![Washington State Department of Transportation — Bridge and Structures Office]

Design Memorandum

TO: All Design Section Staff
FROM: Bijan Khaleghi
DATE: February 20, 2021
SUBJECT: BDM Section 5.2.1C – Stress Limits in Prestressed Concrete Members


This design memorandum updates the recommended procedure for sizing reinforcement for tensile stress limits that require bonded reinforcement sufficient to resist the tensile force in the concrete. This memorandum modifies the Bridge Design Manual Section 5.2.1C as specified herein.

Bridge Design Manual Revisions

Item 1 - The second paragraph of BDM 5.2.1C is moved to follow the third paragraph and amended with the following:

For tensile stress limits that require bonded reinforcement sufficient to resist the tensile force in the concrete, the tensile force shall be computed using the procedure illustrated in ~~AASHTO LRFD C5.9.2.3.1b~~ Figure 5.2.1-2 assuming an uncracked section. The bonded reinforcement is proportioned using a stress of $0.5f_y$, not to exceed 30.0 ksi. Individual reinforcing bars are only considered if they are fully developed and are located within the tensile region on the member.

Item 2 – Add new Figure 5.2.1-2
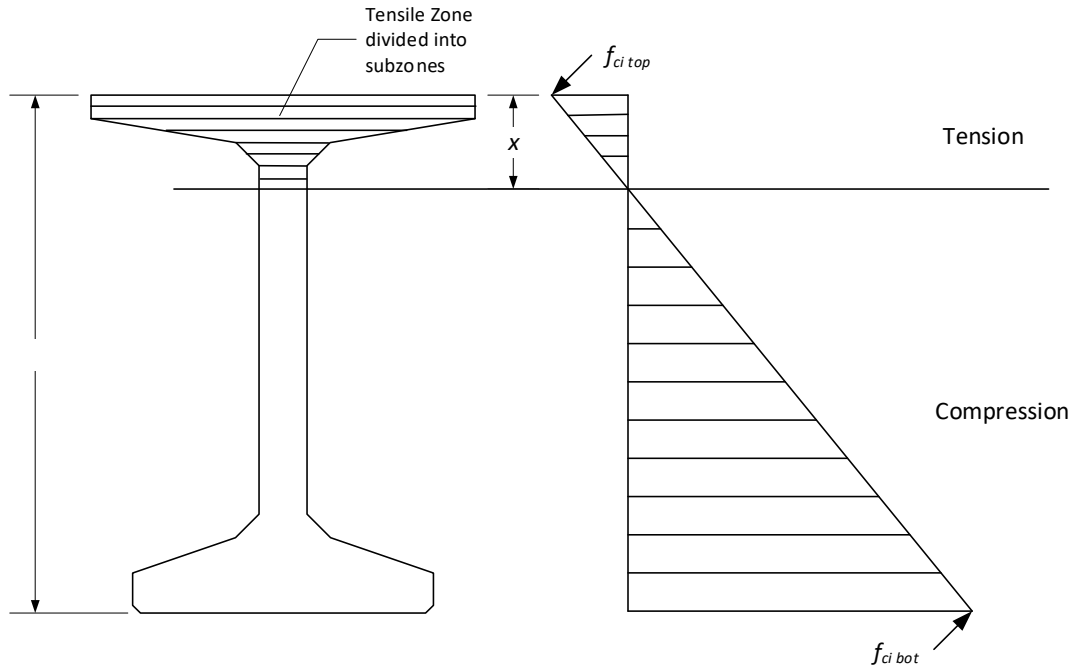
$$T = \int f_{ci}(x)dA \approx \sum T_i = \sum f_{ci}(x_i)A_i$$

$$A_s = \frac{T}{f_s}, where\ f_s = 0.5f_y \le 30.0\ ksi$$

Figure 5.2.1-2 − Calculation of Tensile Force and Required Area of Reinforcement

Background

AASHTO LRFD Article 5.9.2.3.1b provides concrete tensile stress limits for temporary conditions. Tensile stress limits are provided for areas with bonded reinforcement sufficient to resist the tensile force in the concrete and for areas without bonded reinforcement. Larger tensile stresses are permitted in areas with sufficient bonded reinforcement.

The tensile stress limit for areas without bonded reinforcement is generally construed to include areas where bonded reinforcement is not sufficient to resist the tensile force.

The commentary to AASHTO LRFD Article 5.9.2.3.1b prescribes a computational procedure for sizing the bonded reinforcement to permit the application of the larger tensile stress limit. However, the procedure is only accurate when the tensile stress zone is confined to a rectangular region as illustrated in AASHTO LRFD Figure C5.9.2.3.1b-1.

Modern wide flange girders have thinner top flanges than the AASHTO Type I-IV girders. The tensile zone often extends below the rectangular portion of the wide flange top flange and possibly into the web. The prescribed procedure is known to underestimate the tensile force

when this occurs. This procedure also incorrectly estimates the tensile force in the concrete for other sections including U-beams with tapered top flanges and any type of section with internal voids (slabs, box beams, etc.) when the neutral axis extends into the voided region.

This procedure provides a general method for estimating the tension force in the concrete that is applicable to all girder section types regardless of the location of the neutral axis.

If you have any questions regarding this policy memorandum, please contact Anthony Mizumori at Anthony.Mizumori@wsdot.wa.gov, Rick Brice at Richard.Brice@wsdot.wa.gov or Bijan Khaleghi Bijan.Khaleghi@wsdot.wa.gov at (360) 705-7181.

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