CODE

9.5.4.3 Longitudinal and transverse reinforcement required for torsion shall be added to that required for the V_u, M_u, and P_u that act in combination with the torsion.

COMMENTARY

R9.5.4.3 The requirements for torsional reinforcement and shear reinforcement are added and stirrups are provided to supply at least the total amount required. Because the reinforcement area A_v for shear is defined in terms of all the legs of a given stirrup while the reinforcement area A_t for torsion is defined in terms of one leg only, the addition of transverse reinforcement area is calculated as follows:

$$\text{Total}\left(\frac{A_{v+t}}{s}\right) = \frac{A_v}{s} + 2\frac{A_t}{s} \qquad \text{(R9.5.4.3)}$$

If a stirrup group has more than two legs for shear, only the legs adjacent to the sides of the beam are included in this summation because the inner legs would be ineffective for resisting torsion.

The longitudinal reinforcement required for torsion is added at each section to the longitudinal reinforcement required for bending moment that acts concurrently with the torsion. The longitudinal reinforcement is then chosen for this sum, but should not be less than the amount required for the maximum bending moment at that section if this exceeds the moment acting concurrently with the torsion. If the maximum bending moment occurs at one section, such as midspan, while the maximum torsional moment occurs at another, such as the face of the support, the total longitudinal reinforcement required may be less than that obtained by adding the maximum flexural reinforcement, plus the maximum torsional reinforcement. In such a case, the required longitudinal reinforcement is evaluated at several locations.

9.5.4.4 For prestressed beams, the total area of longitudinal reinforcement, A_s and A_{ps}, at each section shall be designed to resist M_u at that section, plus an additional concentric longitudinal tensile force equal to $A_\ell f_y$, based on T_u at that section.

R9.5.4.4 Torsion causes an axial tensile force in the longitudinal reinforcement balanced by the force in the diagonal concrete compression struts. In a nonprestressed beam, the tensile force must be resisted by longitudinal reinforcement having an axial tensile strength of $A_\ell f_y$. This reinforcement is in addition to the required flexural reinforcement and is distributed uniformly inside and around the perimeter of the closed transverse reinforcement so that the resultant of $A_\ell f_y$ acts along the axis of the member.

In a prestressed beam, the same approach (providing additional reinforcing bars with strength $A_\ell f_y$) may be followed, or overstrength of the prestressed reinforcement can be used to resist some of the axial force $A_\ell f_y$. The stress in the prestressed reinforcement at nominal strength will be between f_{se} and f_{ps}. A portion of the $A_\ell f_y$ force can be resisted by a force of $A_{ps}\Delta f_{pt}$ in the prestressed reinforcement. The stress required to resist the bending moment can be calculated as $M_u/(\phi 0.9 d_p A_{ps})$. For pretensioned strands, the stress that can be developed near the free end of the strand can be calculated using the procedure illustrated in Fig. R25.4.8.3.

9.5.4.5 It shall be permitted to reduce the area of longitudinal torsional reinforcement in the flexural compression

R9.5.4.5 The longitudinal tension due to torsion is offset in part by the compression in the flexural compression zone,