June 26, 2008

Peter Bahlo, P.E.
Senior Staff Engineer
ICC Evaluation Service, Inc.

pbahlo@icc-es.org

Re: Proposed Acceptance Criteria AC398-0608-R2

Dear Peter:

Please find attached preliminary comments on the proposed acceptance criteria AC398-0608-R2.

My primary concern, as expressed during the ICC-ES Committee meeting in Chicago, is the proper definition of the scope of the criteria. The "you get what you test" nature of the criteria requires that the scope be tightly defined in order to avoid abuse.

In this regard, I note that connectors for attaching roof diaphragms to concrete walls is included as a connector type. This is not a foundation anchor and the boundary conditions associated with this condition are potentially very different from those associated with anchor straps and hold downs. In my view, connectors for this condition should be addressed separately.

With best regards,

HILTI NORTH AMERICA

J. Silva, S.E.

Director, Codes & Standards

cc: B. Gerber, ICC-ES, K. Stochlia, ICC-ES, R. Eligehausen

Attachment A

Hilti North America
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Attachment A – Comments on AC398-0608-R2

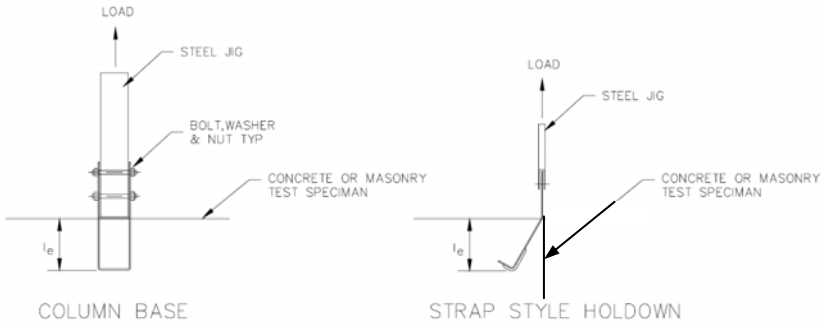
Proposed revision	Comment
1.1 Purpose: The purpose of this criteria is to establish requirements for ICC Evaluation Service, Inc. (ICC-ES), recognition of cast-in-place ~~cold-formed steel connectors~~ foundation anchor straps, strap-style hold down connectors and column base connectors used as anchorage to concrete for light-frame construction ~~in concrete~~ under Sections 1911, 1912, and 2303.5 of the 2006 International Building Code® (IBC), and Section R104.11 of the 2006 International Residential Code® (IRC). ~~The reason for the development of this criteria is the absence of reference standards in the IBC that can be used to establish the code compliance of cast-in-place cold-formed steel connectors used as anchorage to concrete for light-frame construction.~~	The purpose and scope of this criteria should be clearly defined and limited to the types of devices pictured in the original version. The manufacturing process (i.e., cold-forming) should not be the only defining characteristic. The code terminology for devices used to anchor sill plates is alternately "anchor straps" or "foundation anchor straps", e.g.: **2308.6 Foundation plates or sills.** Foundations and footings shall be as specified in Chapter 18. Foundation plates or sills resting on concrete or masonry foundations shall comply with Section 2304.3.1. Foundation plates or sills shall be bolted or anchored to the foundation with not less than 1/2-inch-diameter (12.7 mm) steel bolts or approved anchors spaced to provide equivalent anchorage as the steel bolts. Bolts shall be embedded at least 7 inches (178 mm) into concrete or masonry, and spaced not more than 6 feet (1829 mm) apart. There shall be a minimum of two bolts or *anchor straps* per piece with one bolt or anchor strap located not more than 12 inches (305 mm) or less than 4 inches (102 mm) from each end of each piece. A properly sized nut and washer shall be tightened on each bolt to the plate. **2308.12.9 Sill plate anchorage in Seismic Design Category E.** Steel bolts with a minimum nominal diameter of 5/8 inch (15.9 mm) or *approved foundation anchor straps*

Proposed revision	Comment
	load rated in accordance with Section 1715.1 and spaced to provide equivalent anchorage shall be used in Seismic Design Category E. This language was established in response to code change proposal S90-06/07 submitted by Simpson Strong-Tie.
1.2 Scope: 1.2.1 The provisions of this criteria shall be used to derive the capacity of ~~cold-formed steel connectors~~ foundation anchor straps, strap-style hold down connectors and column base connectors cast in concrete for purposes of transmitting loads from attached wood or cold-formed steel ~~members (e.g.,~~ joists, ties, plates, tracks, posts, and studs~~) or receiving loads from~~ to structural concrete~~ members~~. 1.2.2 The provisions of this criteria shall be used to establish the capacities of ~~cold-formed steel connectors~~ foundation anchor straps, strap-style hold down connectors and column base connectors based on Allowable Stress Design (ASD) methods, where ASD loads are derived considering measured (tested) and calculated strength characteristics, and measured (tested) displacement characteristics. 1.2.3 The provisions of this criteria shall be applicable only to the ~~cold-formed steel connectors~~ foundation anchor straps, strap-type hold	Figures should be included to define the specific type of connectors addressed by the criteria. As new connector types are developed, they may be added to the criteria in the future. The term *cold formed steel connectors* should be replaced throughout with *foundation anchor straps, strap-style hold down connectors and column base connectors*.

Proposed revision	Comment
downs and column bases as defined in Section 1.4.2 of this criteria.	
~~1.4.2.2 Structural Concrete Wall Connector: A structural concrete wall connector is used as diaphragm-to-wall anchorage in accordance with Section 12.11.2.2.5 of ASCE 7. The connector is a strap of cold-formed steel having one end that embeds into the concrete wall before placing concrete and hooks around the wall reinforcement or otherwise terminates so as to effectively transfer forces to the reinforcing steel, and the other end that fastens to the sub-diaphragm purlin member. Refer to Figure 2 for an example.~~	Delete Structural Concrete Wall Connector from this criteria. This is a very different structural condition from that addressed by the scope statement and should not be included here.
1.4.2.4 ~~Sill Plate or Bottom Track Foundation Strap Connector~~ Foundation Anchor Strap: A ~~sill plate or bottom track~~ foundation anchor strap ~~connector~~ is prefabricated from one piece of cold-formed steel into a device having one end that embeds into a concrete foundation before placing concrete and the other end that extends above the concrete member and fastens to a wood sill plate (as permitted by Section 1805.6 of the IBC and the first exception to Section R403.1.6 of the IRC) with either nails or wood screws or a	Code term is *foundation anchor strap*. Change throughout.

Proposed revision	**Comment**
cold-formed steel bottom track with self-drilling tapping screws. This connector is used to resist vertical tension, or uplift, forces and shear forces parallel and perpendicular to the bottom track. Refer to Figure 4 for an example.	
1.4.5 Connector Steel Failure: A failure mode in which the cold-formed steel connector yields, fractures, buckles, cripples, or ruptures ~~(as defined in AISI-NAS)~~.	Reference to AISI is unnecessary.
1.4.6 Ductile Steel: ~~Cold-formed s~~Steel with a tensile test elongation of at least 14 percent and a reduction in area of at least 30 percent.	
Section 3.3.3.1 R_d = Ductility reduction factor. R_d = 1.0 when the connector does not resist~~s forces other than~~ seismic forces, otherwise R_d = 0.75.	Language change to clarify this requirement. As written, could be construed to permit this term to be taken as 1.0 if any percentage of the load is not seismic.
ϕ = Strength reduction factor, which shall be as follows: *(a) Connector governed by strength of ductile steel:* *(i) Tension loads, ϕ = 0.75*	Use of supplementary reinforcement is not addressed by this criteria.

Proposed revision	**Comment**
(ii) Shear loads, ϕ = 0.65 *(b) Connector governed by strength of brittle steel:* *(i) Tension loads, ϕ = 0.65* *(ii) Shear loads, ϕ = 0.60* *(c) Connector governed by concrete:* *(i) Tension loads (breakout failure), ~~ϕ = 0.75 when supplementary reinforcement provided, otherwise~~* *ϕ = 0.70* *(ii) Tension loads (pullout failure), ϕ = 0.70* *(iii) Shear loads, ~~ϕ = 0.75 when supplementary reinforcement provided, otherwise~~ ϕ = 0.70*	
3.3.3.3 When the connector is fabricated from brittle steel and the connector is used in Seismic Design Categories C, D, E, and F, ~~either the available connection strength (as determined in accordance with Section 3.2.2) shall undergo ductile yielding at a load level corresponding to anchor forces no greater than the available anchorage strength, or~~ the available anchorage strength shall be	The language as written is nonsensical: *… the available connection strength…shall undergo ductile yielding…* Define term "available anchorage strength".

Proposed revision	Comment
reduced by one half.	
Figure 4 (from original criteria draft)  **FIGURE 4—TENSION LOAD TEST SETUP FOR A COLUMN BASE AND STRAP STYLE HOLDOWN SHOWING LOCATION OF DEFLECTION GAUGE (LOAD APPLICATION, LATERAL RESTRAINTS, AND TEST BED NOT SHOWN FOR CLARITY; REFER TO FIGURE 6 FOR DETAILS)**	Figures showing test setups should be amplified and modified to indicate that the concrete geometry should reflect the intended use with respect to edge distances. Since this is essentially a "you get what you test" criteria, it is essential that the conditions of use be replicated in the test, e.g., hold downs should be tested in a corner condition (as per Fig. 1), strap anchors should be tested with zero edge distance, etc.
4.2.5 If a shear test is performed on the connector, the load shall be applied ~~perpendicular~~ <u>parallel</u> to the induced crack. Refer to Figure 6.	Per ACI 355.2 Section 9.6.2, load is applied parallel to the crack.

Proposed revision	**Comment**
4.2.6 The cracked concrete reduction factor shall be determined by dividing the connector average peak load from the cracked concrete specimen tests by the connector average peak load from the uncracked concrete specimen tests. This factor may be ~~considered to be~~ taken as 1.0 if the test results can be shown to be statistically equivalent. ~~difference is less than 10 percent~~.	
5.0 QUALITY CONTROL ~~5.1 Welded connectors shall be manufactured under an approved quality control program with inspections by an inspection agency accredited by the International Accreditation Service (IAS) or otherwise acceptable to ICC-ES. Third-party follow-up inspections are not required under this acceptance criteria for non-welded connectors.~~ ~~5.2 Quality documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted.~~ 5.1 The products shall be manufactured under an approved quality control program with inspections by an inspection agency accredited by the International Accreditation Service (IAS) or as otherwise acceptable to ICC-ES. The program shall address requirements in Section 6.3.3 of ACI 355.2, except that inspection agency inspections	Since these connectors are alternatives to anchors in concrete as defined in the code they should be subject to the same quality control requirements. Inspection requirements for the wood portion of the construction and the concrete embedment should be addressed in the same section of the criteria.

Proposed revision	Comment
shall be done at least four times per year. 5.2 Quality documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted. 5.3 Where anchors are used for seismic or wind load resistance, job-site quality assurance shall conform to Sections 1705 and 1706 of the IBC. 5.4 Special inspection shall be provided in accordance with Chapter 17 of the IBC. For each type of anchoring system, the manufacturer shall submit inspection procedures to verify proper usage. 5.5 Periodic special inspection shall be provided for components within the seismic-force-resisting system in Seismic Design Categories C, D, E or F in accordance with Section 1707.3 or 1707.4 of the IBC, with the exception of those structures that qualify under Section 1704.1. 5.6 For jurisdictions adopting the IRC, special inspections shall not be required.	

Comments on AC398-0608-R2

Jake Olsen, PE

Powers Fasteners

Section 1.2.1 – The term “cold-formed steel connectors” is too broad. For example, a cast-in-place headed stud (included in Appendix D) is a cold-formed steel connector. These products should not be included in the scope of this document since they are already in the code. Furthermore, “studs” is given as an example in Section 1.2.1, these should as not be in this criteria.

Section 1.2.2 – Suggested that results are presented as both ASD and Strength Design values as a future looking criteria.

Section 1.4.2 – It is unclear whether these definitions (1.4.2.1 to 1.4.2.4) are the only types of products allowed in this criteria or if these are presented as examples. In other words, can a product that meets the broad definition of 1.4.2: “a cold-formed steel connector consists of one or more pieces of cold-formed steel having one end embedded in concrete construction and the other end attached to light frame construction” be used with this criteria?

Section 1.4.7 – Suggest a load limit or further definition of cold-formed framing members.

3.1.2.1 – It seems that the cold-forming process could change the final material properties (tensile and yield strength) of a steel and therefore original raw material mill-certificates would not be valid. Suggested to make tests on finished products mandatory.

Section 3.2 – For connectors where a welded portion of the assembly is the critical failure mode – what type of overstrength correction must be considered? For connectors that incorporate rebar (or are attached to rebar) is an overstrength correction factor necessary for the bar itself?

Section 3.3.3 – For failure modes that are governed by concrete breakout (in tension or shear) it is recommended that the capacity Nu or Vu be limited by the mean concrete breakout capacity as determined by ACI 318 Appendix D to account for the large variety of concrete mixes that were used to justify the Appendix D equations versus the single testing case in AC398.

Section 3.3.3.3 – Suggest putting the 0.5 factor into the main equations as an additional term in 3.3.3.1 for both tension and shear.

Section 4.2.5 – Why should these perpendicular tests be different than AC193/AC308 parallel shear tests in cracked concrete?

Additional comments on AC398-0608-R2

Mark Ziegler, PE

Powers Fasteners

Section 1.2.2 –The section states that the criteria is to establish capacities for ASD values with no mention of Strength Design. This seems to be in conflict with information in Section 3.3.3.1.

Section 3.3 – Is it necessary to establish guidance for cases where multiple failure modes are encountered during testing, i.e. a mix of steel strength, connection strength and anchorage strength?

Section 3.3 – Is it necessary for the criteria to establish a maximum coefficient of variation for a mean average test series?

July 2, 2008

Peter Bahlo, P.E.
ICC Evaluation Service
5360 Workman Mill Road
Whittier, CA 90601

RE: Proposed Acceptance Criteria for Cast-in-place Cold-formed Steel Connectors in Concrete for Light-frame Construction, Subject AC 398-508-R2

Dear Mr. Bahlo:

Thank you for the opportunity to comment on the proposed revisions to AC 398. Our staff has reviewed the proposed criteria and we have some concerns relative to the proposed methodology.

Here are our comments – some of which are still unresolved from our May, 2008 letter on this topic:

General: Are we correct in assuming that ES still plans to request a review of this Acceptance Criteria by the ACI 318 committee. We believe that this is still an important step prior to approval of this proposed criteria.

Section 1.2.2 retains the **ASD** basis for determining capacities for cold-formed steel connectors. It has been our understanding that **strength design** is used to calculate cast-in-place anchorage in ACI 318, Appendix D, and for post-installed anchors in AC308. We do not recall if this discrepancy was discussed or resolved in Chicago. We are still confused by the concept of using phi factors with Allowable Stress Design -- factors that appear to come from ACI 318 (an LRFD-based document). Examination of the equations for T_{ASD} and V_{ASD} (Section 3.3.3.1) do not appear to include reduction factors that would be expected to move from tested capacities to ASD levels. The phi factors range from 0.6 to 0.75 – compared to typical ASD reduction factors for connectors of at least 3.0. Additionally, in these equations, the basis for the alpha factor (a 'weighted average' of the load factors) is unclear as well.

Sections 3.2.2 includes a linear adjustment for specific gravity. Typically, these adjustments are NDS-based. These sections should be reviewed for consistency with the provisions of the NDS and perhaps revised to improve the readability. A large adjustment might not account for a change in mode of failure in an actual test. We recommend specifying the wood species tested and restricting this adjustment to a fairly narrow range based on the expected variability of that species.

Section 3.3.1.1 should list the species and grademarked grade of the wood used in the test. Additionally, it is unclear how far tests on one specific gravity can be extrapolated. Excessive extrapolation is not recommended due to a possible shift in failure mode.

Section 3.3.3.1 includes various provisions related to COV. We are still concerned that sampling may not include a broad range of realistic sources of variation.

Section 4.1 3.6.4.3 should discuss why cyclic testing is not required to establish resistance under seismic loads.

Additional technical (T) or clarification (C) comments:

Section 3.2.1 (T)

- The strength reduction factor, R_s is referenced for use with steel connectors and steel assemblies in sections 2.3.5 and 2.3.7. The equation in section 3.2.1 defines F_u (spec) and F_u (test) as connector steel capacities. The equation should also reference the steel member capacity for use with section 2.3.7.
- In addition, lengthy perusal of section 3.3.1.2, lines 343-347 was required to understand how this section relates back to section 3.2.1. Perhaps locating the section near the equation would improve clarity.

Section 4.1 (T)

- Lines 398-399 reference an analysis of cracking. It is unclear what this analysis involves. Currently it is also unclear in ACI 318 Appendix D what this analysis involves.

Lines 407-408 – α conversion factor (T)

- How does one calculate a 'weighted average' of the load factors? If this is a conversion from LRFD to ASD, the standard factor is 1.4.

Section 1.4.2.2(C)

- Reword lines 80 and 81. Currently, the statement is unclear. Suggested revision – delete 'before placing concrete and hooks around the wall reinforcement or otherwise terminates so as'
- Reword line 82. Suggested revision – delete ', and the other end that'
- New sentence – (Line 79-82) The connector is a strap of cold-formed steel having one end that embeds into the concrete wall to effectively transfer forces to the reinforcing steel while the other end fastens to the sub-diaphragm purlin member.

Section 1.4.4 (C)

- Reword lines 108,110-111, and 112. Suggested revisions: Line 108 – delete 'that' ; Line 110-111 – place period after 'cone'. Delete '(breakout) failure.' ; Line 112 – place period after 'depth'. Delete 'than for a full concrete cone failure' ; New sentence – (Line 107-109) A failure mode in which a portion of the cast-in-place steel connector pulls out of the concrete… or concrete breakout capacity.

Section 3.1.2.1 (C)

- Reword line 193. Suggested revision – delete 'test specimens was'

Section 3.1.3.2 (C)

- Lines 215-218 unclear. As the sentence currently reads, the PCA document has a semicolon after it. Does this mean you need to use this document plus ACI 211.1 plus either the IBC or ACI 318? Or should I use either the PCA document or ACI 211.1

and either the IBC or ACI 318? Reading the sentence it is unclear how many documents must be used and how many are options. A punctuation repair may be all that is needed.

Section 3.1.3.6 (C)

- Line 238 – the section reference appears incorrect. Not all documents in Section 3.1.3.2 will give information on 90+ day concrete testing. Should the PCA document be used or ACI 211.1? We were unable to find reference to older concrete (90+ day) in either the IBC or ACI 318.

Section 3.3.3.3 (C)

- Lines 430-432. Requirement is unclear – a 'connection strength' is mentioned as 'undergoing ductile yielding'. The connection is defined as brittle. Should this section refer to the wood or steel assembly rather than a connection? Suggested revision- delete 'available connection strength (as determined in accordance with Section 3.2.2)'. New sentence – When the connector is fabricated from brittle steel and …, either the wood or steel assembly shall undergo ductile yielding at….

Section 4.1.3 (C)

- The last statement in the Test Sample Size has been deleted. There is no longer a definition of acceptable variability. Previously a statement was included to the effect that if test sample capacities varied by more that 20% from the average, three more samples would be tested. Is the intent to lower the R_s value rather than creating a larger sample size?

Section 4.2.2 (C)

- Line 480 – delete 'thickness', replace with 'width'

Thank you for consideration of these comments. If you have any questions regarding these comments please don't hesitate to contact Dan Cheney at 208-429-3715 or at Daniel.Cheney2@Weyerhaeuser.com

Sincerely,

David S. Gromala (sent via e-mail)

David S. Gromala, P.E.
Director of Codes & Product Acceptance

July 3, 2008

Peter Bahlo, P.E.
Senior Staff Engineer
ICC-ES
Los Angeles Business/Regional Office
5360 Workman Mill Road
Whittier, CA 90601

Subject: Proposed ICC-ES AC398 for cast-in-place connectors in concrete

Dear Mr. Bahlo,

This letter is to provide public comments to your letter posted on ICC-ES's website and dated June 6, 2008 with the Subject, "Proposed Acceptance Criteria for Cast-in-place Cold-formed Steel Connectors in Concrete for Light-frame Construction, Subject AC398-0608-R2 (PB/BG)."

Line 50: Add reference to ASTM C 1513.

Line 78: Revise to "….used as horizontal diaphragm-to-wall anchorage in accordance…."

Line 80: Revise to "…placing concrete. In SDC C through F it shall hooks ~~-~~around the.."
This requirement is defined in ASCE7-05 Section 12.11.2.2.

Line 82: Revise to "…to the ~~sub-~~diaphragm purlin framing member."

Line 94: Revise title to "Sill Plate or Bottom Track ~~Foundation~~ Anchor Strap"
This is the same as current code verbiage.

Line 96: Revise to "….~~one piece of~~ cold-formed steel ~~into a device having~~ and has one end…."

Line 101: Revise to "...vertical tension~~, or~~ (uplift)~~,~~ forces and shear forces…"

Line 105: Revise to "…from the concrete member."

Lines 107 to 112: Replace section 1.4.4 with "A failure mode in which the embedded portion of the device, or a major component of the embedded portion of the device, slides out from the concrete without breaking out a substantial portion of the surrounding concrete."
ACI318-05 Appendix D defined anchor pullout strength as that corresponding to the device or a major component of the device sliding out from the concrete without breaking out a substantial portion of the surrounding concrete. Typically a smaller breakout cone or a concrete beam or

punching shear type failure is observed in tests of proprietary cold-formed steel connectors in concrete when close to edges or in stemwalls. However, this should not be considered pullout as the device is not pulling out.

Line 116: Revise to "…14 percent ~~and~~ or a reduction in area…."

Line 193: Revise to "….steel test specimens ~~was framing members~~……"

Line 262: Add Section 3.1.4.4 "**3.1.4.4** Self-tapping piercing or drilling screws for cold-formed steel light-frame construction shall comply with either ASTM C 1513 or AC118."

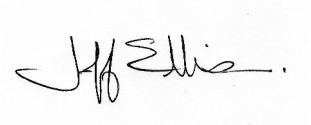
Lines 407 to 409: Revise the definition for the variable α in the denominator for the Tasd and Vask equations to state: "Conversion factor calculated as a weighted average of the load factors for the controlling load combination. For ASD anchorage strengths, this is to be no less than 2.5 for wind and in SDC A and B and 3.0 in SDC C through F. For LRFD anchorage strengths, this to be no less than 1.5 for wind and in SDC A and B and 1.9 for SDC C through F."
This is to ensure a minimum safety factor.

Line 425: Revise to "…at least 14 percent ~~and~~ or the reduction…."

Line 451: Revise to "….for recognition. ~~Test~~ Connectors shall be…."

Thank you for the opportunity to comment on this acceptance criteria. Please contact me with any questions regarding this subject.

Sincerely,
Simpson Strong-Tie Co., Inc.



Jeff Ellis, P.E., S.E.
Senior Engineering Project Manager

Copy: Mark Crawford, Vice President Engineering, Simpson Strong-Tie Co., Inc.

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USP STRUCTURAL CONNECTORS®
A GIBRALTAR INDUSTRIES COMPANY

July 3, 2008

Peter Bahlo, P.E.
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Whittier, CA 90601

Re: Proposed Acceptance Criteria for Cast-in-place Cold-formed Steel Connectors in Concrete for Light-frame Construction, Subject AC398- 0608-R2 (PB/BG)

Mr. Bahlo:

We have had an opportunity to review the proposed draft for AC-398 and offer the comments contained in this letter for your consideration.

Line 81 Replace "*reinforcing steel*" with "*concrete wall*". As written it could be interpreted to imply there needs to be direct contact or a mechanical connection between the connector and reinforcing steel.

Line 82 Replace "*sub-diaphragm purlin member*" with "*framing member*" to include other types of connections with this application.

Section 3.1.2.2 and Section 3.1.2.3 The last sentence of section 3.1.2.1 should also be included at the end of these two sections. Elongation and base metal thickness is typically included on the mill certificate as well. Including this language will eliminate the need to test what has already been tested

Section 3.1.3.3 Suggest adding the following sentence at the beginning of the section: "*The mix design and sources of material used in testing shall be clearly defined*". The tensile capacity of the concrete is as influential as any other item in the test. It is also possible to increase the tensile strength of the concrete without necessarily increasing the compressive strength of the concrete. The user shall be aware of the material used in the test to obtain the published capacities.

Section 3.1.4.1 Add the following sentence to the end of the section: "*Alternatively, the bolt tensile strength may be obtained from information provided by the fastener supplier*". This will eliminate the need to test a material that is known to meet a specific standard and is reflective of what is used in practice.

Section 3.1.4.2 Add the following sentence to the end of the section: "*Alternatively, nails complying with Supplementary Requirements of ASTM F 1667, as specified by the fastener supplier, may be used*". This will eliminate the need to test a material that is known to meet a specific standard and is reflective of what is used in practice.

Section 3.1.4.3 Add the following sentence to the end of the section: "*Alternatively, the bending yield strength of the screws may be obtained from information provided by the fastener supplier*". This will eliminate the need to test a material that has already been tested by the fastener supplier.

Line 305 Add the following sentence at the end of the section: "Additionally, if $Z_{test} / Z_{spec} \leq 1.05$ then R_{sg} may be taken as = 1.0". This will allow for a slight variation in specific gravity since one small test sample may not be indicative of the overall properties along the length of the wood member.

Line 361 Strike the following from the last sentence: "*to account for increased fastener perpendicular to grain strength used in the tests*". This language appears to be commentary and is potentially confusing.

Line 378 Add the following to the section:

Where: $T_{ASD} \leq \frac{N_u \, x \, R_c \, x \, R_d \, x \, R_s \, x \, R_{cr}}{2.5}$ *for Seismic Design Categories A, B*

$T_{ASD} \leq \frac{N_u \, x \, R_c \, x \, R_d \, x \, R_s \, x \, R_{cr}}{3.0}$ *for Seismic Design Categories C, D, E, F*

and

Where: $V_{ASD} \leq \frac{V_u \, x \, R_c \, x \, R_d \, x \, R_s \, x \, R_{cr}}{2.5}$ *for Seismic Design Categories A, B*

$V_{ASD} \leq \frac{V_u \, x \, R_c \, x \, R_d \, x \, R_s \, x \, R_{cr}}{3.0}$ *for Seismic Design Categories C, D, E, F*

Because cyclic testing is not included at this time, it is necessary to establish a minimum factor of safety. The proposed language establishes a minimum factor of safety for both seismic and non-seismic applications consistent with what is currently used in the industry.

Section 4.2 Add a new section 4.1.6 to read: "*The test plan shall also include the proposed concrete mix design and source of materials. Also, if the cracked concrete testing described in section 4.2 is to be conducted, the method of inducing or simulating the crack shall be included in the test plan*".

Line 487 Add the following sentence to the end of the section: "*prior to testing*".

Figures 1-4: The following figures should be used instead of graphics from a specific manufacturer's catalog. If this is not agreeable, it would be better to remove the figures and their references completely.

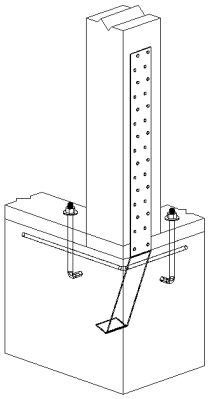


Figure 1

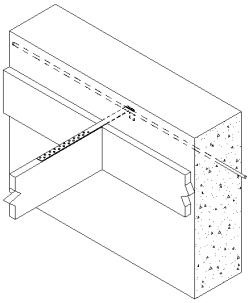


Figure 2

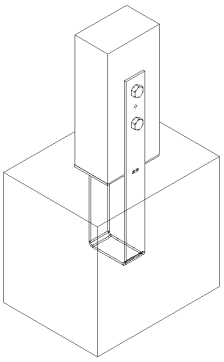


Figure 3

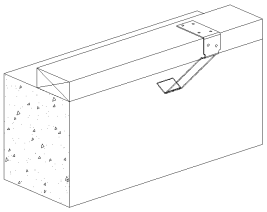
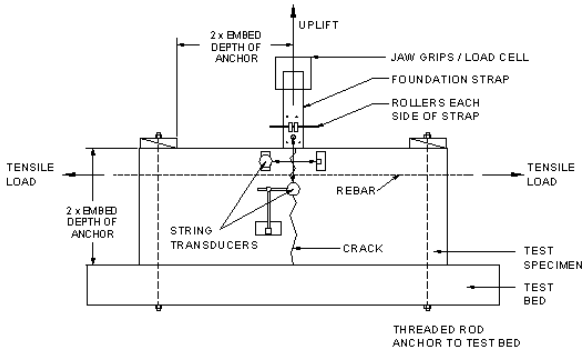


Figure 4

Figure 5 Currently there is not agreement in the industry as to the characteristics of the crack which is to be replicated in the testing. Accordingly it is difficult to prescribe a specific test setup to simulate the unknown. The figure currently in the document may potentially result in overly conservative results as it does not allow for aggregate interlock across the crack. For this reason we prefer the figure shown below. Alternatively, it may be best to eliminate the figure completely and require the manufacturer to submit a proposed test setup as part of the qualification test plan.



CRACKED CONCRETE TEST SETUP

Thank you for the opportunity to review and comment on the proposed acceptance criteria. If you have any questions or need additional information please do not hesitate to contact me.

Sincerely,

Greg Greenlee, P.E.
Director of Engineering

Santa Clara University

Center for Light Frame Structural Research
Department of Civil Engineering

MEMORANDUM

TO: PETER BAHLO, P.E.

FROM: REYNAUD SERRETTE

SUBJECT: ICC-ES AC398-0608-R2

DATE: 6/30/2008

CC:

The comments below on AC398-0608-R2 "Proposed Acceptance Criteria for Cast-in-place Cold-Formed Steel Connectors in Concrete for Light-Frame Construction" (http://www.icc-es.org/Criteria_Development/0806-alt/AC398-alt.pdf) are presented for your consideration and committee deliberation. The basis for my comments is the critical role connectors and connections play in the design, construction and performance of light frame structures.

General: Connectors and connections in light frame (wood and cold-formed steel) structures are critical to developing the expected performance of these structures, particularly in regions where the seismic hazard risk is high. Connectors and connections should be capable of ensuring that the desired seismic performance of designated lateral force-resisting elements is not compromised and assumptions about the structural relationship between connected lateral force-resisting elements, as they apply to overall system performance (dynamic characteristics, lateral resistance and energy dissipation), are valid within the scope of the building code.

Sections 1.4.2.1 through 1.4.2.4 If the connectors addressed in the subject AC are used to resist earthquake induced forces and the structural contribution of these connectors on expected performance of designated lateral force resisting elements (and ultimately the structure) is not explicitly addressed, these connectors should be designed as force-controlled components. As force-controlled components supporting designated lateral force-resisting elements, a **minimum factor of safety** equal to the system overstrength factor Ω_o divided by 0.7 should be considered for compliance with the IBC. For light frame (wood and cold-formed steel) bearing wall structures, Ω_o varies between 2.0 (flat strap bracing) and 3.0 (wood panel or sheet steel). A reasonable compromise may be Ω_o = 2.5, resulting in a **minimum factor of safety** of 2.5/.7 = 3.6 (say 3.5). Alternatively, cyclic load testing should be required to ensure the deformability of the connector is consistent with the expressed intent of the IBC and does not compromise the integrity of the connected structural elements/components.

Sections 1.4.1, 1.4.5, 1.4.6, 3.3.3.1, 3.3.3.2 and 3.3.3.3 These sections involve a determination of brittle and ductile behavior. Sections 1.4.1 and 1.4.6 appear to address deformability of the steel as a material. Section 1.4.5 and Sections 3.3.3.1 through 3.3.3.3 appear to address the connector (that part fabricated from cold-formed steel material). As noted in Section 1.4.5, several connector modes of failure are possible, including facture, buckling, crippling and rupture. A necessary requirement for ductile failure of a connector is an inherent ductility in the constituent material. However, ductile steel does not guarantee ductility in a fabricated part/component when fracture, buckling, crippling and rupture are possible failure modes. Either connector ductility requirements must be explicitly stated and cyclic load testing required to qualify connectors, or connectors should be required to possess a **minimum factor of safety** as noted above.

Section 2.3.5 This section should make it clear that specified physical properties of the steel refer to the specified **minimum** physical properties associated with a particular ASTM.

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Section 3.1.2.1 Section 3.1.2.1 permits a determination of the material properties of the cold-formed steel used for connectors and framing based on traceable mill certificates. Is this a common allowance in ICC-ES acceptance criteria? If traceable mill certificates are permitted in AC398, they should also be permitted in other relevant criteria published by ICC-ES.

Section 3.1.2.2 Unless it is demonstrated that the AISI TS-3 test method is not practical, testing should be conducted in accordance with AISI TS-3 and reference to "*an approved test procedure*" should be deleted. If alternate test methods are acceptable, consideration should be given to making "an approved test procedure" the standard and suggest AISI TS-3 as one approved test procedure.

Section 3.1.4.3 This last sentence in this section assumes that the quality of predrilled holes in the field will be similar to that of a test program (where used). No predrilled hole requirements are specified. Without adequate quality control (i.e. specified predrilled hole requirements) or inspection in the field, undersized or oversized predrilled hole diameters may result in connector performance different from what is expected.

Section 3.2 Specified values should reference minimum ASTM requirements. The word minimum should be used after "specified" in line 263.

Section 3.2.1 At the May 30, 2008 ICC-ES hearing in Chicago, during discussion on AC230, ICC-ES staff was explicit on the issue of the R_s reduction for cold-formed steel. The position adopted by ICC-ES is fully relevant and applicable to the R_s reduction factor in AC398. As such, R_s should consider both **specified minimum** yield and tensile material strengths. The following revisions to R_s, $F_{u(spec)}$ and $F_{u(test)}$ are suggested:

> R_s = Steel strength reduction factor based on the critical steel strength; yield (F_y) or tensile (F_u).
>
> $F_{(spec)}$ = Specified minimum yield (F_y) or tensile (F_u) strength of the connector steel consistent with applicable specifications/standards depending on which strength is a critical factor.
>
> $F_{(test)}$ = Measured yield (F_y) or tensile (F_u) strength of the connector steel depending on which strength is a critical factor.

Delete lines 280 and 281, and the associated equations—calculations are based on specified minimums.

Add, "The measured steel tensile strength shall not exceed the specified minimum value by more than 20 percent" to end of Section 3.2.1.

Section 3.3.1.2 See comment on **Section 3.1.2.2**.

Section 3.3.3.1 As noted previously, the criteria should be revised to include a minimum factor of safety equal to the system overstrength factor Ω_o divided by 0.7 if cyclic load testing is not completed. What's the basis of the ϕ factors for steel? For seismic design, ϕ = 0.65 for a "ductile connector" is not consistent with the maximum ϕ factors (0.60) for diaphragms in AISI-NAS, Table D5.

Section 3.3.3.3 Regardless of the deformability of the steel (brittle or ductile), the connector can exhibit brittle behavior. As noted earlier, both brittle and ductile behavior can affect the performance of connected elements/components, and ultimately the performance of the structure. For seismic design, connectors should be tested under cyclic loading or a minimum factor of safety (as discussed above) should be required regardless of the ductility of the steel material.

HARDY FRAMES Inc.
A MiTek Company
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June 13, 2008

Peter Bahlo, P.E.
Senior Staff Engineer
ICC Evaluation Service, Inc.
5360 Workman Mill Road
Whittier, CA 90601

Subject: AC398-0608-R2, Proposed Acceptance Criteria for Cast-in-place Cold-formed Steel Connectors in Concrete for Light-frame Construction

Dear Mr. Bahlo:

We appreciate the opportunity and time to review AC398 more closely. We believe the connectors addressed in the proposed AC are a critical part of the structural detailing process and that adequate detailing is necessary to obtain the expected performance of elements, components and ultimately a structure. A few editorial revisions are needed and we have identified four substantive issues we believe should be addressed before the AC is approved. This letter only provides comment on the issues we consider substantive, as we are confident you and your staff will address the editorial changes following the comment period.

Comment 1: Material ductility versus connector ductility

AC398 classifies cold-formed steel material as either brittle or ductile and extrapolates the classification to the connector. Thus, if the material from which a connector is fabricated is ductile, there is an automatic assumption that the connector is also ductile. This type of extrapolation is incorrect. As stated in AC398, connector failure may involve yielding, fracture, buckling, crippling or rupture of the connector. Buckling, fracture, crippling or rupture may occur at relatively low strain levels to the point where the connector behavior is essentially brittle. If a connected element forms part of a system or subsystem that is required and designed to develop a minimum displacement capacity, brittle failure of the connector make this system or subsystem ineffective.

Alternatively, a highly ductile connector may introduce displacements in a structures that results in an unanticipated distribution of load in a structure.

We recommend the following action for consideration by ES:

a. References to connector ductility based in the ductility of the constituent material should be removed from the AC.
b. A minimum factor of safety should be established for connectors intended to be qualified for use in seismic design categories C, D, E and F. This minimum safety factor should equal the 4.0 ($\approx [\Omega_o = 3.0] / 0.7$) unless cyclic testing justifies a lower values.

Comment 2: Testing Standards

Where ASTM or AISI test standards are referenced, testing should be conducted in accordance with these standards. Language allowing testing “in general agreement with” or using “an

approved alternative" is vague, for example; Section 3.1.2.2, 3.3.1.2 and 4.1.5. We recommend some clarification of the intent of such language shall be provided.

Comment 3: Reduction of Test Design Values

The language in Section 3.2.1 could be improved to address reductions in design values based on the connector properties. These improvements included:

a. Addressing both material tensile and yield strength reduction in Section 3.2.1.
b. Clearly defining that specified values refer to specified **minimum** values based on existing approved national standards (ASTM and AISI).
c. To qualify to approval under this criteria, $t_{test} \geq t_{spec}$. Delete lines 280 and 281, and the associated equations.
d. Revise the reduction equation for R_s and the notation as follows:

$$R_s = \left(\frac{F_{spec}}{F_{test}} \right) x \left(\frac{t_{spec}}{t_{test}} \right)$$

where:

R_s = Steel strength reduction factor based on the critical steel strength, yield (F_y) or tensile (F_u).

F_{spec} = Specified minimum yield (F_y) or tensile (F_u) strength of the connector steel consistent with applicable specifications/standards depending on which value is a critical factor.

F_{test} = Measured yield (F_y) or tensile (F_u) strength of the connector steel depending on which value is a critical factor.

t_{spec} = Specified minimum base-metal thickness of the connector steel.

t_{test} = Measured base-metal thickness of the connector steel.

Comment 4: Determination of Material Properties

Unless there is a precedent for permitting the use of mill certificates to verify material properties, such an allowance, as in Section 3.1.2.1, should be discouraged or prohibited. Alternatively, if it is permitted, ES needs to consider the same allowance for cold-formed steel products covered by other ACs.

Thanks for the opportunity to respond. Please feel free to contact me should you have any questions.

Sincerely,

/by email/

Ray Yu, P.E./S.E.
VP of Engineering
Hardy Frames Inc.