Now Design According to ACI-318-19 Code

# DETERMINING THE PROPER DEVELOPMENT LENGTH FOR LAP SPLICING HIGH STRENGTH "GRADE 100 CHROMX STEEL" AS PER ACI 318-19

The process for determining the development length of ChromX steel conforming to ASTM A1035/A1035M design strength at 100 ksi is in accordance to the requirements of ACI 318-19 section 25.4.2.1.

25.4.1.4 The values of $\sqrt{(f_c')}$ used to calculate development length shall not exceed 100 psi.

25.4.2.1 The development length $\ell_d$ for deformed bars and deformed wires in tension shall be the greater of (a) and (b):

(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) 12 in.

R25.4.2.1 This provision gives a two-tier approach for the calculation of tension development length. The user can either use the simplified provisions of 25.4.2.3 or the general length equation (Eq. (25.4.2.4a)), which is based on the expression previously endorsed by ACI 408.1R.

In Table 25.4.2.3, ℓd is based on two preselected values of $(c_b + K_{tr})/d_b$, whereas ℓd from Eq. (25.4.2.4a) is based on the actual $(c_b + K_{tr})/d_b$.

Additional requirements are imposed when designing with 100 ksi design strength when the bars are spaced closer than 6 in. on center, transverse reinforcement shall be provided such that $K_{tr}$ shall not be smaller than 0.5 $d_b$.

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

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 ℓd not less than the Code minimum OR Clear spacing of bars or wires being developed or lap spliced at least 2db and clear cover at least $d_b$

For #3, #4, #5 and #6 the development length is $\left(\frac{f_y \Psi_t \Psi_e \Psi_g}{25\lambda\sqrt{f_c'}}\right) d_b$

For #7 and larger bars the development length is $\left(\frac{f_y \Psi_t \Psi_e \Psi_g}{20\lambda\sqrt{f_c'}}\right) d_b$

25.4.2.4 For deformed bars or deformed wires, ℓd shall be calculated by:

$$\ell_d = \left( \frac{3}{40} \frac{f_y}{\lambda\sqrt{f_c'}} \frac{\Psi_t \Psi_e \Psi_s \Psi_g}{\left(\frac{c_b + K_{tr}}{d_b}\right)} \right) d_b \qquad (25.4.2.4a)$$

in which the confinement term $(c_b + K_{tr})/d_b$ shall not exceed 2.5, and

$$K_{tr} = \frac{40A_{tr}}{sn} \qquad (25.4.2.4b)$$

where n is the number of bars or wires being developed or lap spliced along the plane of splitting. It shall be permitted to use $K_{tr} = 0$ as a design simplification even if transverse reinforcement is present or required

25.4.2.5 For the calculation of ℓd, modification factors shall be in accordance with Table 25.4.2.5.

## Typical Development Length with a minimum clear cover of 2 in. according to ACI 318-19 section 25.4.2.4

| | Concrete Compressive Strength (psi)* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bar Size | 3,000 | 4,000 | 5,000 | 6,000 | 7,000 | 8,000 | 9,000 | 10,000 | 11,000 | 12,000 | 14,000 | 16,000 |
| 3 | 21 | 18 | 17 | 15 | 14 | 13 | 12 | 12 | 12 | 12 | 12 | 12 |
| 4 | 28 | 25 | 22 | 20 | 29 | 17 | 16 | 16 | 16 | 16 | 16 | 16 |
| 5 | 36 | 31 | 28 | 25 | 23 | 22 | 21 | 20 | 20 | 20 | 20 | 20 |
| 6 | 43 | 37 | 33 | 30 | 28 | 26 | 25 | 23 | 23 | 23 | 23 | 23 |
| 7 | 62 | 54 | 48 | 44 | 41 | 38 | 36 | 34 | 34 | 34 | 34 | 34 |
| 8 | 71 | 62 | 55 | 50 | 47 | 44 | 41 | 39 | 39 | 39 | 39 | 39 |
| 9 | 80 | 70 | 62 | 57 | 53 | 49 | 46 | 44 | 44 | 44 | 44 | 44 |
| 10 | 90 | 78 | 70 | 64 | 59 | 55 | 52 | 50 | 50 | 50 | 50 | 50 |
| 11 | 100 | 87 | 78 | 71 | 66 | 61 | 58 | 55 | 55 | 55 | 55 | 55 |

*The table calculations are based on a specific design criteria for illustrative purposes. The design engineer of record is responsible for applying the development length formula to the given design per ACI 318-19.

Modification Factors used in the example

Reinforcement grade factor $\psi_g = 1.3$ for Grade 100

Lightweight, $\lambda = 1.0$ for Normal concrete

Epoxy Factor, $\psi_e = 1.0$

Size Factor, $\psi_s = 0.8$ for Sizes #3 through #6,

Size Factor, $\psi_s = 1.0$ for sizes #7 and larger

Casting position, $\psi t = 1.0$

$A_{tr}$ = total cross-sectional area of all transverse reinforcement within spacing s, that crosses the potential plane of splitting through the reinforcement being developed, $in^2$

$c_b$ = lesser of: (a) the distance from center of a bar or wire to nearest concrete surface, and (b) one-half the center-to-center spacing of bars or wires being developed, in.

$d_b$ = nominal diameter of bar, in.

ℓd = development length in tension of deformed bar, in.

$K_{tr}$ = transverse reinforcement index, in.

s = center-to-center spacing of items, such as longitudinal reinforcement, transverse reinforcement, in.

$f_c'$ = specified compressive strength of concrete, psi

$f_y$ = specified yield strength for nonprestressed reinforcement, psi

MMFX® TECHNOLOGIES
A COMMERCIAL METALS COMPANY

11444 East Germann Rd., Mesa, AZ 85212
Phone: 480.396.7124 Toll Free: 866.466.7878
www.cmc.com/chromx