Bridge and Structures Office
Washington State
Department of Transportation

Design Memorandum

TO: All Design Section Staff
FROM: Bijan Khaleghi
DATE: December 15, 2010
SUBJECT: Minimum Flexural Reinforcement

Delete BDM Article 5.1.2 H-1 in its entirety and replace with the following:

5.1.2 H-1 Minimum Flexural Reinforcement:

Unless otherwise specified, at any section of a tension-controlled flexural component, the amount of prestressed and nonprestressed tensile reinforcement shall be adequate to develop a factored flexural resistance at least equal to the lesser of:

- Factored cracking moment, $M_{cr\text{-}mod}$, determined on the basis of elastic distribution and modulus of rupture

$$M_{cr\text{-}mod} = \gamma_3\left[(\gamma_1 f_r + \gamma_2 f_{cpe})S_c - M_{dnc}\left(\frac{S_c}{S_{nc}} - 1\right)\right]$$

where:

f_r = modulus of rupture of concrete specified in LRFD Article 5.4.2.6.
f_{cpe} = compressive stress in concrete due to effective prestress forces only (after allowance for all prestress losses) at extreme fiber of section where tensile stress is caused by externally applied loads (ksi)
M_{dnc} = total unfactored dead load moment acting on the monolithic or noncomposite section (kip-in.)
S_c = section modulus for the extreme fiber of the composite section where tensile stress is caused by externally applied loads (in.^{3})
S_{nc} = section modulus for the extreme fiber of the monolithic or noncomposite section where tensile stress is caused by externally applied loads (in.^{3})

The following factors account for variability in the flexural cracking strength of concrete, variability of prestress and the ratio of nominal yield stress of reinforcement to ultimate.

γ_1 = 1.56, which can be reduced to1.2 for precast segmental structures.
γ_2 = 1.1
γ_3 = the ratio of yield stress to ultimate stress of the reinforcement (0.67 for A615 Grade 60, and 0.75 for A706 Grade 60 reinforcement). For prestressed concrete structures, use 1.0.

Appropriate values for M_{dnc} and S_{nc} shall be used for any intermediate composite sections. Where the beams are designed for the monolithic or noncomposite section to resist all loads, substitute S_{nc} for S_c in the above equation for the calculation of $M_{cr\text{-}mod}$.

- For nonprestressed members, 1.33 times the factored moment required by the applicable strength load combinations specified in LRFD Table 3.4.1-1.

Background:

This memorandum incorporates the recommendations for the NCHRP Report 149, LRFD Minimum Flexural Reinforcement Requirements. It revises $1.2M_{cr}$ to be some coefficients multiplied by M_{cr}. These coefficients are a function of component type's affect on modulus of rupture, the effective prestress, and the ratio of yield to ultimate stress in the prestressing steel.

If you have any questions regarding these issues, please contact Bijan Khaleghi at 705-7181.

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