11/15/2010

- Design of Footing Example
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Example Design a square footing to support an 18"x18" column.

$D_L = 400^k$

$L_L = 270^k$

$f'_c = 5\,ksi$ (column)

8-#9 bars (column)

$f_y = 60\,ksi$ (column)

– Footing: $f'_c = 3\,ksi$

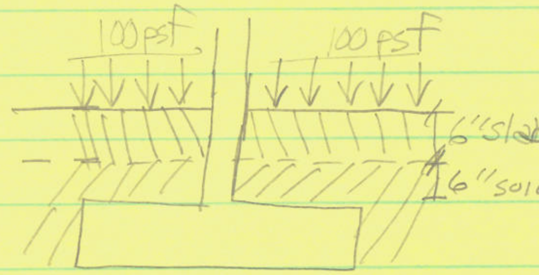
6" fill on top

$\gamma = 120\ \#/ft^3$

6" basement slab

w/LL = 100 psf

$q_{allow} = 6000\ psf$



① Compute factored Load

$U = 1.4DL = 1.4(400^k) = 560^k$

$U = 1.2DL + 1.6LL$

$= 1.2(400^k) + 1.6(270^k) = 912^k$

② Estimate footing size & net soil pressure

$q_{net} = q_{all} - wt\ footing - wt\ over\ burden$

$q_{net} = 6.0 - \left[\left(\frac{27}{12}\right)(0.150)\right] - 0.5(0.12) + 0.5(0.15) + 0.100$

(footing, soil, slab, LL)

$= 5.43\ ksf$

Rule of thumb footing 1.5x column width

$$A_{req} = \frac{D+L}{q_{net}} = \frac{400+270}{5.43} = 123\,ft^2$$

(D+L: unfactored)

≈ 11.1 feet square

try 11'-2" × 11'-2" × 27" thick

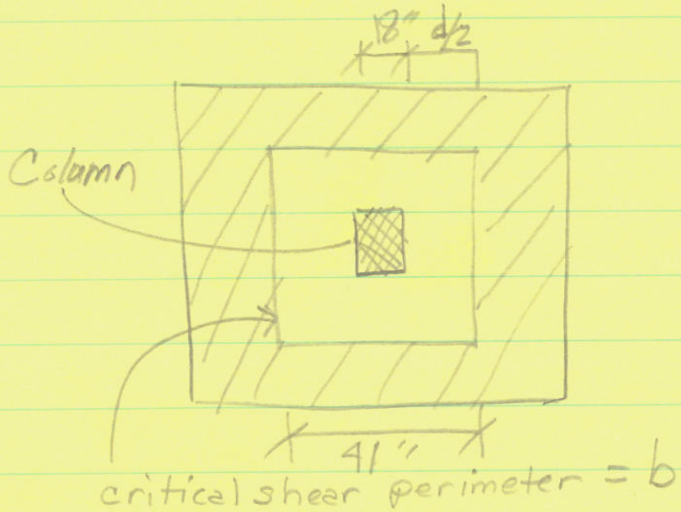
factored net soil pressure $\frac{1.2D + 1.6L}{A}$

$$= \frac{1.2(400) + 1.6(270)}{(11.17)^2} = 7.31\ ksf$$

③ Check thickness for 2-way shear

average $d = 27 - 3 - 1 = 23\ in$

($27 = t_f$, 3 = cover, $1 = d_b$)



Thickness of footing is generally controlled by 2 way slab

$$V_u = 7.3\left[11.17^2 - \left(\frac{41}{12}\right)^2\right]$$

$$= 827^k$$

$$b_o = 4(18+23) = 164 \text{ in}$$

ϕV_c is smallest of

(a) $\phi V_c = \phi(2 + 4/\beta)\sqrt{f'_c}\, b_o d$

$= 0.75(2 + 4/1)\sqrt{3000}(164)(23)$

$= 930^k$

(b) $\phi V_c = \phi\left(\frac{\alpha_s d}{b_o} + 2\right)\sqrt{f'_c}\, b_o d$

$= 0.75\left(\frac{(40)23}{164} + 2\right)\sqrt{3000}(164)(23)$

$= 1179^k$

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(c) $\phi V_c = \phi 4\sqrt{f'_c}\, b_o d = 620^k$

$\phi V_c \overset{?}{>} V_u$

$620 \not> 827k$ ∴ Foot is not thick enough

try $h = 32''$

$d = 28''$

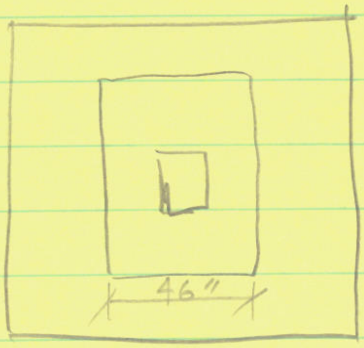
$b_o = 184''$

$$q_n = 6.0 - \left(\frac{32}{12}(0.15) + 0.5(0.12) + 0.5(1.15) + 0.10\right)$$

new A_{req} $\frac{400 + 270}{5.37} = 11'\text{-}2$ (will change sometimes)

if size changes, recalculate factor'd q_{net}

New critical Shear

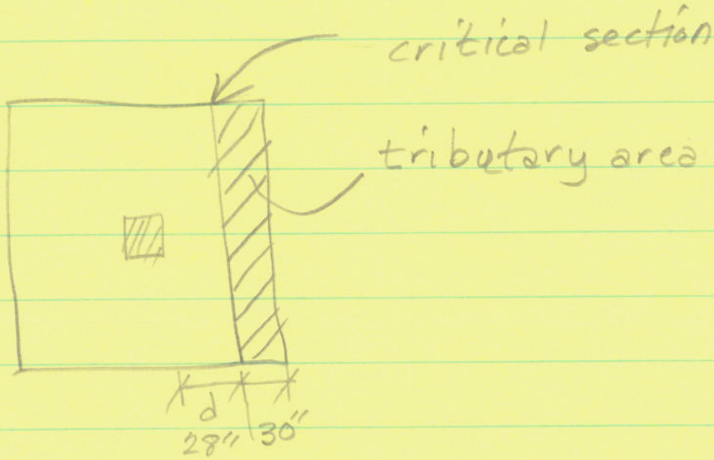


$$V_u = 7.31\left[(11.17)^2 - \left(\frac{46}{12}\right)^2\right] = 804^k$$

(c) governed before & now

$$\phi V_c = 0.75(4)\sqrt{3000}(184)(28)$$
$$= 846^k \checkmark$$

(4) Check for 1 way Shear



$$V_u = 7.31\left(11.17 \times \frac{30}{12}\right) = 204^k$$

$$\phi V_c = \phi \lambda \sqrt{3000}\, b_w d$$
$$= 0.75(2)\sqrt{3000}(134'')(28)$$
$$= 308^k \rightarrow \phi V_c > V_u \quad \therefore Ok$$

(5) Design Flexural reinforcement

$$M_u = 7.31(11.17)\frac{(58/12)^2}{2} = 954 \text{ ft-k}$$

assume $j = 0.9$ & $\phi = 0.9$

$$A_s = \frac{M_u(12{,}000)}{\phi f_y (jd)} = \frac{950(12{,}000)}{(0.9)(60\text{ ksi})(0.9)(28)}$$

$$= 8.41 \text{ in}^2$$

- for square, use same in both directions
- check $A_{s,min}$ [10.5.3] & [7.12, 2]

$A_{s\,min} = 0.0018bh$

$= 0.0018(134)(32) = 7.72 \text{ in}^2$

$S_{max} = 18''$ [7.6.5]

try 11 #8 bars [$A_s = 8.69 \text{ in}^2$]

re compute ϕM_n as check

$$a = \frac{A_s f_y}{0.85 f'_c b_w} = \frac{8.69(60{,}000)}{(0.85)(3000)(134)} = 1.53$$

check $\varepsilon_t \geq 0.005$, then

$\phi M_n = 1070$ ft-k > 954 ft-k

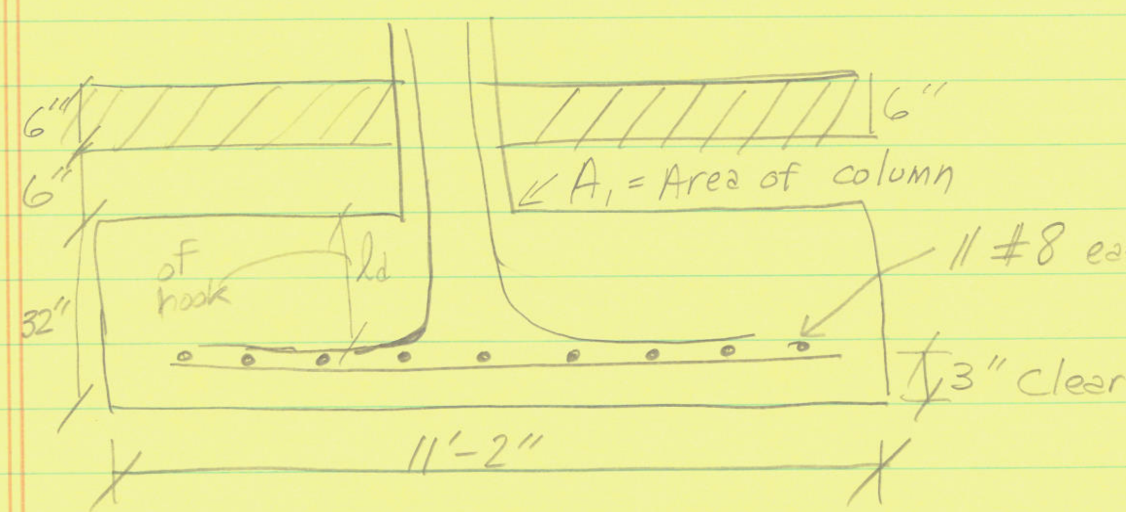
(6) Check development length of steel of footing

clear space $> 2 d_b$
clear cover $> d_b$

$$l_d = \left(\frac{f_y \, \psi_t \, \psi_e}{20 \sqrt{f'_c} \, \lambda} \right) d_b = \left[\frac{60\text{ksi}\,(1)(1)}{20\sqrt{3\text{ksi}}\,(1)} \right] 1.0 = 54''$$

bar extension past critical moment section is $58'' - 3'' = 55$ in > 54 ✓ o.k.

(7) Design Column Footing Joint dowels



factored load $= 912^k$

[10.17.1] check column bearing

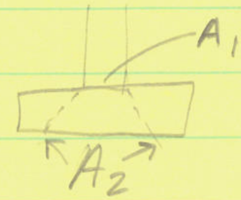
$\phi\, 0.85 f'_c A_1 = 0.65(0.85)(5)(18)^2 = 895^k$ (col)

bearing in foot — this number ≥ 2

$\phi\, 0.85 f'_c A\left(\sqrt{\frac{A_2}{A_1}}\right)$

$(0.65)(0.85)(3\,ksi)(18)^2(2)$

$= 1074^k$ ∴ footing bearing O.K.



$A_d = \frac{912 - 895}{\phi f_y} = 0.44\,in^2$

[15.8.2.1]

$A_d \geq 0.005 A_g = 1.62\,in^2$

try 4 #6 bars (1 in each corner)

$(A_s = 1.76\,in^2)$

→ Check l_d in footing for 90° hook in compression ($l_d = 16''$)

→ Extend dowels into column the length of a compression splice or comp controlled development

(23 in 25 in)