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February 4, 2010

**TO: PARTIES INTERESTED IN EVALUATION REPORTS ON
HEADED DEFORMED BARS**

**SUBJECT: Revisions to the Acceptance Criteria for Headed Deformed Bars,
Subject AC347-0210-R1 (RK/BG)**

Dear Madam or Sir:

Enclosed is a copy of the subject revised acceptance criteria approved by the ICC-ES Evaluation Committee on February 4, 2010, effective July 1, 2010.

The approved revisions included the following:

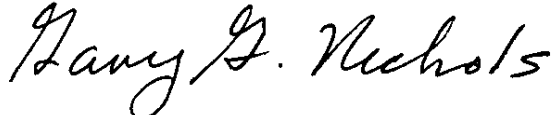
1. The title was revised.
2. The criteria was updated to the 2009 *International Building Code* (IBC) and ACI 318-08, as referenced in Section 1901.2 of the 2009 IBC. Report holders wishing to include recognition under the 2006 IBC or the 1997 *Uniform Building Code* (UBC) must address requirements as outlined in AC347 dated August 2008.
3. The design and detailing requirements in the previous edition of the criteria, for headed deformed bars in concrete, have been replaced with requirements under Section 12.6 of ACI 318-08.
4. The limitations on "obstructions" have been revised in Section 3.2.3, to make the requirements more restrictive.
5. The use of headed deformed bars as an alternative to tension lap splices of reinforcing steel has been removed from the criteria.
6. The limitation to uncoated headed deformed bars has been deleted.

Evaluation reports issued on or after the effective date noted above, and falling within the scope of this criteria, will be required to comply with the enclosed edition of the criteria. Evaluation reports issued prior to the effective date may be in compliance either with the enclosed acceptance criteria or with the previous edition. Evaluation reports based on a superseded version of an acceptance criteria must be brought into compliance with the most recent edition at the time the reports are reissued. Therefore, applicants should submit data verifying compliance at the time they apply for re-examination.

ICC-ES evaluation reports issued on or after the effective date noted above, both new reports and conversions of legacy reports, must comply with this criteria if they fall within its scope.

If you have any questions, please contact Russ Krivchuk, Senior Staff Engineer, at (800) 423-6587, extension 3275. You may also reach us by e-mail at es@icc-es.org.

Yours very truly,

A handwritten signature in black ink that reads "Gary G. Nichols". The signature is written in a cursive, flowing style.

Gary G. Nichols, P.E., SECB
Vice President

GGN/md

Enclosure

cc: Evaluation Committee

ACCEPTANCE CRITERIA FOR HEADED DEFORMED BARS

AC347

Approved February 2010

Effective July 1, 2010

Previously approved August 2008, October 2006

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 purpose of issuing ICC-ES evaluation reports.

ACCEPTANCE CRITERIA FOR HEADED DEFORMED BARS (347)

1.0 INTRODUCTION

1.1 Purpose: The purpose of this criteria is to establish requirements for headed deformed bars to be recognized in ICC Evaluation Service, Inc. (ICC-ES), evaluation reports under Sections 12.1.1 and 12.6 of the American Concrete Institute ACI 318-08, referenced in Section 1901.2 of the 2009 *International Building Code*[®] (IBC).

The reason for development of this criteria is to establish guidelines for the evaluation of headed ends of concrete reinforcement, since the IBC, and documents referenced by those codes do not specify requirements for the testing and installation of headed ends of concrete reinforcement.

1.2 Scope: This criteria is for headed deformed bars that develop the yield strength of the reinforcing bars under tensile forces without concrete or headed end damage. Under this criteria, development of the reinforcing bar is based on the headed end of the reinforcing bar bearing on the concrete, and the bond of the concrete to the reinforcing bars.

The headed deformed bars are alternatives to the embedment lengths of straight bars or hooks of deformed steel reinforcing bars in reinforced concrete specified in ACI 318 Sections 12.1.1 and 12.6 as a means for development of reinforcing bars in tension. Related sections in the codes that permit or require mechanical anchorage of reinforcing bars are ACI 318 Sections 12.1.1, 12.10.6, 12.11.2, 12.11.3, 12.11.4 and 12.12.1.

This criteria applies to headed deformed bars that comply with ASTM A 970, as required by ACI 318 Section 3.5.9 and comply with the conditions specified in ACI 318 Section 12.6.1, including having a net headed bearing area of at least four times the nominal area of the reinforcing bar; a specified yield strength not exceeding 60 ksi (420 MPa); reinforcing bar size not exceeding No. 11; installation in normal-weight concrete; spacing between headed bars not less than four times the bar diameter; and concrete coverage measured to any portion of the headed bar not less than two times the bar diameter.

This criteria is applicable to reinforcement with a factory-forged headed end; reinforcement with a factory-welded headed end; products that are mechanically attached to the end of reinforcing bars at the jobsite without factory preparation of the reinforcing bars; and products that are, in whole or in part, mechanically attached to the end of the reinforcing bars at a factory.

Use of the headed deformed bars on compression reinforcement is outside the scope of this criteria.

1.3 Codes and Referenced Standards:

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

1.3.2 ASTM A 970-06, Standard Specification for Headed Steel Bars for Concrete Reinforcement, ASTM International.

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

1.3.4 ASTM E 8-04, Test Methods for Tension Testing of Metallic Materials, ASTM International.

1.3.5 ACI 318-08, Building Code Requirements for Structural Concrete, American Concrete Institute.

1.4 Definitions:

1.4.1 Critical Section: The critical section is that location on the reinforcing bar where the full bar stress is required.

1.4.2 Net Headed Bearing Area: The net headed bearing area, A_{brg} , is the surface area of the headed end that bears with direct contact onto the concrete, orthogonal to the reinforcing bar's longitudinal axis, exclusive of the nominal reinforcing bar cross sectional area, A_b , and projected area of any device used to connect the headed end to the bar. Limited features that obstruct the orthogonal surface area of the head from bearing on the concrete are permitted only to the extent specified in Section 3.2.3.

2.0 BASIC INFORMATION

2.1 General: The following general product information shall be submitted:

2.1.1 Product Description: Description of headed deformed bar product shall include dimensions, designations and material specifications.

2.1.2 Installation Instructions: Installation instructions for the headed deformed bars shall include requirements and limitations regarding installation of the product.

2.1.3 Packaging and Identification: The method of packaging of the headed deformed bars shall be described. Labels on packaging shall include the name and address of the evaluation report applicant, product model or name, size, the applicable ICC-ES evaluation report number and the name or logo of the inspection agency, as applicable (see Section 5.2).

For headed deformed bars that are reinforcement with factory forged or welded heads, each headed bar shall be labeled in accordance with Section 15 of ASTM A 970.

For headed deformed bars with mechanically attached heads that are field or factory assembled onto the reinforcement, each component shall be identified by the manufacturer's mark or logo.

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: For tests specified in this criteria, products with welded ends and products with components factory attached to the reinforcing bar ends shall be sampled in accordance with Section 3.1 of AC85. All other products are permitted to be sampled in accordance with Section 3.2 of AC85. The assembly of the test specimens shall comply with Section 3.3 of AC85.

3.0 TEST, PERFORMANCE AND PRODUCT REQUIREMENTS

3.1 Headed Bar Materials, Manufacture and Chemical Composition: The material specifications, bar deformations, manufacturing and chemical composition of the components of the headed bar shall comply with

ACCEPTANCE CRITERIA FOR HEADED DEFORMED BARS (AC347)

Sections 1.2, 1.4 (except 1.4.6), 5 and 6 of ASTM A 970. For use as reinforcement resisting earthquake-induced flexural and axial forces in frame members structural walls and coupling beams, the reinforcing bar component of the headed bars shall comply with ACI 318 Section 21.1.5.2.

3.2 Head Dimensions:

3.2.1 General: The dimensions of the headed end of the bars shall be such that the headed end is sufficiently rigid to ensure uniform bearing of the headed end on the concrete with the headed bars subjected to tensile forces up to a tensile stress in the bar at the specified yield strength based on the headed end concrete bearing strength capacity. Head rigidity shall be assessed in accordance with Section 4.3.

3.2.2 Net Headed Bearing Area: The net headed bearing area, A_{brg} , shall be equal to or greater than four times the nominal cross sectional area of the reinforcing bar.

3.2.3 Obstructions to Head Bearing Area: Obstructions to the head bearing face shall not extend along the longitudinal axis of the reinforcing bar for a distance greater than two times the bar diameter, $2x d_b$, from the bearing face of the head. The obstructions shall not have a diameter greater than 1.5 times the nominal diameter of the steel reinforcing bar. Bearing surfaces that are not orthogonal to the longitudinal axis of the reinforcing bar shall be treated as obstructions.

3.2.4 Bar Deformations: Obstruction or alteration of the bar deformations, to the extent that the deformations are not engaged by concrete or no longer conform to the requirements of the ASTM standard applicable to the unheaded bar, shall extend along the longitudinal axis of the reinforcing bar for a distance not greater than $2d_b$ from the bearing face of the head.

EXCEPTION: Headed bars that provide A_{brg} of at least $9A_b$, need not comply with the limit on obstructed or altered bar deformations.

3.3 Tensile Tests: Reports of load tests (cyclic tension followed by monotonic tension tests) of the headed bars in accordance with Section 4.1 of this criteria shall be submitted. In order to verify compliance with the conditions of acceptance in Section 4.1.7.1, tension tests of control reinforcing bar specimens from the same heat as the reinforcing bar of the headed bar load tests shall be conducted in accordance with ASTM A 370 to establish the actual yield and actual tensile strength, final elongation at fracture of the reinforcing bar and strain in the bar at actual yield stress.

3.4 Bend Tests: For welded headed bars, report(s) of bend tests in accordance with Section 4.2 of this criteria shall be submitted.

3.5 Structural Design and Installation: Structural design and installation provisions in the evaluation report shall be consistent with ACI 318 Sections 12.6.1 through 12.6.3.

4.0 TEST METHODS

4.1 Cyclic Tension Followed by Monotonic Tension Tests:

4.1.1 The cyclic tension tests of headed bars shall be in accordance with Stages 1, 2 and 3 described in Table 1. After the third stage, the specimens shall be

monotonically tested in tension to failure, as noted as Stage 4 in Table 1.

4.1.2 At least five specimens shall be tested for each bar size and head type for which recognition is sought.

Where the interface between the bar and the head is potentially affected by bar deformation shape, size or pattern (such as spiral, diamond and bamboo), the evaluation report needs to be limited to the bar deformation pattern used in the tests, unless five additional specimens for at least three different bar deformation patterns are tested in each bar size and head type. For headed end products that have substantially the same design for all bar diameters, all bar diameters need not be tested to determine the effects of bar deformation pattern, if tests of the smallest and largest bar size demonstrate compliance with Section 4.1.7.

4.1.3 In order to conduct Stages 2 and 3, a reference strain shall be measured on the reinforcing bar of each headed bar test specimen, remote from the bar to headed end connection or affected zone. The reference strain shall be used to determine the tension loads in Stages 2 and 3. The tensile loads in Stages 2 and 3 shall be based on the first cycle load that results in $2\epsilon_y$ and $5\epsilon_y$ strain in the bar, respectively. The zero strain (i.e., baseline strain) reading shall be taken at zero applied load prior to the start of the cyclic load test, and shall not be zeroed during the test. The reference strain shall be recorded throughout stages 1 through 3, and as far into Stage 4 as practicable. For purposes of this criteria, the affected zone is that portion of the bar where any property of the bar, including physical, metallurgical or material characteristics, has been altered by the manufacture, fabrication or installation of the headed end of the bar. Examples of affected zones are heat affected zones, bar upset zones, sections of the bar affected by threading or other machining, and significant sharp marks or notches left in the bar by gripping during manufacture, fabrication or installation of the headed end.

4.1.4 Although the headed bar test specimens shall not include concrete, the test fixture shall load the bearing face of the headed end of the test specimens in a uniform manner that simulates the bearing of the headed end onto concrete.

4.1.5 The Stage 4, monotonic tension tests shall include recordings of tension and elongation of the headed bars in accordance with Sections 7.1 through 7.4 of ASTM A 970, except as modified by this criteria.

For headed bars having the reinforcing bar hot- or cold-worked adjacent to the head as a result of the head manufacturing process, the location of marks for measuring elongation after fracture shall be located as described herein. The mark closest to the headed end of the reinforcing bar shall be located at a point that is on the hot- or cold-worked portion of the reinforcing bar, approximately $1/2$ inch (12.7 mm) away from the transition point between the hot- or cold-worked reinforcing bar and unaffected reinforcing bar. The second mark shall be located on unaffected reinforcing bar, away from the headed end and beyond the transition point.

4.1.6 The slip of the head-to-bar connection shall be monitored during the Stages 1 through 4 testing. Slip of the head-to-reinforcing bar connection shall be reported in the form of load-slip graphs.

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4.1.7 Conditions of Acceptance:

4.1.7.1. The Stage 2 yield strength, Stage 4 tensile strength and Stage 4 elongation of each tested headed bar assembly shall comply with the requirements of Sections 7.3.1, 7.3.2 and Table 1 of ASTM A 970 with the yield and tensile stress based on the nominal cross sectional area of the reinforcing bar.

4.1.7.2. The Stage 4 failure mode of each tested headed bar assembly shall comply with the conditions of acceptance of Section 7.3.3 of ASTM A 970.

4.2 Bend Test of Welded Headed Products:

4.2.1 Bend tests of welded headed assemblies shall be conducted in accordance with Section 7.5 of ASTM A 970.

4.2.2 At least three specimens shall be tested for each bar size and head type.

4.2.3 Conditions of acceptance of each specimen are as specified in Section 7.5.2 of ASTM A 970.

4.3 Head Rigidity: The rigidity of the headed ends shall be assessed in accordance with either Section 4.3.1 or 4.3.2:

4.3.1 Analysis: It shall be demonstrated using an engineering analysis that the head material does not yield when the head is subjected to a concrete bearing stress associated with the specified yield strength of the reinforcing bar.

4.3.2 Tests: A minimum of three specimens of each bar size and head type shall be subjected to a minimum tension force, applied as described in Section 4.1.4, equal to $f_y \times A_b$ for a minimum of 60 seconds prior to release of the applied load. The value of f_y shall be the specified yield strength of the reinforcing bar. Following release of the applied load, the heads of the test specimens visually examined and measured, shall not exhibit a residual deformation in excess of 0.05 inch (1.27 mm) as compared to the profile of the specimen measured prior to load application.

5.0 QUALITY CONTROL

5.1 The products shall be manufactured under an approved quality control program, with quality documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) submitted for each manufacturing facility.

The quality documentation, as it relates to manufacturing, shall include the tolerance for physical and

chemical properties, acceptance test standards, fabrication geometric tolerance and other aspects of the controls on the production of the headed bar system. The quality program shall include production testing that is in accordance with Section 8 of ASTM A 970. Records of all tests shall be kept and logged in a register for inspection and audit purposes in accordance with the quality control manual.

5.2 The quality control program shall include inspections by a third-party inspection agency accredited by the International Accreditation Service (IAS) or otherwise acceptable to ICC-ES, for products that include components that are factory-attached to reinforcing bar (including, but not limited to, friction-welded headed ends) and to reinforcing bar that is factory-prepared for field assembly, such as threading of the ends of the reinforcing bar.

6.0 EVALUATION REPORT RECOGNITION

6.1 The evaluation report shall indicate that special inspection shall be provided at the jobsite as required by IBC Section 1704 and UBC Section 1701, as applicable. The evaluation report shall include statements that, in addition to verifying placement of the headed end of the reinforcing bar, the special inspector shall verify field preparation of components (including preparation of reinforcing bar ends) and assembly of the components resulting in reinforcing bar with a headed end.

6.2 The evaluation report shall include the net headed bearing area for each size headed end reinforcing bar consistent with Sections 1.4.3 and 3.2 of this criteria and shall include design and installation information details consistent with Section 3.5 of this criteria.

6.3 The evaluation report shall specify the use and limitations of use of the headed ends of reinforcement bars consistent with Sections 1.1 and 1.2 of this criteria.

6.4 The evaluation report shall include a condition of use that requires the minimum concrete cover to be in accordance with applicable code and measured from the outer surface of the headed end of the headed bars.

6.5 The evaluation report shall include requirements that headed bar calculations and installation details for each project shall be submitted to the code official for approval, with this information prepared by a registered design professional when required by the statutes of the jurisdiction in which the headed bars are installed. ■

TABLE 1—DESCRIPTION OF CYCLIC TENSION TESTS

STAGE	MAXIMUM LOAD	MINIMUM LOAD	CYCLES
1	0.95 f_y	0.05 f_y	20
2	2 ϵ_y	0.05 f_y	4
3	5 ϵ_y	0.05 f_y	4
4	Load in tension to failure		

Notes:

f_y is the specified yield strength of the bar.

ϵ_y is the strain of the reinforcing bar at actual yield stress.