

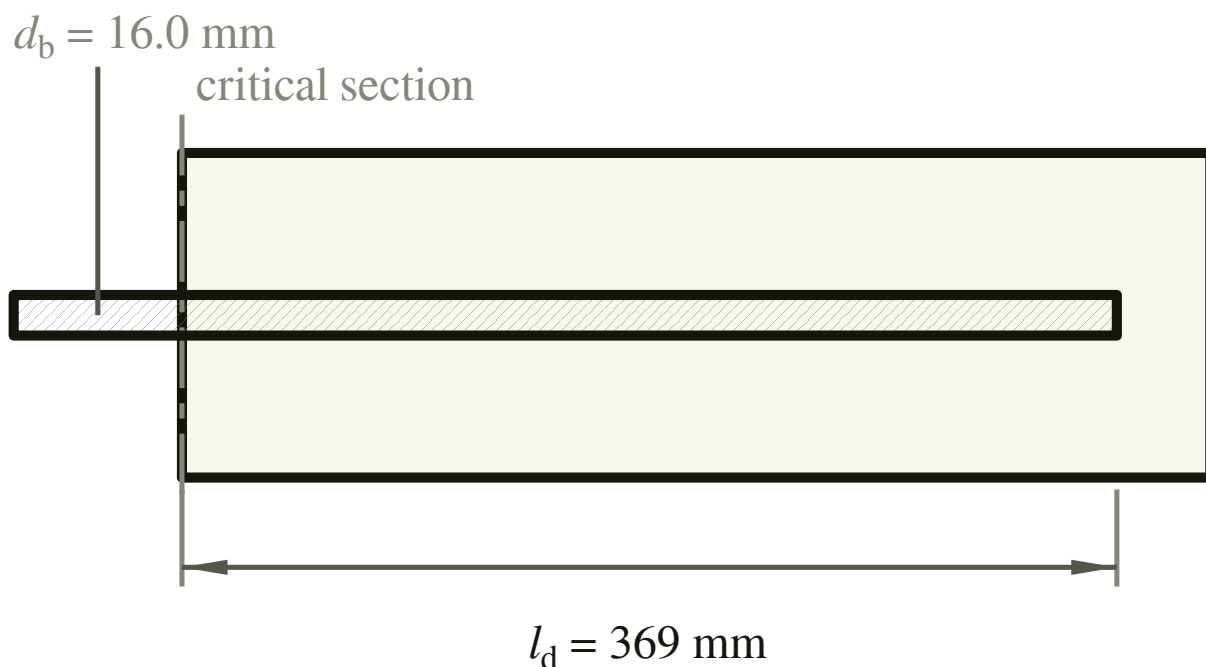
Tension development length

Development length of a straight reinforcing bar in tension, to CSA A23.3-24 Cl. 12.2.

Inputs

Symbol	Value	Unit	Description
f_c	25	MPa	Concrete compressive strength
f_y	400	MPa	Specified yield strength, f_{yg}
c_c	40	mm	Clear cover to the bar
s_c	100	mm	Clear spacing between bars being developed
A_{tr}	200	mm ²	Transverse steel crossing the splitting plane
s	150	mm	Spacing of the transverse reinforcement
n	2		Number of bars being developed
$A_{s, \text{ratio}}$	1		A_s required over provided, Cl. 12.2.5
rebar	15M		Bar size
horiz _{reinf}	No		Horizontal bar, over 300 mm of concrete cast below
coating	Uncoated reinforcement		Bar coating
conc _{density}	Normal-density concrete		Concrete density
min _{ties}	No		Minimum ties or stirrups throughout l_d
bundle	Single bar		Bundled bars, Cl. 12.2.7

Figures



Straight bar embedded past the critical section, drawn from the values above.

Results

Quantity	Description	Value	Unit
l_d	Development length required in tension	368.6	mm
$l_{d,\text{general}}$	General expression, Eq. 12.1	368.6	mm
$l_{d,\text{simplified}}$	Simplified expression, Table 12.1, where Cl. 12.2.3 allows it	460.8	mm

Derivation

$$d_b = 16 \text{ mm}$$

Bar diameter | 15M

$$k_l = 1$$

Other bar location | Table 12.2

$$k_c = 1$$

Uncoated | Table 12.2

$$k_d = 1$$

Normal-density concrete | Table 12.2

$$k_s = 0.8$$

20M and smaller | Table 12.2

Branch: $f_y \leq 400 \text{ MPa}$ held

$$k_g = 1$$

Yield strength up to 400 MPa | Table 12.2

$$\begin{aligned} k_{lc} &= \min(k_l \cdot k_c, 1.7) \\ &= \min(1 \cdot 1, 1.7) \\ &= 1 \end{aligned}$$

Table 12.2, note 1

$$\begin{aligned}
 d_{cs} &= \min \left(c_c + \frac{d_b}{2}, \frac{2}{3} \cdot (s_c + d_b) \right) && \text{Cl. 3.2, } d_{cs} \\
 &= \min \left(40 \text{ mm} + \frac{16 \text{ mm}}{2}, \frac{2}{3} \cdot (100 \text{ mm} + 16 \text{ mm}) \right) \\
 &= 48 \text{ mm}
 \end{aligned}$$

Branch: $s < 12 \cdot d_b$ held

$$\begin{aligned}
 K_{tr} &= \frac{40 \cdot A_{tr}}{s \cdot n} && \text{Cl. 12.2.2} \\
 &= \frac{40 \cdot 200 \text{ mm}^2}{150 \text{ mm} \cdot 2} \\
 &= 26.67 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 l_{d,\text{general}} &= 0.9 \cdot \frac{k_{lc} \cdot k_d \cdot k_s \cdot k_g}{\frac{\min(d_{cs} + K_{tr}, 2.5 \cdot d_b)}{d_b}} \cdot \frac{f_y}{\min(\sqrt{f_c} \cdot 1 \text{ MPa}, 8 \text{ MPa})} \cdot d_b \\
 &\quad \text{Cl. 12.2.2, Eq. 12.1, with the 8 MPa cap of Cl. 12.1.2} \\
 &= 0.9 \cdot \frac{1 \cdot 1 \cdot 0.8 \cdot 1}{\frac{\min(48 \text{ mm} + 26.67 \text{ mm}, 2.5 \cdot 16 \text{ mm})}{16 \text{ mm}}} \cdot \frac{400 \text{ MPa}}{\min(\sqrt{25 \text{ MPa}} \cdot 1 \text{ MPa}, 8 \text{ MPa})} \cdot 16 \text{ mm} \\
 &= 368.6 \text{ mm}
 \end{aligned}$$

Branch: $c_c \geq d_b$ and $s_c \geq 1.4 \cdot d_b$ held

Branch: $s_c \geq 2 \cdot d_b$ and $c_c \geq 1.5 \cdot d_b$ held

$$\begin{aligned}
 l_{d,\text{simplified}} &= 0.45 \cdot k_{lc} \cdot k_d \cdot k_s \cdot k_g \cdot \frac{f_y}{\min(\sqrt{f_c} \cdot 1 \text{ MPa}, 8 \text{ MPa})} \cdot d_b \\
 &\quad \text{Table 12.1, with the 8 MPa cap of Cl. 12.1.2} \\
 &= 0.45 \cdot 1 \cdot 1 \cdot 0.8 \cdot 1 \cdot \frac{400 \text{ MPa}}{\min(\sqrt{25 \text{ MPa}} \cdot 1 \text{ MPa}, 8 \text{ MPa})} \cdot 16 \text{ mm} \\
 &= 460.8 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 l_{d,\text{single}} &= \max(\min(l_{d,\text{general}}, l_{d,\text{simplified}}) \cdot A_{s,\text{ratio}}, 300 \text{ mm}) && \text{Cl. 12.2.1 and 12.2.5} \\
 &= \max(\min(368.6 \text{ mm}, 460.8 \text{ mm}) \cdot 1, 300 \text{ mm}) \\
 &= 368.6 \text{ mm}
 \end{aligned}$$

$$k_{\text{bundle}} = 1$$

Single bar | Cl. 12.2.7

$$\begin{aligned}l_d &= l_{d,\text{single}} \cdot k_{\text{bundle}} && \text{Cl. 12.2.7} \\&= 368.6 \text{ mm} \cdot 1 \\&= 368.6 \text{ mm}\end{aligned}$$