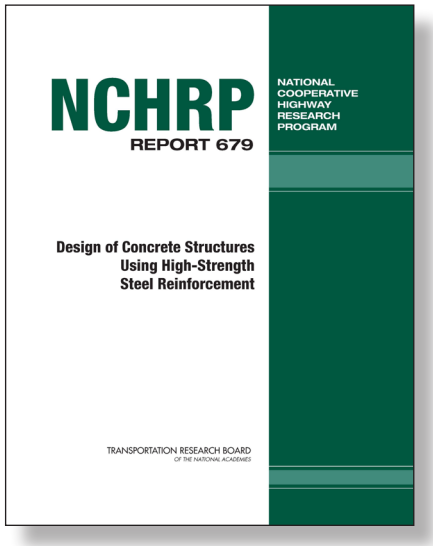
DESIGNING MORE ECONOMICAL, DURABLE AND SAFER BRIDGES WITH $MMFX_2$

AASHTO LFRD DESIGN CONSIDERATIONS BASED ON NCHRP REPORT 679

Beginning in 2007, research funded by the Transportation Research Board (TRB), was performed under National Cooperative Highway Research Program (NCHRP) Project 12-77 to provide an evaluation of existing AASHTO LRFD Bridge Design Specifications related to the use of high-strength reinforcing steel. At the conclusion of this comprehensive research and analytical program in 2011, NCHRP Report 679 was published. This report makes recommendations to AASHTO LRFD Bridge Design Specifications, Sections 3, 5 and 9 that permit use of high-strength reinforcing steel with yield strengths up to and including 100 ksi (690 MPa), such as ASTM A1035/AASHTO MP 18.

Research and analysis covered in NCHRP Report 679 confirmed that:



- 100 ksi (690 MPa) yield strength design can be done without significant changes to the AASHTO LFRD Bridge Design Specifications
- High strength reinforced flexural beams showed behavior similar to beams with conventional reinforcement, while exceeding their design strength and ductility requirements
- Accepted values for the fatigue limit for conventional steel are also applicable to high strength bars
- Current procedures for calculating shear capacity are acceptable for values of shear reinforcement yield f_y equal or less than 100 ksi (690 MPa)
- Shear Friction f_y needs to be limited to 60 ksi (420 MPa)
- Current requirements for design in compression members for both longitudinal and transverse reinforcement are valid for f_y equal or less than 100 ksi (690 MPa)
- Current design requirements for high-strength bars used in development, splice, and anchorage regions should be provided with cover and confining reinforcement
- Use of current serviceability provisions for service load levels deflections and crack widths were determined to be predictable and within accepted limits

NCHRP Report 679 Appendix K—Design Examples compare ASTM A1035 Grade 100 designs (690 MPa) with conventional ASTM A615 Grade 60 (420 MPa).

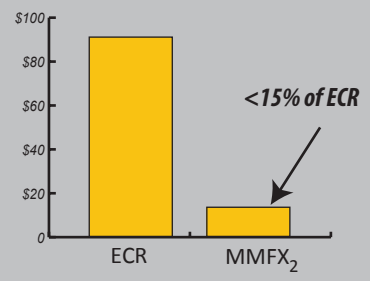
Example 1 – Based on "Training Classes on AASHTO LRFD Bridge Specifications," ODOT, R.A. Miller - Bridge Deck Reinforcement comparison –

- Bridge deck tension steel - reduced by 33%
- Shear reinforcement – reduced by 43%

Example 2 - Based on "LRFD Design of Cast-in-Place Concrete Bridges," 1st Ed., Schneider, E.F. and Bhide, S.B. Portland Cement Association, - Simple T Beam

- Beam Flexural reinforcement – reduced by 49%
- Stirrup reinforcement – red

Lower Life-Cycle Costs



<15% the life-cycle costs of epoxy coated rebar per VTRC LCCA based on 75-year SL

$MMFX_2$ Steel. Today's Steel Standard.

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Steel Advantages for Use in Bridge Structures
USE OF $MMFX_2$ STEEL FOR BRIDGES LOCATED IN HIGH SEISMIC ZONES

"Design Guide for Use of ASTM A1035 High-Strength Reinforcement in Concrete Bridge Elements with Consideration of Seismic Performance", H. Russell, S. K. Ghosh, M. Saiidi - August 2011 has been published 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 $MMFX_2$ Steel reinforcement that may be used in the design of different bridge structural members in Seismic Zones 3 and 4. A brief summary of the findings of this report are shown in the table below.

Use of $MMFX_2$'s higher strength and corrosion resistance presents the opportunity to optimize the structural design of bridges, minimizing materials and reinforcing steel congestion, and provide long service life to structures located in high seismic zones.

Maximum Tensile Strength of ASTM A1035 Reinforcement for Use in Design

Yield Strength, ksi (MPa)	Foundations			Columns/Walls		Decks	Beams/Girders		
	Abutments	Piles	Pile Caps	Vertical	Confinement	Top and Bottom	Tension	Compression	Shear
Non Seismic (Zone 1)									
100 (690)	X	X	X	X	X	X	X	X	X
75 (520)									
60 (420)									X(1)
Seismic (Zones 3 and 4)									
100 (690)	X	X	X	N(2)	X	X	X	X	X
75 (520)				N(2)					
60 (420)	X(3)	X(3)	X(3)	N(2)	X(3)				X(1)

(1) Yield strength limited to of 60 ksi (420 MPa) for shear-friction calculations.
(2) Not recommended.
(3) Yield strength of transverse reinforcement limited to 60 ksi (420 MPa) for shear strength computations.
Note: Application of high-strength reinforcerment in bridges located in Seismic Zone 2 was beyond the scope of this study.

Use of $MMFX_2$ Steel for Corrosion Protection of Structures

In addition to the strength advantage of $MMFX_2$ Steel (ASTM A1035/AASHTO MP 18) rebars, corrosion-resistant $MMFX_2$ rebars are ideal for structural members and systems exposed to, or in direct contact with, corrosive environments, such as: marine environment, de-icing salts, foundation systems in high water tables, or corrosive soil conditions. $MMFX_2$ rebars have been successfully used in the following applications for corrosion protection: bridge decks and beams, foundation piles and systems, pavement dowel and tie bars, diaphragm walls, marine structures and seawalls. Structural systems reinforced with $MMFX_2$ rebars have been shown to achieve design service lives in excess of 75 years, as noted in publications such as the following: The Use of Corrosion Resistant Reinforcement as a Sustainable Technology for Bridge Deck Construction - TRB Annual Meeting 2010 Paper #10-2214 – January 2010 – A. Moruza, S. Sharp

Conclusion:

$MMFX_2$ (ASTM A1035/AASHTO MP 18) rebar's unique combination of strength and corrosion-resistance properties provides engineers the opportunity to design more economical, durable, and safer structures.