Approved Changes to the Ninth Edition *AASHTO LRFD Bridge Design Specifications*: Use of High-Strength Steel in Concrete Bridges and Bar Cut-Offs

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This article focuses on two of the changes to the ninth edition of the American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*[1] that were approved at the May 2023 meeting of the AASHTO Committee on Bridges and Structures (COBS). These changes were prepared by AASHTO Technical Committee T-10, which is now known as AASHTO Concrete Committee. The changes will be included in the forthcoming 10th edition of the AASHTO LRFD specifications.[2]

High-Strength Steel in Concrete Bridges (Working Agenda Item 168, COBS Agenda Item 31)

This agenda item makes modifications to three different parts of the AASHTO LRFD specifications and adds new references[3–5] that underpin the changes:

- The fourth paragraph of Article 5.4.3.1 will be revised as follows:
  Where ductility is to be assured or where welding is required, steel conforming to the requirements of ASTM A706/A706M, "Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement," shall be specified. Reinforcement to be welded and the weld design and details shall be specified in the contract documents. Welding of steel reinforcement shall conform to the current edition of the AWS D1.4 Structural Welding Code—Steel Reinforcement Bars.
- Article 5.4.3.3 will be revised to read:
  Where permitted by specific articles listed in Appendix D5, reinforcement with specified minimum yield strengths of less than or equal to 100 ksi may be used for all elements and connections in Seismic Zone 1. The following ASTM designations and grades of reinforcing steel shall be used in members containing potential plastic hinge regions:
  - *For bridges in Seismic Zones 2 and 3, ASTM A706 Grade 60, except that ASTM A615 Grade 60 or ASTM A706 Grade 80 may be used with the owner's approval*
  - *For bridges in Seismic Zone 4, ASTM A706 Grade 60, except that ASTM A706 Grade 80 may be used with the owner's approval*

  In Seismic Zones 2, 3, and 4, unless prohibited by the owner, the following ASTM designations and grades of reinforcing steel may be used in members not containing potential plastic hinge regions:
  - *ASTM A615 Grades 60, 80, and 100*
  - *ASTM A706 Grades 60 and 80*
  - *ASTM A1035 Grade 100.*
- The commentary to the Article 5.4.3.3 (C5.4.3.3) will be revised as follows:
  In 2004, ASTM published A1035/A1035M, "Standard Specification for Deformed and Plain, Low-Carbon, Chromium, Steel Bars for Concrete Reinforcement." This reinforcement has a yield strength equal to or greater than 100 ksi and offers the potential for corrosion resistance. Material and column specimen tests conducted by Overby et al. (2015), Barbosa et al. (2016), and Barcley and Kowalsky (2020) showed that ASTM A706 Grade 80 reinforcing steel has acceptable elongation characteristics and may be used in members containing plastic hinge regions to reduce steel reinforcement congestion. When Grade 60 reinforcing steel along with the minimum specified material properties are used for designing members subjected to high load demands, a large amount of reinforcing steel may be needed, which may cause rebar congestion and construction challenges. The use of high strength bar reinforcement may result in a more reasonable amount of reinforcing steel in the members, leading to savings in material, shipping, and placement costs. Reducing reinforcement congestion also leads to better quality of concrete construction.
- The background on these changes as found in the ballot item is as follows:
  The 2012 Interims of the AASHTO LRFD Bridge Design Specifications (Agenda Item 38) permitted the use of high strength reinforcing bars with minimum yield strength of 100 ksi in non-seismic regions. High strength reinforcing bars could be used for structures in non-seismic zones and with some limitation in moderate to high seismic zones. ACI 318-19, Article 20.2.1.3 specifies additional requirements for ASTM A615 Grades 40, 60, 80, 100 rebar and ASTM A706 Grades 60, 80, and 100 rebar. The requirements include ratio of actual tensile strength to actual yield strength, tensile properties, and elongations for use in design of reinforced concrete elements. A number of states have been using high strength bars, especially ASTM A706 Grade 80, in structural elements including capacity-protected members, such as drilled shafts, cap beams, etc. Over almost a decade, a large amount of material test data for ASTM A615 Grade 80 and Grade 100 and ASTM A1035 Grade 100 bars has become available. The data showed that steel rolling mills have been manufacturing high strength bars that meet the requirements of the material specifications for construction.

Reinforcement Detailing and Bar Cut-Offs (Working Agenda Item 208, COBS Agenda Item 32)

This agenda item makes modifications to six different parts of the AASHTO LRFD specifications and adds a reference.

- A new term will be added to the Article 5.3.
  L_{CLR} = *clear span between supports (in.) (5.10.8.1.2a)*
- The first paragraph in Article 5.10.8.1.2a will be revised to read:
  Critical sections for development of reinforcement in flexural members shall be taken at points of maximum stress and at points within the span where bent or terminated tension reinforcement is no longer required to resist flexure.
- The items in the bullet list in Article 5.10.8.1.2a will be revised as follows:
  - *The effective depth of member, d,*
  - *15 times the nominal diameter of bar, d_b, or*
  - *1/20 of the clear span, L_{CLR}*
- **Figure 1** will be added to the beginning of Article C5.10.8.1.2a.

Note the extension of bars D in Figure C5.10.8.1.2a-1 (Fig. 1) must also meet the requirements of Article 5.10.8.1.2b.

These provisions vary from those in the American Concrete Institute's *Building Code Requirements for Structural Concrete (ACI 318-19) and Commentary (ACI 318R-19)*,[6] requiring a slightly greater bar diameter limit (15 instead of 12) and including a ratio of the clear span. (ACI has no span requirement.) The reinforcement extension accounts for the possibility of higher-than-anticipated moments due to live-load positioning, support settlements, or other causes.

- The items in the bullet list in Article 5.10.8.1.2c will be revised as follows:
  - *The effective depth of member, d,*
  - *12 times the nominal diameter of bar, d_b, or*
  - *1/16 of the clear span, L_{CLR}*
- **Figure 2** will be added to Article C5.10.8.1.2c.

While no background on these changes was provided in the ballot item, these changes are intended to clarify for the designer the bar cut-off requirements for typical structures. Importantly, the newly developed figures provide additional clarity for the subject design provisions.

In upcoming issues of *ASPIRE*, I will discuss the details of the remaining agenda items approved by COBS in May 2023.

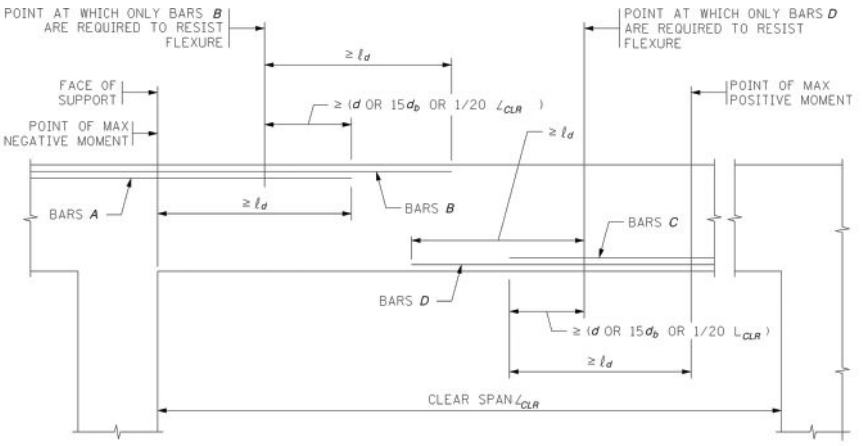

Figure 1. General flexural reinforcement termination requirements. Adapted from Fig. C5.10.8.1.2a-1 of the forthcoming *AASHTO LRFD Bridge Design Specifications*, 10th edition.[2]

References

1. American Association of State Highway and Transportation Officials (AASHTO). 2020. *AASHTO LRFD Bridge Design Specifications.* 9th ed. Washington, DC: AASHTO.
2. AASHTO. Forthcoming. *AASHTO LRFD Bridge Design Specifications.* 10th ed. Washington, DC: AASHTO.
3. Overby D., M. Kowalsky, and R. Seracino. 2015. *A706 Grade 80 Reinforcement for Seismic Applications*. Research Report No. RD-15-15. Sacramento, CA: California Department of Transportation. https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/f0016541-ca16-2563-finalreport.pdf.
4. Barbosa, A. R., T. Link, and D. Trejo. 2016. "Seismic Performance of High-Strength Steel RC Bridge Columns." *Journal of Bridge Engineering* 21 (2).
5. Barcley, L., and M. Kowalsky. 2020. "Seismic Performance of Circular Concrete Columns Reinforced with High-Strength Steel." *Journal of Structural Engineering* 146 (2).
6. American Concrete Institute (ACI) Committee 318. 2019. *Building Code Requirements for Structural Concrete (ACI 318-19) and Commentary (ACI 318R-19).* Farmington Hills, MI: ACI.

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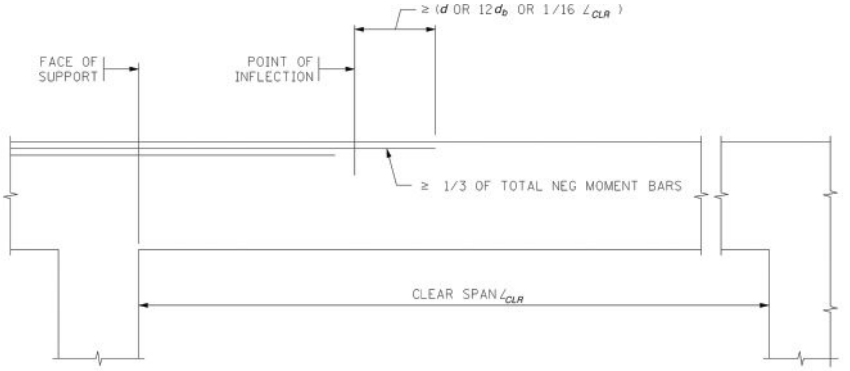

Figure 2. Negative-moment reinforcement termination requirements. Adapted from Fig. C5.10.8.1.2c-1 of the forthcoming *AASHTO LRFD Bridge Design Specifications*, 10th edition.[2]