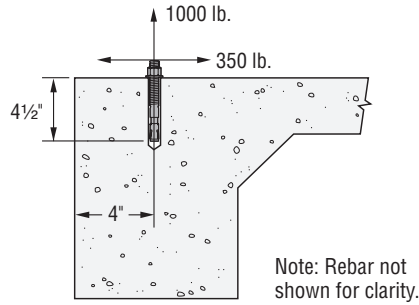


EXAMPLE CALCULATION *Mechanical Anchors (ACI 318 App. D/ICC-ES AC193)*

Example calculation for a single Strong-Bolt™ anchor using USD:

Determine if a single 1/2" diameter Strong-Bolt™ torque-controlled expansion anchor with a minimum 5" embedment ($h_{ef} = 4\frac{1}{2}$ inches) installed 4" from the edge of a 12" deep spandrel beam is adequate for a service tension load of 1,000 lb. for wind and a reversible service shear load of 350 lb. for wind. The anchor will be in the tension zone, away from other anchors in $f'_c = 3,000$ psi normal-weight concrete.

Reference the appropriate tables in this catalog for Strong-Bolt anchor performance values as determined from testing in accordance with ACI 355.2 and ICC-ES AC193.



Calculations and Discussion

REFERENCE

Note: Calculations are performed in accordance with ACI 318-05.

- Determine the factored tension and shear design loads:

ACI 318, 9.2.1

$$N_{UA} = 1.6W = 1.6 \times 1,000 = 1,600 \text{ lb.}$$

$$V_{UA} = 1.6W = 1.6 \times 350 = 560 \text{ lb.}$$

- Design considerations:

D.4.1.2

This is a combined tension and shear interaction problem where values for both ϕN_n and ϕV_n need to be determined. ϕN_n is the lesser of the design tension strength controlled by: steel (ϕN_{sa}), concrete breakout (ϕN_{cb}), or pull-out (ϕN_{pn}). ϕV_n is the lesser of the design shear strength controlled by: steel (ϕV_{sa}), concrete breakout (ϕV_{cb}), or pryout (ϕV_{cp}).

- Steel capacity under tension Loading:

D.5.1

$$\phi N_{sa} \geq N_{UA}$$

Eq. (D-1)

$$N_{sa} = 13,500 \text{ lb.}$$

This catalog

$$\phi = 0.75$$

This catalog

$$n = 1 \text{ (single anchor)}$$

Calculating for ϕN_{sa} :

$$\phi N_{sa} = 0.75 \times 1 \times 13,500 = 10,125 \text{ lb.} > 1,600 \text{ lb.} - \text{OK}$$

∴ 1/2 in. diameter anchor is adequate

Calculations and Discussion

REFERENCE

- Concrete breakout capacity under tension loading:

D.5.2

$$\phi N_{cb} \geq N_{UA}$$

Eq. (D-1)

$$N_{cb} = \frac{A_{Nc}}{A_{Nco}} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b$$

Eq. (D-4);

where:

$$N_b = k_c \sqrt{f'_c} h_{ef}^{1.5}$$

Eq. (D-7)

substituting:

$$\phi N_{cb} = \phi \frac{A_{Nc}}{A_{Nco}} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} k_c \sqrt{f'_c} h_{ef}^{1.5}$$

where:

$$k_c = k_{cr} = 17$$

This catalog

(Anchor is installed in a tension zone, therefore, cracking is assumed at service loads)

$$\Psi_{cp,N} = 1.0$$

D.5.2.7

$$\Psi_{ed,N} = 0.7 + 0.3 \frac{c_{a,min}}{1.5h_{ef}} \text{ when } c_{a,min} < 1.5h_{ef}$$

Eq. (D-11)

by observation, $c_{a,min} = 4 < 1.5h_{ef}$

$$\Psi_{ed,N} = 0.7 + 0.3 \frac{(4)}{1.5(4.5)} = 0.88$$

$\Psi_{c,N} = 1.0$ assuming cracking at service loads ($f_t > f_r$)

D.5.2.6

$\phi = 0.65$ for Condition B (no supplementary reinforcement provided)

This catalog

$$A_{Nco} = 9h_{ef}^2 = 9(4.5)^2 = 182.25 \text{ in.}^2$$

Eq. (D-6)

$$A_{Nc} = (c_{a1} + 1.5h_{ef})(2 \times 1.5h_{ef}) = (4 + 1.5(4.5))(2 \times 1.5(4.5)) = 145.13 \text{ in.}^2$$

Fig. RD.5.2.1(a)

$$\frac{A_{Nc}}{A_{Nco}} = \frac{145.13}{182.25} = 0.8$$

Calculating for ϕN_{cb} :

$$\phi N_{cb} = 0.65 \times 0.8 \times 1.0 \times 0.88 \times 1.0 \times 17 \times$$

$$\sqrt{3,000} \times (4.5)^{1.5} = 4,067 \text{ lb.} > 1,600 \text{ lb.} - \text{OK}$$

Would you like help with these calculations?
Visit www.simpsonanchors.com to download the
Simpson Strong-Tie® Anchor Designer™ software.



EXAMPLE CALCULATION *Mechanical Anchors (ACI 318 App. D/ICC-ES AC193)*

Continued from previous page.

CALCULATIONS AND DISCUSSION **REFERENCE**

5. Pullout capacity: *D.5.3*

Pullout capacity, $N_{pn,cr}$, is established by reference tests in cracked concrete by the reliability test of ACI 355.2. Data from the anchor prequalification testing must be used. Reference Strong-Bolt™ anchor "characteristic tension design values" table for the 5 percent fractile value, $N_{pn,cr}$.

$$\phi N_{pn} \geq N_{ua} \quad \text{Eq. (D-1)}$$

$$N_{pn,cr} = 2,995 \times \left(\frac{3,000}{2,500}\right)^{0.5} = 3,281 \text{ lb.} \quad \text{This catalog}$$

$$\phi = 0.65 \quad \text{This catalog}$$

$$\phi N_{pn} = 0.65 \times 3,281 = 2,133 \text{ lb.} > 1,600 \text{ lb.} - \text{OK}$$

6. Check all failure modes under tension loading: *D.4.1.2*

Summary:

$$\text{Steel capacity} = 10,125 \text{ lb.}$$

$$\text{Concrete breakout capacity} = 4,067 \text{ lb.}$$

$$\text{Pullout capacity} = 2,133 \text{ lb.} \leftarrow \text{Controls}$$

$\therefore \phi N_n = 2,133 \text{ lb.}$ as pullout capacity controls

7. Steel capacity under shear loading: *D.6.1*

$$\phi V_{sa} \geq V_{ua} \quad \text{Eq. (D-2)}$$

$$V_{sa} = 6,560 \text{ lb.} \quad \text{This catalog}$$

$$\phi = 0.65 \quad \text{This catalog}$$

Calculating for ϕV_{sa} :

$$\phi V_{sa} = 0.65 \times 6,560 = 4,264 \text{ lb.} > 560 \text{ lb.} - \text{OK}$$

\therefore 1/2 in. diameter anchor is adequate

8. Concrete breakout capacity under shear loading: *D.6.2*

$$\phi V_{cb} \geq V_{ua} \quad \text{Eq. (D-2)}$$

$$V_{cb} = \frac{A_{VC}}{A_{VCO}} \Psi_{ed,V} \Psi_{c,V} V_b \quad \text{Eq. (D-21)}$$

where:

$$V_b = 7 \left(\frac{\ell_e}{d_o}\right)^{0.2} \sqrt{d_o} \sqrt{f'_c} c_{a1}^{1.5} \quad \text{Eq. (D-24)}$$

substituting:

$$\phi V_{cb} = \phi \frac{A_{VC}}{A_{VCO}} \Psi_{ed,V} \Psi_{c,V} 7 \left(\frac{\ell_e}{d_o}\right)^{0.2} \sqrt{d_o} \sqrt{f'_c} c_{a1}^{1.5}$$

where:

$$\phi = 0.70 \text{ for Condition B} \quad \text{D4.4(c)(i)}$$

(no supplementary reinforcement provided)

$$A_{VCO} = 4.5c_{a1}^2 \quad \text{Eq. (D-23)}$$

$$= 4.5(4)^2$$

$$\therefore A_{VCO} = 72 \text{ in.}^2$$

$$A_{VC} = 2(1.5c_{a1})(1.5c_{a1}) \quad \text{Fig. RD.6.2.1(a)}$$

$$= 2(1.5(4))(1.5(4))$$

$$\therefore A_{VC} = 72 \text{ in.}^2$$

$$\frac{A_{VC}}{A_{VCO}} = \frac{72}{72} = 1 \quad \text{D.6.2.1}$$

$$\Psi_{ed,V} = 1.0 \text{ since } c_{a2} > 1.5c_{a1} \quad \text{Eq. (D-27)}$$

$$\Psi_{c,V} = 1.0 \text{ assuming cracking} \quad \text{D.6.2.7}$$

at service loads ($f_t > f_r$)

$$d_o = 0.5 \text{ in.}$$

$$\ell_e = 8d_o = 8(0.5) = 4" \quad \text{D.6.2.2}$$

$$c_{a1} = 4 \text{ in.}$$

$$\phi V_{cb} = 0.70 \times 1 \times 1.0 \times 1.0 \times 7 \times \left(\frac{4}{0.5}\right)^{0.2} \times \sqrt{0.5}$$

$$\times \sqrt{3,000} \times (4)^{1.5} = 2,301 \text{ lb.} > 560 \text{ lb.} - \text{OK}$$

CALCULATIONS AND DISCUSSION **REFERENCE**

9. Concrete pryout strength: *D.6.3*

$$\phi n V_{cp} \geq V_{ua} \quad \text{Eq. (D-2)}$$

$$V_{cp} = k_{cp} N_{cb} \quad \text{Eq. (D-29)}$$

where:

$$n = 1$$

$$k_{cp} = 2.0 \text{ and } \phi = 0.70 \quad \text{This catalog}$$

$$k_{cp} N_{cb} = 2.0 \times \frac{4,067}{0.65} = 12,514 \text{ lb.} \quad \text{D.6.3.1}$$

$$\phi n V_{cp} = 0.70 \times 1 \times 12,514 = 8,760 \text{ lb.} > 560 \text{ lb.} - \text{OK}$$

10. Check all failure modes under shear Loading: *D.4.1.2*

Summary:

$$\text{Steel capacity} = 4,264 \text{ lb.}$$

$$\text{Concrete breakout capacity} = 2,301 \text{ lb.} \leftarrow \text{Controls}$$

$$\text{Pryout capacity} = 8,760 \text{ lb.}$$

$\therefore \phi V_n = 2,301 \text{ lb.}$ as concrete breakout capacity controls

11. Check interaction of tension and shear forces: *D.7*

If $0.2 \phi V_n \geq V_{ua}$, then the full tension design strength is permitted. *D.7.1*

By observation, this is not the case.

If $0.2 \phi N_n \geq N_{ua}$, then the full shear design strength is permitted *D.7.2*

By observation, this is not the case.

Therefore:

$$\frac{N_{ua}}{\phi N_n} + \frac{V_{ua}}{\phi V_n} \leq 1.2 \quad \text{Eq. (D-31)}$$

$$\frac{1,600}{2,133} + \frac{560}{2,301} = 0.75 + 0.24 = 0.99 < 1.2 - \text{OK}$$

12. Summary

A single 1/2" diameter Strong-Bolt™ anchor at a 5" embedment depth is adequate to resist the applied service tension and shear loads of 1,000 lb. and 350 lb., respectively.