Bridge Factors Factual Report Attachment 69 – AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications, 7th Edition, 2014, with 2015 Interims, Guidance on Intentionally Roughened Surface

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(3 pages)

Recent research (Markowski et al., 2005; Tadros and Girgis, 2006; Badie and Tadros, 2008; Sullivan et al., 2011) has demonstrated that increasing interface shear connector spacing from 24.0 to 48.0 in. has resulted in no deficiency in composite action for the same resistance of shear connectors per foot, and girder and deck configurations. These research projects have independently demonstrated no vertical separation between the girder top and the deck under cyclic or ultimate loads. However, the research did not investigate relatively shallow members; hence, the additional limitation related to the member depth is provided.

As the spacing of connector groups increases, the capacities of the concrete and grout in their vicinity become more critical and need to be carefully verified. This applies to all connected elements at the interface. Eqs. 5.8.4.1-2 and 5.8.4.1-3 are intended to ensure that the capacity of the concrete component of the interface is adequate. Methods to enhance that capacity, if needed, include use of high-strength materials and of localized confinement reinforcement.

5.8.4.3—Cohesion and Friction Factors

The following values shall be taken for cohesion, c, and friction factor, μ:

- For a cast-in-place concrete slab on clean concrete girder surfaces, free of laitance with surface roughened to an amplitude of 0.25 in.

  c = 0.28 ksi
  μ = 1.0
  K_1 = 0.3
  K_2 = 1.8 ksi for normal-weight concrete
  = 1.3 ksi for lightweight concrete

- For normal-weight concrete placed monolithically:

  c = 0.40 ksi
  μ = 1.4
  K_1 = 0.25
  K_2 = 1.5 ksi

- For lightweight concrete placed monolithically, or nonmonolithically, against a clean concrete surface, free of laitance with surface intentionally roughened to an amplitude of 0.25 in.:

  c = 0.24 ksi
  μ = 1.0
  K_1 = 0.25
  K_2 = 1.0 ksi

C5.8.4.3

The values presented provide a lower bound of the substantial body of experimental data available in the literature (Loov and Patnaik, 1994; Patnaik, 1999; Mattock, 2001; Slapkus and Kahn, 2004). Furthermore, the inherent redundancy of girder/slab bridges distinguishes this system from other structural interfaces.

The values presented apply strictly to monolithic concrete. These values are not applicable for situations where a crack may be anticipated to occur at a Service Limit State.

The factors presented provide a lower bound of the experimental data available in the literature (Hofbeck, Ibrahim, and Mattock, 1969; Mattock, Li, and Wang, 1976; Mitchell and Kahn, 2001).

Available experimental data demonstrates that only one modification factor is necessary, when coupled with the resistance factors of Article 5.5.4.2, to accommodate both all-lightweight and sand-lightweight concrete. Note this deviates from earlier specifications that distinguished between all-lightweight and sand-lightweight concrete.

Due to the absence of existing data, the prescribed cohesion and friction factors for nonmonolithic lightweight concrete are accepted as conservative for application to monolithic lightweight concrete.

- For normal-weight concrete placed against a clean concrete surface, free of laitance, with surface intentionally roughened to an amplitude of 0.25 in.:

  c = 0.24 ksi
  μ = 1.0
  K_1 = 0.25
  K_2 = 1.5 ksi

- For concrete placed against a clean concrete surface, free of laitance, but not intentionally roughened:

  c = 0.075 ksi
  μ = 0.6
  K_1 = 0.2
  K_2 = 0.8 ksi

- For concrete anchored to as-rolled structural steel by headed studs or by reinforcing bars where all steel in contact with concrete is clean and free of paint:

  c = 0.025 ksi
  μ = 0.7
  K_1 = 0.2
  K_2 = 0.8 ksi

For brackets, corbels, and ledges, the cohesion factor, c, shall be taken as 0.0.

5.8.4.4—Minimum Area of Interface Shear Reinforcement

Except as provided herein, the cross-sectional area of the interface shear reinforcement, A_{vf}, crossing the interface area, A_{cv}, shall satisfy:

$$A_{vf} \geq \frac{0.05A_{cv}}{f_y} \quad (5.8.4.4\text{-}1)$$

For a cast-in-place concrete slab on clean concrete girder surfaces free of laitance, the following provisions shall apply:

- The minimum interface shear reinforcement, A_{vf}, need not exceed the lesser of the amount determined using Eq. 5.8.4.4-1 and the amount needed to resist $1.33V_{ui}/\phi$ as determined using Eq. 5.8.4.1-3.

Tighter constraints have been adopted for roughened interfaces, other than cast-in-place slabs on roughened girders, even though available test data does not indicate more severe restrictions are necessary. This is to account for variability in the geometry, loading and lack of redundancy at other interfaces.

Since the effectiveness of cohesion and aggregate interlock along a vertical crack interface is unreliable the cohesion component in Eq. 5.8.4.1-3 is set to 0.0 for brackets, corbels, and ledges.

C5.8.4.4

For a girder/slab interface, the minimum area of interface shear reinforcement per foot of girder length is calculated by replacing A_{cv} in Eq. 5.8.4.4-1 with $12b_{vi}$.

Previous editions of these specifications and of the AASHTO Standard Specifications have required a minimum area of reinforcement based on the full interface area; similar to Eq. 5.8.4.4-1, irrespective of the need to mobilize the strength of the full interface area to resist the applied factored interface shear. In 2006, the additional minimum area provisions, applicable only to girder/slab interfaces, were introduced. The intent of these provisions was to eliminate the need for additional interface shear reinforcement due simply to a beam with a wider top flange being utilized in place of a narrower flanged beam.

The additional provision establishes a rational upper bound for the area of interface shear reinforcement required based on the interface shear demand rather than the interface area as stipulated by Eq. 5.8.4.4-1. This