Single Studs, No Edge Effects per ACI 349-2R-89 / 1994

Cautionary Note

Derived from Klingner in ACI SJ 93 1 p.132) (to get the usual confidence of 95%) you will need an additional safety factor for anchorages of 2, that is, if you usually for forces amplify by 1.7, for anchors extra amplify multiplying again by 2 to get 3.4. You **need** this 3.4 load factor to get the proper level of 95% confidence using $\phi_p := 0.65$ pullout strength reduction factor and $\phi_y := 0.9$ steel strength reduction factor .

$f_c := 25 \cdot MPa$ specified strength $f_y := 500 \cdot MPa$ yield $f_{ut} := 600 \cdot MPa$ rupture stud data

plates assumed not protruding from concrete

$\phi := 0.9$ steel tension strength reduction factor $\phi_p := 0.65$ pullout cone shear strength reduction factor (preferably don't change)

A1. Single Stud, Tension Loading, Optimum Design

$P_u := 32000 \cdot lbf$ factored load cone assumed concentric at 45° and no reduction from cone interception $b_{p\_min} := 4 \cdot in$ minimum width of plate

$d_b := 20 \cdot mm$ $l_d := 20 \cdot cm$ $d_h := 4 \cdot cm$ $t_h := 1 \cdot cm$ $t_p := 1 \cdot cm$ $b_p := 12 \cdot cm$ unwarranted guesses

$$V(d_b, l_d, d_h, t_h, t_p, b_p) := \pi \cdot \frac{d_b^2}{4} \cdot l_d + \pi \cdot \frac{d_h^2}{4} \cdot t_h + b_p^2 \cdot t_p$$

Given

$$P_u \le \pi \cdot \frac{d_b^2}{4} \cdot f_{ds} \qquad d_h^2 \ge 2.5 d_b^2 \qquad t_h \ge \frac{d_h - d_b}{2} \qquad 4 \cdot \phi_p \cdot \sqrt{\frac{f_c}{psi}} \cdot psi \cdot \pi \cdot \left[\left(l_d + t_p + \frac{d_h}{2} \right)^2 - \left(\frac{d_h}{2} \right)^2 \right] \ge \pi \cdot \frac{d_b^2}{4} \cdot f_{ut}$$

$$t_p > \frac{d_b}{2.7} \qquad b_p > b_{p\_min} \qquad t_p > \frac{0.4 \cdot b_p}{4}$$

$$\begin{pmatrix} d_b \\ l_d \\ d_h \\ t_h \\ t_p \\ b_p \end{pmatrix} := \text{Minimize}\left(V, d_b, l_d, d_h, t_h, t_p, b_p\right)$$

$$\begin{pmatrix} d_b \\ l_d \\ d_h \\ t_h \\ t_p \\ b_p \end{pmatrix} = \begin{pmatrix} 0.79 \\ 8.31 \\ 1.25 \\ 0.23 \\ 0.4 \\ 4 \end{pmatrix} \text{in}$$

minimum diameter of stem

minimum length of stem

minimum diameter of head (nut or bolt)

minimum thickness of head (nut or bolt)

minimum plate thickness

width of plate