

# **Response to Public Comments on Draft Regulatory Guide (DG)-1372** **“Design Limits, Loading Combinations, Materials, Construction and Testing of Concrete Containments”** **Proposed Revision 4 of Regulatory Guide (RG) 1.136**

On July 8, 2020, the NRC published a notice in the *Federal Register* (85 FR 41071) that Draft Regulatory Guide, DG-1372, a proposed revision of RG 1.136 was available for public comment. The Public Comment period ended on September 8, 2020. The NRC received the comments listed below. The NRC has combined the quoted comments and NRC staff responses in the following table.

Comments were received from the following:

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Comment No. and Commenter	Section of DG-1372	Specific Comments	NRC Resolution
1. Louis Colarusso, LENTON	Regulatory Position C.8.d and C.11.a [Code Sections CC-3532, CC-4333.2.3(a) and CC-4334]	<p><b>Item 1 (Determination of fy_actual and ft_actual):</b> [I]n the NRC draft proposal, actual yield strength, fy and actual tensile strength, ft of the rebar being mechanically spliced or mechanically headed bars are used to determine pass or failure of a mechanical splice or headed bar. Therefore, the determination of such values must be very precise and the process for determining these values must be defined clearly in the code.</p> <p>DG-1372 Section CC-4333.2.3(a)(1) specifies that the actual yield and actual tensile strength for <u>qualification samples</u> is to be determined by testing an unspliced specimen of rebar taken from the same heat of rebar used for the mechanically spliced or headed rebar samples. DG-1372 Section CC-3532 defines that actual yield for <u>production sample</u> testing “may” be determined from corresponding certified material test reports (CMTR). The usage of the word “may” is ambiguous and suggests that there are other acceptable</p>	<p>The staff generally agrees with the concern.</p> <p>Consistent with the intent of Regulatory Position 11 discussed on page 11 of DG-1372 and considering the comment, the only deviation that the staff will take from Code paragraphs CC-3532, CC-4333 and CC-4334 is that an individual mechanical splice, welded splice, or mechanically headed deformed bar system should be qualified by testing to be capable of developing at least the minimum specified tensile strength of the reinforcing bar (in lieu of code requirement of 125 percent of specified minimum yield strength). This is consistent with the requirements for a Type 2 splice in ACI 318-19 and ACI 349-13. Regulatory Positions 8.d and 11 have been revised accordingly. The previously recommended acceptance criteria based on fy_actual for qualification testing, and fy_actual or ft_actual for continuing production performance testing has been deleted in</p>

methods to determine actual yield. If so, what are those acceptable methods? Additionally, DG-1372 Section CC-3532 DOES NOT define how actual tensile strength is to be determined for production sample testing.

Based on testing of rebar in the industry, it is not uncommon for the measured actual yield and tensile strengths within a particular rebar heat and grade, or in each 60-foot length of rebar, to vary by as much as 5%. Determining the actual yield or tensile for qualification samples based on a single tensile test, or extracting from the CMTR in the case of production samples, will result in occasions where samples are falsely rejected or accepted simply because the determined yield strength is not truly representative of the actual length of rebar used in the mechanically spliced or headed sample. In addition, the methodology for determining the yield strength needs to be more clearly defined for steels with a “roundhouse” characteristic when a sharp yield plateau is not present.

Variation of methodology of extension under load EUL vs offset vs drop of beam methods can produce significantly different yield values. The methodology for yield determination for the steel characteristic needs strictly defined in DG-1372 to utilize the lower of the methods, because of the variation cited previously.

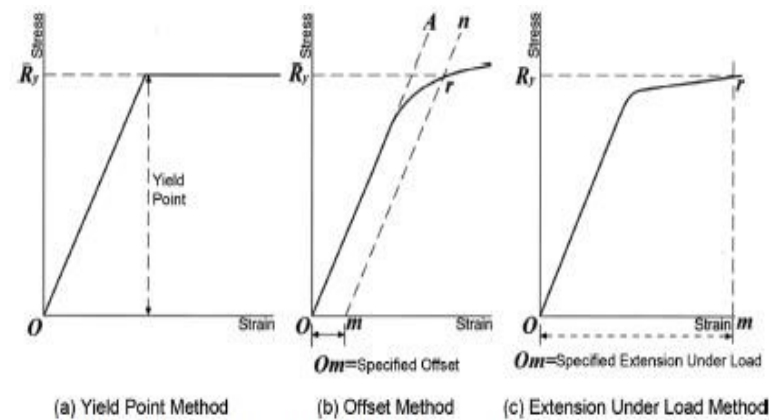


Fig. 1—Stress-strain diagrams showing methods of yield strength determination.

regulatory position 11. However, it should be noted that code paragraph CC-4333.2.3(a) requires that the average tensile strength of the splices and mechanically headed deformed bars shall not be less than 90% of the actual tensile strength of the reinforcing bar being tested; this requires determination of actual tensile strength but as alluded in the comment, the Code does not state how the actual tensile strength is to be determined. This code requirement continues to remain as-is, but the staff has clarified in the RG that actual tensile strength should be determined in accordance with testing standards, definitions and methods specified in ASTM A370.

		<p>To minimize the frequency of false rejection or acceptance, a more accurate method to determine fy_actual for qualification and production samples should be permitted. Two viable options for consideration are:</p> <ol style="list-style-type: none"> <li>1. A rebar length adjacent to the section used in the qualification or production samples could be cut and tested to determine fy_actual and ft_actual. Though this method somewhat improves the accuracy of the determination of fy_actual and ft_actual, it requires a substantial additional cost associated with the sample prep and testing.</li> <li>2. Actual yield and tensile of the rebar could be determined from the same splice or head sample being tested. This method would require no additional sample preparation, materials, nor testing, but would simply require the use of a strain gauge for each test. However, most gauges will not survive through rebar rupture and, therefore, the test must be stopped and gauges removed before continuing to ultimate force.</li> </ol> <p>It is likely that the need for determining fy_actual and ft_actual for each production sample is redundant and utilizing the CMTR in most cases would be sufficient, but the option should at a minimum be permitted to more accurately determine fy_actual or ft_actual to override rejected samples due to inaccurately determined values of fy_actual and ft_actual, as cited previously</p>	
2. Louis Colarusso, LENTON	Regulatory Position C.11.a [Code Section CC- 4333.2.3(a)]	<p><b>Item 2 (Determination of “Average Tensile Strength” in qualification testing:</b> Proposed changes to CC- 4333.2.3(a)(3) in DG-1372 for qualification testing require that</p> <p><i>“The average tensile strength of the splices and mechanically headed deformed bars should not be less than 90 percent of the actual tensile strength (ft_actual) and 125% of the actual yield strength of the reinforcing bar spliced...”</i></p> <p>Additional clarification is needed with respect to which samples are used for determining the average tensile strength for qualification samples. Does the average tensile strength come from the static tension tests performed only at room temperature per the current CC-4333.2.3(a)? Or, are any cold</p>	Based on changes made to DG-1372 in response to Comment 1 above, this comment is moot because samples used and sample temperature criteria for the static tests will be the same as in code paragraph CC-4333.2.3(a) as no deviation is taken in this regard in the RG. Also, there were no deviations in this regard in DG-1372 as the regulatory positions are in addition to or supplement the requirements in the Code.

		temperature samples to be included? Per CC-4333.2.3(a) of the current code, up to 3 static cold temperature samples may be tested during qualification testing. Samples tested at lower temperatures will alter the resultant yield and tensile strengths, and thus have an impact on the averages used for pass/fail criteria.	
3. Louis Colarusso, LENTON	Regulatory Position C.11 [Code Section CC- 4333 and CC- 4334]	<b>Item 3 (Performance Requirements and Design Strength):</b> The general approach of requiring that coupler or headed bar performance be based on the actual yield and tensile strengths of rebar is arguably equivalent to creating a moving target that adds unnecessary cost and time with unsubstantial benefit, as buildings are designed to the minimum rebar strengths (fixed target) and not to actuals (moving target). If there are substantial benefits to making these changes, they should be clearly laid out for the industry, as such changes can have a significant impact on rebar splice and headed bar suppliers.	The staff agrees with the concern. Based on changes made to DG-1372 in response to Comment No.1, except as already required by the Code, the performance criteria is now based on specified minimum tensile strength, which is not a moving target.
4. Louis Colarusso, LENTON	Regulatory Position C.11 [Code Sections CC- 4333 and CC- 4334]	<b>Item 4 (A615-19 Grade 60 Changes):</b> With the 2020 overhaul of the ASTM A615-20 reinforcing steel properties, A615 now has an actual Tensile to Yield ratio of 1.10 and a reduced tensile strength of 80,000 psi. Given the timing and that these changes are significant, it is uncertain if the DG-1372 proposals considered these changes during its creation. For A615 Grade 100 and other Grade 100 reinforcing steels A706, A1035, etc. , these steel's Tensile to Yield ratio capacity is below the 1.25 ratio cited in the draft Guide, future direction will be needed on the applicability and use of Grade 100 should it be adopted.	Based on changes made to DG-1372 in response to Comment No.1, the comment is now moot because the performance criteria in the RG for mechanical and welded splices, and headed bar system is now based on specified minimum tensile strength of the reinforcing bar (equivalent to a Type 2 splice in ACI 349-13 and ACI 318-19), and no longer based on ratio of actual tensile strength to actual yield strength specified for the reinforcing steel.
5. Louis Colarusso, LENTON	Regulatory Position C.8.d and C.11 [Code Section CC- 3532, CC- 4333 and CC-4334]	<b>Item 5 (Other Splicing Methods):</b> As noted in provision 11 on page 11 of DG-1372, more robust Type 2 mechanical or welded splices and mechanical headed bar systems should be encouraged to be used whenever possible in concrete containment structures. The use of other splicing methods including Arc Welding and Lap Splicing, should be limited. Any provisions adopted for their use must not only include modifications to Arc Welded Splice provisions, but Lap Splices as well. Lap Splices provisions were developed around 1.25 Specified Yield and rely on surrounding concrete to perform; therefore, Lap Length calculations should be revised to be based on Actual	This comment is the same as Comment No. 10 below. See resolution to Comment No. 10.

		Yield strengths. Similarly changes in the hook development provisions should be based on Actual Yield strengths for consistency.	
6. Louis Colarusso, LENTON	Regulatory Position C.8.d and C.11 [Code Sections CC-4333 and CC-4334]	<b>Item 6 (Use of Post Fabricated Reinforcing Steel):</b> 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 draft Guide should provide language to assure that only non-work hardened steels should be utilized in determining the conformance to CC-3532 or CC-4333.	While the NRC staff appreciates the comment and suggestion, no change has been made to DG-1372 as a result of this comment. The comment is now moot based on changes made to the DG in response to Comment No. 1 because the regulatory position taken for the qualification of splices and headed bar systems are now based on the specified minimum tensile strength of the rebar, and not on the basis of the ratio actual tensile strength to actual yield strength. Regardless, the staff notes that any performance testing done should be based on the fabricated reinforcing bar configuration that will be installed into the structure in order to be representative of its performance in the structure in which it is installed (i.e., if post-fabricated reinforcing steel will be installed in the structure, then the testing should be done on that reinforcing steel) .
7. Daniel J. Reider, nVent LENTON	Regulatory Position C.8.d and C.11 [Code Sections CC-4333.2.3(a)(1) & CC-3532]	<p><b>Concern 1 (Determination of fy_actual and ft_actual):</b> As shown in the table above, fy_actual and ft_actual of the rebar being spliced or headed are used to determine pass or failure of a mechanical splice or head. Therefore, the determination of such values must be very accurate and the process for determining these values must be defined clearly in the code.</p> <p>DG-1372 Section CC-4333.2.3(a)(1) specifies that the actual yield and actual tensile strength for <u>qualification samples</u> is to be determined by testing an unspliced specimen of rebar taken from the same heat of rebar used for the mechanically spliced or headed rebar samples. DG-1372 Section CC-3532 defines that actual yield for <u>production sample</u> testing “may” be determined from corresponding certified material test reports (CMTR). The usage of the word “may” is ambiguous and suggests that there are other acceptable methods to determine actual yield, if so, what are they? Additionally, DG-1372 Section CC-3532 DOES NOT define how actual tensile strength is to be determined for production sample testing.</p> <p>According to internal testing at nVent, it is not uncommon for the measured actual yield and tensile strengths within a particular rebar heat to vary by as much as 5%. Determining the actual yield or tensile for qualification samples based on a single tensile test, or extracting from the CMTR in the case of production samples, will result in occasions where samples are falsely</p>	This comment is the same as Comment No. 1. See resolution to Comment No. 1.

		<p>rejected or accepted simply because the determined fy_actual is not truly representative of the actual section of rebar used in the sample.</p> <p>To minimize the frequency of false rejection or acceptance, a more accurate method to determine fy_actual for qualification and production samples should be permitted. Two viable options for consideration are:</p> <ol style="list-style-type: none"> <li>1. A rebar section adjacent to the rebar section used in the qualification or production samples could be cut and tested to determine fy_actual and ft_actual. Though this method improves the accuracy of the determination of fy_actual and ft_actual, it requires a substantial additional cost associated with the sample preparation and testing.</li> <li>2. Actual yield and tensile of the rebar could be determined from the same splice or head sample being tested. This method would require no additional sample preparation, no additional materials, no additional testing, but simply may require the use of a strain gauge for each test. However, if the fracture in the sample were to occur in the splice affected zone and does not reach the full strength of the rebar, ft_actual could not be determined, unless a rebar section from the sample is sufficiently long to reload in the tensile machine and pull until break.</li> </ol> <p>It is likely that the need for determining fy_actual and ft_actual for each production sample is redundant and utilizing the CMTR in most cases would be sufficient, but the option should at a minimum be permitted to more accurately determine fy_actual or ft_actual to override rejected samples due to inaccurately determined values of fy_actual and ft_actual.</p>	
8. Daniel J. Reider, nVent LENTON	Regulatory Position C.11.a [Code Section CC- 4333.2.3(a)]	<p><b>Concern 2 (Determination of “Average Tensile Strength” in qualification testing):</b> Proposed changes to CC-4333.2.3(a)(3) in DG-1372 for qualification testing require that...</p> <p><i>“The average tensile strength of the splices and mechanically headed deformed bars should not be less than 90 percent of the actual tensile strength (ft_actual) and 125% of the actual yield strength of the reinforcing bar spliced...”</i></p>	This comment is the same as Comment No. 2. See resolution to Comment No. 2.

		Additional clarification is needed with respect to which samples are used for determining the average tensile strength for qualification samples. Does the average tensile strength come from the static tension tests performed only at room temperature per the current CC-4333.2.3(a)? Or are any cold temperature samples to be included? Per CC-4333.2.3(a) of the current code, up to 3 static cold temperature samples may be pulled during qualification testing. Samples pulled at lower temperatures can alter the resultant yield and tensile strengths, and thus have an impact on the averages used for pass/fail criteria.	
9. Daniel J. Reider, nVent LENTON	Regulatory Position C.11 [Code Sections CC- 4333 and CC- 4334]	<b>Concern 3 (Performance Requirements and Design Strength):</b> Finally, the general approach of requiring that mechanical splice and headed bar performance be based on the actual yield and tensile strengths of rebar is arguably equivalent to creating a moving target that adds unnecessary cost and time with negligible benefit, as buildings are designed to the minimum rebar strengths (fixed target) and not to actuals. If there are substantial benefits to making these changes, they should be clearly laid out for the industry, as such changes can have a significant impact on mechanical splice and head suppliers.	This comment is the same as Comment No. 3. See resolution to Comment No. 3.
10. Daniel J. Reider, nVent LENTON	Regulatory Positions 8.d and C.11 [Code Sections CC-3532, CC- 4333 and CC- 4334]	<b>Concern 4 (Other Splicing Methods):</b> As noted in provision 11 on page 11 of DG-1372, more robust Type 2 mechanical or welded splices and mechanical headed bar systems should be encouraged to be used whenever possible in concrete containment structures. The use of other splicing methods, including arc welding and lap splicing, should be limited. Any provisions adopted for their use must not only include modifications to arc welded splice provisions, but lap splices as well. Lap splice provisions were developed around 1.25 specified yield and rely on surrounding concrete to perform; therefore, lap length calculations should be revised to be based on actual yield strengths. Similarly, changes in the hook development provisions should be revised to be based on actual yield strengths for consistency. Moreover, these revisions for lap splices and hooks should be implemented at the same time as any of the proposed changes are made to mechanical or welded splices and mechanical headed bar systems to provide consistency across all methods of splicing, hooks and headed bars.	The Staff agrees with the comment that proposed changes in the RG regarding strength criteria for mechanical or welded splices and mechanical headed bar systems should also apply to lap splices and standard hooks for consistency.  Code paragraph <b>CC-3532(b)</b> already requires that “Lap splices shall not be used for bars larger than No. 11. ...” Code paragraph <b>CC-3532(c)</b> also requires “Where a non-prestressed reinforcement [except nominal temperature reinforcement] bar splice must be located in a region where tension is predicted in a direction perpendicular to the bar to be spliced, only a positive mechanical splice or a welded butt splice shall be used, unless calculations or tests of the selected splice detail are made to demonstrate that there is an adequate transfer of force.”  In addition, Code subparagraph <b>CC-3532.1.3 states:</b> “Splices in regions of maximum tensile stress should be avoided. Where such splices must be

			<p>used, they shall be mechanically spliced in accordance with CC-4333, welded butt splice in accordance with CC-4334, or Class B lap spliced in accordance with CC-3532.1.1.”</p> <p>Based on the above cited code provisions, the Code requirements already address the comment with the exception of the second sentence in CC-3532.1.3. Therefore, to further clarify and address the comment, Regulatory provision 8.d in DG-1372 has been revised to also include the following recommendation:</p> <p>“If their use cannot be avoided, lap splices and end anchorage by standard hooks or bends of tension reinforcement (except nominal temperature reinforcement) that must be used in regions of maximum tensile stress, potential yielding regions, or in regions where tension is predicted in a direction perpendicular to the bar to be spliced or anchored should be capable of developing at least the specified minimum tensile strength of the reinforcing bar.”</p>
11. Daniel J. Reider, nVent LENTON	Regulatory Position C.8.d and C.11 [Code Section CC-3532, CC- 4333 and CC-4334]	<b>Concern 5 (Use of Post Fabricated Reinforcing Steel):</b> 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 Draft Guide should provide language to assure that only non-work hardened steels be utilized in determining the conformance to CC-3532 or CC-4333.	<p>This comment is the same as Comment No. 6. See resolution to Comment No. 6.</p>