Florida Department of Transportation

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TO: District Design Engineers, District Structures and Facilities Engineers, District Structures Design Engineers, District Materials Engineers

FROM: William Nickas, P.E., State Structures Design Engineer

COPIES: Ananth Prasad, Bob Greer, Lora Hollingsworth, Jeffrey Ger (FHWA), Robert Robertson, Larry Sessions, Larry Jones, Lex Collins, Andre Pavlov, Marcus Ansley,

SUBJECT: Temporary Design Bulletin C06-08
Concrete Modulus of Rupture

This Design Bulletin specifies the Department's policy for a lower mean value for the modulus of rupture.

REQUIREMENT

Replace the concrete modulus of rupture defined in the "AASHTO LRFD Bridge Design as follows:

In LRFD Article 5.4.2.6, under "For normal-weight concrete:", in the second bullet, replace the modulus of rupture value of $0.37\sqrt{f_c'}$ with $0.24\sqrt{f_c'}$.

COMMENTARY

Delete last sentence of 1st paragraph in LRFD commentary C5.4.2.6.

The use of a minimum reinforcing check was originally developed to insure reinforced concrete beams (with low reinforcement ratios), had adequate ductility. This concept has been expanded to cover both non-prestressed and prestressed concrete beams and now applies to all flexural sections. AASHTO Technical Committee for Concrete Design is reviewing these issues and changes to the specifications may be forthcoming. In the 2005 LRFD interim, AASHTO increased the Modulus of Rupture values used in the minimum reinforcement check, thereby increasing the minimum amount of reinforcing required.

The FDOT has chosen to use the traditional modulus of rupture value that has been in the AASHTO specifications since the 1960's.

BACKGROUND

The split tensile test more closely represents the tensile strength of the concrete beams in flexure while the modulus of rupture test ASTM C78 (AASHTO T97) overestimates the flexural tensile stress for bridge girders (see data below). When using the modulus of rupture values to establish the cracking moment, the lower bound value should be used and this is estimated in ACI 363R (5.1) as $7.5\sqrt{f'_c}$ psi. The reason the lower bound value should be used is a function of the test method. ACI 318 (10.7) defines a deep beam as one having a clear span less than four times the overall depth or regions with concentrated loads within twice the member depth from the face of the support. ASTM C78 test set-up for the modulus of rupture has a span of only three times the member depth and concentrated loads are applied at a distance of only one times the member depth. Therefore, a portion of the load is transmitted directly to the support without creating any bending in the test beam yielding a computed flexural stress higher than the actual flexural stress.

Extensive testing of Florida concrete and mix designs performed by the University of Florida (report HPR # 86-22 December 1992) resulted in the following data:

Modulus of Rupture (f_r)

$f_r = A(f'c)^{0.5}$ psi $\qquad$ $A = 10.721 - 13.708$

Split Tensile (f_{ct})

$f_{ct} = A\,(f'c)^{0.5}$ psi $\qquad$ $A = 6.141 - 7.865$

Relationship between Split Tensile Strength and Modulus of Rupture

$f_{ct} = 0.58\, f_r$

The variability of the constant A is due to aggregate type, shape and gradation.

Since the minimum reinforcing requirement is being applied at each design section and the concrete resistance to cracking varies, it is not rational to require the maximum value for the modulus of rupture to be applied at every section. Therefore, the FDOT has adopted a Florida specific value for the modulus of rupture $f_r = 0.24\sqrt{f'c}$ ksi ($7.5\sqrt{f'c}$ psi).

It is worthy to note the "CEB-FIB Model Code" uses split tensile strength for the mean flexural tensile strength which is $0.2\sqrt{f'c}$ ksi or $6.5\sqrt{f'c}$ psi.

IMPLEMENTATION

This Design Bulletin is effective immediately.

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