Rosalind Fazel

From: jjbraun@dextragroup.com
Sent: Monday, August 04, 2008 4:08 AM
To: Rosalind Fazel
Subject: AC347 Comments

*Comments on Criteria **AC347**.*

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Comments:
We support the proposed change.

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Date: 8-27-2008

To: ICC EVALUATION SERVICES, INC.

Subject: Proposed Revisions to the Acceptance Criteria for Headed Ends of Concrete Reinforcement, Subject AC347-0808-R1 (RK/BG)

Dear Madam or Sir,

The proposed change will correct the current inaccurate section 4.1.7.1. I agree the change should be implemented.

Upon future review of the proposed revisions to the Acceptance Criteria for Headed Ends of Concrete Reinforcement, Subject AC347-0808-R1 (RK/BG), I noted some other changes that require ICC's attention. AC347 per section 1.3 currently references ASTM A970-06 and ACI 318-05. The most current revisions of ASTM A970 is 2007 (ASTM A970-07) and ACI 318 is 2008 (ACI 318-08). Section 1.3 of AC347 should be updated to ASTM A970-07 and ACI 318-08.

Please keep in mind both of these standards have under gone significant changes. Some of these changes are listed below:

1) ASTM A970-06 has one class of headed bar ends. Per sections 7.3.1 and 7.3.3, the tension test requirements for ASTM A706 rebar are a minimum stress of 80,000 psi and no fracture of the head or the bar-head connection is permitted.

ASTM A970-07 has two classes for headed bar ends. The tension test requirement per section 6.3.1: Class A is minimum specified tensional strength of the rebar -or- Class B is minimum specified tensional strength of the reinforcing bar and the minimum specified elongation of the reinforcing bar.

2) ACI -318-05: contains no size limitations or equations for utilizing headed bar ends in concrete (Refer to section 12.6).

ACI 318-08: Contains headed bar size limitations. Section 12.6.1 states that the net bearing area of head A_{brg} shall not be less than $4A_b$ (4*Reinforcing bar area) and section 12.6.2 utilizes the following equation: $l_{dt} = (\frac{0.016\psi_e f_y}{\sqrt{f_c'}}) * d_b$ while at the same time AC347 section 3.5.2 currently has the following equation:

$$f_{c,bear} = 0.6*(f_c')*(\omega_t)\frac{(2c_b)}{\sqrt{A_{brg}}} \le 8*(f_c') \qquad \omega_t = 0.6 + 0.4*\left(\frac{c_2 /}{c_b}\right) \le 2.0$$

As a designer these two equations provide different headed bar development lengths. Which method should design engineers be utilizing, those in AC347 or those in ACI-318?

These two concerns demonstrate the major differences of the current documents of ASTM A970, ACI 318 and AC347. ICC needs to address these outlined issues. The current AC347 acceptance criteria was written based on the outdated ASTM A970-06 specification and written while ACI 318-05 did not formally address headed bar ends. Now that ASTM A970-07 and ACI 318-08 are addressing headed bar ends, would it not be better to eliminate AC347 and adapt performance based testing in AC133 to also apply for headed bar ends? Both AC347 and AC133 currently utilized the same cyclic/tension/compression criteria.

Best Regards,
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To: The ICC Evaluation Committee

Regarding: Proposed Revisions to the Acceptance Criteria for Headed Ends of Concrete Reinforcement, Subject AC347-0808-R1 (RK/BG)

Date: August 28, 2008

Dear Committee,

The enclosed letter summarizes comments regarding revisions to AC 347 as solicited by ICC in their August 1 notification.

AC 347 references two significant documents:

- ASTM A970-06 "Standard Specification for Headed Steel Bars for Concrete Reinforcement"
- ACI 318-05 "Building Code Requirements for Structural Concrete"

Each of these documents is essential for evaluation and use of headed reinforcement in the United States. Both documents have undergone significant revisions since the initial approval of AC 347 in October 2006 and the changes now make AC 347 inconsistent with ASTM A970 and ACI 318 (Table 1 provides a summary of key differences). The most significant change has occurred in ACI 318-08 which did not include any specific design requirements for headed bars in 2005, but now does in its 2008 version.

The changes in ASTM A970 and ACI 318 suggest that a more thorough review of AC 347 than what has been proposed. Two fundamental questions come to mind: Does AC 347 still need to exist? If so, what changes should be made to bring it in agreement with the latest versions of ASTM A970 and ACI 318.

Question 1 – Does the AC still need to exist?

AC 347 was developed in response to industry concerns that few design provisions for headed reinforcement existed. ICC-ES's statement regarding acceptance criteria supports this:

> "An acceptance criteria is developed when an application is received for an ICC-ES report on a product that is an alternative to what is specified in the code, and there is no existing criteria that would apply to the product. Acceptance criteria may also be developed when the codes are not clear in a particular area or on specific issues related to a product; when

industry raises concerns regarding report requirements; or when a new criteria is deemed necessary by the report applicant, ICC-ES staff, or the ICC-ES Evaluation Committee." (from the FAQ page on the ICC-ES website)

At the time of AC 347's first development, ACI had not yet implemented design provisions in the 318 code and AC 347 filled this gap. However, this gap would no longer exist in the absence of AC 347. Furthermore, the new provisions are different than those of AC 347 creating a possibility for confusion in the design industry. Similar conflicts exist with ASTM A970. In trying to capture the requirements of both ASTM and ACI, AC347 exists in the difficult position of needing to be up-to-date with both. This creates a difficult administrative task for ICC-ES. Given these conditions, is it necessary that AC347 continue?

Question 2 – What changes should be made to bring it in agreement with the latest versions of ASTM A970 and ACI 318?

The key differences between AC 347 and ASTM A970-07 and ACI 318-08 are summarized in Table 1. The most important differences that exist now are:

- ASTM A970 has become much less restrictive than it was in 2006. Some products which would not have met ASTM criteria in 2006 will meet the criteria using the 2007 version.

- ACI use different terminology than AC 347. AC 347 uses the term "anchorage length" while ACI uses the concept of "development length." In the research literature (see references 1 through 4), these terms are not the same. Anchorage length is used with strut and tie modeling practice and is measured from a critical section defined by strut and tie models. Development length is used with conventional elastic analysis methods and is measured from a critical section typically defined by maximum moment locations. The two types of "critical section" are not necessarily the same. Both documents use the same term however. It is probable that most designers are not aware of the subtle differences.

- ACI has much less restrictive requirements for obstructions. Though not stated in the code, it is intended that net bearing area (A_{brg}) should exclude the area of an obstruction. This is not the case with AC 347.

- ACI uses a completely different set of design equations.

Given these dramatic differences, it seems prudent for ICC-ES to consider a major revision of AC 347 to bring the sections cited in Table 1 in line with both ASTM A970-07 and ACI 318-08.

Table 1 – Summary of Differences Between AC 347 and ASTM A970-07 and ACI 318-08

AC 347, Section 4.1 "Cyclic Tension Followed by Monotonic Tension Tests"	**ASTM A970-07, Section 6.3.1 "Tensile Properties"**
• Based on ASTM A970-06 • Requires a specific cyclic test sequence • All products must satisfy minimum tensile strength and minimum elongation requirements • The headed end is disqualified if final break occurs at the head to bar connection	• No cyclic testing required • Products are classified as Type A or Type B • Type A products are only required to meet a minimum tensile strength of the reinforcing bar • Type B products must meet minimum tensile strength and minimum elongation requirements of the reinforcing bar • Minimum tensile and elongation properties for the reinforcing bar come from ASTM A615 or A706 • There is no requirement regarding the nature of the final break
AC 347, Section 3.2.2 "Obstructions to Head Bearing Area"	**ACI 318-08, Section 3.5.9**
• Obstructions may not extend more than d_b from the bearing face • Obstructions shall not occupy more than 1/3 of A_{brg} • Obstructions shall not extend more than $0.5d_b$ in the radial direction • Alterations or obstruction of bar deformations shall not extend more than $2d_b$ from the bearing surface • Heads with bearing area, A_{brg}, greater than $9A_b$ do not need to comply with any of the above	• Obstructions may not extend more than $2d_b$ from the bearing face • This restriction applies to all headed bars regardless of bearing area, A_{brg}
AC 347, Section 3.5 "Structural Design and Installation"	**ACI 318-08, Section 12.6 "Development of headed and mechanically anchored deformed bars in tension"**
• AC347 distinguishes between heads with net bearing area that are greater than $9A_b$ and those which are between $4A_b$ and $9A_b$. Heads with net bearing area less than $4A_b$ are not covered under the provisions. • For heads between $4A_b$ and $9A_b$, the bearing stress is defined as:	• Heads with net bearing area less than $4A_b$ are not covered. All other heads are treated the same. • Headed bar development is specified as: $L_{dt} = \frac{0.016\psi_e f_y}{\sqrt{f_c'}} d_b$ • L_{dt} shall not be less than $8d_b$ and 6" • Clear cover may not be less than $2d_b$

$f_{c,bear} = 0.6(f_c')(\omega_t)\frac{(2c_b)}{\sqrt{A_{brg}}} \leq 8(f_c')$ where $\omega_t = 0.6 + 0.4\left(\frac{c_2}{c_b}\right) \leq 2.0$ and the following must be satisfied: $f_{c,bear}A_{brg} \geq f_y A_b$ • Heads greater than $9A_b$ need not satisfy the above if c_b/d_b is greater than 3 and f_c' is greater than 4000 psi • Anchorage length, L_a, must be greater than or equal to $8d_b$ or 6" • A special formula is provided to convert anchorage length into a lap splice length	• Clear spacing may not be less than $4d_b$
AC 347, Section 1.4 "Definitions"	**ACI 318-08, Section 12.10 "Development of flexural reinforcement - General"**
• Anchorage length is measured from the critical section to the bearing face of the head • Critical section is defined as the location on the reinforcing bar where the full bar stress is required	• Development length is measured from the critical section to the bearing face of the head and is the minimum length required to achieve the design strength of the bar at the critical section (this comes from the ACI definitions and various text of Chapter 12) • Section 12.10.2 provides a more specific definition of critical section as points of maximum stress in the bar or points in the span where adjacent reinforcement is terminated. Figure R12.10.2 further clarifies the point of maximum stress as a maximum moment location on the span.

I thank the committee for their time and work. If there are questions concerning my comments, I can be reached at (608) 342-1479 (my office number); (608) 348-5837 (my home number); or thompsmi@uwplatt.edu (my university e-mail address). E-mail is the best way to contact me.

Sincerely,

Michael Keith Thompson

References:

1. M.K. Thompson, M.J. Young, J.O. Jirsa, and J.E. Breen, “CCT Nodes Anchored by Headed Bars, Part 1: Behavior of Nodes,” ACI Structural Journal, November-December 2005, pp. 817-824.
2. M.K. Thompson, J.O. Jirsa, and J.E. Breen, “CCT Nodes Anchored by Headed Bars, Part 2: Capacity of Nodes,” ACI Structural Journal, ACI Structural Journal, January-February 2006, pp. 65-73.
3. M.K. Thompson, A. Ledesma, J.O. Jirsa, and J.E. Breen, “Lap Splices Anchored by Headed Bars,” ACI Structural Journal, ACI Structural Journal, ACI Structural Journal, March-April 2006, pp. 271-279.
4. M.K. Thompson, J.O. Jirsa, and J.E. Breen, “The Behavior and Capacity of Headed Reinforcement,” ACI Structural Journal, July-August 2006, pp. 522-530.