ENGINEERING
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Technical Note

Guide to the Use of Grade 100 Reinforcing Bars in ACI 318-19

Introduction

Grade 60 reinforcing steel, with a yield strength of 60,000 psi, is the most commonly used grade in North America. Recent advances, including substantial new research, have enabled reinforcing steels of higher strengths to be a viable option in a variety of applications in reinforced concrete structures.

Permissible applications of high-strength steel reinforcement (that is, reinforcement with a yield strength of 80,000 or 100,000 psi) were significantly expanded in the 2019 edition of *Building Code Requirements for Structural Concrete and Commentary* (ACI 2019). The purpose of this Technical Note is to summarize the requirements in ACI 318-19 related to Grade 100 reinforcing bars. Industry professionals should find the information useful when designing, detailing, and specifying Grade 100 reinforcing bars in building projects. Benefits related to the use of Grade 100 reinforcing bars are also included.

Information on the design and detailing of cast-in-place reinforced concrete buildings with high-strength steel reinforcement, including worked-out design examples, can be found in *Design Guide on the ACI 318 Building Code Requirements for Structural Concrete – ACI 318-19* (CRSI 2020).

Types of Nonprestressed Grade 100 Reinforcing Bars

Grade 100 deformed reinforcing bars must conform to the following specifications (ACI 20.2.1.3):[1]

- ASTM A615 (ASTM 2018a) – carbon steel, including the requirements in ACI Table 20.2.1.3(a)
- ASTM A706 (ASTM 2016a) – low-alloy steel, including the requirements in ACI 20.2.1.3(b)
- ASTM A1035 (ASTM 2016c) – low-carbon chromium steel

Similarly, Grade 100 plain reinforcing bars for spiral reinforcement must conform to the following specifications (ACI 20.2.1.4):

- ASTM A615 (ASTM 2018a)
- ASTM A706 (ASTM 2016a)
- ASTM A1035 (ASTM 2016c)

Bar sizes larger than #18 are given in current editions of ASTM A615 and ASTM A1035. Due to the lack of information on their performance (including bar bends and the determination of development lengths), bar sizes larger than #18 are not permitted by ACI 318-19 (ACI R20.2.1.3).

New property requirements are given in ACI Table 20.2.1.3(a) for ASTM A615 Grade 100 deformed reinforcing bars and in ACI Tables 20.2.1.3(b) and (c) for ASTM A706 Grade 100 deformed reinforcing bars (see Tables 1 and 2, respectively). These requirements are not included in the 2018 edition of ASTM A615 and the 2016 edition of ASTM A706, which are the referenced specifications in ACI 318-19 (see ACI 3.2.4).[2] The reasons for these requirements are as follows:

- To provide for harmonization of minimum tensile strength requirements between ASTM A615 and ASTM A706;
- To add new ductility requirements to both ASTM A615 and ASTM A706; and
- To introduce Grade 100 reinforcement for ASTM A706.

Bend test requirements for ASTM A706 Grade 100 reinforcement must meet the same bend test requirements for ASTM A706 Grade 80 reinforcement, which are given in the latest version of that specification (ASTM 2016a) [ACI 20.2.1.3(b)(i)]. [Note: Due to potential safety concerns

[1] *Disclaimer: This CRSI document contains requirements that can, at the time of the document's adoption by CRSI, be satisfied only by use of a patented material, product, process, procedure, or technology. During the document preparation, the Engineering Practice Committee (EPC) was informed in writing that the document under consideration involves the potential use of patented technology. The specific patented product being referenced include the following: reinforcing steel bar produced to ASTM A1035/A1035M and certain stainless steel alloys listed in Table 1 of ASTM A276.*
[2] *It is anticipated that the requirements in ACI 20.2.1.3 will appear in the 2020 editions of ASTM A615 and ASTM A706.*

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Table 1 – Modified Tensile Strength and Additional Tensile Property Requirements for ASTM A615 Grade 100 Reinforcement

Minimum tensile strength (psi)	115,000
Minimum ratio of actual tensile strength to actual yield strength[3]	1.10

Table 2 – Tensile Property Requirements and Elongation Requirements for ASTM A706 Grade 100 Reinforcement

Minimum tensile strength (psi)	117,000
Minimum ratio of actual tensile strength to actual yield strength	1.17
Minimum yield strength (psi)	100,000
Maximum yield strength (psi)	118,000
Minimum fracture elongation[4] in an 8-in. gauge (%)	10
Minimum uniform elongation[5] for all bar sizes (%)	6

with shop fabrication, CRSI does not recommend bending reinforcing bars larger than #14 with a grade designation of Grade 75 or higher.]

The following new requirement was introduced for all grades of ASTM A706 deformed reinforcing bars [ACI 20.2.1.3(b)(iii)]: The radius on newly-machined rolls used to manufacture reinforcing bars must be at least 1.5 times the height of the deformation, h (see Figure 1). This requirement applies to all deformations, including transverse lugs, longitudinal ribs, grade ribs, grade marks, and intersections between deformations. Conformation is assessed by measurements taken on newly-machined rolls used to manufacture reinforcing bars, instead of measurements taken on bar samples.

The ratio (r/h) affects the magnitude of the strain localization occurring at the juncture between the deformation and the barrel of the bar. Increased strain localization has a negative effect on inelastic fatigue and tensile fracture (ductility) performance. The reason for this limitation is to ensure that inelastic fatigue cracks do not develop at the root of the deformation (which is a critical issue in seismic design).

When specifying ASTM A615 and ASTM A706 Grade 100 reinforcing bars for a project, it is important to include these new property requirements in the project specifications along with the corresponding ASTM requirements.

Applications Where Grade 100 Reinforcing Bars are Permitted

Types of deformed reinforcing bars permitted for particular structural applications are given in ACI Table

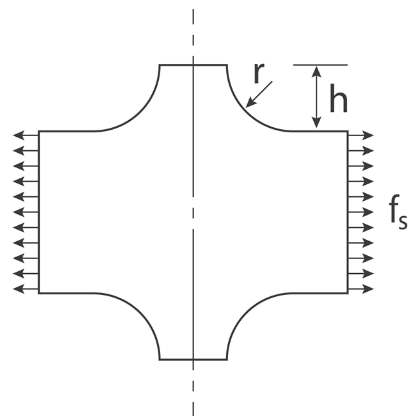


Figure 1 Radius and height of deformation on a deformed reinforcing bar.

20.2.2.4(a). Grade 100 reinforcement is now permitted to resist the following:

- Flexure and axial forces due to gravity and wind loads (previously, the maximum permitted value of the yield strength in such applications was 80,000 psi).
- Flexure, axial forces, and shear forces due to gravity and earthquake loads in special structural walls, which are required in buildings assigned to Seismic Design Category (SDC) D, E, and F (previously, the maximum permitted yield strength was 60,000 psi).[6]

Permitted usages and applications of Grade 100 reinforcement are given in Table 3 *(note: maximum values of f_y and f_{yt} are given in Table 3 in accordance with ACI Table 20.2.2.4(a); therefore, ASTM A996 and ASTM A955 are included in the table even though these two*

[3] *The yield strength of high-strength nonprestressed reinforcing bars without sharp-kneed or well-defined yield points is determined by the offset method (ASTM 2018c) [ACI 20.2.1.2].*

[4] *The fracture elongation is determined as follows: A reinforcing bar is marked with an initial 8-in. gauge length and is pulled to fracture. The ends of the fractured reinforcing bar are fit together and the distance between the gauge marks is remeasured. The fracture elongation is calculated as follows: [(Distance between gauge marks after fracture) – (Original gauge length)]/Original gauge length.*

[5] *Uniform elongation is the strain occurring at the tensile strength and is determined in accordance with ASTM E8 (ASTM 2016d).*

[6] *Design and detailing requirements for special structural walls are given in ACI 18.10; these requirements have also undergone significant revisions in ACI 318-19 (see CRSI 2020).*

Table 3 Usages and Applications of Grade 100 Deformed Reinforcement in ACI 318-19

Usage	Application	Maximum Value of f_y or f_{yt} Permitted for Design Calculations (psi)[(1)]	Deformed Bars
• Flexure • Axial force • Shrinkage and temperature	Special structural walls[(2)]	100,000 (60,000)	A706[(3)]
	Other[(4)]	100,000 (80,000)	A615, A706, A955, A996, A1035
• Lateral support of longitudinal bars • Concrete confinement	Special seismic systems[(5)]	100,000	A615, A706, A955, A996, A1035
	Spirals	100,000	A615, A706, A955, A996, A1035
Shear	Special structural walls[(6)]	100,000 (60,000)	A615, A706, A955, A996

(1) Number in parentheses indicate the permitted values of f_y and f_{yt} in ACI 318-14.
(2) Applicable to all components of special structural walls, including coupling beams and wall piers.
(3) ASTM A615 Grade 60 is permitted to be used instead if the requirements of ACI 20.2.2.5(b) are satisfied.
(4) Members of special moment frames are not included in this category. Also, Grade 100 longitudinal reinforcement is not permitted for intermediate moment frames and ordinary moment frames resisting earthquake demands, E.
(5) Special seismic systems include special moment frames and special structural walls.
(6) Shear reinforcement in this application includes all transverse reinforcement in special structural walls, coupling beams, and wall piers. Diagonal bars in coupling beams must comply with ASTM A706 or Footnote (3) in this table.

types of deformed bars are not available with a yield strength of 100,00 psi). The numbers in parentheses below the tabulated values of f_y and f_{yt} are the maximum permitted yield strengths in ACI 318-14. Permitted values of f_y and f_{yt} for lateral support of longitudinal bars and concrete confinement are the same as those in ACI 318-14.

According to Footnote [2] in ACI Table 20.2.2.4(a), ASTM A615 Grade 60 reinforcement is permitted to be used in lieu of ASTM A706 Grade 100 reinforcement in special structural walls provided the requirements in ACI 20.2.2.5(b) are satisfied (the requirements in ACI 20.2.2.5(b) have been revised in ACI 318-19). ASTM A615 Grade 100 (and ASTM A615 Grade 80) reinforcement is not permitted in special seismic systems [that is, in special moment frames[7] and special structural walls; see ACI 20.2.2.5(b)].

In ACI 318-19, Grade 100 plain spiral reinforcement (ASTM A615, ASTM A706, and ASTM A1035) is permitted to be used as lateral support of longitudinal bars or as concrete confinement for members in special seismic systems and in all other systems [ACI Table 20.2.2.4(b)]. These requirements are the same as those in ACI 318-14.

Development and Splice Lengths

Development of Deformed Bars in Tension

Revised equations for the development length, ℓ_d, of deformed bars in tension in accordance with ACI 25.4.2.3 are given in Table 4. ACI Eq. (25.4.2.4a) in ACI 25.4.2.4 has also been revised:

$$\ell_d = \left[\frac{3}{40}\frac{f_y}{\lambda\sqrt{f_c'}}\frac{\psi_t\psi_e\psi_s\psi_g}{\left(\dfrac{c_b + K_{tr}}{d_b}\right)}\right]d_b$$

The modification factors in these equations are given in ACI Table 25.4.2.5.

The reinforcement grade factor, ψ_g, was introduced into ACI 318-19 to account for the effect of reinforcement yield strength on the required tension development length of deformed bars. According to recent research studies, the required tension development length increases disproportionately with increases in yield strength. Values of ψ_g for Grades 40, 60, 80, and 100 reinforcement are given in Table 5 (ACI Table 25.4.2.5).

As in previous editions of ACI 318, ℓ_d must be greater than the calculated value and 12 in. (ACI 25.4.2.1).

The new requirement in ACI 25.4.2.2 must be satisfied regardless of the method used to determine ℓ_d: For longitudinal bars with $f_y \geq 80{,}000 \text{ psi}$ and a center-to-center spacing less than 6 in., transverse reinforcement must be provided such that the transverse reinforcement index $K_{tr} = 40A_{tr} / sn \geq 0.5d_b$ [see ACI Eq. (25.4.2.4b)]. The term A_{tr} is the total cross-sectional area of transverse reinforcement within the spacing

[7] *Design and detailing requirements for special moment frames are given in ACI 18.6 through 18.8; these requirements have undergone significant revisions in ACI 318-19 (see CRSI 2020).*

Table 4 Tension Development Lengths for Deformed Reinforcing Bars in Accordance with ACI 25.4.2.3

Spacing and Cover	#6 and Smaller Bars	#7 and Larger Bars
• Clear spacing of bars being developed or lap spliced $\geq d_b$ • Clear cover $\geq d_b$ • Stirrups or ties throughout ℓ_d greater than or equal to ACI 318 minimum *or* • Clear spacing of bars being developed or lap spliced $\geq 2d_b$ • Clear cover $\geq d_b$	$\left(\frac{f_y\psi_t\psi_e\psi_g}{25\lambda\sqrt{f_c'}}\right)d_b$	$\left(\frac{f_y\psi_t\psi_e\psi_g}{20\lambda\sqrt{f_c'}}\right)d_b$
Other cases	$\left(\frac{3f_y\psi_t\psi_e\psi_g}{50\lambda\sqrt{f_c'}}\right)d_b$	$\left(\frac{3f_y\psi_t\psi_e\psi_g}{40\lambda\sqrt{f_c'}}\right)d_b$

Table 5 Reinforcement Grade Factor, ψ_g

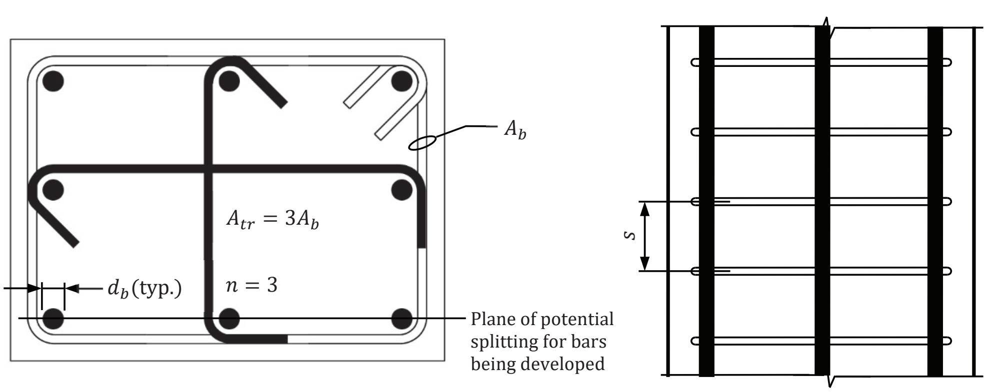
Grade	ψ_g
40 or 60	1.0
80	1.15
100	1.3

s crossing the potential plane of splitting through the reinforcement being developed and n is the number of reinforcing bars developed or lap spliced along the plane of splitting (see Figure 2 for the case of a rectangular column). Thus, for a given area of transverse reinforcement, the maximum permitted spacing is $s \leq 80A_{tr} / nd_b$. The purpose of this requirement is to ensure that closely-spaced Grade 80 and Grade 100 reinforcing bars are adequately confined so that splitting failures do not occur due to relatively large axial forces in the bars.

Development of Standard Hooks in Tension

The equation to determine the development length, ℓ_{dh}, for deformed bars in tension terminating in a standard hook has been revised based on recent test results, and accounts for the effects of bar yield strength, spacing, and confinement by ties or stirrups (ACI 25.4.3.1):

$$\ell_{dh} = \left(\frac{f_y\psi_e\psi_r\psi_o\psi_c}{55\lambda\sqrt{f_c'}}\right)d_b^{1.5}$$



For Grade 100 longitudinal bars:

$$K_{tr} = \frac{40A_{tr}}{sn} = \frac{40(3A_b)}{3s} = \frac{40A_b}{s} \geq 0.5d_b$$

$$\text{With } A_{tr} \text{ given: } s \leq \frac{40A_{tr}}{n(0.5d_b)} = \frac{80A_b}{d_b}$$

Figure 2 Transverse reinforcement index, K_{tr}.

This equation is applicable to any f_y and the modification factors are given in revised ACI Table 25.4.3.2. As in previous editions of ACI 318, ℓ_{dh} must be the greater of that calculated by the above equation, $8d_b$, and 6 in. (ACI 25.4.3.1).

Development of Headed Deformed Bars in Tension

Like hooked bars, the equation to determine the development length, ℓ_{dt}, for headed deformed bars conforming to ACI 25.4.4.1 in tension has been revised based on recent test results (ACI 25.4.4.2):

$$\ell_{dt} = \left(\frac{f_y \psi_e \psi_p \psi_o \psi_c}{75\sqrt{f'_c}} \right) d_b^{1.5}$$

This equation is applicable to any f_y (prior to ACI 318-19, there was an upper limit of 60,000 psi on f_y). The modification factors are given in revised ACI Table 25.4.4.3. Also, ℓ_{dt} must be the greater of that calculated by the above equation, $8d_b$, and 6 in. (ACI 25.4.4.2).

Lap Splice Lengths

The new requirement in ACI 25.5.1.5 pertaining to confinement of lap splices is the same requirement in ACI 25.4.2.2 for confinement of deformed bars in tension: For lap-spliced bars with $f_y \geq 80{,}000 \text{ psi}$ and a center-to-center spacing less than 6 in., transverse reinforcement must be provided along the entire lap splice length such that $K_{tr} \geq 0.5d_b$. A minimum amount of transverse reinforcement is required to confine Grade 80 and Grade 100 bars to prevent splitting failures due to relatively large axial forces in the bars.

Requirements for compression lap splice lengths have been modified to account for higher strength reinforcement. For Grade 100 reinforcement, the compression lap splice length, ℓ_{sc}, is equal to the following (ACI 25.5.5.1):

$$\ell_{sc} = \text{longer of} \begin{cases} (0.0009f_y - 24)d_b \\ \\ \ell_{st} \end{cases}$$

where ℓ_{st} is the tension lap splice length calculated in accordance with ACI 25.5.2.1 (which has not been revised). Tests have shown that splice strengths in compression depend mostly on end bearing and do not increase proportionally in strength when the lap splice length is doubled.

Structural Members

Two-way Slabs Designed in Accordance with ACI Chapter 8

Where deflections are calculated in two-way slab systems without interior beams and with Grade 100 flexural reinforcement, the calculated deflection limits in ACI 8.3.2 must be satisfied using a modulus of rupture, f_r, equal to $5\sqrt{f'_c}$ instead of $7.5\lambda\sqrt{f'_c}$ (ACI 8.3.1.1; see also ACI 19.2.3.1). Slabs with Grade 100 longitudinal reinforcement may experience larger long-term deflections than those with Grade 60 longitudinal reinforcement unless services stresses calculated for cracked sections are smaller than 40,000 psi.

Beams Designed in Accordance with ACI Chapter 9

The equations in ACI 9.6.1.2 to determine minimum area of flexural reinforcement, $A_{s,min}$, in nonprestressed beams are the same as in previous editions of ACI 318, except an upper limit of 80,000 psi on f_y is imposed in ACI 318-19. Thus, where Grade 100 longitudinal reinforcement is used in beams, $A_{s,min}$ must be determined using $f_y = 80{,}000 \text{ psi}$.

The new confinement requirements in ACI 9.7.1.4 for development lengths and lap splice lengths of Grade 80 and Grade 100 longitudinal bars in beams are basically the same as those in ACI 25.4.2.2 and ACI 25.5.1.5 discussed previously; the only difference is the center-to-center spacing limitation in those sections is not specified in ACI 9.7.1.4. Therefore, transverse reinforcement in beams must be provided such that $K_{tr} \geq 0.5d_b$ for Grade 80 and Grade 100 longitudinal bars regardless of the bar spacing.

Columns Designed in Accordance with ACI Chapter 10

The new confinement requirements in ACI 10.7.1.3 for development lengths and lap splice lengths of Grade 80 and Grade 100 longitudinal bars in columns designed in accordance with ACI Chapter 10 are the same as those for beams designed in accordance with ACI Chapter 9: Transverse reinforcement must be provided along development and lap splice lengths such that $K_{tr} \geq 0.5d_b$.

For columns with Grade 100 longitudinal reinforcement subjected to axial compression, f_y must be set equal to 80,000 psi when calculating the maximum axial strength, $P_{n,max}$, determined by ACI Table 22.4.2.1 (ACI 22.4.2.1). This limit on f_y is imposed because the compression capacity of unconfined concrete, which is assumed to occur at a strain limit of 0.003, is likely to be reached before the stress in the longitudinal bars reaches 80,000 psi. This 80,000-psi limit is not applicable when determining the strength of columns with Grade 100 longitudinal bars subjected to axial force and bending moment.

The nominal and design strength interaction diagrams for an 18-in. square, tied column with 4-#9 longitudinal bars (Grade 100) and $f'_c = 4{,}000 \text{ psi}$ are given in Figure 3. Point A on the nominal strength interaction diagram represents the nominal axial force P_o determined by ACI Eq. (22.4.2.2) corresponding to the 80,000-psi limit for pure axial compression. A horizontal lines connects that point to the point where $M_n = 0$. For comparison purposes, the interaction diagrams for the column with Grade 60 reinforcement are also given in the figure.

Special Moment Frames

Grade 100 reinforcement is not permitted to resist flexure and axial forces in special moment frames, which are required in buildings assigned to SDC D, E, or F [ACI Table 20.2.2.4(a)]. The main reason for this is test data are not available for special moment frames with Grade 100 reinforcement.

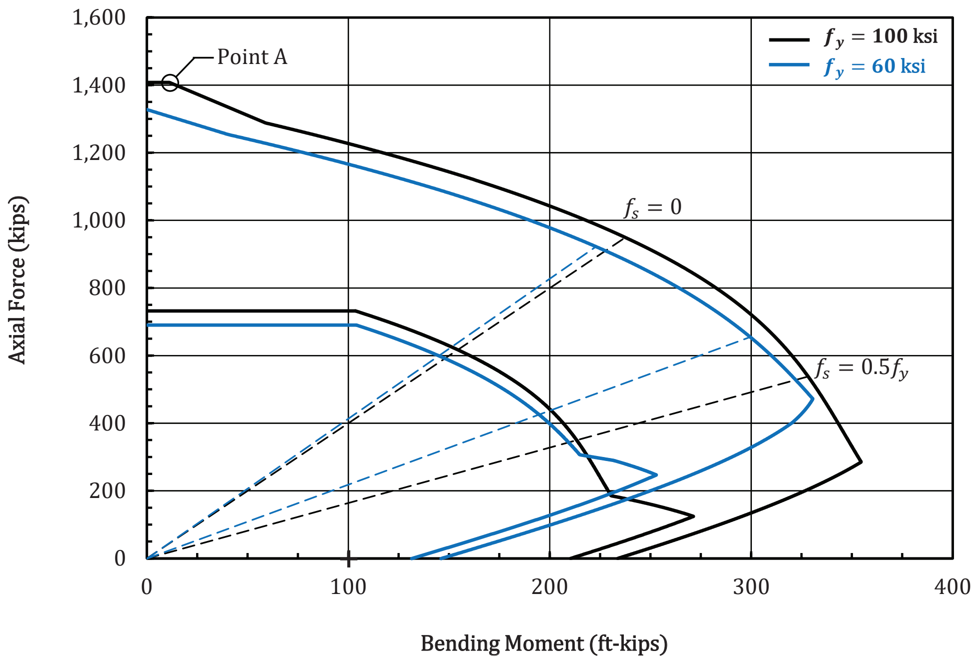


Figure 3 Design and nominal strength interaction diagrams for an 18-in. square column with Grade 100 longitudinal reinforcement.

The tension development length requirements in ACI 18.8.5.2 for headed bars in joints of special moment frames, which are applicable to any f_y, are not correct because the development lengths calculated in accordance with that section are greater than the development lengths for hooked bars calculated in accordance with ACI 18.8.5.1. At the time of this published Technical Note, ACI Committee 318 is working to correct this issue.

Special Structural Walls

New maximum vertical spacing limits of transverse reinforcement at the boundaries of special structural walls, which are required in building frame systems and dual systems in buildings assigned to SDC D, E, or F, are given in ACI 18.10.6.5 (ACI 18.10.6.1). These spacing limits are intended to prevent bar buckling at the ends of a wall. For a given longitudinal bar size, the maximum spacing of the transverse reinforcement in a wall with Grade 100 longitudinal reinforcement is smaller than that in a wall with Grade 60 reinforcement; the purpose of the smaller spacing is to attain performance capability similar to that of walls with Grade 60 longitudinal reinforcement.

The following vertical spacing limits are given in ACI Table 18.10.6.5(b) for special structural walls with Grade 100 longitudinal reinforcement:

- Within the greater of ℓ_w and $M_u / 4V_u$ above and below critical sections[8], maximum spacing is equal to the lesser of $4d_b$ and 6 in.
- At other locations, maximum spacing is equal to the lesser of $6d_b$ and 6 in.

The term ℓ_w is the length of the wall, M_u and V_u are the factored bending moment and shear force, respectively, at the critical section, and d_b is the diameter of the smallest longitudinal bar in the wall.

Significant revisions other than the one noted above related to Grade 100 reinforcement were made to the design and detailing requirements for special structural walls in ACI 18.10 (see CRSI 2020).

Diaphragms in Buildings Assigned to SDC D, E, or F

A new requirement is given in ACI 18.12.7.4 pertaining to mechanical splices used to transfer forces between a diaphragm and the vertical elements of the seismic-force-resisting system (SFRS): Grade 80 and Grade 100 reinforcing bars are not permitted to be mechanically spliced for this application.

Limits on Concrete Compressive Strength

Limits on f'_c are given in revised ACI Table 19.2.1.1, which are applicable to both normalweight and lightweight concrete. For special structural walls with Grade 100 longitudinal reinforcement, minimum f'_c is equal to 5,000 psi because test data are not available for special structural walls with Grade 100 reinforcement and concrete compressive strengths less than 5,000 psi.

[8] *Critical sections are defined as locations where yielding of longitudinal reinforcement is likely to occur as a result of lateral displacements.*

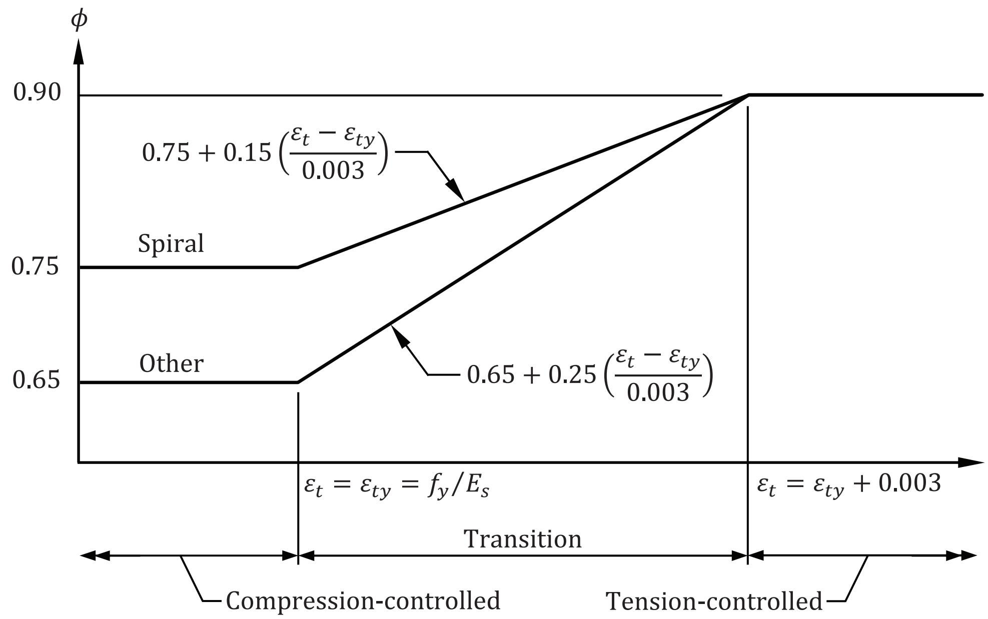


Figure 4 Variation of strength reduction factor, ϕ, with net tensile strain, ε_t.

Strength Reduction Factors

A new tension-controlled limit is defined in ACI 21.2.2, which accounts for high-strength reinforcement: Reinforced concrete sections are defined as tension-controlled where the net tensile strain in the extreme layer of longitudinal tension reinforcement at nominal strength, ε_t, is greater than or equal to $\varepsilon_{ty} + 0.003$. The term ε_{ty} is the net tensile strain in the extreme layer of longitudinal tension reinforcement used to define a compression-controlled section and is equal to f_y / E_s where E_s is the modulus of elasticity of the reinforcing steel, which is equal to 29,000,000 psi for all grades of reinforcement (ACI 20.2.2.2). The maximum strain at the extreme concrete compression fiber is taken as 0.003 (ACI 22.2.2.1).

For sections with Grade 100 reinforcement, the tension-controlled limit is equal to the following:

$$\varepsilon_t = (100{,}000 / 29{,}000{,}000) + 0.003$$
$$= 0.0034 + 0.003 = 0.0064$$

The variation of the strength reduction factor, ϕ, based on revised ACI Table 21.2.2, is given in Figure 4.

Benefits of Grade 100 Reinforcement

Utilizing Grade 100 reinforcement in concrete members may result in the following:

- Less congestion, especially at joints, because smaller bar sizes and/or a fewer number of Grade 100 bars may be needed compared to members reinforced with Grade 60 bars
- Improved concrete placement and consolidation because of less congestion
- Lower placement costs because of the fewer number of bars to be placed in the field
- Smaller member sizes
- More usable space because of smaller member sizes

The information in Figure 5 gives some insight into how smaller member sizes can be obtained with Grade 100 reinforcement. The curves in this figure give required gross areas, A_g, for uniaxially loaded reinforced concrete columns based on concrete compressive strength, area of longitudinal reinforcement, A_{st}, and grade of reinforcement. As expected, for a given percentage of longitudinal reinforcement (A_{st} / A_g), the required A_g for a column with Grade 100 longitudinal bars is less than the required A_g for a column with Grade 60 longitudinal bars. Combining Grade 100 reinforcement and high-strength concrete has the greatest impact on decreasing the required column area, which, in turn, increases the area of usable space.

Considering the aforementioned benefits and other factors, it is expected that Grade 100 reinforcement will be utilized as follows in buildings:

- As longitudinal reinforcement in columns designed in accordance with ACI Chapter 10, especially in the lower stories of high-rise buildings in combination with high-strength concrete

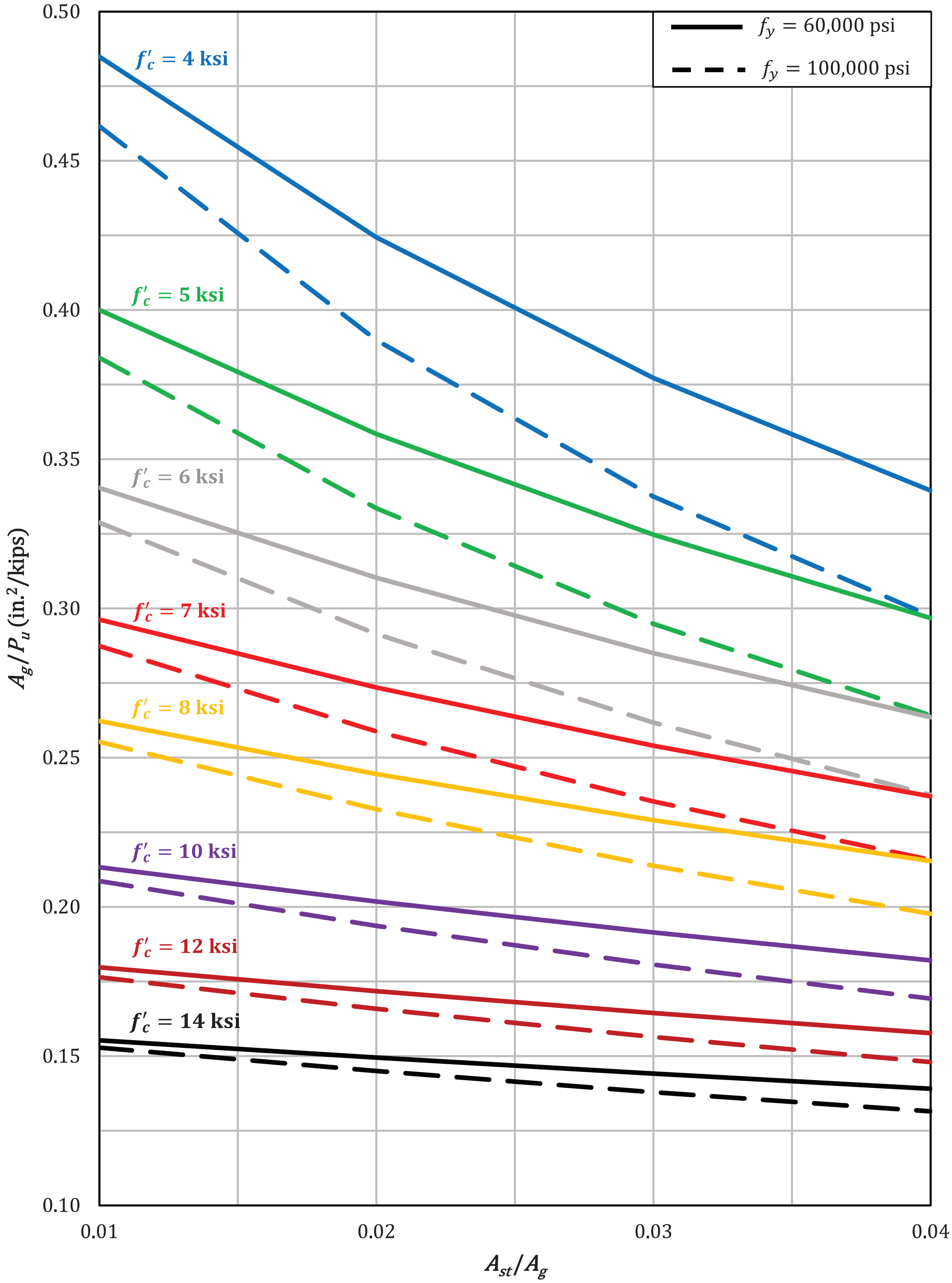


Figure 5 Required column area, A_g, for reinforced concrete columns with Grade 60 and Grade 100 longitudinal reinforcement as a function of concrete compressive strength, f'_c.

- As longitudinal wall reinforcement in buildings assigned to SDC A, B, or C
- As flexural reinforcement in mat foundations supporting buildings assigned to SDC D, E, or F
- As longitudinal and transverse reinforcement in special structural walls
- As diagonal, longitudinal, and transverse reinforcement in coupling beams that are part of special structural walls
- As longitudinal reinforcement in collector elements in buildings assigned to SDC D, E, or F

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