CODE

Table 23.9.2—Nodal zone coefficient β_n

Configuration of nodal zone	β_n	
Nodal zone bounded by struts, bearing areas, or both	1.0	(a)
Nodal zone anchoring one tie	0.80	(b)
Nodal zone anchoring two or more ties	0.60	(c)

23.9.3 If confining reinforcement is provided within the nodal zone and its effect is documented by tests and analyses, it shall be permitted to use an increased value of f_{ce} when calculating F_{nn}.

23.9.4 The area of each face of a nodal zone, A_{nz}, shall be taken as the smaller of (a) and (b):

(a) Area of the face of the nodal zone perpendicular to the line of action of F_{us}

(b) Area of a section through the nodal zone perpendicular to the line of action of the resultant force on the section

23.9.5 In a three-dimensional strut-and-tie model, the area of each face of a nodal zone shall be at least that given in 23.9.4, and the shape of each face of the nodal zone shall be similar to the shape of the projection of the end of the strut onto the corresponding face of the nodal zone.

23.10—Curved-bar nodes

23.10.1 Curved-bar nodes shall be designed and detailed in accordance with this section.

23.10.2 If specified clear cover normal to plane of bend is $2d_b$ or greater, the bend radius r_b shall be in accordance with (a) or (b), but shall not be less than half the minimum bend diameter specified in 25.3.

(a) Curved bar nodes with bends less than 180 degrees:

$$r_b \geq \frac{2A_{ts}f_y}{b_s f_c'} \quad (23.10.2a)$$

(b) Ties anchored by 180-degree bends:

$$r_b \geq \frac{1.5A_{ts}f_y}{w_t f_c'} \quad (23.10.2b)$$

COMMENTARY

As described in R23.4.3, β_c accounts for the effect of concrete confinement on the effective compressive strength of a node containing a bearing surface. β_c is the same for the node as for the node-strut interface.

R23.9.4 If the stresses in all the struts meeting at a node are equal, a hydrostatic nodal zone can be used. The faces of such a nodal zone are perpendicular to the axes of the struts, and the widths of the faces of the nodal zone are proportional to the forces in the struts.

Stresses on nodal faces that are perpendicular to the axes of struts and ties are principal stresses, and 23.9.4(a) is used. If, as shown in Fig. R23.2.6b(ii), the face of a nodal zone is not perpendicular to the axis of the strut, there will be both shear stresses and normal stresses on the face of the nodal zone. Typically, these stresses are replaced by the normal (principal compressive) stress acting on the cross-sectional area, A_{nz}, of the strut, taken perpendicular to the axis of the strut as given in 23.9.4(a).

R23.10—Curved-bar nodes

R23.10.1 A curved-bar node is formed by the bend region of a continuous reinforcing bar (or bars) where two ties extending from the bend region are intersected by a strut or the resultant of two or more struts (Fig. R23.10.5), or where a single tie is anchored by a 180-degree bend (Fig. R23.10.2).

R23.10.2 Equation (23.10.2a) is intended to avoid f_{ce} exceeding the limit for C-T-T nodes given by 23.9.2 (Klein 2008). b_s is the width of the strut transverse to the plane of the strut-and-tie model. Equation (23.10.2a) applies whether the tie forces at the node are equal or different; where the tie forces are different, ℓ_{cb} required by 23.10.6 must also be satisfied.

Ties anchored by 180-degree bends can be used at C-C-T nodes, as illustrated in Fig. R23.10.2. The parallel straight legs of the bar(s) that extend into the member form a single tie. Equation (23.10.2b) is intended to ensure that f_{ce} does not exceed the limit for C-C-T nodes given by 23.9.2. Width w_t is the effective tie width as illustrated in Fig. R23.10.2.