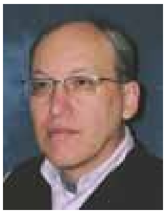
The Fatigue Limit States, Part 2



by Dr. Dennis R. Mertz

The fatigue limit states of Article 5.5.3 of the *AASHTO LRFD Bridge Design Specifications* include two distinct checks: one for metallic reinforcement in members subjected to tension, the other for concrete of fully prestressed concrete members subjected to compression.

The fatigue limit-state function for metallic reinforcement in concrete members subjected to tension is:

$$\gamma(\Delta f) \leq (\Delta F)_{TH}$$

where:

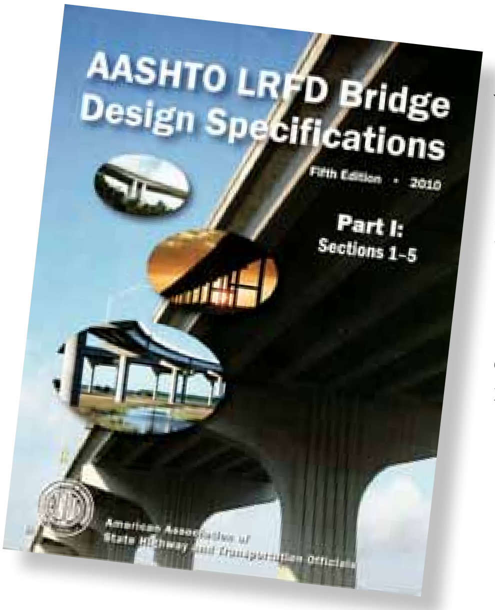
γ = load factor specified for the Fatigue I load combination discussed in Part 1 of this article (*ASPIRE*™, Summer 2011)

Δf = force effect, live load stress range due to the passage of the fatigue truck, as specified in LRFD Article 3.6.1.4

$(\Delta F)_{TH}$ = constant-amplitude fatigue threshold for the metallic reinforcement being considered

As discussed in the previous article, the constant-amplitude threshold is a threshold value of stress range below which the metallic reinforcement will not crack during the expected life of the bridge. In this case, metallic reinforcement in a concrete member is said to theoretically exhibit an infinite fatigue life.

The metallic reinforcement to be checked for fatigue includes nonprestressed reinforcing bars, prestressing strands, and welded or mechanical splices of reinforcement. It is of paramount importance to point out that fully prestressed concrete components designed to have an extreme fiber tensile stress due to the Service III Limit State within the tensile stress limit specified in LRFD Table 5.9.4.2.2-1, are specifically exempted from the fatigue check of their metallic reinforcement. Further, for reinforced concrete members, fatigue needs be considered only in regions where the permanent compressive stress is less than the maximum tensile live-load stress resulting from the Fatigue I load combination; in other words, only if the Fatigue I live-load stress overcomes any permanent compression due to dead load and prestressing.



Reinforcing Bars

For nonprestressed reinforcing bars, the constant-amplitude fatigue threshold specified in LRFD Article 5.5.3.2 is:

$$(\Delta F)_{TH} = 24 - 0.33 f_{min}$$

where f_{min} = minimum live-load stress resulting from the Fatigue I load combination, combined with the more severe stress from either the permanent loads or the permanent loads, shrinkage, and creep-induced external loads; positive if tension, negative if compression.

For welded wire reinforcement without a cross weld in the high-stress region:

$$(\Delta F)_{TH} = 24 - 0.33 f_{min}$$

For welded wire reinforcement with a cross weld in the high-stress region:

$$(\Delta F)_{TH} = 16 - 0.33 f_{min}$$

For flexural reinforcement, the high-stress region is one third of the span on each side of the section of maximum moment.

Prestressing Tendons

For prestressing tendons not satisfying the exemption above, the constant-amplitude fatigue thresholds specified in LRFD Article 5.5.3.3 are:

$(\Delta F)_{TH}$ = 18.0 ksi for radii of curvature in excess of 30.0 ft.

$(\Delta F)_{TH}$ = 10.0 ksi for radii of curvature not exceeding 12.0 ft.

For radii of curvature between 12.0 and 30.0 ft, linear interpolation is permitted.

Finally, for welded or mechanical splices, the constant-amplitude fatigue thresholds are given in LRFD Table 5.5.3.4-1.

Concrete

The fatigue limit-state function for concrete of fully prestressed concrete members subjected to compression is specified in LRFD Article 5.5.3.1 as:

Fatigue I compressive stress + ½(effective prestress + permanent loads) ≤ 0.40 f_c'

Previously, this compressive stress-limit check was not explicitly specified as a fatigue check.

A future article will discuss the determination of Δf, the force effect, live load stress range due to the passage of the fatigue truck, in more detail.

EDITOR'S NOTE

If you would like to have a specific provision of the AASHTO LRFD Bridge Design Specifications *explained in this series of articles, please contact us at www.aspirebridge.org.*