The AASHTO LRFD Bridge Design Specifications: Torsional Resistance

by Dr. Dennis R. Mertz

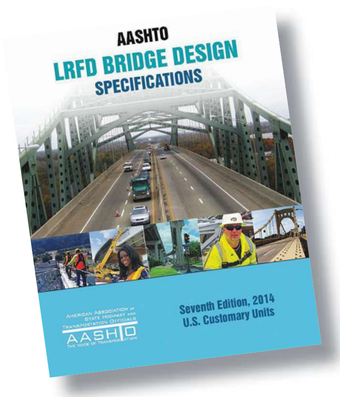
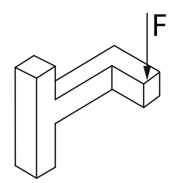
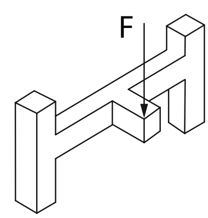
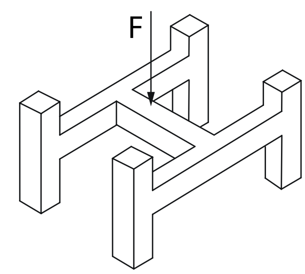


Table 1. Categorization of torsion. Note: N/A = not applicable. Figure: Dennis Mertz.

Structural Determinacy	Torsion Category	
	Equilibrium	Compatibility
Statically Determinate		N/A
Statically Indeterminate		

Beam regions (B-regions), where it is appropriate to assume that plane sections remain plane after loading, may be designed for shear and torsion using either the sectional modified compression-field theory (MCFT) resistance model or the strut-and-tie method (STM). Disturbed regions (D-regions) where the plane-sections-remain-plane assumption of flexural theory is not valid should be designed for shear and torsion using the STM.

B-region theory assumes that the resistance at a particular section depends only on the calculated values of the sectional force effects—that is, moment, shear, axial load, and torsion—and does not consider the specific details of how the force effects are introduced into the member. The STM recognizes the significance of how the loads are introduced into a D-region and how that region is supported. It is applicable to both B- and D-regions, but it is not practical to apply the STM to B-regions.

As the STM used for D-regions proportions and details members without an explicit treatment of moment, shear, torsion or thrust, it will not be discussed further herein. (See my column in the Winter 2011 issue of *ASPIRE*™.)

Sections that are designed for live loads using the distribution-factor methods for beam-slab bridges are not typically investigated for torsion.

Torsion is often categorized as either compatibility or equilibrium torsion as illustrated in Table 1. Equilibrium torsion is required for stable equilibrium by the topology of the structure and must be addressed in the design. All torsion in a statically determinant structure is equilibrium torsion. Torsion in a statically indeterminate structure may be either compatibility or equilibrium torsion. Torsion that results from rotational restraint, but which is not required to keep the applied loads in stable equilibrium because other load paths exist to support the loads, is called compatibility torsion. It is not necessary to design for compatibility torsion as long as the other load paths are properly designed for the redistributed forces. Consideration should be given to aesthetic issues that arise from cracking associated with not designing for compatibility torsion.

Thus, in a statically indeterminate structure where significant reduction of torsional moment in a member can occur due to redistribution of internal forces upon cracking, the applied factored torsional moment at a section T_u may be reduced to ϕT_{cr} provided that moments and forces in the member and adjoining members are adjusted to account for the redistribution.

If the factored torsional moment T_u is less than or equal to 25% of the factored pure torsional cracking moment, only a very small reduction in shear capacity or flexural capacity will occur and, hence, can be neglected. Further, equations for the torsional cracking moment for solid and hollow sections are specified.

The nominal torsional resistance is taken as:

$$T_n = \frac{2A_0 A_t f_y \cot\theta}{s}$$

with the familiar variables used for shear resistance with the addition of A_0, the area enclosed by the shear-flow path.

The topic of combined shear and torsion will be discussed in a future column.