CHROMX®

AASHTO LRFD Bridge Design Specifications

ENGINEERING BULLETIN #11

Designing Economical, Durable and Safer Bridges with ChromX®

DESIGN ACCORDING TO ACI 318-19 CODE

The American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications are meant for use in the design, evaluation and rehabilitation of bridges, and the U.S. Federal Highway Administration (FHWA) mandates the specifications for use in all bridges using federal funding. These specifications use LRFD methodologies with factors developed from current statistical knowledge of loads and structural performance. The following updates (code and commentary articles) are related to the AASHTO LRFD Bridge Design Specifications, 7th Edition (2016 Interim Revisions, Section 5, “Concrete Structures”) addressing the use of ASTM A1035 Grade 100 [690]/AASHTO M334 steel reinforcing bar at yield strengths up to and including 100 ksi (690 MPa) for all elements and connections in Seismic Zone 1:

AASHTO LRFD Bridge Design Specifications 100 ksi (690 MPa) Related Sections		
Reinforcing Bars	5.4.3.1 5.4.3.3	Permits reinforcing bars with minimum yield strength up to 100 ksi (690 MPa) for use in all elements and connections in Seismic Zone 1.
Reinforcing Bars - Fatigue Threshold	5.5.3.2	Equation 5.5.3.2.1 has been calibrated and provides more reasonable values of $(\Delta F)_{TH}$ for higher strength reinforcing bars.
Design of High Strength Steel Rebar	5.7	For nonprestressed reinforcing steel with a specified minimum yield strength of 100 ksi, the compression-controlled strain limit shall be taken as ε_{cl} = 0.004. The tension-controlled strain limit, $_{\varepsilon tl}$, shall be taken as 0.008 for nonprestressed reinforcing steel with a specified minimum yield strength, f_y = 100 ksi.
Control of Cracking	5.7.3.4	In certain situations involving higher strength reinforcement or large concrete cover, the use of Equation 5.7.3.4.1 can result in small or negative values for bar spacing, s. Where higher strength reinforcement is used, s need not be less than 5 inches for control of flexural cracking.
Moment Redistribution	5.7.3.5	In lieu of more refined analysis, where bonded reinforcement that satisfies the provisions of Article 5.11 is provided at the internal supports of continuous reinforced concrete beams, negative moments determined by elastic theory at strength limit states may be increased or decreased by not more than 1000 $_{\varepsilon t}$ percent, with a maximum of 20 percent. Redistribution of negative moments shall be made only where $_{\varepsilon t}$ is equal to or greater than 1.5 $_{\varepsilon tl}$ at the section at which moment is reduced, where $_{\varepsilon tl}$ is the tension-controlled strain limit specified in Article 5.7.2.1. Positive moments shall be adjusted to account for the changes in negative moments to maintain equilibrium of loads and force effects.
Spirals and Ties	5.7.4.6	f_{yh} = specified minimum yield strength of spiral reinforcement (ksi) = 100 ksi for elements and connections specified in Article 5.4.3.3; ≤ 75.0 ksi otherwise.
Transverse Reinforcement	5.8.2.4 5.8.2.5 5.8.3.8 5.10.6.1	For members subjected to flexural shear without torsion, reinforcing steel with specified minimum yield strengths up to 100 ksi may be used for transverse reinforcement for elements and connections as specified in Article 5.4.3.3.
Longitudinal Reinforcement	5.8.3.5	Longitudinal or transverse reinforcing steel, or a combination thereof, with specified minimum yield strengths up to 100 ksi, may be used in elements and connections specified in Article 5.4.3.3.

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Standard Hooks	5.10.2.1	Standard hooks may be used with reinforcing steel having a specified minimum yield strength between 75.0 and 100 ksi for elements and connections specified in Article 5.4.3.3 only if ties specified in Article 5.11.2.4 are provided.
Development Length	5.11.1 5.11.2 5.11.5	Development lengths shall be calculated using the specified minimum yield strength of the reinforcing steel. Use of nonprestressed reinforcing steel with a specified minimum yield strength up to 100 ksi may be permitted for elements and connections specified in Article 5.4.3.3. Reinforcing steel with specified minimum yield strengths up to 100 ksi may be used in elements and connections specified in Article 5.4.3.3. For spliced bars having a specified minimum yield strength greater than 75.0 ksi, transverse reinforcement satisfying the requirements of Article 5.8.2.5 for beams and Article 5.10.6.3 for columns shall be provided over the required splice length. Confining reinforcement is not required in slabs or decks.

Reference: AASHTO LRFD Bridge Design Specifications, Customary U.S. Units, 7th Edition (2016 Interim Revisions). Issued by the American Association of State Highway and Transportation Officials, 444 N Capitol St. NW - Suite 249 - Washington, DC 20001.

AASHTO LRFD permits reinforcing bars with minimum yield strengths up to 100 ksi (690 MPa) in non-seismic applications (elements, connections and systems). It also permits the use of high strength reinforcing bars but with owner or agency approval in seismic applications higher than Seismic Zone 1. In August 2011, H. Russell, S. K. Ghosh and M. Saiidi published Design Guide for Use of ASTM A1035 High-Strength Reinforcement in Concrete Bridge Elements with Consideration of Seismic Performance, to supplement the findings of Design of Concrete Structures Using High-Strength Steel Reinforcement National Cooperative Highway Research Program (NCHRP) Report 679, B. Shahrooz, R. Miller, K. Harries, H. Russell (April 2011).

This study used both the NCHRP report and sponsored research projects to evaluate the applicability and the maximum strength of ChromX® series steel reinforcement that may be used in the design of different bridge structural members in Seismic Zones 3 and 4. The study's findings are summarized in the table below.

Use of ChromX® series' higher strength and corrosion resistance presents the opportunity to optimize the structural design of bridges, reducing steel congestion and providing long service life to structures located in high seismic zones.

Maximum Tensile Strengths (ksi) of Reinforcement for Use in Bridge Designs[1]

Seismic Zones	Foundations			Columns/Walls		Decks	Beams/Girders		
	Abutments	Piles	Pile Caps	Vertical	Confinement	Top & Bottom	Tension	Compression	Shear
Zone 1	100	100	100	100	100	100	100	100	100[2]
Zone 2	100[3]	100[3]	100[3]	100[4]	100[3]	100	100	100	100[2]
Zone 3	100[3]	100[3]	100[3]	N/R[5]	100[3]	100	100	100	100[2]
Zone 4	100[3]	100[3]	100[3]	N/R[5]	100[3]	100	100	100	100[2]

(1) Design Guide for Use of ASTM A1035 High-Strength Reinforcement in Concrete Bridge Elements with Consideration of Seismic Performance, H.G. Russell, S.K. Ghosh, Mehdi Saiidi (2011) and Design Guide for Use of ASTM A1035 High-Strength Reinforcement in Concrete Bridge Elements in AASHTO Seismic Zone 2, S.K. Ghosh (2012).
(2) Yield strength limited to 60 ksi for shear friction calculation.
(3) Yield strength of transverse reinforcement limited to 60 ksi for shear strength computations.
(4) Required shear strength must be calculated per Articles 8.3.2 and 8.6.1 and minimum shear reinforcement must be provided per Article 8.6.5 of the AASHTO Guide Specifications for LRFD Bridge Design.
(5) Not recommended. Concrete reinforcing steel used must meet ASTM A706 seismic requirements.