

Bangkok, January 18th, 2010

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ICC Evaluation Services Inc.
5360 Workman Mill road
Whittier, California 90601
U.S.A.

Ref : AC 347-0210-R1

Object : Proposed revisions to the acceptance criteria for headed ends of concrete reinforcement

For the attention of MM Russ Krivchuk and Brian Gerber

Dear Sirs,

Referring to your mail of December 29th, 2009 we respectfully submit here our point of view on the comments for which you are seeking input from the industry : on your proposed draft AC 347-0210-R1 :

1. Limitations on obstructions to the bearing area :

We agree that the second sentence of section 3.2.3 should be deleted, and that a sentence should be added to section 3.2.2, which should specify that any obstruction must be considered when computing the net area.

2. Head rigidity :

We agree that the current requirement in section 3.2.1 is prudent and should be maintained as long as it is not covered by ASTM A970.

3. Cyclic testing :

Our opinion is that the cyclic testing requirement should be maintained. First of all, the fact that requirements in ACI 318 are less demanding than those in ICC-ES' acceptance criteria is nothing new : It is already the case for mechanical splices.

Most importantly, behaviour under seismic loading is becoming more of a concern with every passing day, rather than becoming a thing of the past.

As far as headed bars are concerned, cyclic loading figures very prominently in other ACI publications, such as for example ACI 352R-02 "Recommendations for Design of Beam-Column Connections in Monolithic Reinforced Concrete Structures" : See sections 2.1.2, 4.2.2.4, 4.2.2.8, 4.5.1 for references to stress reversals during seismic loading.



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4. Maximum bar size :

ACI 318 indeed excluded large bars from its headed bars provisions due the absence of experimental research. Research is on-going, and the results of a Korean experimental programme featuring #18 headed bars have recently been published in the ACI Structural Journal. (See attached paper “Anchorage strength and behaviour of headed bars in exterior beam-column joints”).

More significantly, it must be reminded that state Departments of Transportation have been using #14 & #18 in large quantities for a long time, especially in California.

Finally it is worth noting that the European code [EN 1992-1-1, section 8.8 (3) attached] actually requests that headed bars be used to anchor bars of large diameters.

For all these reasons, it is our opinion that the performance under cyclic loading as specified in AC 347 should be considered sufficient to satisfy to section 12.6.4 of ACI 318, and that AC 347 should therefore not limit itself to #11 bars.

5. ASTM A970 :

IBC 2009 and ACI 318-08 refer to ASTM A970-06. The impact of the substantial modifications in the 2007 update of ASTM A970 has therefore not yet been evaluated by ACI 318 and the IBC. It is our understanding that ACI has requested ASTM to amend its current A970 standard in order to make it compatible with the new headed bars provisions in ACI 318-08. We therefore recommend strictly following the order of things and keeping referring in AC 347 to the same editions of ASTM standards as ACI and IBC do.

6. Use as shear reinforcement :

No comment.

Sincerely Yours,

Jean-Jacques BRAUN
Technical Director

P.J. : ACI 352R-02
Technical paper n° 106-S53 in ACI Structural Journal
Extract of EN 1992-1-1 Chapter 8

Michael Keith Thompson

The University of Wisconsin - Platteville
Department of Civil & Environmental Engineering
1 University Plaza
Platteville, Wisconsin 53818

To: The ICC Evaluation Committee

Regarding: Proposed Revisions to the Acceptance Criteria for Headed Ends of Concrete Reinforcement, Subject AC347-0210-R1

Date: January 19, 2010

Dear Committee,

This letter is in response to your solicitation for public comment on the latest revision of AC 347 dated December 29, 2009. This letter specifically addresses the committee comment items 1, 3, and 5.

Comment Item 1: Should obstructions meeting the criteria set forth in AC347 be deducted from the Net Bearing Area of the head?

No The committee has taken the correct course in the latest version of AC347

The language of the ACI 318-08 code suggests that obstructions of any sort should be deducted (see R3 5 9 of ACI 318-08). However, ACI has recently re-evaluated that language and has proposed a slightly different approach that is well in agreement with the latest version of AC347. Obstructions meeting criteria exactly the same as those listed in section 3.2.3 of AC 347 are considered small enough to not to affect the bearing area of the head. This is in agreement with numerous test data that were used to write the headed bar provisions of ACI 318. Any head configuration outside of those criteria are excluded from use except at the permission of a building official after review of test results indicating safe performance of the headed device. These proposed revisions may or may not be enacted in the 2011 edition of ACI 318, however, they have already been reflected in ASTM A970-09 which includes Annex A1 setting forth dimension criteria for an "type HA" head. The purpose of the type HA head is to provide a standard head suitable of "certain consensus building codes and design standards" such as ACI 318 which is explicitly cited in ASTM A970-09. The dimension criteria of ASTM A970-09, Annex A1 match those of AC347.

After review of test data, it was the judgment of ACI and ASTM committee members that obstructions limited in size would have no significant impact on the head bearing area. The criteria set forth for obstruction size reflect their judgment to that effect.

Comment Item 3: Should cyclic testing of head to bar connections similar to those required for mechanical connectors be required?

Yes and no I suggest that ICC-ES create multiple head-bar connection classes (or types).

ASTM A970-07 and ASTM A970-09 already list two classes of head-bar connection. Class A requires a monotonic strength limit. Class B requires a monotonic strength and elongation limit. ICC-ES could define a Class C type in that also satisfies a cyclic test standard. The precedence for this as already been set, so it would not really affect the producers much to add an additional class of headed bar.

Comment Item 5: *What version of ASTM A970 should be referenced?*

There is in fact a newer version of ASTM A970 available, the 2009 version. On the latest version of ASTM A970, a strong effort was made between ACI and ASTM to coordinate the ASTM specification with ACI 318. Primarily this is reflected in the creation of the Annex A1 requirements of ASTM A970-09, which set obstruction and head size limits for a type HA head. Even though ACI 318-08 references ASTM A970-06, it is now ASTM A970-09 that most accurately reflects the design requirements of the ACI 318 code. ICC has stated that 2007 version contains many incompatibilities with ACI 318-08, however the committee should bear in mind that the changes in ASTM A970 have come about with coordination and consultation with the same people who drafted the ACI 318 provisions. The differences between the three versions of ASTM A970 are summarized in Table 1.

ICC listed three key reasons in choosing not to reference ASTM A970-07. These three reasons are confronted below:

- “ASTM D 970-07 no longer includes a limitation on the steel grade to a specified yield strength of 60 ksi (a higher grade of steel may promote concrete failure prior to yielding of the bar)”

There is a slight mis-statement here. Actually ASTM A970-06 limits the maximum yield stress to 78 ksi and the minimum yield stress to 60 ksi. Regardless, this point may be moot. Assuring that the concrete will not fail before the steel reinforcement yields is the prerogative of the structural engineer. ACI 318-08, section 12.6.1 (a) limits the usable yield stress of the bar (f_y) to 60 ksi. Under this condition, the development length formula provided in that section is deemed to be safe. The engineer may only account for a higher yield stress using alternative design methods or test results approved by the appropriate building official. Thus, it is not necessary for ASTM A970 to impose any limits on the yield stress of the reinforcing bar aside from those already required by ASTM A615 or ASTM A706.

- “ASTM D 970-07 contains two headed bar classifications, but ACI 318-08 does not include headed bar classifications”

The development of the two classes of headed bars in no way impedes the use of ACI 318-08. There are no test data to indicate that the development length equation provided would not be equally applicable to each category of headed bar provided.

that the head dimensions and obstructions did not violate the limitations stated in ACI 318-08 sections 12.6.1 and 3.5.9

- “the conditions of acceptance for the tension tests specified in ASTM D 970-07 are not the same as those in ASTM D 970-06 and may be more lenient”

There are two primary differences on the conditions for acceptance of tension tests: (1) that fracture of the bar must occur away from the head-bar connection, and (2) that the tensile strength, yield stress, and elongation limits must satisfy those of ASTM A615 or ASTM A706 rather than the requirements listed in ASTM A970-06, table 1.

The requirement that fracture needs to occur away from the head-bar connection is not considered necessary anymore. Provided that fracture occurs at a sufficient strength and after a sufficient elongation has been demonstrated, then the nature of the fracture is irrelevant. A break is a break, it doesn't matter where it occurs.

The issue of yield stress has already been argued above. Regarding the tensile strength and minimum elongation, the values required by ASTM A970-06 (table 1 of that specification) match those of ASTM A706 exactly. This was because headed bars meeting ASTM A970-06 and earlier versions of that specification were required to use A706 reinforcing bars. This reflected the fact that the A970 standard was originally written for welded headed bars only. The test data used to craft the design procedures given in ACI 318-08 comes from tests of various head types, including non-welded heads using A615 class reinforcing bars. By essentially limiting the type of reinforcing bar to an A706 type bar (through the required stress and elongation limits), ASTM A970-06 is an overly restrictive standard and does not reflect the basis of ACI 318-08.

In summary, I am suggesting two changes for AC347: (1) updating the ASTM A970 reference to the 2009 version and (2) creating a third head type to augment those already defined in the 2007 and 2009 version of ASTM A970 which would be qualified for cyclic applications using the test procedure currently defined in AC347.

Thank you for your time. Please contact me if you have any questions.

Sincerely,



Keith Thompson

Table 1 – Summary of Differences Between 2006, 2007, and 2009 versions of ASTM A970

ASTM A970-06	ASTM A970-07	ASTM A970-09
<ul style="list-style-type: none"> • All products must satisfy minimum tensile strength and minimum elongation requirements listed in Table 1 of that specification (which match ASTM A706 limits) • The headed end is disqualified if final break occurs at the head to bar connection 	<ul style="list-style-type: none"> • 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 	<p>All those points listed for ASTM A970-07 plus the following:</p> <ul style="list-style-type: none"> • Head size must be $\geq 4A_b$ to qualify as Type HA • Obstructions are limited to qualify as Type HA • The purpose of the Type HA head is to meet consensus design standards such as ACI 318

Via Email:

January 19, 2010

Mr. Russ Krivchuk
Senior Staff Engineer
ICC Evaluation Service, Inc.
5360 Workman Mill Road
Whittier, California 90601

Re: Proposed Revisions to AC347, ICC-ES Subject AC347-0210-R1
WJE No. N/A

Dear Mr. Krivchuk:

In your letter dated December 29, 2009, Subject AC347-0210-R1, you requested response from industry on certain comments related to AC347, which is the acceptance criteria applicable to headed deformed reinforcement. This writer is a voting member of American Concrete Institute Subcommittee 318B, Structural Concrete Building Code-Reinforcement and Development. This subcommittee has historically been the originator of code provisions related to headed deformed reinforcement that appear in the ACI 318 "Building Code for Structural Concrete." While this writer is able to share with ICC-ES non-confidential, personal insight into the deliberations of Subcommittee 318B, in this letter this writer is expressing his personal opinions regarding the matters at hand and is not acting as a formal representative of Subcommittee 318B. This writer's employer is a structural engineering consulting firm that is also recognized as an independent test laboratory (IAS Certificate TL-165), and in this capacity, this writer has conducted or directed numerous laboratory projects carried out according to AC347 and also AC133.

Regarding specific responses to the comments posed beginning on Page 2 of the ICC-ES letter dated December 29, 2009, this writer offers the following.

ICC-ES Comment 1: Limitations on Obstructions

Subcommittee 318 has recently developed proposed changes to the current ACI 318 Code limitations on head dimensions and head obstructions for headed deformed bars used under the provisions of Sections 3.5.9, 12.6.1 and 12.6.2 of ACI 318-08. Over the course of 2009, Subcommittee 318B also worked with the relevant ASTM committees to have these limitations incorporated in a revised version of ASTM A970, "Standard Specification for Headed Steel Bars for Concrete Reinforcement." On November 15, 2009 ASTM A970-09 was approved that includes the mandatory information Annex A1 defining a Class HA head with limitations on head dimensions and head obstructions that are consistent with those recommended by Subcommittee 318B. The ASTM A970-09 Class HA head limitations are as follows:

A1.1.1.2 Class HA head dimensions shall comply with A1.1.1.3 through A1.1.1.5.

A1.1.1.3 The net bearing area of the head shall not be less than four times the nominal area of the bar. The net bearing area of bars

meeting the requirements of this annex is the gross area of the head minus the area of the deformed reinforcing bar.

A1.1.1.4 The bearing face shall consist of a single, nominally flat surface that lies in a plane perpendicular to the longitudinal axis of the bar.

A1.1.1.5 Obstructions or interruptions of the bar deformations and non-planar features on the bearing face of the head shall not extend more than two nominal bar diameters from the bearing face and shall not have a diameter greater than 1.5 nominal bar diameters (Fig. A1.1). Such obstructions shall not be considered to detract from the net bearing area of the head. Obstructions exceeding any of these limits are not permitted.

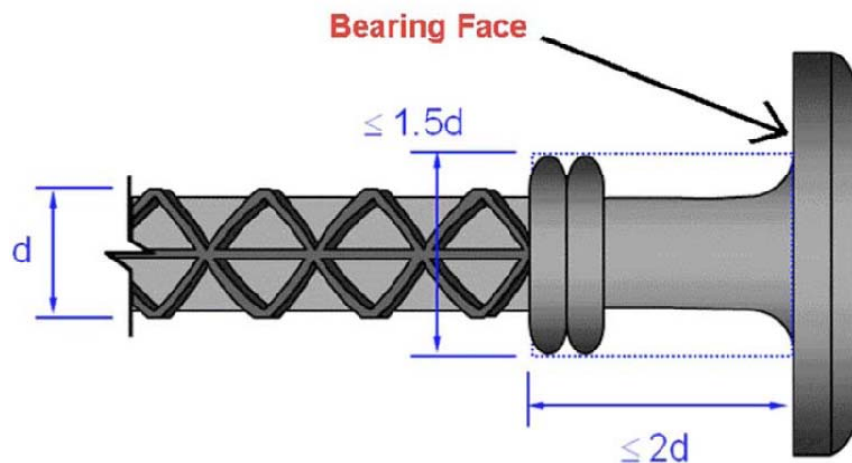


FIG. A1.1 Maximum Dimensions of Obstruction or Interruptions of Bar Deformations and Non-Planar Features of the Bearing Surface.

At this writing, Subcommittee 318B intends to propose changes to the ACI 318 Code that would remove the definition of obstructions from ACI 318 and instead specify that headed deformed bars conform to the requirements of Class HA when designed according to Sections 12.6.1 and 12.6.2 of ACI 318. If successfully balloted within both Subcommittee 318B and also main Committee 318, this requirement would become effective, at the earliest, with the anticipated 2011 supplement to the ACI 318 Code. Headed bars not conforming to the requirements of Class HA heads would remain permitted for use under the provisions of Section 12.6.4 of the ACI 318 Code.

The head dimensional limitations found in ASTM A970-09 for Class HA heads effectively include the definition of obstructions as found in ACI 318-08, if not also providing requirements that are more restrictive than ACI 318-08. Therefore, it can be argued that the Class HA dimensional requirements are compatible with the requirements of ACI 318-08. On this basis, this writer encourages the ICC-ES Evaluation Committee to incorporate the Class HA limitations into AC347. This change could be implemented as follows:

- Delete existing Sections 3.2.2, 3.2.3 and 3.2.4 in their entirety, including the “exception” found at the end of Section 3.2.4.

- Insert a new Section 3.2.2 that reads as follows: **3.2.2 Head dimensions shall comply with A1.1.1.3 through A1.1.1.5 of Annex A1 of ASTM A970-09.**

Alternatively, existing Sections 3.2.1 through 3.2.4 of AC347 could be replaced by verbatim transcription of A1.1.1.3 through A1.1.1.5 of Annex A1 of ASTM A970-09.

The primary benefit for using the more restrictive Class HA dimensional limitations is that, as quoted above, *“The net bearing area of bars meeting the requirements of [these limitations] is the gross area of the head minus the area of the deformed reinforcing bar.”* This eliminates the need for a separate assessment of bearing face area occupied by obstructions, and for subsequent adjustment of the available net bearing area.

ICC-ES Comment 2: Evaluation of Head Rigidity

This writer concurs with ICC-ES staff recommendation that AC347 continue to assess head rigidity. In support of this viewpoint, it is important to note that ASTM A970 is primarily a manufacturing standard, and as such, ASTM A970 does not necessarily address all aspects of structural performance that might be of concern to the licensed design professional or to the building official. Head rigidity is one of these aspects, because if a head were not sufficiently rigid, then the head could deform to an unacceptable degree, thereby causing excessive bar slippage before the required head-to-concrete bearing stresses are developed.

ICC-ES Comment 3: Cyclic Testing of Head-to-Bar Connection

This writer recommends that AC347 continue to include the current requirements for cyclic testing. As stated previously in this writer’s response to Comment 2, it is important to note that ASTM A970 is primarily a manufacturing standard, and as such, ASTM A970 does not necessarily address all aspects of structural performance that might be of concern to the licensed design professional or to the building official. Cyclic performance of the headed bar is one of these aspects.

In support of this viewpoint, the American Concrete Institute committee report ACI 352R-02, “Recommendations for Design of Beam-Column Connections in Monolithic Reinforced Concrete Structures,” by Joint ACI-ASCE Committee 352, can be consulted. Section 2.1.2 of this report includes the following definition of a “Type 2” beam-to-column joint: *“Type 2 [beam-to-column joint] is a connection that has members that are required to dissipate energy through reversals of deformation into the inelastic range.”* Section 4.5.3 of this same report is captioned as “Headed bars terminating in the connection,” which includes discussion of the use of headed bars in Type 2 beam-to-column joints. These discussions point out that the headed longitudinal reinforcement is *“subjected to cyclic forces that reached approximate yield.”* Therefore, it is reasonable for AC347 to include the present cyclic loading requirements, until such time as the state-of-the-art conclusively indicates that headed bars in Type 2 beam-to-column joints are not exposed to cyclic forces above yield.

ICC-ES Comment 4: Requirements for Testing under Section 12.6.4 of ACI 318-08

This writer supports the general concept of a future revision to AC347 to accommodate evaluation of headed deformed reinforcement under Section 12.6.4 of ACI 318-08. There are numerous headed bar products on the market that do not satisfy the requirements of ACI 318 Section 12.6.1 or the Class HA head dimension limits found in Annex A1 of ASTM A970-09. A consistent approach to evaluation products in accordance with 12.6.4 would therefore be appropriate and very beneficial to the industry.

The design requirements for headed bars found in ACI 318 Sections 12.6.1 and 12.6.2 are empirically derived from results of tests of headed bars in concrete. This is in part because there is no widely-accepted behavioral theory for headed bars in concrete that would allow for an analytical assessment of headed bars without in-concrete testing. It therefore follows that evaluation of headed bars under ACI 318 Section 12.6.4 should also be based on in-concrete testing.

As a starting point, the following test considerations are suggested by this writer:

- The limit state of crushing of concrete at the bearing face of the head should be evaluated.
- The limit state of side face blowout of the concrete should be evaluated for headed bars installed at the minimum concrete cover.
- The in-concrete test specimen should be designed so as to preclude the limit state of concrete breakout. This is because, in general, the design provisions of Section 12.6.2 implicitly assume that this limit state is precluded.
- The deformed bar should be debonded from the concrete for at least some of the tests.
- The slip of the head and also of the loaded end of the headed bar should be monitored.

There are certainly other structural limit states and other test parameters to be considered. Also, there does not appear to be a standardized in-concrete test specimen for these types of tests. A detailed review of available public domain research reports could be useful for identifying possible in-concrete test specimen configurations. Furthermore, it might be more expedient for AC347 to take a “performance specification” approach to this kind of in-concrete testing, rather than developing a standardized test methodology within AC347. In any event, the industry should anticipate the need to devote considerable time and effort to the development of a standardized test protocol.

ICC-ES Comment 5: Use of ASTM A970-07 (or A970-09) instead of ASTM A970-06

This writer suggests that the Evaluation Committee adopt Class HA heads from ASTM A970-09 as the reference edition of the specification for AC347. If the Evaluation Committee has concern that the ASTM A970-09 strength requirement for Class HA heads is not appropriate for use with ACI 318-08, then the language of AC347 Section 4.1.7 can be revised to include the appropriate strength and elongation requirements as found in the 2006 edition of ASTM A970.

ICC-ES Comment 6: Expanding Scope of ACI 347 beyond Section 12.6 of ACI 318

It is this writer’s opinion that the scope of AC347 should be limited to headed bar applications falling under Chapter 12 of ACI 318-08. Other applications, such as slab and footing shear reinforcement from Chapter 11 of ACI 318 and cast-in anchorage to concrete from Appendix D of ACI 318, among others, are probably best handled by modifying existing acceptance criteria other than AC347 that already addresses these applications. This is because the structural design and installation requirements would be generally the same regardless of the type of product, and these are typically already developed within the existing acceptance criteria. The existing acceptance criteria would be modified to include appropriate requirements for headed deformed bar products in addition to those products that traditionally fall under the existing acceptance criteria.

Regrettably, this writer is unable to attend the February 4, 2010 Evaluation Committee hearing due to prior commitments. Therefore, if you have any question, please feel free to contact this writer by telephone or by email.

Sincerely,

WISS, JANNEY, ELSTNER ASSOCIATES, INC.

Conrad Paulson
Principal

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