

# Anchor Bolt Design for Shear and Tension

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When column base plates are subject to both uplift and very large shear loads, two independent systems are normally used to resist tension in the anchor bolts and shear at the level of the base plate: (1) the length of embedment and the diameter of the anchor bolts are determined on the basis of uplift tension and (2) a shear key is welded to the column base plate to resist shear.

If very large shear loads do not accompany the uplift, the anchor bolts can be designed to resist both shear and tension, without using a shear key, as in the following example.

## EXAMPLE

**Given:** Design anchor bolts for a column base plate for an uplift of 100 kips, and a shear load of 40 kips due to wind or seismic loading. Use 4 anchor bolts. (See Fig. 1.)

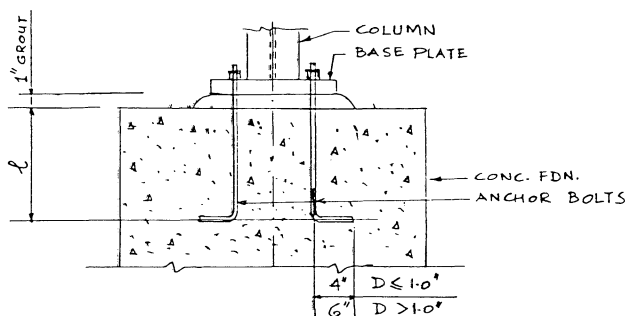


Figure 1

**Design Data:** Load per anchor bolt is as follows:

$$100/4 = 25 \text{ kips}$$

$$40/4 = 10 \text{ kips}$$

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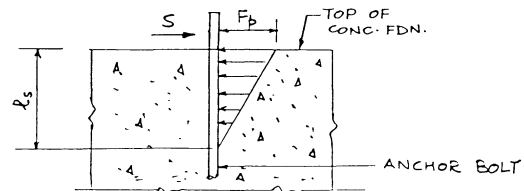


Figure 2

**Solution:**

**Shear:**

See Fig. 2.

$$f'_c = 3.0 \text{ ksi}$$

$$F_p = 0.25f'_c = 0.75 \text{ ksi}$$

$$l_s = 12D \text{ (assumed)}$$

$$A_c = (l_s D) = 12D^2$$

Concrete resistance for shear:

$$S = \frac{1}{2}F_p A_c = 6F_p D^2 = (6 \times 0.75)D^2 = 4.5D^2$$

$$\therefore D = \left( \frac{S}{4.5} \right)^{1/2} = \left( \frac{10}{4.5} \right)^{1/2} = 1.49 \text{ in.}$$

Use  $D = 2 \text{ in.}$

$$l_s = 12D = 24 \text{ in.}$$

**Tension:**

$$\text{For plain bars, } u = 4.75 \times 10^{-3/2} (f'_c)^{1/2} / D$$

For  $D = 2$ :

$$u = 4.75 \times 10^{-3/2} (3.0)^{1/2} / 2 = 0.13 \text{ ksi}$$

$\therefore$  use  $u = 0.13 \text{ ksi}$

$$T = u(\pi D) l_t$$

$$l_t = \frac{T}{u(\pi D)} = \frac{25}{0.13(\pi \times 2.0)} = 30.61 \text{ in.}$$

$$l = (l_s + l_t) = (24 + 30.61) = 54.61 \text{ in.}$$

Use  $l = 4 \text{ ft-6 in.}$

Check Bolt Stresses:

$$(a) A_g = \frac{\pi D^2}{4} = 3.141 \text{ in.}^2$$

$$A_t = 0.75 A_g = 2.356 \text{ in.}^2 \quad (\text{AISC Spec. Sect. 1.5.2.1, with } n = 7)$$

$$\text{For A307 bolts, } F_y = 33 \text{ ksi; } F_v = 0.3 F_y = 10 \text{ ksi}$$

$$F_n f_n b = F_t = 0.6 F_y = 20 \text{ ksi}$$

$$(b) f_v = \left( \frac{S}{A_g} \right) = \left( \frac{10}{3.141} \right) = 3.188 \text{ ksi}$$

$$f_t = \left( \frac{T}{A_t} \right) = \left( \frac{25}{2.356} \right) = 10.61 \text{ ksi}$$

$$F_t = 28.0 - 1.6 f_v = 22.90 \text{ ksi} \leq 20 \text{ ksi} \quad (\text{AISC Spec. Sect. 1.6.3})$$

$$\therefore \text{ Use } F_t \text{ or } F_b = 20 \text{ ksi}$$

(c) See Fig. 3.

Bending moment due to shear  $S$  at the level of top of grout =  $m$ .

$$m = (S \times 1.0) = (10 \times 1.0) = 10 \text{ kip-in.}$$

$$f_b = \frac{m}{(\pi/32) D^3} = \frac{10.0}{(\pi/32) \times 2.0^3} = 12.73 \text{ ksi}$$

$$(1/1.33) (f_t + f_b) = (1/1.33) (10.61 + 12.73) = 17.55 \text{ ksi} < F_t = 20 \text{ ksi} \quad \text{o.k.}$$

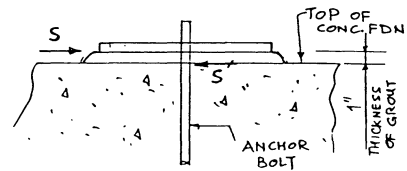


Figure 3

#### NOMENCLATURE

$F_y$	= Yield stress of anchor bolt material, ksi
$F_v$	= Allowable shear stress in anchor bolt, ksi
$F_t$	= Allowable tensile stress in anchor bolt, ksi
$F_b$	= Allowable bending stress in anchor bolt, ksi
$A_c$	= Area of concrete in compression, in. <sup>2</sup>
$D$	= Diameter of anchor bolt, in.
$A_g$	= Gross area of anchor bolt, in. <sup>2</sup>
$A_t$	= Tensile stress area of anchor bolt, in. <sup>2</sup>
$F_p$	= Allowable bearing stress on concrete, ksi
$f'_c$	= Specified compressive strength of concrete at the end of 28 days, ksi
$l_s$	= Length of anchor bolt required for resisting shear force on bolt, in.
$l_t$	= Length of anchor bolt required for resisting tensile force on bolt, in.
$l$	= Total length of embedment required, in.
$u$	= Allowable bond stress of concrete, ksi
$f_v$	= Actual shear stress in anchor bolt, ksi
$f_t$	= Actual tensile stress in anchor bolt, ksi
$n$	= Number of threads per inch for anchor bolt