Changes to Mechanical Coupler Provisions In ACI 318-19

V3 6/11/20

TECH NOTE

Introduction:

This document has been prepared to provide a summary of changes made to the mechanical splice (coupler) provisions in the latest ACI 318-19 Code.

Background:

Under certain conditions in cast-in-place construction, lap splicing of reinforcing bars can cause congestion at the splice locations, and can make their use impractical. In precast concrete construction, lack of space between the ends of structural members may preclude the use of lap splices as well. In both scenarios, mechanical splices are a commonly used alternative.

To avoid congestion of the reinforcing bars in columns, the ACI Code limits the amount of reinforcement to a maximum of 8%. When this maximum % is exceeded based on the combination of quantity of bars, bar size and column dimensions, mechanical splices are used.

#14 and #18 bars must be mechanically-spliced; lap splices of these bars are not permitted except for compression only lap splices to #11 bars and smaller (for example, with footing dowels).

Code Overview:

There are 2 separate, but related sections of the Code containing provisions for mechanical splices (couplers). When referencing 318-14 and/or 318-19, section 25.5.7 establishes the minimum requirements for mechanical splices and the section 18.2.7 establishes additional requirements for mechanical splices in special moment frames and special structural walls.

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Section 25.5.7

ACI 318-14:

25.5.7 *Mechanical and welded splices of deformed bars in tension or compression*	**R25.5.7** *Mechanical and welded splices of deformed bars in tension or compression*—The 2014 Code eliminated mechanical and welded splices with strengths less than $\mathbf{1.25}f_y$. With the elimination of these mechanical and welded splices, the term "full" was deleted in reference to mechanical and welded splices that develop at least $\mathbf{1.25}f_y$.
25.5.7.1 A mechanical or welded splice shall develop in tension or compression, as required, at least $\mathbf{1.25}f_y$ of the bar.	**R25.5.7.1** The maximum reinforcement stress used in design under the Code is the specified yield strength. To ensure sufficient strength in splices so that yielding can be achieved in a member and thus brittle failure avoided, the 25 percent increase above the specified yield strength was selected as both an adequate minimum for safety and a practicable maximum for economy.

ACI 318-19:

25.5.7.1 A mechanical or welded splice shall develop in tension or compression, as required, at least $\mathbf{1.25}f_y$ of the bar.	**R25.5.7.1** To ensure sufficient strength in splices so that yielding can be achieved in a member and thus brittle failure avoided, the 25 percent increase above the specified yield strength was selected as both an adequate minimum for safety and a practicable maximum for economy. A welded splice is primarily intended for large bars (No. 6 and larger) in main members. The tensile strength require-

Key Points:

- **The minimum requirements defined in section 25.5.7 remain unchanged.**
- **The 2014 Code eliminated mechanical (and welded) splices with strengths less than $1.25f_y$**

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Section 18.2.7

ACI 318-14:

18.2.7 *Mechanical splices in special moment frames and special structural walls*	**R18.2.7** *Mechanical splices in special moment frames and special structural walls*—In a structure undergoing inelastic deformations during an earthquake, the tensile stresses in reinforcement may approach the tensile strength of the reinforcement. The requirements for Type 2 mechanical splices are intended to avoid a splice failure when the reinforcement is subjected to expected stress levels in yielding regions. Type 1 mechanical splices are not required to satisfy the more stringent requirements for Type 2 mechanical splices, and may not be capable of resisting the stress levels expected in yielding regions. The locations of Type 1 mechanical splices are restricted because tensile stresses in reinforcement in yielding regions can exceed the strength requirements of 25.5.7. The restriction on Type 1 mechanical splices applies to all reinforcement resisting earthquake effects, including transverse reinforcement. Recommended detailing practice would preclude the use of splices in regions of potential yielding in members resisting earthquake effects. If use of mechanical splices in regions of potential yielding cannot be avoided, there should be documentation on the actual strength characteristics of the bars to be spliced, on the force-deformation characteristics of the spliced bar, and on the ability of the Type 2 mechanical splice to be used to meet the specified performance requirements. Although mechanical splices as defined by 18.2.7 need not be staggered, staggering is encouraged and may be necessary for constructibility or provide enough space around the splice for installation or to meet the clear spacing requirements.
18.2.7.1 Mechanical splices shall be classified as (a) or (b): (a) Type 1 – Mechanical splice conforming to 25.5.7 (b) Type 2 – Mechanical splice conforming to 25.5.7 and capable of developing the specified tensile strength of the spliced bars	**R18.2.7.1** The additional requirement for a Type 2 mechanical splice is intended to result in a mechanical splice capable of sustaining inelastic strains through multiple cycles.

While the minimum requirements defined in section 25.5.7 remain unchanged, the current consensus Code 318-19 contains fairly substantial changes to the provisions in section 18.2.7 for seismic applications.

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ACI 318-19:

18.2.7 *Mechanical splices in special moment frames and special structural walls*	**R18.2.7** *Mechanical splices in special moment frames and special structural walls*
	In a structure undergoing inelastic deformations during an earthquake, the tensile stresses in reinforcement may approach the tensile strength of the reinforcement. The requirements for Type 2 mechanical splices are intended to avoid a splice failure when the reinforcement is subjected to expected stress levels in yielding regions. Type 1 mechanical splices on any grade of reinforcement and Type 2 mechanical splices on Grade 80 and Grade 100 reinforcement may not be capable of resisting the stress levels expected in yielding regions. The locations of these mechanical splices are restricted because tensile stresses in reinforcement in yielding regions can exceed the strength requirements of 18.2.7.1. The restriction on all Type 1 mechanical splices and on Type 2 mechanical splices on Grade 80 and Grade 100 reinforcement applies to all reinforcement resisting earthquake effects, including transverse reinforcement. Recommended detailing practice would preclude the use of splices in regions of potential yielding in members resisting earthquake effects. If use of mechanical splices in regions of potential yielding cannot be avoided, there should be documentation on the actual strength characteristics of the bars to be spliced, on the force-deformation characteristics of the spliced bar, and on the ability of the mechanical splice to be used to meet the specified performance requirements. Although mechanical splices as defined by 18.2.7 need not be staggered, staggering is encouraged and may be necessary for constructibility or provide enough space around the splice for installation or to meet the clear spacing requirements.

Summary of changes:

- **Type 2 mechanical splices with Grade 80 and Grade 100 reinforcement now have the same location restrictions as Type 1 mechanical splices (with any grade of reinforcement). These location restrictions prevent the use of these coupler type/rebar grade combinations in potential high-strain locations because they can easily result in insufficient or inconsistent ductility.**

- **The restriction on all Type 1 mechanical splices and on Type 2 mechanical splices with Grade 80 and 100 applies to ALL reinforcement resisting earthquake effects.**

Key Point from R18.2.7:

- "If use of mechanical splices in regions of potential yielding cannot be avoided, there should be documentation on the actual strength characteristics of the bars to be spliced, on the force-deformation characteristics of the spliced bar, and on the ability of the mechanical splice to be used to meet the specified performance requirements."

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18.2.7.1 Mechanical splices shall be classified as (a) or (b):
(a) Type 1 – Mechanical splice conforming to 25.5.7
(b) Type 2 – Mechanical splice conforming to 25.5.7 and capable of developing the specified tensile strength of the spliced bars

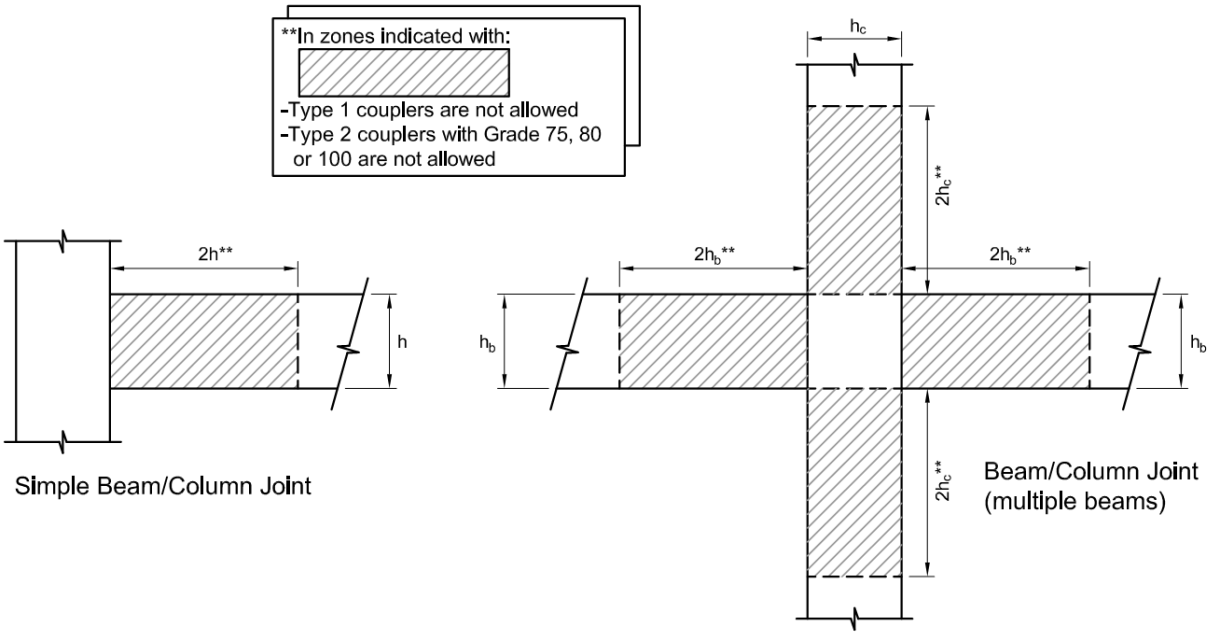
18.2.7.2 Except for Type 2 mechanical splices on Grade 60 reinforcement, mechanical splices shall not be located within a distance equal to twice the member depth from the column or beam face for special moment frames or from critical sections where yielding of the reinforcement is likely to occur as a result of lateral displacements beyond the linear range of behavior. Type 2 mechanical splices on Grade 60 reinforcement shall be permitted at any location, except as noted in 18.9.2.1(c).

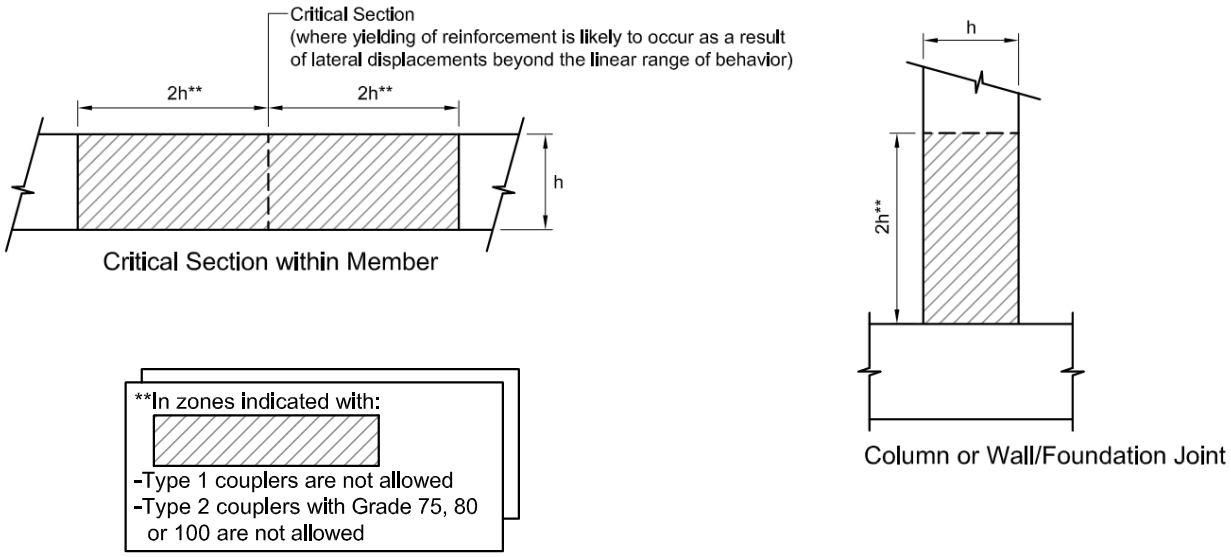
18.9.2.1 Special moment frames with ductile connections constructed using precast concrete shall satisfy (a) through (c):

(a) Requirements of 18.6 through 18.8 for special moment frames constructed with cast-in-place concrete
(b) V_n for connections calculated according to 22.9 shall be at least $2V_e$, where V_e is in accordance with 18.6.5.1 or 18.7.6.1
(c) Mechanical splices of beam reinforcement shall be located not closer than $h/2$ from the joint face and shall satisfy 18.2.7

Summary of changes:

- **Type 2 mechanical splices with Grade 60 reinforcement are permitted at any location, except as noted in 18.9.2.1(c) for special moment frames constructed using precast concrete. ALL other splices (Type 1 and Type 2 with Grade 75, 80 and Grade 100 reinforcement) have restrictions on their location…see sketches below:**





HRC Product Spotlight

The HRC 500 Series Splicing System is designed to exceed the capacity, stress and strain, tension, compression and full plastic, cyclic loading of A706 and A615 reinforcing steel. Specified as 175% fy, Xtender Splice will ensure available ductility from the rebar whenever it will be needed. It can be used as a standard coupler, splicing new reinforcement to existing bars in a retrofit project, or as a position/transition coupler splicing multiple bars in pre-tied reinforcing cages. The reliable performance and simple quality control of the splice makes it less sensitive to field conditions.

For more information, please visit: https://www.hrc-usa.com/hrc-500-series/