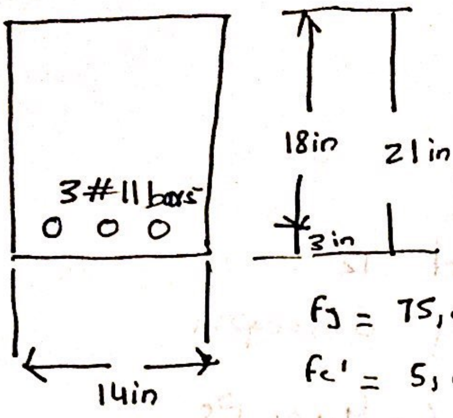
Rollno:- 15581 Iyftidar Ali (1)

Q1 Determine the values of ϵt, ϕ and ϕM_n for the section shown below

A :-



$f_y = 75{,}000\,psi$

$f_c' = 5{,}000\,psi$

$\epsilon t = \frac{d-c}{c}(0.003)$ $\quad c = \frac{a}{B_1}$ $\quad a = \frac{A_s f_y}{0.85 f_c'}$

$a = \frac{4.68 \times 75}{0.85 \times 5 \times 14}$

$a = 0.89\,in$

$c = \frac{a}{B_1} = \frac{5.89}{0.85}$

$c = 6.93\,in$

$\epsilon t = \frac{d-c}{c}(0.003)$

$= \frac{18-6.93}{6.93}(0.003)$

$\epsilon t = 0.00479 < 0.005$

$\phi = 0.65 + (\epsilon t - 0.002)\frac{250}{3}$

$\phi = 0.826$

$M_n = A_s F_y\left(d - \frac{a}{2}\right)$

$= 4.68 \times 75\left(18 - \frac{5.89}{2}\right)$

$M_n = 351(15.055)$

$M_n = 5284.305\ in\text{-}k$

$\phi Mn = 0.826 \times 5284.305$

$= 4364.84 \text{ ink}$

$\phi Mn = 4364.84 \text{ in-k}$

B

4# 10 bars:

$d = 12''$

$fy = 60{,}000 psi$

$fc' = 4000 Psi$

$b = 18''$

$AS = 5.06 \text{ in}^2$

$$\epsilon t = \frac{d-c}{c}(0.003)$$

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

$$a = \frac{As\,Fy}{0.85 fc' b}$$

$$= \frac{5.06 \times 60}{0.85 \times 4 \times 18}$$

$$a = 4.96''$$

$$c = \frac{4.96}{0.85} = 5.83$$

$$c = 5.83$$

$$\epsilon t = \frac{d-c}{c}(0.003)$$

$$= \frac{12 - 5.83}{5.83}(0.003$$

$$\epsilon t = 0.003177$$

$$\phi = 0.65 + (\epsilon t - 0.002)\frac{250}{3}$$

$$\phi = 0.65 + (0.003177 - 0.002)\frac{250}{3}$$

$$\phi = 0.75$$

$M_n = A_s F_y \left(d - \frac{a}{2}\right)$

$= 5 \times 60 \left(12 - \frac{4.96}{2}\right)$

$M_n = 2856$ in-k

ϕ mn = 2856 ink

$\phi M_n = 0.75 \times 2856$

$\phi M_n = 2142$ in-k Ans

Q1 (B) Design a rectangular beam for MD = 155 and ML = 410 if fc' = 4000 Psi and fy = 60,000 psi

Ans ① Factored Moment

$M_u = 1.2 M_D + 1.6 M_L$

$M_u = 1.2 \times 155 + 1.6(410)$

$M_u = 186 + 656$

$= 842$ ft-k

② ~~Ato~~ Nominal Moment

$M_n = \frac{M_u}{\phi} = \frac{842 \text{ Ft-k}}{0.90}$

$M_n = 935.55$ ft-k

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

ρ_{max} (from A Table A.7) $= 0.0181$

$A_{s1} = \rho_{max} bd = 0.0181 \times 15 \times 28$

$A_{s1} = 7.60$ in²

for $\rho_{max} = 0.0181$

$$\frac{M_u}{\phi b d^2} = 912 \text{ Psi} \quad (\text{From Table A.13})$$

$$M_{u1} = 912 \times \phi b d^2$$
$$= 912 \times 0.9 \times 15 \times (28)^2$$

$$M_{u1} = \frac{9652608 \text{ in-lb}}{12}$$

$$M_{u1} = 804.4 \text{ ft.k}$$

$$M_{n1} = \frac{M_{u1}}{\phi} = \frac{804.4}{0.90}$$

$$M_{n1} = 893.8 \text{ ft-k}$$

$$M_{n2} = M_n - M_{n1} = 1144.4 - 893.8$$

$$M_{n2} = 250.67 \text{ ft-k}$$

(3) Theoritical As' required =

$$A_s = \frac{M_{n2}}{f_y(d-d')} = \frac{250.6 \times 12}{60\ (8-3)}$$

$A_s' = 2.00 \text{ in}^2$ Try 2#9 (2.00 in^2)

$$A_s' f_s' = A_{s2} f_y$$

$$A_{s2} = \frac{A_s' f_s'}{f_y} = \frac{2 \times 60}{60} = 2.00 \text{ in}^2$$

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

$$A_s = A_{s1} + A_{s2}$$

$$A_s = 7.60 + 2$$

$A_s = 9.60 \text{ in}^2$ Try 8#10 (10.12 in^2)

note that the actual value of As' is exactly the same as the theoritical value. The actual value of As however is higher than the theoretical value by $10.2 - 9.6 = 0.52 \text{ in}^2$ if new bar selection for As' is made where by the actual value of As' exceeds the theoritical value actual value of As' exceeds the theoritical value by about this much (0.52 in²) the design will be adequate

Select 3 # 8 bars ($A_s' = 2.36 in^2$) and repeat the Previous steps

Assuming $f_s' = f_y$

(1) $\dfrac{(A_s - A_s')f_y}{0.85 f_c' b \beta_1} = \dfrac{(10.12 - 2.36) \times 60}{0.85 \times 4 \times 15 \times 0.85} = 10.74 in$

(2) $\epsilon_s' = \left(\dfrac{c - d'}{c}\right)(0.003) = \left(\dfrac{10.74 - 3}{10.74}\right)(0.003) = 0.00216 > \epsilon_y$

(3) $\epsilon_t = \left(\dfrac{d - c}{c}\right) 0.003 = \left(\dfrac{28 - 10.74}{10.74}\right)(0.003) = 0.00482 < 0.005$

$\phi = 0.65 + (\epsilon_t - 0.002)\dfrac{250}{3}$ $\qquad \phi \neq 0.90$

$\phi = 0.65 + (0.00482 - 0.002)\dfrac{250}{3}$

$\phi = 0.88$

$A_{s2} = \dfrac{A_s' f_s'}{f_y} = \dfrac{2.36 \times 60}{60} = 2.36 in^2$

$A_{s1} = A_s - A_{s2} = 10.12 - 2.36 = 7.76 in^2$

$M_{n1} = A_{s1} f_y \left(d - \dfrac{a}{2}\right) = 7.76 \times 60 \left[28 - \dfrac{0.85 \times 10.74}{2}\right]$

$M_{n1} = \dfrac{10912 \text{ in-k}}{12}$

$M_{n1} = 909.3 \text{ ft-k}$

$M_{n2} = A_{s2} f_y (d - d') = (2.36)(60)[28 - 3]$

$M_{n2} = \dfrac{3540 \text{ in-k}}{12}$

$M_{n2} = 295 \text{ ft-k}$

$M_n = 295 \text{ ft-k}$

$M_n = M_{n1} + M_{n2} = 909.3 + 295$

$M_n = 1204.3 \text{ ft-k}$

$\phi M_n = 0.88 \times 1204.3$

$\phi M_n = 1057.9 \text{ ft-k} > M_u$ $\boxed{ok}$

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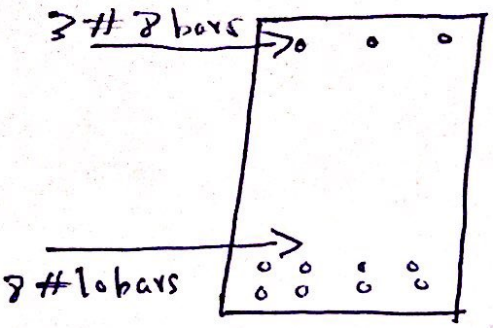
$A_s' = 2.36\ in^2$ (3 #8 bars)

$A_s = 10.12\ in^2$ (8 #10 bars)



Q2 Design a short square column for the following conditions $P_u = 155$, $M_u = 15$ $f_c = 4000$ psi and $f_y = 60{,}000$ psi. Place the bars uniformly around all four face of the column

Ans Assume the column will have average compression stress = about $0.6 f_c = 2400$ Psi $= 2.4$ ksi.

$$A_g \text{ required} = \frac{155k}{2.4ksi} = 64.5\ in^2$$

Try 16 x 16 column (A_g =

$$e = \frac{M_u}{P_u} = \frac{(12\ in/ft)(15)}{155} = \frac{180}{155}$$

$$= 1.161$$

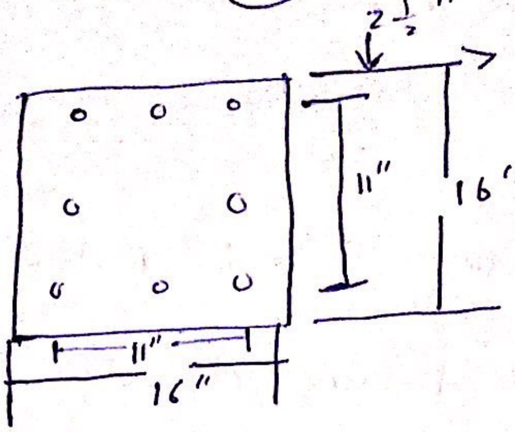
$$P_n = \frac{P_u}{\phi} = \frac{155}{0.65} = 238.4\ k$$

$$K_n = \frac{P_n}{f'_c A_g} = \frac{238.4}{(4ksi)(16in \times 16in)} = \frac{238.4}{1024} = 2.32$$

$$R_n = \frac{P_n e}{f'_c A_g h} = \frac{(\cancel{423.1k}\ 238.4)(1.16in)}{(4ksi)(16 \times 16)(16)} = 0.0901$$

$$\gamma = \frac{11in}{16in} = 0.6875$$

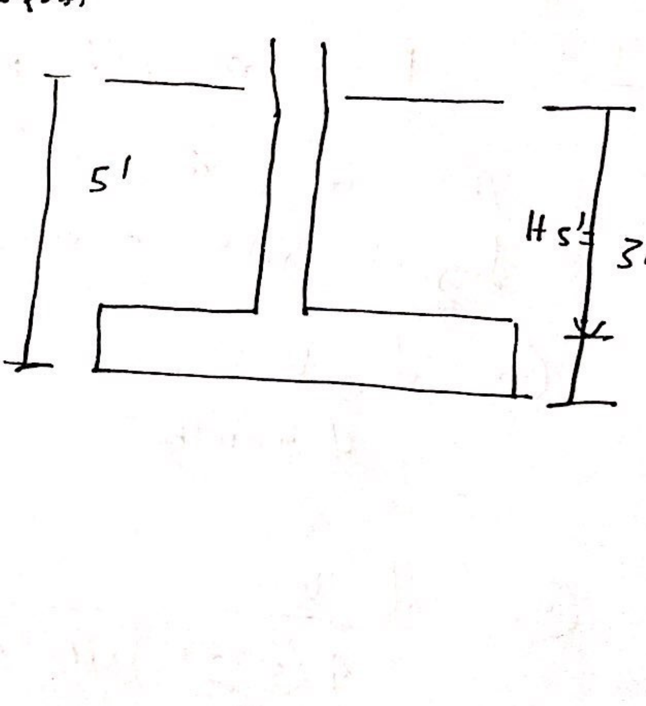
$A_s = (0.023)(16)(16) = 5.89\ in^2$ use 8 #8 bars $= 6.28\ in^2$



Q3 Design a square column footing for a 16 inch square tied interior column that support a dead load $P_D = 155$ and live load $P_L = 160\,k$ The colun is reinforced with #8 bars, the soil weight is 100 lb/ft³

f_y = 60,000 Psi 5' ~~below grade, the soit~~ and $f_c' = 3000$ psi

and q_a = 1558 Psf.



Ans Given data

$P_D = 155\,k$

$P_L = 160\,K$

$\gamma_s = 100\,lb/ft^3$

$F_y = 60{,}000$ psi

$q_a = 1558$ Psf

sol $\gamma_c = 150\,lb/ft^3$

$h_c = 24"$, $d = 19.5"$

$H_s = 36"$

<u>step 1</u> effective soil Pressure "q_e"

$$q_e = q_a - h_c \times \gamma_c - H_s' \times \gamma_s$$

$$= 1558 - \left(\frac{24}{12} \times 150\right) - \left(\frac{36}{12}\right) \times 100$$

q_e = 4400 Psf = 4.40 ksf

q_e = 4.40 ksf

Step 2 Area of Footing

$$\text{Area of footing} = \frac{DP + PL}{q_e} = \frac{200 + 160}{4.40} = 81.22\, ft^2$$

use 9' x 9'' footing Area = 81 ft²

Step 3 ultimate bearing capacity

$$q_u = \frac{1.2\,PD + 1.6\,PL}{\text{Area of footing}}$$

$$= \frac{(1.2 \times 155 + 1.6 \times 160)}{81}$$

$$q_u = 6.12\, ksf$$

Step 4 :- Depth required for two way or Punching shear

The "d" required for two-way shear is the largest value obtained from the following expression

$\alpha_s = 40$ for column

Perimeter is four sided

— square column

(i) $$d = \frac{V_{u2}}{\phi 4 \sqrt{f_c'}\, b_o}$$

(ii) $$d = \frac{V_{u2}}{\phi \left(\frac{\alpha_s d}{b_o} + 2\right) \sqrt{f_c'}\, b_o}$$

b_o = Perimeter around the punching area = 4(a+d)

$b_o = 4(a+d) = 4(16 + 19.5)$

$b_o = 142$ in

$$V_{u2} = \{A - (a+d)\} \times q_u$$

$$V_{u2} = \left\{81 - \frac{(16 + 19.5)}{12}\right\} \times 6.12$$

$V_{u2} = 442.07k = 442090\,lb$

$V_{u2} = 442090\,lb$

① $d = \dfrac{V_{u2}}{\phi 4\sqrt{f_c'}\, b_o} = \dfrac{442090}{0.75\times 4\sqrt{3000}\times 142} = 18.95 < 19.5$ ok

② $d = \dfrac{V_{u2}}{\phi \left(\dfrac{\alpha_s d}{b_o} + 2\right)\sqrt{f_c'}\, b_o} = \dfrac{442090}{0.75\left(\dfrac{40\times 19.5}{142} + 2\right)\sqrt{3000}\times 142}$

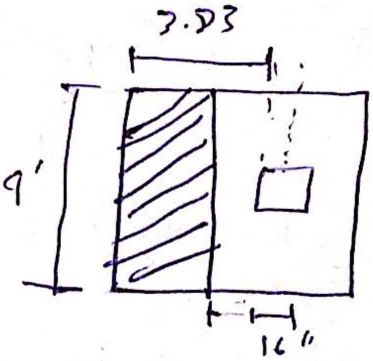
Step 5 :- Depth required for oneway shear $= 16.12'' < 19.5$ ok

$V_{u1} = (9 \times 2.208) \times q_u$

$V_{u1} = (9 \times 2.208) \times 6.12$

$V_{u1} = 121.62\ k$

$V_{u1} = 121620\ lb$



$d = 19.5$

$d = \dfrac{V_u}{\phi 2\sqrt{f_c'}\, b_w} = \dfrac{121620}{0.75\times 2\times\sqrt{3000}\times(9\times 12)}$

$d = 13.71'' < 19.5$ ok

Use $h = 24''$ in Total depth

Moment

$M_u = 3.83 \times 9 \times 6.12 \times \dfrac{3.83}{2}$

$M_u = 404\ ft\text{-}k$

$\dfrac{M_u}{\phi b d^2} = \dfrac{404\times 1000\times 12}{0.9\times(9\times 12)\times(19.5)^2} = 131.2\ Psi$

Use appendix A Table A.12

$\dfrac{M_u}{\phi b d^2} = 134.3 \quad \rho = 0.0023 < \rho_{min}$ for Flexure

then use Greater of

① $\dfrac{200}{6000} = 0.0033$

② $\dfrac{3\sqrt{3000}}{60000} = 0.00274$

so $\rho = 0.0033$

Area of steel

$A_s = \rho b d$

$A_s = 0.00337 \times (9 \times 12) \times 19.5$

$A_s = 6.95 \text{ in}^2$

use Table A.4   9 # 8 bar in both direction

Development length

$\psi_t = \psi_e = \psi_s = \lambda = 1$

$$\frac{l_d}{d_b} = \frac{3}{40} \frac{f_y}{\lambda\sqrt{f_c'}} \frac{\psi_t \psi_e \psi_s}{\frac{c_b}{d_b}} \quad \text{—(1)}$$

if $\frac{c_b}{d_b} > 2.5$ then use 2.5

$c_b =$ side cover $= 3.5''$

$d_b =$ dia of bars $= \frac{8}{8} = 1''$

$$\frac{c_b}{d_b} = \frac{3}{40} \times \frac{60000}{1\sqrt{3000}} \times \frac{1 \times 1 \times 1}{2.5} = 32.86$$

$$\frac{l_d}{d_b} = \frac{A_s\,req}{A_s\,selected} = \frac{32.86 \times 6.95}{7.07} = 32.30$$

$l_d = 32.30 \times d_b = 32.30 \times 1$

$\boxed{l_d = 32''}$ ok