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INDUSTRY ANNOUNCEMENT

CRSI Bulletin: Changes to ASTM A615 tensile strength requirements

With the 2020 revision to the ASTM A615 specification (A615-20), the tensile strength requirements for A615 Grades 60 and 80 have been reduced to 80,000 psi and 100,000 psi, respectively. These are the same requirements as A706, so with these changes A706 material now meets or exceeds all chemical and mechanical requirements for the respective size and grade of A615.

Historically, bars marked with a 'W' are certified to meet A706 and bars marked with an 'S' meet A615. Bars marked with a 'W' and an 'S' are considered dual grade since they meet both A706 and A615. Since A706 rebar inherently meets the requirements of A615, all 'W' bar should also be accepted as dual grade.

Future A706 and A615 specification revisions may permit bar with only a 'W' marking to be certified to meet both A706 and A615, but this change has not yet been adopted as of the publishing of this bulletin.

Some producers may continue the practice of putting both letter markings on the bar, but this will no longer be a requirement. If there are any questions regarding product, the best source for information will be the producing mill.

Table 3—Tensile Requirements, SI Units

	Type S Grade 280 [40] [a]	Type S Grade 420 [60]	Type S Grade 550 [80]
Tensile strength, min MPa [psi]	420 [60,000]	550 [80,000]	690 [100,000]
Yield strength, min, MPa [psi]	280 [40,000]	420 [60,000]	550 [80,000]
Ration of actual tensile strength to actual yield strength, min	1.10	1.10	1.10
Elongation in 200 mm, min %			
Bar Designation No.			
10 [3]	11	9	7
13, 16 [4, 5]	12	9	7
19 [6]	12	9	7
22, 25 [7, 8]	—	8	7
29, 32, 36 [9, 10, 11]	—	7	6
43, 57 [14, 18]	—	7	6

	Type W Grade 420 [60]	Type W Grade 550 [80]
Tensile strength, min MPa [psi]	550 [80,000] [b]	690 [100,000] [b]
Yield strength, min, MPa [psi]	420 [60,000]	550 [80,000]
Yield strength, max , MPa [psi]	540 [78,000]	675 [98,000]
Elongation in 200 mm, min %		
Bar Designation No.		
10 [3]	14	12
13, 16 [4, 5]	14	12
19 [6]	14	12
22, 25 [7, 8]	12	12
29, 32, 36 [9, 10, 11]	12	12
43, 57 [14, 18]	10	10

[a] Grade 280 bars are furnished only in sizes 10 through 19. [Grade 40 bars are furnished only in sizes 3 through 6.]
[b] Tensile strength shall not be less than 1.25 times the actual yield strength.

9.2. *The yield point or yield strength shall be determined by one of the following methods:*

9.2.1. The yield point shall be determined by drop of the beam or halt of the pointer method as described in Section 14.1.1 of T 244.

9.2.2. Where the steel tested does not have a well-defined yield point, the yield point shall be determined at extension under load using an autographic diagram method or an extensometer as described in Sections 14.1.2 and 14.1.3 of T 244.

The extension under load shall be 0.005 mm/mm [0.005 in./in.] of gauge length (0.5 percent) for Grade 280 [40] and Grade 420 [60] and shall be 0.0035 mm/mm [0.0035 in./in.] of gauge length (0.35 percent) for Grade 550 [80].

9.3. When material is furnished in coils, the test sample must be straightened prior to placing it in the jaws of the tensile testing machine. Straightening shall be done carefully to avoid formation of local sharp bends and to minimize cold work.

Note 3—Insufficient straightening prior to attaching the extensometer can result in lower-than-actual yield strength readings.

9.4. The percentage of elongation shall be as prescribed in Table 3 when tested in accordance with Section 14.4 of T 244.

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requirements of Article 5.7.2.5 for beams and Article 5.10.4.3 for columns shall be provided over the required splice length.

applications in Seismic Zone 1. See Article C5.4.3.3 for further information.

5.10.8.4.1—Detailing

Permissible locations, types, and dimensions of splices, including staggers, for reinforcing bars shall be shown in the contract documents.

5.10.8.4.2—General Requirements

5.10.8.4.2a—Lap Splices

This provision of this article shall apply only to the grades of reinforcement noted.

The lengths of lap for lap splices of individual bars shall be as specified in Articles 5.10.8.4.3a and 5.10.8.4.5a.

Lap splices within bundles shall be as specified in Article 5.10.8.2.3. Individual bar splices within a bundle shall not overlap. Entire bundles shall not be lap spliced.

For reinforcement in tension, lap splices shall not be used for bars larger than No. 11.

Bars spliced by noncontact lap splices in flexural members shall not be spaced farther apart transversely than the lesser of the following:

- one-fifth the required lap splice length; or
- 6.0 in.

For columns with longitudinal reinforcement that anchors into oversized shafts, where bars are spliced by noncontact lap splices, and longitudinal column and shaft reinforcement are spaced farther apart transversely than the greater of the following:

- one-fifth the required lap splice length; or
- 6.0 in.,

the spacing of the shaft transverse reinforcement in the splice zone shall meet the requirements of the following equation:

$$S_{max} = \frac{2\pi A_{sp} f_{ytr} \ell_s}{k A_\ell f_{u\ell}} \quad (5.10.8.4.2a\text{-}1)$$

where:

S_{max} = spacing of transverse shaft reinforcement (in.)

A_{sp} = area of shaft spiral or transverse reinforcement (in.^{2})

f_{ytr} = specified minimum yield strength of shaft transverse reinforcement (ksi)

ℓ_s = required tension lap splice length of the column longitudinal reinforcement (in.)

k = factor representing the ratio of column tensile reinforcement to total column reinforcement at the nominal resistance

C5.10.8.4.2a

This ratio, k, could be determined from the column moment-curvature analysis using appropriate computer programs. For simplification, k = 0.5 could safely be used in most applications.

The development length of column longitudinal reinforcement in drilled shafts is from WSDOT-TRAC Report WA-RD 417.1 titled *Noncontact Lap Splices in Bridge Column-Shaft Connections*. Eq. 5.10.8.4.2a-1 is based upon a strut-and-tie analogy of the noncontact splice with an assumed strut angle of 45 degrees.

A_ℓ = area of longitudinal column reinforcement (in.^{2})

f_{ut} = specified minimum tensile strength of column longitudinal reinforcement (ksi), 90.0 ksi for ASTM A615 and 80.0 ksi for ASTM A706

5.10.8.4.2b—Mechanical Connections

The resistance of a full-mechanical connection shall not be less than 125 percent of the specified yield strength of the bar in tension or compression, as required. The total slip of the bar within the splice sleeve of the connector after loading in tension to 30.0 ksi and relaxing to 3.0 ksi shall not exceed the following measured displacements between gauge points clear of the splice sleeve:

- For bar sizes up to No. 14 .... 0.01 in.
- For No. 18 bars .... 0.03 in.

5.10.8.4.2c—Welded Splices

Welding for welded splices shall conform to the current edition of *Structural Welding Code—Reinforcing Steel of AWS* (D1.4).

A full-welded splice shall be required to develop, in tension, at least 125 percent of the specified yield strength of the bar.

No welded splices shall be used in decks.

5.10.8.4.3—Splices of Reinforcement in Tension

The provisions herein may be used for No. 11 bars or smaller in normal weight concrete with concrete compressive strengths for use in design up to 15.0 ksi and lightweight concrete up to 10.0 ksi. Transverse reinforcement consisting of at least No. 3 bars at 12.0-in. centers shall be provided along the required splice length where the design concrete compressive strength is greater than 10.0 ksi. A minimum of three bars shall be provided.

C5.10.8.4.3

The tension development length, ℓ_d, used as a basis for calculating splice lengths should include all of the modification factors specified in Article 5.10.8.2.

The extension of this article to design concrete compressive strengths between 10.0 and 15.0 ksi is limited to No. 11 bars and smaller based on the work presented in NCHRP Report 603 (Ramirez and Russell, 2008). The requirement for minimum transverse reinforcement along the splice length is based on research by Azizinamini et al. (1999). Transverse reinforcement used to satisfy the shear requirements may simultaneously satisfy this provision.

5.10.8.4.3a—Lap Splices in Tension

The minimum length of lap for tension lap splices shall be as required for Class A or B lap splice, but not less than 12.0 in., where:

Class A splice.................................... $1.0\ell_d$

Class B splice.................................... $1.3\ell_d$

The tension development length, ℓ_d, for the specified yield strength shall be taken in accordance with Article 5.10.8.2.1a.

C5.10.8.4.3a

Research by Shahrooz et al. (2011) verified these provisions for applications in Seismic Zone I for reinforcement with specified minimum yield strengths up to 100 ksi combined with design concrete compressive strengths up to 15.0 ksi. See Article C5.4.3.3 for further information.

Tension lap splices were evaluated under NCHRP Report 603. Splices of bars in compression were not part of the experimental component of the research. Class C lap splices were eliminated based on the modifications to development length provisions.

f_{ps} = average stress in prestressing steel at the time for which the nominal resistance of member is required (ksi) (5.6.3.1)
f_{psl} = stress in the strand at the service limit state. Cracked section shall be assumed (ksi) (5.12.3.3.9c)
f_{pt} = stress in prestressing strands immediately after transfer (ksi) (5.9.3.4.2c)
f_{pu} = specified tensile strength of prestressing steel (ksi) (5.4.4.1)
f_{pul} = stress in the strand at the strength limit state (ksi) (5.12.3.3.9c)
f_{px} = design stress in pretensioned strand at nominal flexural strength at section of member under consideration (ksi) (5.9.4.3.2)
f_{py} = yield strength of prestressing steel (ksi) (5.4.4.1)
f_r = modulus of rupture of concrete (ksi) (5.4.2.6)
f_s = stress in the nonprestressed tension reinforcement at nominal flexural resistance (ksi); stress in steel (ksi) (5.6.3.1.1) (5.9.4.4.1)
f'_s = stress in the nonprestressed compression reinforcement at nominal flexural resistance (ksi) (5.6.3.1.1)
f_{ss} = calculated tensile stress in nonprestressed reinforcement at the service limit state not to exceed 0.60 f_y (ksi) (5.6.7)
f_t = direct tensile strength of concrete (ksi) (C5.4.2.7)
$f_{u\ell}$ = specified minimum tensile strength of column longitudinal reinforcement (ksi), 90 ksi for ASTM A615 and 80 ksi for ASTM A706 (5.10.8.4.2a)
f_y = specified minimum yield strength of reinforcement (ksi), note that limits on physical yield strength or on substitution limits in equations may be specified in various articles (5.5.3.2) (Appendix D5)
f_{ytr} = specified minimum yield strength of shaft transverse reinforcement (ksi) (5.10.8.4.2a)
f'_y = specified minimum yield strength of compression reinforcement (ksi) (5.6.2.1)
f_{yh} = specified minimum yield strength of spiral reinforcement (ksi); yield strength of tie or spiral reinforcement (ksi) $\leq$ 75.0 ksi (5.6.4.6) (5.11.4.1.4)
H = average annual ambient relative humidity (percent) (5.4.2.3.2)
h = overall thickness or depth of a member (in.); lateral dimension of the cross section in the direction considered (in.); overall dimension of precast member in the direction in which splitting resistance is being evaluated (in.); least thickness of component section (in.) (5.6.7) (5.8.4.5.3) (5.9.4.4.1) (5.10.6)
h_a = length of the back face of an STM node (in.) (5.8.2.2)
h_c = span of the web between the top and bottom slabs measured along the axis of the web (in.); core dimension of tied column in direction under consideration (in.) (5.9.5.4.4d) (5.11.4.1.4)
h_{ds} = height of the duct stack (in.) (5.9.5.4.4c)
h_f = compression flange depth (in.); compression flange depth of an I- or T-member (in.) (5.6.3.1.1) (5.6.3.2.2)
h_{STM} = node-to-node depth of STM (C5.8.2.2)
h_1 = largest lateral dimension of member (in.) (C5.9.5.6.5b)
h_2 = least lateral dimension of member (in.) (C5.9.5.6.5b)
I_c = moment of inertia of section calculated using the gross composite concrete section properties of the girder and the deck and the deck-to-girder modular ratio at service (in.^{4}) (5.9.3.4.3a)
I_{cr} = moment of inertia of the cracked section, transformed to concrete (in.^{4}) (5.6.3.5.2)
IE = for segmental construction: dynamic load from equipment (kip) (5.12.5.3.2)
I_e = effective moment of inertia (in.^{4}) (5.6.3.5.2)
I_g = moment of inertia of the gross concrete section about the centroidal axis, neglecting the reinforcement (in.^{4}) (5.6.3.5.2)
I_s = moment of inertia of the longitudinal reinforcement about the centroidal axis (in.^{4}) (5.6.4.3)
K = effective length factor for compression members; wobble friction coefficient (per ft of tendon) (5.6.4.1) (5.9.3.2.2b)
K_{df} = transformed section coefficient that accounts for time-dependent interaction between concrete and bonded steel in the section being considered for time period between deck placement and final time (5.9.3.4.3a)
K_{id} = transformed section coefficient that accounts for time-dependent interaction between concrete and bonded steel in the section being considered for time period between transfer and deck placement (5.9.3.4.2a)
K_L = factor accounting for type of steel taken as 30 for low relaxation strands and 7 for other prestressing steel, unless more accurate manufacturer's data are available (5.9.3.4.2c)
K'_L = factor accounting for type of steel equal to 45 for low relaxation steel (C5.9.3.4.2c)
K_1 = correction factor for source of aggregate taken as 1.0 unless determined by physical test, and as approved by the Owner; fraction of concrete strength available to resist interface shear (5.4.2.4) (5.7.4.3)