (ICC-ES), evaluation report under the 2006 (2009) *International Building Code*® (IBC). The basis of recognition is IBC Section 104.11.

The reason for developing this acceptance criteria is to provide guidelines allowing reinforcement to be designed with a yield strength, f_y, exceeding the 80,000 psi (551 MPa) limit in the IBC.

1.2 Scope: This acceptance criteria applies to threaded high-strength steel bars as longitudinal and transverse reinforcement in reinforced concrete, subject to the following restrictions:

1.2.1 The high-strength bars shall not be used in beams or slabs.

1.2.2 The high-strength bars shall not be used in buildings assigned to Seismic Design Category C, D, E, or F.

1.2.3 The high-strength bars shall not be welded.

1.2.4 The high-strength bars shall not be bent, if the nominal bar size exceeds No. 14 (43 mm) diameter.

1.2.5 The specified concrete compressive strength shall range from 6,000 psi (41.3 MPa) to 12, 000 psi (82.7 MPa).

1.2.6 This criteria is applicable to reinforcement under Sections 3.5.3.2, 9.4, 11.5.2, 11.6.3.4 and 11.7.6 of ACI 318-05, referenced in Section 1901.2 of the IBC.

1.3 Reference Standards:

1.3.1 2006 (2009) *International Building Code*® (IBC), International Code Council.

1.3.2 ACI 318-05 (08), Building Code Requirements for Structural Concrete, American Concrete Institute.

1.3.3 ASTM A 370-05, Test Methods and Definitions for Mechanical Testing of Steel Products, ASTM International.

1.3.4 ASTM A 615-04a (07), Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement, ASTM International.

1.3.5 ASTM A 944-05, Standard Test Method for Comparing Bond Strength of Steel Reinforcing Bars to Concrete Using Beam-End Specimens, ASTM International.

1.4 Definitions:

High-strength Threaded Steel Reinforcing Bars: High-strength threaded steel reinforcing bars are steel bars with protrusions in a threaded orientation for use as reinforcement in concrete construction. The bars shall have minimum yield strength of 97,000 psi (670 MPa). The threaded protrusions permit connections with approved mechanical anchorages and splices.

2.0 BASIC INFORMATION

2.1 General: The following information shall be submitted:

2.1.1 Product Description: Description of the bars, splices, and anchorages shall be reported, including general specifications, dimensions, tolerances, threading requirements, deformation requirements and mechanical properties.

2.1.2 Installation Instructions: Complete installation instructions for the placement of bars, mechanical splices, and anchorages shall be provided. The instructions shall include provisions to mark bars for proper coupler installation.

2.1.3 Identification:

2.1.3.1 Steel Bars: Bundled bars shall have an attached tag identifying the production mill, heat number and roll number. An additional tag shall bear the ICC-ES evaluation report number. Individual bars shall be identified by a distinguishing set of marks, rolled into the surface of one side of the bar, denoting point of origin, size designation and minimum yield strength designation.

2.1.3.2 Mechanical Couplers: Couplers shall be identified in accordance with the ICC-ES Acceptance Criteria for Mechanical Connectors for Steel Bar Reinforcement (AC133).

2.2 Testing Laboratories: Testing laboratories shall comply with 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. In addition, the test reports shall include sampling procedures, test specimen preparation, test procedures, and results of all tests. Where indicated, photographs shall be included in the report.

2.4 Product Sampling: Sampling of the bar and couplers for tests under this criteria shall comply with Sections 3.2, 3.3 and 3.4 of AC85.

3.0 TEST AND PERFORMANCE REQUIREMENTS

3.1 Bond:

3.1.1 Procedure: Testing for steel bar bond to concrete with and without splices shall be in accordance with Section 4.1. Splices may consist of lap splices or mechanical couplers.

3.1.2 Conditions of Acceptance: The result of every test shall satisfy the relationship

$$u_{test} \geq u_{aci} \qquad (3\text{-}1)$$

$$u_{aci} = \frac{f_y d_b}{4 l_{d,aci}} \qquad (3\text{-}2)$$

where:

f_y = specified yield strength of reinforcement (psi or MPa).

d_b = bar diameter (in. or mm).

$l_{d,aci}$ = required development length in tension, determined using Eq. (12-1) of ACI 318 (in. or mm).

u_{test} obtained from a beam-end specimen test is:

$$u_{test} = \frac{P_{max}}{\pi d_b l_{bond}} \quad (3\text{-}3)$$

where:

P_{max} = maximum load measured in test (lbf or N).

l_{bond} = bonded length of bar being tested (in. or mm).

u_{test} obtained from a splice specimen test is:

$$u_{test} = \frac{f_s d_b}{4 l_s} \quad (3\text{-}4)$$

where:

f_s = maximum stress measured in reinforcing bar (psi or MPa)

l_s = splice length (in. or mm).

3.2 Steel Bar Mechanical Properties:

3.2.1 Procedure: Testing for mechanical properties of steel bars shall be in accordance with ASTM A 370.

3.2.2 Conditions of Acceptance: Conditions of acceptance are as noted in Table 1.

3.3 Steel Bar Dimensions: The following dimensions shall be determined and reported by the testing laboratory: weight, plf (kg/m); diameter, in. (mm); cross-sectional area, in^2 (mm^2); perimeter, in. (mm); and deformations, in. (mm). Deformations shall be determined based on procedures in Section 8 of ASTM A 615.

3.4 Steel Bar Bending Requirements: Test procedures and conditions of acceptance for each steel bar size shall be in accordance with ASTM A 615.

3.5 Splices:

3.5.1 Mechanical couplers shall be in conformance with Section 12.14.3 of ACI 318 and shall be Type 1 in compliance with AC133. Verification of compliance, in the form of test results, in accordance with Section 4.2 shall be provided.

3.5.2 Lap splices shall comply with ACI 318 Chapter 12 and this criteria.

3.5.3 The clearance between a splice and an adjacent reinforcing bar, or clearance between splices, shall not be less than the maximum size of coarse aggregates. In the event of making a splice after arrangement of reinforcing bars, clearances allowing insertion of equipment for construction of splices shall be provided.

3.5.4 The cover for a splice shall satisfy the requirements of Section 7.7 of ACI 318.

3.5.5 Splices of reinforcing bars of different diameters shall be in accordance with the following:

3.5.5.1 In case the degree of concentration of splices is $^1/_2$ or under, the ratio of cross-sectional areas of reinforcing bars having different diameters shall be not less than $^1/_2$. The degree of concentration of splices is to be determined by the ratio of the sum of cross-sectional areas of reinforcing bars to be spliced and the total sum of cross-sectional areas of all reinforcing bars at the cross section under consideration.

3.5.5.2 In case the degree of concentration of splices exceeds $^1/_2$, the ratio of cross-sectional areas of reinforcing bars having different diameters shall be not less than $^3/_4$.

3.6 Anchorage:

3.6.1 Anchorage shall be provided by development length in accordance with Chapter 12 of ACI 318 based on compliance with Section 3.1 of this criteria. Mechanical anchorages are permitted to be used in addition, but shall not be utilized to decrease the embedment length needed to transfer stresses by bond alone.

4.0 TEST METHODS

4.1 Required Bond Tests: Bond tests shall be carried out, as required by Table 2.

The beam-end test specimen configurations and the testing of those specimens shall be in accordance with ASTM A 944. Section 1.2 of ASTM A 944 limits the scope of the standard to bars of size No. 3 to No. 10 (8 mm diameter to 35 mm diameter). For the purposes of this acceptance criteria, these limitations shall not apply. The standard specimen dimensions and reinforcement as outlined in Section 5.1 of ASTM A 944 and as shown in Figure 2 of ASTM A 944 are not appropriate for No. 14 (43 mm diameter) and No. 20 (63.5 mm diameter) bars. Specimen dimensions shall be increased to those shown in Figure 1 of this criteria and a minimum amount of transverse reinforcement shall be added to accommodate the large-diameter bars. No. 3 (8 mm diameter) Grade 60 (414 MPa yield strength) ties shall be placed on 5.5-inch (140 mm) center for the entire length of the specimen to prevent premature splitting.

The splice test specimens shall be configured as shown in Figure 2. One tie consisting of No. 3 (8 mm diameter) Grade 60 reinforcing bar at each end of the splice shall be provided for No. 20 (63.5 mm) bars.

The longitudinal bars shall be instrumented so that the strains developed are monitored. Equal load increments shall be applied at the two ends of a beam. The load at each end shall be applied in increments of 0.5 to 2 kips (2.22 to 8.89 kN), depending on the estimated strength of the beam specimens. Displacement control shall be used for specimens with ties, following yielding of the longitudinal bars. Load and displacement increments shall continue until a specimen fails.

4.2 Required Mechanical Coupler Tests: Mechanical couplers shall be tested with all reinforcing bar sizes for which recognition is sought. Test procedures and conditions of acceptance shall comply with AC133. A typical coupler is shown in Figure 3. Equal lengths of the opposing bar ends shall be engaged within the coupler. The bar ends engaged within the coupler shall be in as-received factory-cut condition. After initial assembly, a specific torque shall be applied to each connection, as indicated in Table 3.

5.0 QUALITY CONTROL

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

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

6.0 EVALUATION REPORT RECOGNITION

The evaluation report shall include the following:

6.1 Restrictions and requirements summarized in Section 2.1.

6.2 Basic information required by Section 2.1, including product description, installation procedures, packaging and identification.

6.3 Permitted mechanical couplers complying with Section 3.5.

6.4 Restriction that for computing shear strength and torsional strength, the yield strength shall not exceed 60,000 psi (413 MPa).■

TABLE 1—CONDITIONS OF ACCEPTANCE

PROPERTY	VALUE
Minimum tensile strength, psi (MPa)	116,000 psi (800 MPa)
Minimum yield strength, psi (MPa)	97,000 psi (670 MPa)
Minimum elongation in 8 in. (203 mm), %	
Smaller than No. 6 (18 mm diameter) bars)	9
No. 6 (18 mm diameter) to smaller than No. 9 (28 mm diameter) bars	7
No. 9 (28 mm diameter) to smaller than No. 14 (43 mm diameter) bars	6
No. 14 (43 mm diameter) to smaller than No. 20 (63.5 mm diameter) bars	6
No. 20 (63.5 mm diameter)	6

TABLE 2—BOND TEST SCHEDULE

TEST REQUIREMENTS	CONCRETE STRENGTH							
	6,000 psi (41 MPa)				12,000 psi (83 MPa)			
	Diameter				*Diameter*			
	0.709 in. (18 mm) No. 6 or smaller	1.102 in. (28 mm) No. 9	1.693 in. (43 mm) No. 14	2.5 in. (63.5 mm) No. 20	0.709 in. (18 mm) No. 6 or smaller	1.102 in. (28 mm) No. 9	1.693 in. (43 mm) No. 14	2.5 in. (63.5 mm) No.20
No. of beam-end specimens ASTM A 944	3	3	3	3	3	3	3	3
No. of splice specimens without transverse reinforcement	—	1	—	1	—	1	—	1
No. of splice specimens with minimum transverse reinforcement per Section 7.10.5 of ACI 318	—	2	—	2	—	2	—	2
No. of splice specimens (Transverse reinforcement size - same as above. Transverse reinforcement. Spacing is one-half spacing in Section 7.10.5 of ACI 318)	—	1	—	1	—	1	—	1

TABLE 3—TORQUE APPLIED

NOMINAL DIAMETER, mm (No.)	TORQUE, kN-m	TORQUE, foot-pound force
18 (6)	0.14	100
22 (7)	0.16	120
25 (8)	0.19	140
28 (9)	0.22	160
30 (10)	0.24	180
35 (11)	0.27	200
43 (14)	0.31	230
57.5 (18)	0.35	260
63.5 (20)	0.41	300

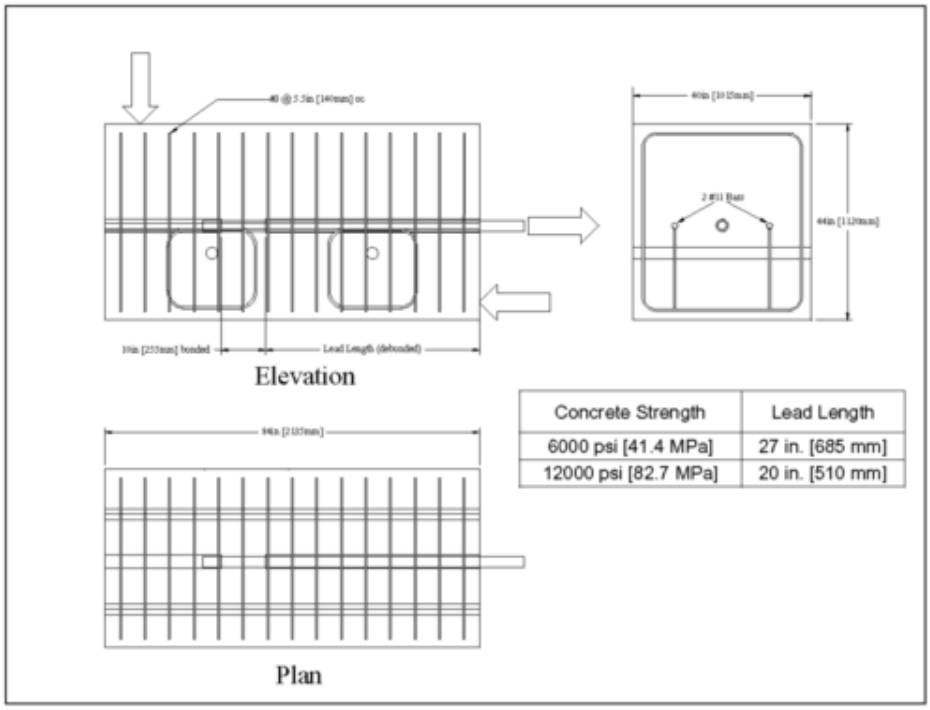


FIGURE 1A—BEAM END SPECIMEN FOR NO. 14 (43 mm) DIAMETER BARS

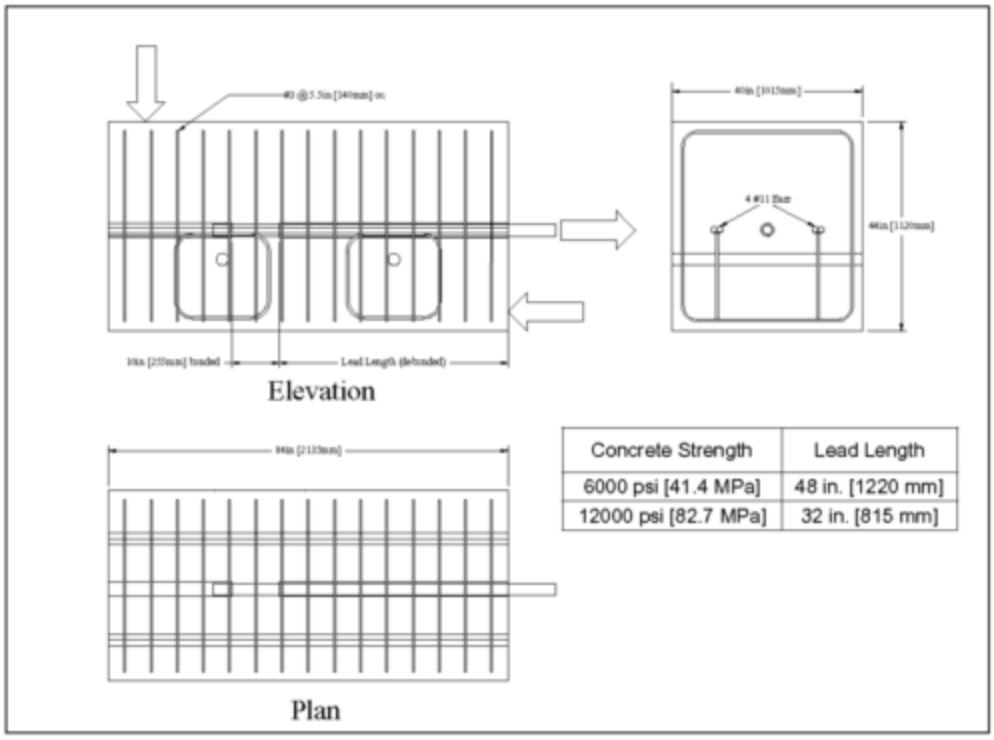


FIGURE 1B—BEAM END SPECIMEN FOR NO. 20 (63.5 mm) DIAMETER BARS

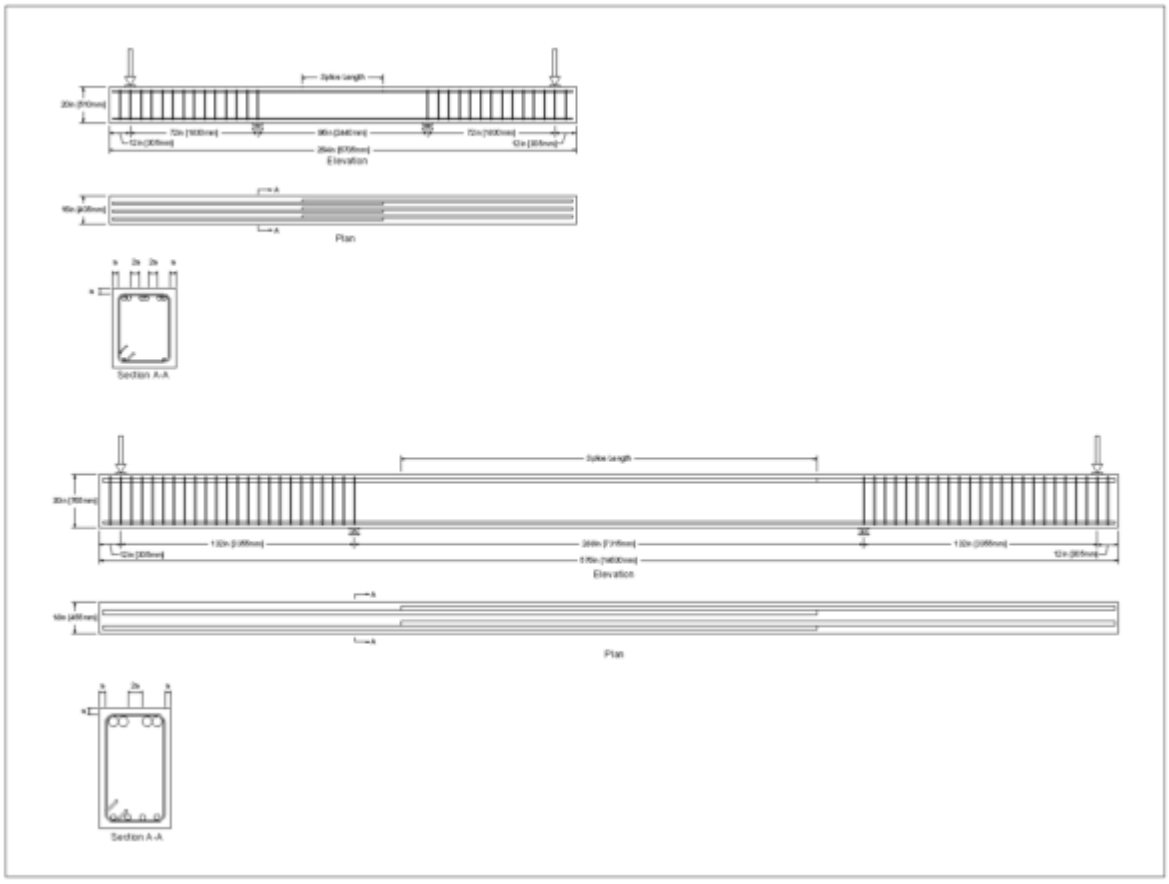
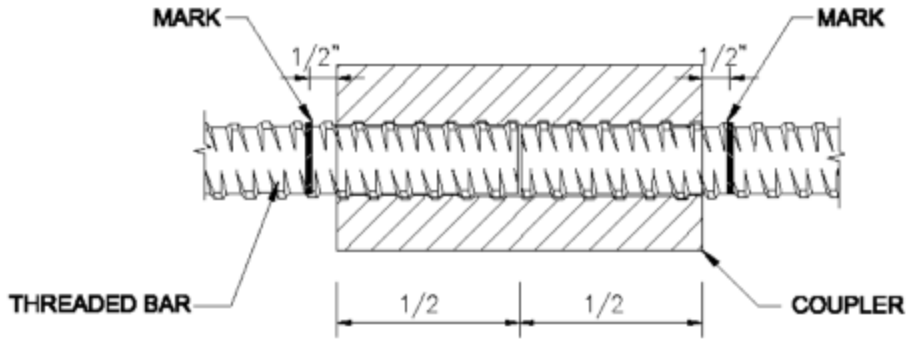


FIGURE 2



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

FIGURE 3