Comments on proposed changes to AC133-1020-R1:

1. Section 3.2.1a: A new Type 2HS (High Strain) Splice has been added to the criteria. The Building Codes only refer to Type 1 and Type 2 mechanical splices, so what is the justification for this new splice type? If Acceptance Criteria are developed for the purpose of issuing ICC-ES evaluation reports and evaluation reports are based upon performance features of the Building Codes, then there currently is no need for a Type 2HS splice since there is no Code requirement for a high strain mechanical splice. It is recommended that the new Type 2HS Splice requirements be removed from the acceptance criteria until the new requirements can be added to the Building Codes.

2. Section 3.25a refers to section 4.4.3.1. This section number does not exist.

3. Section 3.3.3 states, "… the specified tensile strength of the bars shall be the minimum specified tensile strength prescribed in the corresponding ASTM standard for the grade of steel reinforcement". Section 3.3.2 states, "… a Type 2HS mechanical splice shall also conform to the requirements of ACI 318-19 Section 20.2.1.3(b) for the grade of reinforcement for inclusion in the evaluation report". ACI Section 20.2.1.3(b) provides requirements for ASTM A706 Grade 100 reinforcement, however there is no Grade 100 in the ASTM A706 specification. By referring to the ASTM standard for tensile strength in section 3.3.3, the reader cannot obtain this information for Grade 100 bar. Also, it is not recommended to include Grade 100 as an option until ASTM adds that grade to the A706 standard.

4. Section 4.2.3 states, "Residual slip shall be determined at the end of Stage 1". However, Table 6 states "No requirement" for residual slip of a Type 1 splice. It takes special fixturing and equipment to measure residual slip and not all labs have this capability. It can be an expensive test to run and is an unnecessary burden on the report holders if there is no pass/fail requirement. It is recommended that residual slip be removed from section 4.2.3 and from the Conditions of Acceptance immediately following the section.

5. Section 4.3.3: Residual slip has been added as a new requirement. What is the basis for this addition? Will this require all new cyclic tension and compression testing for existing reports? If so, this addition will result in a massive financial burden for the existing report holders. There is no residual slip requirement in the Building Codes and acceptance criteria should be based upon performance features of the Codes. It is recommended that residual slip be removed from section 4.3.3 and from the Conditions of Acceptance immediately following the section until the Codes are revised to include a slip requirement.

6. Proposed new section 6.19 states, "The mechanical splice system shall be fully engaged with the reinforcing bar, removing preload slack during installation…" If preload slack can be removed during installation, wouldn't it be removed during installation of the test specimens and therefore not reported per section 3.2.3? Wouldn't that make section 6.19 not applicable? The intent for adding preload slack in the acceptance criteria is unclear and should be clarified.

7. Table 6: The residual slip requirement of 0.3mm (0.012 in) for Stages 1 and 2 and 0.6mm (0.024 in) for Stage 3 is unrealistic because the slip value does not vary by rebar size. It is unreasonable to impose the same slip value on a #14 or #18 splice as a #4 or #5 splice. For example, the load at 30ksi in a #18 bar is 120,000 lbf whereas the load at 30ksi in a #4 bar is 6,000 lbf. It is unjustifiable to expect a splice loaded to 120,000 lbf and then unloaded to have the same amount of slip as a splice loaded to 6,000 lbf and then unloaded.

8. Figure 1: The residual slip test illustrated in Figure 1 is unlike any slip test used by Departments of Transportation or any other entity in the US. Why has this slip test been chosen over a more established and widely accepted slip test used by Caltrans? It doesn't make sense to introduce a requirement that is foreign to the US market.

9. Annex B, paragraph c: Replace first word "Applied" with "Apply".

Submitted by: Tim Cartwright
Barsplice Products, Inc.

HEADED REINFORCEMENT CORP.
11200 Condor Avenue
Fountain Valley, CA 92708

TEL: (714) 557-1455
FAX: (714) 557-4460

September 8, 2020

Manuel Chan P.E. S.E.
ICC-ES Western Regional Office
3060 Saturn Street, Suite 100
Brea, California 92821

RE: Proposed Revisions to the Acceptance Criteria for Mechanical Splice Systems for Steel Reinforcing Bars AC133-1020-R1

Mr. Chan,

We have reviewed the proposed revisions to AC133 and would like to present some comments / concerns for your consideration prior to the hearing in October. These comments are primarily guided at the proposed slip requirements.

- Overall we are concerned that manufacturers of mechanical splice systems for steel reinforcing bars have not been adequately involved in discussions leading up to this proposal. A collaborative process, seeking input from the industry or experts should be employed. This proposal feels very similar to a last minute comment that was proposed for incorporation into the 318-19 Building Code earlier this year. As I'm sure you know, this comment which included a type 3 splice with strain requirements, did not pass and was ultimately excluded from the 318-19 Code. Additional time should be granted to the industry to fully review, discuss and evaluate the impact of this propsoal. This additional time would ensure that the proper language is developed and we do not rush to institute substantial changes.

- The cyclic testing required by the current AC 133 is already very expensive with very few capable laboratories offering it. Adding slip to this will only increase the complexity and cost of a test that currently prevents manufacturers from seeking approval of the full range of their products.

- Based on years of experience with conventional slip testing, this testing commonly yields inconsistent results. Furthermore ,it is the static tensile tests that are currently governing (we have not seen products that meet the tensile requirement but fail stage 3 of the cyclic test). It has taken us years to complete Type 2 tests for our main coupler product only. Repeating the tests with slip measurements within a year is not a viable option for us economically or practically.

- If overall stiffness of mechanically spliced reinforcing bars is a concern, the coupler length should be considered more of an issue than slip. For high strain locations, longer couplers will change the behavior when compared to shorter couplers and/or un-spliced continuous bars, both when staggered or spliced in one plane. Caltrans, which to date have the only "high strain" mechanical splice requirement in the U.S., do not allow couplers longer than 10db. What is the point of restricting slip to a fraction of a mm, but not addressing increased stiffness over excessive coupler lengths (ie. 2 feet) in a plastic hinge?

HEADED REINFORCEMENT CORP.
11200 Condor Avenue
Fountain Valley, CA 92708

TEL: (714) 557-1455
FAX: (714) 557-4460

- The proposed slip requirements for Type 2 and the new Type 2HS splices are more restrictive than the current Caltrans slip requirements. Caltrans has required QC testing and ultimate performance for decades. However, it has proven difficult to measure slip accurately even with preloading to 3,000 psi and loading to a max of 50%fy (slip is measured at serviceability loads). Caltrans allowable slip at 50%fy, is:

CALIFORNIA DEPARTMENT OF TRANSPORTATION
AUTHORIZATION PROCEDURES AND ACCEPTANCE CRITERIA FOR MECHANICAL COUPLERS ON ASTM A706 and ASTM A615 REINFORCING STEEL

Total Slip

Reinforcing Bar No.	Total Slip (inch)
#4 - #6	0.020
#7 - #9	0.028
#10 - #11	0.036
#14	0.048
#18	0.060

- Restrictive, complicated qualification tests for the most demanding applications sounds good on paper. However, we must acknowledge that in reality these products are installed by contractors and fabricators not making the qualification tests and usually not subject to QC testing. Meeting the slip and high strain requirement allows absolutely no safety factor or margin for error. A manufacturer can certainly achieve this with carefully prepared samples, but reinforced concrete require more tolerances for the users applying these products. With variable conditions, rebar properties and no margin for error, it is unlikely that products designed for this performance will achieve it consistently without QC or project prequal testing which again adds cost and complexity.

I hope the points raised above demonstrate the importance of providing additional time for the industry to fully review, discuss and evaluate the impact of this propsoal. This additional time would ensure that points like the ones presented above are fully addressed, the proper language is developed and we do not rush to institute substantial changes.

Thank you in advance for your consideration.

Sincerely,

Robbie Hall

Headed Reinforcement Corporation
(678) 333-4450
Robbie.hall@hrc-usa.com

Bob Stewart
Worldwide Applications Engineering
LENTON

Electrical & Fastening Solutions
Office +1.330.528.3344
Mobile +1.330.703.0096
bob.Stewart@nVent.com

34600 Solon Road
Solon, Ohio 44139, USA

nVent.com

September 10, 2020

ICC Evaluation Service, LLC
Western Regional Office
3060 Saturn Street, Suite 100
Brea, CA 92821

Subject: Proposed Revisions to the Acceptance Criteria for Mechanical Splice Systems for Steel Reinforcing Bars AC133-1020-R1 (MC/VC)

To whom it may concern,

NVent appreciates the opportunity to provide this letter in response to your proposed change to AC133 dated August 18, 2020.

Point 1)
The proposed change to AC133 for Type 1, Type 2 and Type 2HS mechanical splices has tensile acceptance criterion by stating the mechanical splice shall meet "*125 percent of the specified yield strength, fy, of the reinforcing bar*."

The proposed change to AC133 section 3.2.1.a states: "*Type 2HS Splice (Optional): The manufacturer may seek additional evaluation of the splice system as a Type 2HS mechanical splice ("HS" denotes "High Strain"). The Type 2HS splice is a mechanical splice with a minimum tensile strength and tensile strain capacity intended for use in seismic applications with reinforcing bar conforming to ACI 318-19 Section 20.2.1.3(b)*."

ACI 318-19 Table 20.2.1.3(b) reads as follows:

Table 20.2.1.3(b)—Tensile property requirements for ASTM A706 Grade 100 reinforcement

	Grade 100
Tensile strength, minimum, psi	117,000
Ratio of actual tensile strength to actual yield strength, minimum	1.17
Yield strength, minimum, psi	100,000
Yield strength, maximum, psi	118,000
Fracture elongation in 8 in., minimum, %	10

How can the mechanical splice be expected to meet 125 percent of the specified yield strength of the reinforcing bar per ACI 318-19 Section 20.2.1.3(b) but the reinforcing bar only needs to meet 117 percent of the specified yield strength?

As an example, suppose a monotonic tension test of reinforcing bar only demonstrates compliance with a 100,000 psi yield strength and a 117,000 psi tensile strength.

Reinforcing bar Yield Strength (minimum) = 100,000 psi

Reinforcing bar Tensile Strength (minimum) = 117,000 psi

A mechanical splice tested with this compliant reinforcing bar would need to meet a tensile strength of 125,000 psi.

Mechanical splice Tensile requirement = 125,000 psi (100.000 psi x 1.25 = 125,000 psi)

While Monotonic Tension testing the mechanical splice, the reinforcing bar would break below the required minimum load capacity of 125,000 psi for the mechanical splice. If the reinforcing bar does not meet the proposed AC133 code, how can a mechanical splice utilizing this reinforcing bar meet the proposed code?

This conflict needs to be resolved.

Point 2)

The proposed AC133 Type 1 and Type 2 states per section 4.1.2 and 4.2.2 respectively Monotonic Compression Tests "*Each test specimen shall develop in compression with at least 125 percent of the specified yield strength, fy, of the reinforcing bar.*"

The proposed AC133 of Type 2HS states per section 4.4.2 Monotonic Compression Tests: "*Each test specimen shall develop in compression at least 100 percent of the specified tensile strength, fu, of the reinforcing bar*."

What the proposed AC133 code requires is a Type 2HS mechanical splice with ASTM A706 grade 100 tested in compression to meet 117,000 psi but in same scenario a Type 1 is required to meet 125,000 psi in compression. Is this logical? Take another example, the proposed AC133 code requires a Type 2HS mechanical splice with ASTM A706 grade 60 tested in compression to meet 80,000 psi but in same scenario a Type 1 is required to meet 75,000 psi in compression. Why are a Type 1 and Type 2 mechanical splices in compression required to meet 125 percent of the specified yield strength while a Type 2HS is required to meet 100 percent of the specified tensile strength? What is the justification for the change in Type 2HS mechanical criteria? Where in ACI 318-19 is the mechanical splice in compression required to meet 100 percent of the specified tensile strength?

This conflict needs to be resolved.

Point 3)

The proposed AC133 ANNEX B Section a states: "*Before applying any load to the mechanical splice test assembly, place punch or scribe marks to create two 8-inch (200-mm) gage lengths, one gage length on each reinforcing bar on each side of the mechanical splice and outside of the splice affected zone. Leave a space of at least two bar diameters between any mark and an end of the mechanical splice or the face of a test machine grip.*"

The proposed AC133 ANNEX B punch marks appear to follow the logic of Caltrans 670 test protocol. This punch mark protocol per Caltrans 670 section Part III 4. 3) a) is utilized only in monotonic tensile testing (not compression).

Have any precautions been given to ensure the test sample will not buckle at these increased lengths? We have safety concerns for the laboratory technicians. Per the proposed AC133 the mechanical splice test sample length between the jaws of a #4 grade 100 would be 20 inches ((8 inch + .500 inch * 4) * 2) minimum, plus the length of the mechanical splice. This mechanical splice test sample requires a compressive stress of 50,000 psi or 10,000 lb. load of force. It is our experience that this mechanical splice test sample will buckle when loaded in compression during the cyclic tension/compression testing. Knowing this concern, we conducted a test with a #4 reinforcing bar only test with a jaw-grip-to-jaw-grip distance of 20 inches per AC133 cyclic tension/compression protocol. In the first compression cycle the reinforcing bar only met 47% of the required compressive force before it buckled. Note: This load was well below the required load for a grade 60 reinforcing bar. Refer to the picture below.

Proposed AC133 section 4.4 Conditions of Acceptance for a Type 2HS mechanical splice Criteria 3.2.1.a states: "*For cyclic tension and compression tests, each test specimen shall sustain Stages 1 through 3 of loading without failure… Under Stage 4 of the test, each test specimen shall develop in tension all of the following: 100 percent of the specified tensile strength, fu, of the reinforcing bar; 125 percent of the specified yield strength, fy, of the reinforcing bar; and strain in tension in the reinforcing bar as specified in Table 7*."

The above statement makes it clear that the proposed Type 2HS tension requirements must first sustain Stages 1 through 3 of loading prior to the stage 4 tensile testing.

The above #4 grade 100 test clearly demonstrates the proposed longer Type 2HS mechanical splice test sample lengths cannot carry the loads required for the cyclic tension/compression test and buckle the reinforcing bar. If the reinforcing bar cannot carry the loads for the Type 2HS cyclic tension/compression for stage 1 though stage 3 before buckling, how can the tension requirement in stage 4 be accomplished? The proposed Type 2HS protocol is physically impossible to complete.

The proposed AC133 should allow:

1) Monotonic tension testing with the longer jaw-grip-to-jaw-grip lengths for the Type 2HS strain requirement.
2) The proposed AC133 should follow the current released AC133 cyclic compression/tension testing which has greatly reduced jaw-grip-to-jaw-grip lengths (stable and safer).

Additional points indicating the need for monotonic testing for Type-2HS mechanical splice.

A) Proposed AC133 section 4.4.1 for 2HS splices states: "Monotonic Tension Tests: Monotonic tension tests are not required. "

   Proposed AC133 section 6.10 d states: "*For Type 2 or 2HS splices, splices using the fabricator-prepared assemblies of couplers and steel reinforcing bars, tested in monotonic tension, must develop 100 percent of the specified tensile strength of the steel reinforcing bar and 125 percent of the specified yield strength of the reinforcing bar for use under the IBC or IRC. This may be demonstrated in test report(s) submitted to the code official.*"

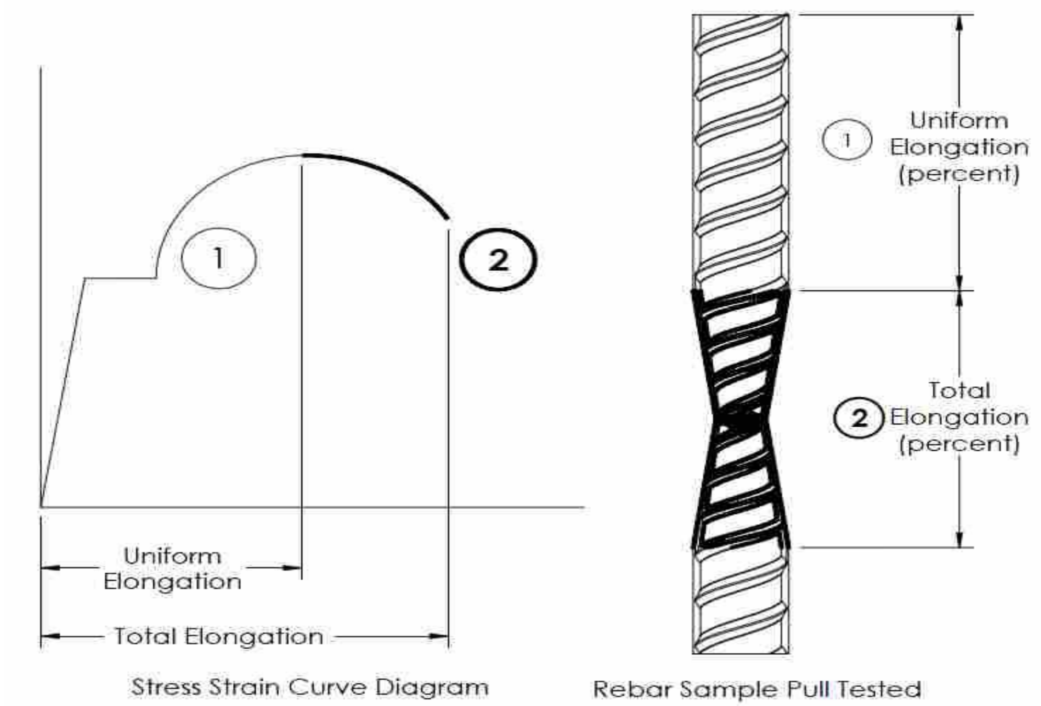
   Proposed AC133 section 4.4.1 and section 6.10 d have conflicting statements

B) As the rebar is cycled beyond the proportional limit, the reinforcing bar becomes strain hardened.
   ACI 439.6R-19 in section 10.3 states "*Inelastic cyclic testing is therefore not recommended for use in evaluation of strain capacity of mechanically spliced A1035/A1035 M (CS) Grade 100 (690) bars. Only test samples cut from original straight lengths of reinforcing steel, not from coil or post-fabricated steel, should be used for tensile strain evaluation.*"
   As noted in 439.6R-19 the reinforcing bar Uniform Elongation as defined by ACI 318-19 can be altered in an inelastic cyclic test, such as AC133 testing.

Again, allowing a monotonic tension test could improve this issue. But, Type 2HS mechanical splice under the proposed AC133 does not allow monotonic tension testing.
These conflicts need to be resolved.

Point 4)
The proposed change to AC133 section 3.2.1.a states: "*Type 2HS Splice (Optional): The manufacturer may seek additional evaluation of the splice system as a Type 2HS mechanical splice ("HS" denotes "High Strain"). The Type 2HS splice is a mechanical splice with a minimum tensile strength and tensile strain capacity intended for use in seismic applications with reinforcing bar conforming to ACI 318-19 Section 20.2.1.3(b).*"

Both ASTM A706 and A615 are silent on how to measure Uniform Elongation and do not require reporting of Uniform Elongation. It is important to note that both ASTM A706 and A615 require Total Elongation. Uniform Elongation and Total Elongation are two different measurements. Note the diagram below:



Uniform Elongation (as per ACI 318-19) = measured section 1
Total Elongation (as per ASTM A706) = measured section 2

To add further confusion, both ASTM A706 and ACI 318-19 do not define how to measure Uniform Elongation. Due to an individual's interpretation and knowledge, Uniform Elongation will have wide variances due to measuring techniques. ASTM A706 reinforcing bar is required to meet Total Elongation but, may not meet Uniform Elongation as defined in ACI 318-19. How can a mechanical splice meet the requirements of Uniform Elongation of ACI 318-19 if the reinforcing bar does not meet Uniform Elongation?
This conflict needs to be resolved.

Point 5)
Proposed AC133 section 3.2.1.a states: "*The conditions of acceptance in Section 4.4 for the Type 2HS splice includes strain-based performance requirements that are in addition to the stress-based performance requirements of the Type 2 splice in Section 4.3.*" The strain requirements proposed AC133's Type 2HS Conditions of Acceptance references Table 7 and reads as follows:

TABLE 7— MINIMUM STRAIN DEVELOPED DURING STAGE 4 OF CYCLIC TENSION AND COMPRESSION TESTS FOR TYPE 2HS SPLICE

	Reinforcing Bar Grade		
	Grade 60	Grade 80	Grade 100
	Strain Developed during Stage 4, minimum, percent		
Bar designation No.			
3, 4, 5, 6, 7, 8, 9, 10	9	7	6
11, 14, 18	6	6	6

Note: Strain requirements listed in this table are based on the requirements for uniform elongation of deformed bar reinforcement as specified in ACI 318-19 Table 20.2.1.3(c).

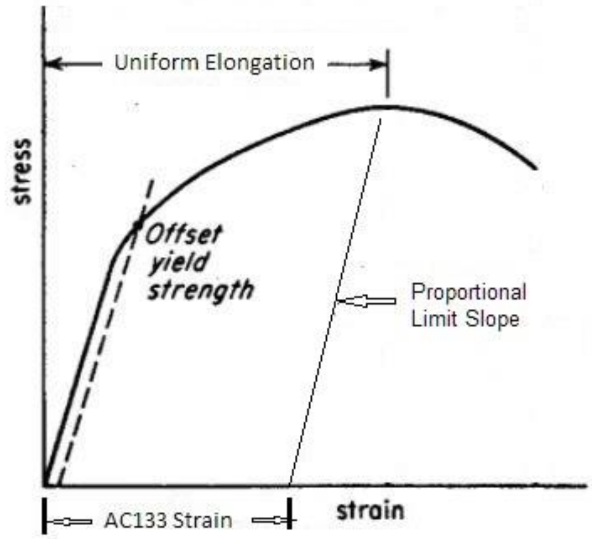
ACI 318-19 Section 20.2.1.3(c) has a uniform elongation requirement as shown below.

Table 20.2.1.3(c)—Uniform elongation requirements for ASTM A706 reinforcement

	Grade 60	Grade 80	Grade 100
Uniform elongation, minimum, percent			
Bar designation No.			
3, 4, 5, 6, 7, 8, 9, 10	9	7	6
11, 14, 18	6	6	6

Table 7 should state that it is for ASTM A706 reinforcing bar only.

As demonstrated above in point 4, both ASTM A615 and A706 are silent on how to measure Uniform Elongation and do not require reporting of Uniform Elongation. The proposed AC133 addresses this concern by adding ANNEX B. ANNEX B measures reinforcing bar Permanent Deformation, not Uniform Elongation. Uniform Elongation includes the elongation while under load. ANNEX B allows the reinforcing bar to relax, thus all the strain that would occur under the proportional limit is not included in the ANNEX B measurement. By allowing the strain to be measured post load, as proposed by AC133, some mechanical splicing systems will fail this new requirement while passing per ACI 318-19. This is explained in the diagram below:



AC133 should add the strain that would occur under the proportional limit.

Added strain = stress / modulus of elasticity (Added strain = stress / 29,000,000 psi)

As an example, if the test sample went to a stress of 90,000 psi the added strain will be calculated as follows: 90,000 / 29,000,000 = .0031 strain

Point 6)

The proposed AC133 Type 2HS mechanical splice is based on the strain of the reinforcing bar. By this interpretation, the proposed AC133 is inferring a structure made from #10 ASTM A706 grade 60 reinforcing bars will resist a 9% strain while structure made from #11 ASTM A706 grade 60 reinforcing bar will resist a 6% strain. Does this make logical sense? The strain in the mechanical splice should be based on the strain experienced in a structure while under seismic loads. This was the original intent of AC133 when first published and the inelastic cycles for 2Ey and 5Ey already serve that purpose well for 20 years. Thus, any need to change to different strain level is unwarranted

ACI 439.6R-19 states in section 10.3: "*On this basis, the Type 1 mechanical splice minimum strength corresponds to a strain in the spliced bars that is beyond the yield plateau and into the onset of strain hardening; the onset of strain hardening occurs at strains in the range of 1 to 2 percent for ASTM A615/A615M Grade 60 and ASTM A706/A706M Grade 60 reinforcement. The Type 2 mechanical splice minimum strength requirement corresponds to a strain in the spliced bars that is even larger and beyond the onset of strain hardening and into the strain hardening range, corresponding to strains in the range of 2.5 to 4 percent for ASTM A615/A615M Grade 60 and ASTM A706/A706M Grade 60 reinforcement. Consequently, to achieve stress strain performance similar to those of the strength-based requirements for mechanical splices specified in ACI 318, new designated Type A and B mechanical splices are recommended by this guide with monotonic strain limits based on strain of the bars. Based on the historical statistical analysis of ASTM A1035/A1035M (CS) bars' test data, it is recommended that bars be mechanically spliced to develop 2 percent static tensile strain for Type A connections and 3 percent static tensile strain for Type B connections. Testing of the mechanical splices for strain capacity should be performed under static tensile test loading.*"

ACI 439.6R-19 recommends a 3 percent static tensile strain for Type B connections. The Type B connection in ACI 439.6R-19 is a mechanical splice for seismic areas with a strain requirement. In other words, the proposed AC133 Type 2HS mechanical splice.

A large portion of the ductility in reinforcing steel exists to assure the rebar can be fabricated and still have residual capacity to meet the 3% demand of a structure. Strain and Uniform Elongation are required for fabricating and bending reinforcing bar. As pointed out in ACI 439.6R-19, the strain and uniform elongation required for fabricating and bending reinforcing bar are not the same as what is needed for the structural demands. Mechanical splices evaluated to AC 133 as currently written, already assures the seismic demand is met regardless of bar strength and is consistent with the ACI code. If ACI 439.6R clearly establishes the strain capacity for of Type 2 (Type B) grade 100 why would we do anything different and not consistent with these provisions. What is the code justification for this proposed AC133 Type 2HS mechanical splice? These conflicts need to be resolved.

Point 7)
Post fabricated reinforcing steel including coiled or spooled bars, have significantly been work hardened prior to installation into the structure. As a result of this work hardening, coiled rebar and post fabricated (bent) rebar will not exhibit the same actual yield strength, Tensile to Yield properties and corresponding actual Tensile strength as the unaltered non-work hardened steel. The proposed AC133 should provide language to assure that only non-work hardened steels should be utilized in determining conformance.

SUMMARY

NVent supports adding residual slip criteria to both Type 1 and Type 2 splices.
NVent does not support the addition of Type 2HS qualification criteria to AC133 as described.

Slip

It is nVent's position that residual slip needs to be a requirement for Type 1 splices. Residual slip is directly related to crack propagation, which is critical for the durability and reliability of all structures whether reinforcing bar connections are Type 1 or Type 2, the structure cannot tell the difference between the two types of connections.

Type 2HS

It is nVent's position that Type 2HS qualification criteria cannot be adopted at this time for several reasons:

1. Type 2HS or similar has not been defined by the governing body of building construction that developed Type 1 and Type 2 definitions – ACI 318.
2. The material specifications ASTM A706 has not adopted Grade 100.
3. Uniform elongation requirement is not in ASTM A706. There is not a consensus in the industry on how to measure strain and/or uniform elongation.
4. There is not enough data regarding strain and uniform elongation capabilities of the new referenced reinforcing steel
5. The proposed wording needs much work as has been cited in this rebuttal. One month for revision from industry experts is not enough. Some of that work includes:
    a. Test protocol for Type 2HS cannot be run due to buckling of test samples.
    b. Control bar tests with consensus on measurement of yield strength, strain and uniform elongation.
    c. Monotonic splice tests need included to determine strain and uniform elongation in the same way as strain and uniform elongation was measured to create table 20.2.1.1.3 in ACI 319-19. This table's values were not determined from measurements after inelastic cycles were performed on the reinforcing steel.
    d. Consensus/discussion on why compression tests need to go to 100% fu
    e. The current AC 133 protocol already provides the safeguards needed for strain response of the structure.

If you have any additional questions regarding this issue, please feel free to contact me.

Thanks,

Robert C. Stewart

Worldwide Application Engineer

Comments on AC133-1020-R1

Mostafa Tazarv, PhD, PE

South Dakota State University

Email: Mostafa.Tazarv@sdstate.edu

This is to provide a few feedback on AC133-1020-R1 based on my multi-year research performed on mechanical bar splices and mechanically spliced bridge columns. I will also list a few studies at the end of this letter for further information. I appreciate your consideration.

Type 2HS Splice: The definition of Type 2HS Splice is not complete specifically the strain limits proposed in **Table 7** are excessive. There are several issues that need further consideration:

1. ASTM A706 and A615 have different strain limits, which should be included in the table.
2. **Table 7** is presenting the minimum strain requirements for <u>unspliced bars not spliced bars</u>. It has been well documented (e.g. more than 160 coupler tests by Dahal and Tazarv, 2020) that couplers reduce the strain capacity of a splice compared with unspliced specimen from 30% to 90%. <u>For each bar size, coupler type, and manufacturer, the strain limit will be different</u>. The limits in **Table 7** cannot be met for mechanical splices.

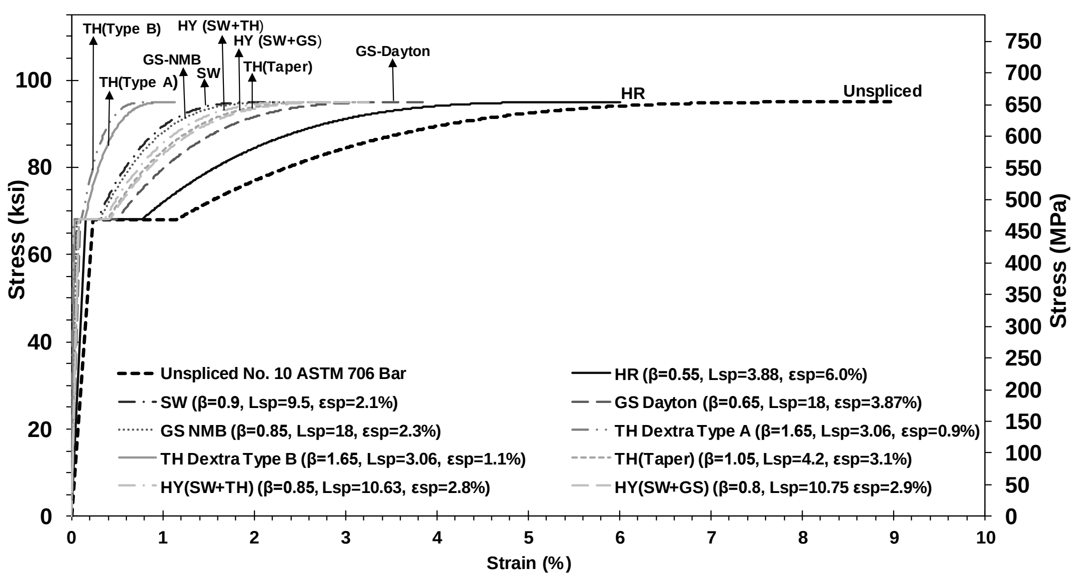


Figure a. Expected stress-strain relationships for spliced and unspliced No.10 (32-mm) ASTM A706 reinforcing steel bars (Dahal and Tazarv, 2020)

NOTE: HR= Headed Coupler; GS = Grouted Sleeve Coupler; TH = Threaded Coupler; SW = Swaged Coupler, HY = Hybrid Coupler,

Compressive Tests: Compressive tests of splices (or even bars) are extremely difficult and needs special care/equipment. Further, there are studies (Boudaqa et al., 2017) that have shown that unspliced bars will buckle under 0.5fy in compression. A few more concerns on this:

1. What is the proposed compressive test setup?
2. How bar/splice buckling is prevented?
3. Couplers will be used in concrete members. If a conventional lap splice can transfer compressive loads, why a mechanical splice needs further testing in compression?

I recommend removing the text for compressive testing.

Full-Cyclic Tests: Full tensile-compressive tests are not recommended due to issues discussed above. The benefits of such testing are not clear. Half-cyclic tensile tests will provide sufficient information to evaluate a mechanical splice.

Slip Tests: The total slip in a mechanical splice (such as those shown in **Fig. 1** of AC133-1020-R1) includes (1) residual elongation of bars inside the coupler (e.g. caused by strain concentration even at linear elastic range), (2) residual elongation of the coupler (e.g. yielding of threads in threaded couplers), and (3) rigid body movement of the inside face of the bar embedded in the coupler (the dead end slippage). The third term is indeed the slip, not all three combined. Further, all should be quantitatively measured, which are extremely hard to do. Therefore, the document needs to clarify which of the three is defined as "slip" and how it is measured without including the other components.

Overall, some requirements on slippage are needed for service limit states of the design; however, the requirements should not be excessive. From past large-scale testing of bridge columns, mechanical bar splices even with some slip did not cause any additional damage/cracking in spliced columns compared with reference columns without any splices (Haber at al., 2013; Tazarv and Saiidi, 2014). If component/system level testing of mechanically spliced RC members (beams, columns, walls) are available and not showing any signs of damage, the slip limits can be relaxed.

Recently, we developed standard testing methods for AASHTO on bar couplers (Appendix B of NCHRP 935). I recommend reviewing that document especially for the "seismic splices".

Thank you for considering these comments. Please feel free to contact me know if you have any questions.

References:

Boudaqa, A., Tazarv, M., and Tuhin, I. (2017). "Ductility without Confinement - A New Design and Construction Approach for RC Bridge Columns," International Journal of Bridge Engineering, Special Issue, pp. 53-77

Dahal, P.K., and Tazarv, M. (2020). “Mechanical Bar Splices for Incorporation in Plastic Hinge Regions of RC Members,” Construction and Building Materials, Vol. 258, 120308, 17 pp.

Haber ZB, Saiidi MS, Sanders DH. (2013). “Precast column-footing connections for accelerated bridge construction in seismic zones.” Reno, Nevada: Center for Civil Engineering Earthquake Research, Department of Civil and Environmental Engineering, University of Nevada; 2013. p. 502. Report No. CCEER-13-08.

Saiidi, M.S., Mehraein, M., Shrestha, G., Jordan, E., Itani, A., Tazarv, M., Sanders, D., Murphy, T.M., Reno, M.L., and Pohll, M.N. (2020). “Proposed AASHTO Seismic Specifications for ABC Column Connections,” National Academies of Sciences, Engineering, and Medicine, NCHRP Report No. 935, Washington, DC: The National Academies Press, 354 pp.

Tazarv, M. and Saiidi, M.S. (2014). “Next Generation of Bridge Columns for Accelerated Bridge Construction in High Seismic Zones,” Center For Civil Engineering Earthquake Research, Department of Civil and Environmental Engineering, University of Nevada, Reno, Nevada, Report No. CCEER-14-06, 400 pp.

From: Paulson, Conrad <CPaulson@wje.com>
Sent: Thursday, September 10, 2020 4:18 PM
To: es
Subject: Comments on Proposed Revisions to Acceptance Criteria for Mechanical Splice Systems AC133-1020-R1 (MC/VC)

To Whom it May Concern:

The following are offered as comments on the Proposed Revisions to Acceptance Criteria for Mechanical Splice Systems AC133-1020-R1 (MC/VC) as attached to ICC-ES letter dated August 18, 2020:

Section 3.2.3, sentence beginning on the seventh typeset line of the paragraph, delete “is” and replace with “and Preload slack are”, so that the beginning of the sentence reads: “Residual Slip and Preload Slack are to be measured …” Reason: the title of Section 3.2.3 reads “Residual Slip and Preload Slack Measurement”. This makes it clear that the measurement methods in this section are also applicable to Preload Slack.

For each of subsections 6.7.c(ii), 6.8.b(ii), 6.9.b(ii), and 6.10.d, insert the following as the second sentence in each subsection: “The Type 2HS splice shall additionally develop strain in tension in the reinforcing bar as specified in Table 7.” Reason: so that the monotonic tensile strength requirements for Type 2HS splices as specified in these subsections match the conditions of acceptance for Type 2HS splices as specified in Section 4.4.3.

Section A3.2.2, second paragraph, second typeset line, delete “using the same grout” and replace with “from each batch (bag) of grout”. Reason: to resolve ambiguity.

Section A3.2.2, second paragraph, seventh typeset line, delete “within 24 hours of the structural tests” and replace with “within the permissible tolerance on test age as specified in ASTM C109.” Reason: the as-stated single value of 24-hour tolerance is inconsistent with the permissible tolerance on test age as specified in ASTM C109, which varies by test age.

Sincerely,

Conrad Paulson, PE (CA, others), SE (IL)
Principal

Wiss, Janney, Elstner Associates, Inc.
Engineers | Architects | Materials Scientists
225 South Lake Avenue, Suite 500, Pasadena, CA 91101
tel 626.696.4650 | direct 626.696.4676
www.wje.com
CPaulson@wje.com