CODE

(a) Length calculated in accordance with 25.4.2.3 or 25.4.2.4 using the applicable modification factors of 25.4.2.5

(b) 300 mm

25.4.2.2 For bars with $f_y \geq$ **550 MPa** spaced closer than 150 mm on center, transverse reinforcement shall be provided such that K_{tr} shall not be smaller than $\mathbf{0.5}d_b$.

25.4.2.3 For deformed bars or deformed wires, ℓ_d shall be calculated in accordance with Table 25.4.2.3.

Table 25.4.2.3—Development length for deformed bars and deformed wires in tension

Spacing and cover	No. 19 and smaller bars and deformed wires	No. 22 and larger bars
Clear spacing of bars or wires being developed or lap spliced not less than d_b, clear cover at least d_b, and stirrups or ties throughout ℓ_d not less than the Code minimum or Clear spacing of bars or wires being developed or lap spliced at least $2d_b$ and clear cover at least d_b	$\left(\dfrac{f_y\psi_t\psi_e\psi_g}{2.1\lambda\sqrt{f_c'}}\right)d_b$	$\left(\dfrac{f_y\psi_t\psi_e\psi_g}{1.7\lambda\sqrt{f_c'}}\right)d_b$
Other cases	$\left(\dfrac{f_y\psi_t\psi_e\psi_g}{1.4\lambda\sqrt{f_c'}}\right)d_b$	$\left(\dfrac{f_y\psi_t\psi_e\psi_g}{1.1\lambda\sqrt{f_c'}}\right)d_b$

COMMENTARY

based on the expression previously endorsed by ACI 408.1R. In Table 25.4.2.3, ℓ_d is based on two preselected values of $(c_b + K_{tr})/d_b$, whereas ℓ_d from Eq. (25.4.2.4a) is based on the actual $(c_b + K_{tr})/d_b$.

Although there is no requirement for transverse reinforcement along the tension development or lap splice length, research (Azizinamini et al. 1999a,b) indicates that in concrete with very high compressive strength, brittle anchorage failure may occur for bars with inadequate transverse reinforcement. In lap splice tests of No. 25 and No. 36 bars in concrete with an f_c' of approximately 105 MPa, transverse reinforcement improved ductile anchorage behavior.

R25.4.2.3 This provision recognizes that many current practical construction cases use spacing and cover values along with confining reinforcement, such as stirrups or ties, that result in a value of $(c_b + K_{tr})/d_b$ of at least 1.5. Examples include a minimum clear cover of d_b along with either minimum clear spacing of $2d_b$, or a combination of minimum clear spacing of d_b and minimum ties or stirrups. For these frequently occurring cases, the development length for larger bars can be taken as $\ell_d = [f_y\psi_t\psi_e\psi_g/(1.7\lambda\sqrt{f_c'})]d_b$. In the formulation of the provisions in ACI 318-95, a comparison with past provisions and a check of a database of experimental results maintained by ACI 408.1R indicated that for No. 19 deformed bars and smaller, as well as for deformed wire, the development lengths could be reduced 20 percent using $\psi_s = \mathbf{0.8}$. This is the basis for the *No. 19 and smaller bars and deformed wires* column of Table 25.4.2.3. With less cover and in the absence of minimum ties or stirrups, the minimum clear spacing limits of 25.2.1 and the minimum concrete cover requirements of 20.5.1.3 result in minimum values of c_b equal to d_b. Thus, for "other cases," the values are based on using $(c_b + K_{tr})/d_b = \mathbf{1.0}$ in Eq. (25.4.2.4a).

The user may easily construct simple, useful expressions. For example, in all members with normalweight concrete ($\lambda = \mathbf{1.0}$), uncoated reinforcement ($\psi_e = \mathbf{1.0}$), No. 22 and larger bottom bars ($\psi_t = \mathbf{1.0}$) with $f_c' =$ **28 MPa**, and Grade 420 reinforcement ($\psi_g = \mathbf{1.0}$), the expressions reduce to

$$\ell_d = \frac{(420)(1.0)(1.0)(1.0)}{1.7(1.0)\sqrt{28}}d_b = 47d_b$$

or

$$\ell_d = \frac{(420)(1.0)(1.0)(1.0)}{1.1(1.0)\sqrt{28}}d_b = 72d_b$$

Thus, as long as minimum cover of d_b is provided along with a minimum clear spacing of $2d_b$, or a minimum clear