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Semester 4th

Program M.S, T.E

Subject RCD

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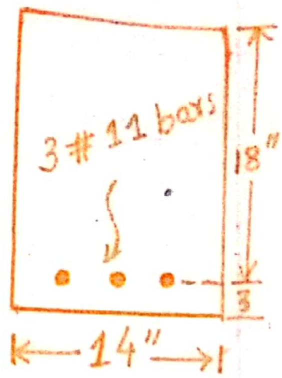
Q1 (A) Given Data

$f_y = 75000$ psi

$f_c' = 5000$ psi



Required ÷ ϵ_t, ϕ and ϕM_n

$$a = \frac{A_s f_y}{0.85 f_c' b} = \frac{4.68 \times 75}{0.85 \times 5 \times 14}$$

$$a = 5.89 \text{ in}$$

For $f_c' = 5000$ psi $\qquad \beta_1 = 0.80$

$$C = \frac{a}{\beta_1} = \frac{5.89}{0.80}$$

$$\boxed{C = 7.36 \text{ in}}$$

Now $\epsilon_t = \left(\frac{d-c}{c}\right) 0.003 = \left(\frac{18 - 7.36}{7.36}\right) 0.003$

$$\boxed{\epsilon_t = 0.0043}$$

$0.004 < \epsilon_t < 0.005$ Transition zone

Now $\phi = 0.65 + (\epsilon_t - 0.002) \frac{250}{3}$

$= 0.65 + (0.0043 - 0.002) 250/3$

$$\boxed{\phi = 0.841}$$

Now finding ϕM_n

First ~~find~~ check "ρ"

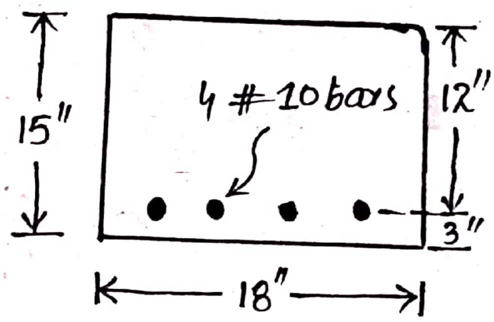
$$\rho = \frac{A_s}{bd} = \frac{4.68}{14 \times 18}$$

$\rho = 0.0185$ $\quad > \rho_{min} = 0.0028$

$\quad < \rho_{max} = 0.0194$ OK

$$M_n = A_s f_y \left(d - \frac{a}{2}\right)$$
$$= 4.68 * 75 * \left(18 - \frac{5.89}{2}\right)$$
$$M_n = 5284.3 \text{ in-K} = 441.1 \text{ ft-K}$$
$$\phi M_n = 0.836 * 441.1$$
$$\boxed{\phi M_n = 368.75 \text{ ft-K}}$$

Now for section



Given Data

$f_y = 60,000 \text{ psi}$

$f_c' = 4000 \text{ psi}$

$$a = \frac{A_s f_y}{0.85 * f_c' b} = \frac{5.06 * 60}{0.85 \times 4 \times 18}$$

$$a = 4.96 \text{ in}$$

For $f_c' = 4000 \text{psi}$ $\quad \beta_1 = 0.85$

$$C = \frac{a}{\beta_1} = \frac{4.96}{0.85}$$

$$C = 5.835 \text{ in}$$

Now $\quad \epsilon_t = \left(\frac{d-c}{c}\right)(0.003) = \left(\frac{12 - 5.83}{5.83}\right) 0.003$

$$\epsilon_t = 0.003 < 0.004$$

As The section is not ductile so may not be used as per ACI code.

P # 3

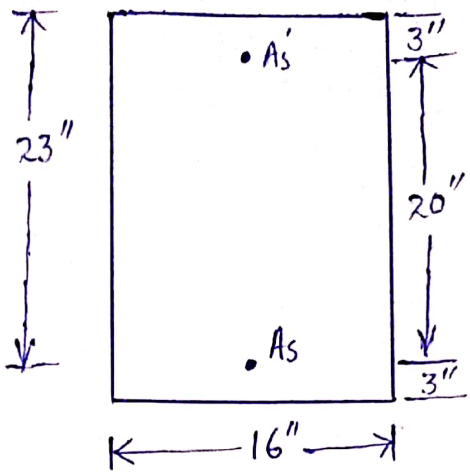
(b)

$M_D = I \cdot D = 152$ ft-K

$M_L = 400$ ft-K

$f_c' = 4000$ psi

$f_y = 60{,}000$ psi



Factored Moment

$$M_u = 1.2 M_D + 1.6 M_L$$

$$= 1.2(152) + 1.6(400)$$

$$M_u = 822 \text{ ft-K}$$

Nominal Moment

$$M_n = \frac{M_u}{\phi} = \frac{822}{0.9}$$

$$M_n = 913.3 \text{ ft-K}$$

Assuming maximum possible tensile steel with no compression steel and computing beams nominal strength moment.

From Table A.7 $\rho_{max} = 0.0181$

$$A_s = \rho_{max} b d$$

$$= 0.0181 * 16 * 23$$

$$A_s = 6.66 \text{ in}^2$$

For $\rho_{max} = 0.0181$ $\frac{M_u}{\phi b d^2} = 912$ psi

Table A-13

$$M_{u1} = 912 * \phi b d^2$$
$$= 912 * 0.9 * 16 * 23^2$$
$$= 6947251 \text{ in-lb}$$
$$= \frac{6947251}{12 * 1000} \text{ ft-K}$$
$$M_{u1} = 579 \text{ ft-K}$$

Now $M_{n1} = \frac{M_{u1}}{\phi} = \frac{579}{0.9}$

$$M_{n1} = 643 \text{ ft-K}$$

$$M_{n2} = M_n - M_{n1}$$
$$= 913.3 - 643$$
$$M_{n2} = 270.3$$

Now Theoritical A_s' required is

$$A_s' = \frac{M_{n2}}{f_y(d-d')} = \frac{270.3 \times 12}{60(25-3)}$$

$$\boxed{A_s' = 2.46 \text{ in}^2}$$

Let $f_s' = f_y$

$$A_s' f_s' = A_{s2} f_y$$
$$A_{s2} = \frac{A_s' f_s'}{f_y}$$
$$= \frac{2.46 * 60}{60}$$
$$A_{s2} = 2.46 \text{ in}^2$$

P # 05

$$A_s = A_{s1} + A_{s2}$$
$$= 6.66 + 2.46$$
$$A_s = 9.12 \text{ in}^2 \qquad \text{Try } 7 \# 10 \text{ bars}$$

Checks : Assuming $f_s' = f_y$

① $$\frac{(A_s - A_s') f_y}{0.85 f_c' b \beta} = \frac{9.12 - 2.46}{0.85 * 4 * 16 * 0.85}$$
$$= 8.6 \approx 9$$

② $$\varepsilon_s' = \left(\frac{c - d'}{c}\right) 0.003$$
$$= \frac{9.4 - 3}{9.4} * 0.003$$
$$\varepsilon_s' = 0.0020 \text{ ---- OK}$$

③ $$\epsilon_t = \frac{d - c}{c} * 0.003$$
$$= \frac{25 - 9.4}{9.4} * 0.003$$
$$\epsilon_t = 0.0049 < 0.005$$

So $\epsilon_t \neq 0.9$

Now find ϵ_t

$$\epsilon_t = 0.65 + (0.0049 - 0.002) \frac{250}{2}$$
$$\epsilon_t = 0.89.$$

P # 06

$$As2 = \frac{As' fy'}{fy} = \frac{2.46 * 60}{60}$$

$$As2 = 2.46 \ in^2$$

$$As1 = As - As2$$

$$= 8.86 - 2.46$$

$$As1 = 6.4 \ in^2$$

$$c = \frac{a}{\beta_1}$$

$$a = c\beta_1$$

$$Mn1 = As1 \, fy \left(d - \frac{a}{2}\right)$$

$$Mn1 = 6.4 * 60 \left(23 - \frac{0.85 * 9.4}{2}\right)$$

$$Mn1 = 8104.5 \ ft-K$$

$$Mn1 = 675 \ ft-K$$

$$Mn2 = As2 \, fy \, (d - d')$$

$$= 2.46 * 60 * (23 - 3)$$

$$= 2952 \ in-K$$

$$Mn2 = 266 \ ft-K$$

Thus

$$Mn = Mn1 + Mn2$$

$$= 675 + 266$$

$$Mn = 941 \ ft-K$$

$$\phi Mn = 0.89 * 941$$

$$\phi Mn = 837.4 > Mu \ \text{---} \ OK$$

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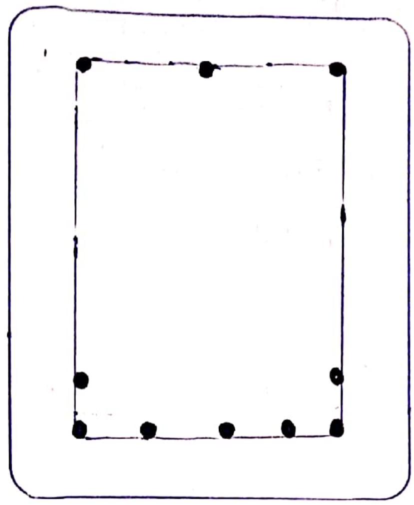
$A_s' = 2.46\ in^2$ 3 # 8 bars

$A_s = 9\ in^2$ 7 # 10 bars



Q2 **Given Data**

$P_u = 152\ K$

$M_u = 15\ ft\text{-}K$

$f_c' = 4000\ psi$

$f_y = 60{,}000\ psi$

Assuming Average compression stress

$0.6\ f_c' = 0.6 * 4000\ psi$

$= 24000\ psi$

$= 2.4\ Ksi$

$$A_g = \frac{P_u}{0.6\ f_c'} = \frac{152}{2.4}$$

$A_g = 63.34\ in^2$

ACI recomended size of column is
$12'' * 12''$

Lets Try $12'' * 12''$ $A_g = 252\ in^2$

Now $e = \frac{M_o}{P_u} = \frac{12 * 15}{152}$

$e = 1.184\ in^2$

$P_n = \frac{P_u}{\phi} = \frac{152}{0.65}$

$P_n = 233.84K$

$K_n = \frac{P_n}{f_c' A_g} = \frac{233.84}{4 * 12 * 12}$

$K_n = 0.40$

Now $R_n = \frac{P_n e}{f_c' A_g h} = \frac{233.84 * 1.184}{4 * 12 * 12 * 12}$

$R_n = 0.04$

$\gamma = \frac{7in}{12in} = 0.58 \approx 0.6$

Considering clear cover 2.5 in

Now from graph 6

For $\gamma = 0.6$

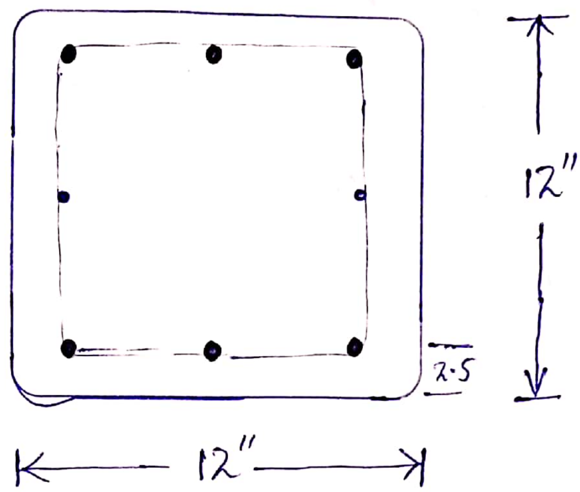
$\rho_g = 0.025$

$A_s = 0.025 * 12 * 12$

P # 09

$A_s = 3.6\ in^2$

Try 6 #7 bars $\qquad A_s = 3.61\ in^2$



Q3

Given Data

Column = 16" x 16" $\qquad P_D = 152\,K$

$P_L = 160\,K$ $\qquad$ Depth = 5 ft

Soil weight = 100 lb/ft³ $\qquad f_y = 60{,}000\ psi$

$f_c' = 3000\ psi$ $\qquad$ Bars = #8

$q_a = 3900\ psi$ → (Selected properly)

Sol:

Assuming height of footing

$h = 12'' = 2'$

$d_{avg} = h - 3 - 1 = 24 - 3 - 1$

$d_{avg} = 20''$

$b_o = 4(c + d_{avg})$

$b_o = 4(16 + 20) = 144$ in

$W =$ Pressure of Soil + Pressure of RC

$= \gamma_{fill}(z - h) + \gamma_c h$

$= 100(5 - 2) + 150(2)$

$= 300 + 300$

$W = 600$

Now $q_e = q_a - W$

$= 3900 - 600$

$q_e = 3300$

$q_e = 3.300$ Ksf

$A_{required} = \dfrac{\text{Total Load}}{q_e}$

$= \dfrac{152 + 160}{3.300}$

$A_{required} = 94.54 \text{ in}^2$

$B \times B = 94.54$

$B \approx 10 \text{ ft}^2$

So $A \cong 100 \text{ ft}^2$

Bearing pressure

$q_o = \dfrac{1.2(P_D) + 1.6(P_L)}{A}$

$$q_o = \frac{1.2(152) + 1.6(160)}{10 \times 10}$$

$$q_o = 4.384 \text{ Ksf}$$

Now · Punching shear $\quad b_o = 144$ in

$$V_{u2} = q_o A - q_o (C + d_{avg})$$

$$= 4.384 * 100 - 4.384 \left(\frac{16+20}{2}\right)^2$$

$$V_{u2} = 398.944K$$

Checking (i)

$$d = \frac{V_{u2}}{0.75 * 4\sqrt{f_c'} * b_o}$$

$$= \frac{398.944}{0.75 \times 4\sqrt{3000} \times 144}$$

$$d = 17.05 \text{ in} < 20 \text{ in} \text{ --- OK}$$

(ii)

$$d = \frac{V_{u2}}{0.75\left(\frac{40 * d}{b_o} + 2\right)\sqrt{f_c'} * b_o}$$

$$d = \frac{398.944}{0.75\left(\frac{40 * 20}{144} + 2\right)\sqrt{3000} * 144}$$

$$d = 9.02 \text{ in} < 20 \text{ in} \text{ --- OK}$$

So both "d" < 20 Thus punching shear is OK.

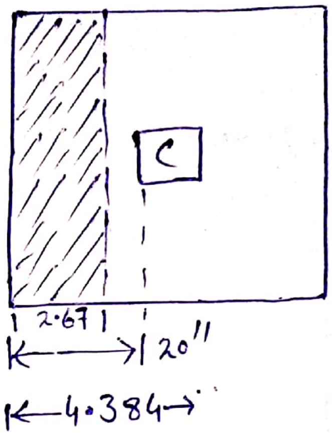
Depth required for one way shear

$$V_{u1} = (10ft)(2.67)(4.384)$$

$$V_{u1} = 117.0528$$

$$d = \frac{117\,0528}{0.75 * 2\sqrt{3000} * 120}$$

$$d = 11.87'' < 20'' \text{ — OK}$$



Now $\quad M_u = (4.33)(10)(4.384) * \frac{4.33}{2}$

$$M_u = 410.97 \approx 411 \text{ ft-K}$$

$$\frac{M_u}{\phi b d^2} = \frac{12 * 411000}{0.9 * 120 * 20^2}$$

$$= 114.1667 \text{ psi}$$

Now from Appendix "A"

$\rho = 0.0021 < \rho_{min}$ for flexure

use Larger one from the following.

$$\rho = \frac{200}{60,000} = 0.0033$$

$$\text{or } \rho = \frac{3\sqrt{3000}}{60,000} = 0.0027$$

So $\quad A_s = 0.0033(120)(20)$

$A_s = 7.2 \text{ in}^2$ $\quad$ use 6#10 bars

Development Length

$\phi_L = \phi_e = \phi_s = 1$

Assuming bar spaced 16in on centre and 16in on side

$C_b =$ bottom Cover $= 3.5$in

$C_b = \frac{1}{2}(16in) = 8in$

Let $K_{tr} = 0$

$$\frac{C_b + K_{tr}}{d_b} = \frac{3.5 + 0}{1} = 3.5$$

$$\frac{l_d}{d_b} = \frac{3}{40} \cdot \frac{f_y}{\lambda\sqrt{f_c'}\ \frac{C + K_{tr}}{d_b}}$$

$$= \frac{3}{40} \cdot \frac{60,000}{(1)\sqrt{3000}} \times \frac{1 \times 1 \times 1}{2.5}$$

$= 32.86$ dimension

$$\frac{l_d}{d_b} = \frac{A_{s\,req}}{A_s} = 32.86\left(\frac{7.2}{7.59}\right)$$

$= 31.30$ dimension

$l_d = 31.30\ (1)$

$l_d = 31.30 \approx 32$ in

$<$ Qailible $\quad l_d = 4ft - 6in - \frac{20}{2} - 3$

$= 40$ in --- OK

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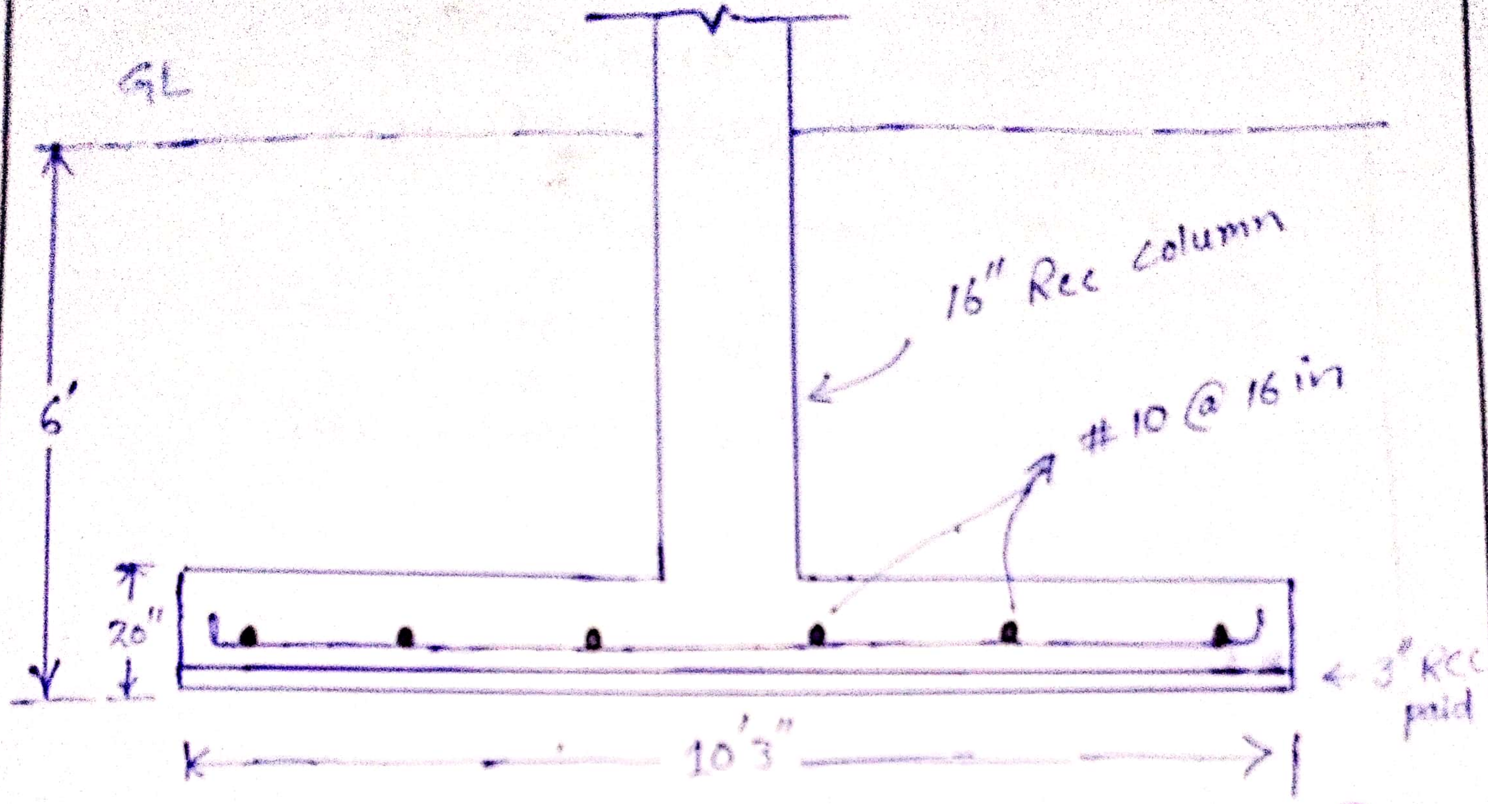
GL
16" Rcc column
#10 @ 16 in
6'
20"
3" RCC pad
10'3"