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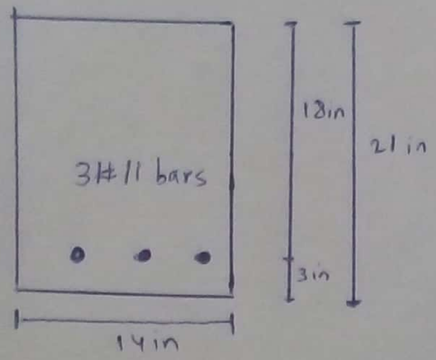
Q NO (1) Determine ε_t, ϕ and ϕM_n for



$f_y = 75{,}000$ psi
$f_c' = 5{,}000$ psi

Solu

Step #01

1st we will find a
As We know That

$$a = \frac{A_s f_y}{0.85 f_c' b}$$ => frome Table Area of steel for #11 is $4.68 in^2$

by putting values

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

$a = 5.899$ in

Step #02 $c = ?$

As $c = \frac{a}{\beta_1}$ As β_1 for 5000 psi Concrete is 0.85

$$c = \frac{5.899}{0.85}$$

$c = 6.940$ in

Step #03 $\quad \varepsilon_T = ?$

As we know that

$$\varepsilon_T = \frac{d-c}{c} \cdot (0.003)$$

$$= \frac{18 - 6.940}{6.940} (0.003)$$

$$\boxed{\varepsilon_T = 0.00478}$$

So $\varepsilon_T > 0.004$

and $\varepsilon_T < 0.005$

So frome the value it is cleared that our beam will be in Transition zone.

Step #04 $\quad \phi = ?$

As we know that

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

$$= 0.65 + (0.00478 - 0.002) \frac{250}{3}$$

$$\boxed{\phi = 0.881}$$

Step # 5 $\phi M_n = ?$

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

$M_n = 4.68 \times 75 \left(18 - \frac{5.899}{2}\right)$

$M_n = 5282.72$ in.k

convert frome in.k To ft.k

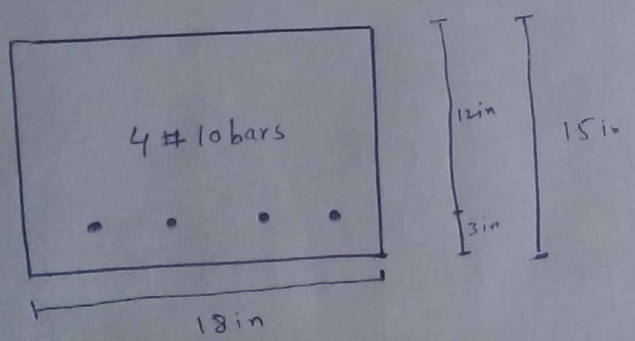
$= 5282.72 \text{ in.k} \times \frac{1 \text{ ft}}{12 \text{ in}}$

$M_n = 440.227$ ft.k

Now

$\phi M_n = 0.881 (440.227)$

$\boxed{\phi M_n = 387.84 \text{ ft.k}}$



$f_y = 60{,}000$ psi

$f_c' = 4{,}000$

Solu

Step # 01 $EI = ?$

1st we find a

As we know That

$$a = \frac{As \cdot fy}{0.85 \cdot fc'b}$$

As Area for sTeel for #10 is 5.06

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

$a = 4.96$ in

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

β_1 for 4000 psi is 0.85

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

$$\boxed{c = 5.835 \text{ in}}$$

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

$$\epsilon t = \frac{12 - 5.835}{5.835}(0.003)$$

$$\boxed{\epsilon t = 0.00316}$$

As $\epsilon t < 0.004$

SecTion is noT DucTile and may noT be used as per ACi SecTion 10.3.5

sTep #02 $\phi = ?$

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

$$\boxed{\phi = 0.746}$$

STep #03 ⑤

$\phi Mn = ?$

$Mn = As \times fy \left(d - \frac{a}{2} \right)$

$= 5.06 \times 60 \left(12 - \frac{4.96}{2} \right)$

$Mn = 2890.27 \text{ in.k}$

Convert in-k into ft-k

$Mn = 2890.27 \text{ in.k} \times \frac{1 \text{ ft}}{12 \text{ in}}$

$Mn = 120.428 \text{ ft-k}$

Now $\phi Mn = ?$

$\phi Mn = 0.746 \times (120.428)$

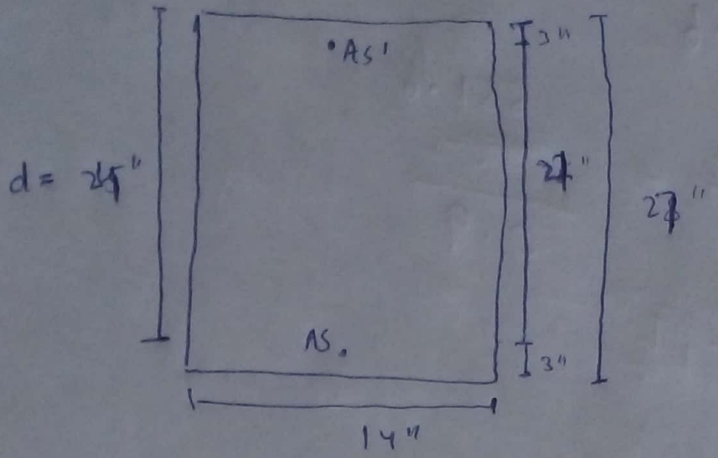
$\boxed{\phi Mn = 89.11 \text{ ft.k}}$

NO (1) (b) Design a DuBly rienforced beam having Dimension 28"×14" MD = 150 ft-k ML = 410 k-ft

$f_c' = 4000$ psi $f_y = 60{,}000$ psi

Solu

The required diagram is



Step #01 1st we find factored movment

$$Mu = 1.2(MD) + 1.6(ML)$$

$$Mu = 1.2(150) + 1.6(410)$$

$$Mu = 836 \text{ fT-k}$$

Step #02 Nominal movment $Mn = ?$

$$Mn = \frac{Mu}{\phi} = \frac{836}{0.9} = \boxed{928.88 \text{ fT-k}}$$

Assuming maximum possible tensile steel with no compression steel and computing beam nominal strength movment.

ρ_{max} (frome Apenden A. Table A.7) = 0.0181

$As_1 = \rho_{max} bd = 0.0181 \times 14 \times 2\cancel{5} = \boxed{6.\cancel{35}\ in^2}$ $6.0\cancel{0}\ in^2$

for $\rho_{max} = 0.0181$, $\frac{Mu}{\phi bd^2} = 912$ psi

$Mu_1 = 912 \times \phi bd^2 = 912 \times 0.9 \times 14 \times (2\cancel{5})^2 = \cancel{7182000}$ 6618931.2 in lb

$\boxed{Mu_1 = \cancel{598.5}\ 551.6\ ft.k}$

$Mn_1 = \frac{Mu_1}{\phi} = \frac{\cancel{598.5}\ 551.6}{0.9}$

$\boxed{Mn_1 = \cancel{665}\ 612.86\ k.ft}$

$Mn_2 = mn - mn_1 \Rightarrow$

$= 928.88 - \cancel{665}\ 612.86$

$\boxed{Mn_2 = 2\cancel{63.8}}$ 316.02 ft.k

step # 03 Theoraticle As' required

$As' = \frac{Mn_2}{fy(d-d')} = \frac{\cancel{263.8}\ 316.02 \times 12}{60(2\cancel{5}-3)} = 2.\cancel{39}\ in^2$ $3.0\ in^2$

Try 3 # 9 bars Area = 3.0 in²

$As' fs' = As_2 fy$

$As_2 = \frac{3 \times 6\cancel{0}}{60} = 3.00\ in^2$

$A_{S2} = 3.00 \text{ in}^2$

$A_S = A_{S1} + A_{S2}$

$A_S = 6.00 + 3.00$

$A_S = 9.00 \text{ in}^2$ Try 4#14 bars (9 in^2)

Note The actual value of As' is quite similler To Theoratick value.
The actual value of As is also equal To Theoratick value. so no need of new bar selection.

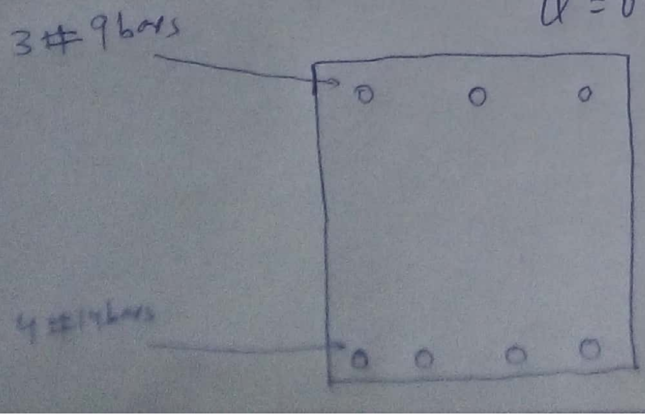
Assuming $f_s' = f_y$

① $\dfrac{(A_S - A_S')f_y}{0.85 \times f_c' b \beta_1} = \dfrac{(9-3) \times 60}{0.85 \times 4 \times 14 \times 0.85} = 8.89 \text{ in}$

② $\varepsilon_s' = \left(\dfrac{c-d'}{c}\right)(0.003) = \dfrac{8.89-3}{8.89}(0.003) = 0.00198 > 0.002$

③ $\varepsilon_t = \left(\dfrac{d-c}{c}\right)(0.003) = \left(\dfrac{24-8.89}{8.89}\right)(0.003) = 0.00509 > 0.005$

$\phi = 0.9$ ok



Q No (2)

Design a short squre coloumn if

$P_u = 150\ k$

$M_u = 15\ ft \cdot k$

$f_c' = 4000\ psi$

$f_y = 60{,}000$

Solution: Assume The coulumn will have an average compresion stress = about $0.6 f_c' = 2400\ psi$

$2.4\ ksi$

$$A_g \text{ required} = \frac{150\ k}{2.4\ ksi} = 62.5\ in^2$$

Try a 8in x 8in in coulumn ($A_g = 64\ in^2$) with The bar arrangement

$$e = \frac{M_u}{P_u} \Rightarrow \frac{(15\ ft \cdot k)(12\ in/ft)}{150}$$

$$\boxed{= 1.2\ in}$$

$$P_n = \frac{P_u}{\varphi} = \frac{150\ k}{0.65} = \boxed{230.76\ k}$$

$$K_n = \frac{P_n}{f_c' A_g} = \frac{230.76}{(4\ ksi)(8'' \times 8'')} = \boxed{0.901}$$

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230-76

$$R_n = \frac{P_n e}{f_c' \cdot A_g \cdot h} = \frac{(230.76k)(1.2)}{(4ksi)(8'' \times 8'')(8'')}$$

$$\boxed{R_n = 0.1352}$$

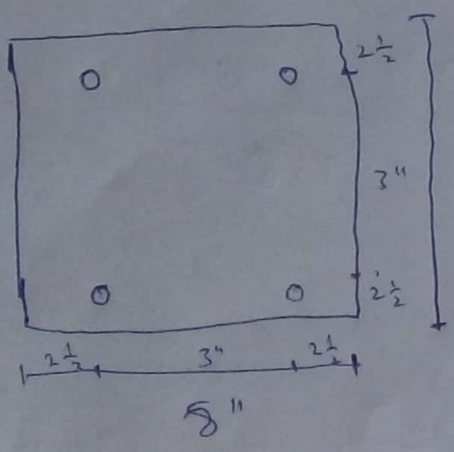
$$\gamma = \frac{3''}{8''} = 0.375 \text{ OR } \gamma$$

interpolation b/w value given in Graph 6 and 7 of Appendix A

$$A_s = (0.0123) \times (8'' \times 8'')$$

$$= 0.78 \text{ in}^2$$

use 4 #4 bars



(3) Design a squre coulumn footing for a 16 inch squre Tied interior column that suport a $P_D = 150\,k$ and $P_L = 160k$. The coulumn is rienforced with #8 bars. The base of footing is 5 feet below. The wieght of soil is $100\,lb/ft^3$, $f_y = 60000\,psi$ and $f_c' = 3000\,psi$ and $q_a = 1505\,psf$. Developement Length for main bars is also To be done in footing design.

Given data:

$P_D = 150k$

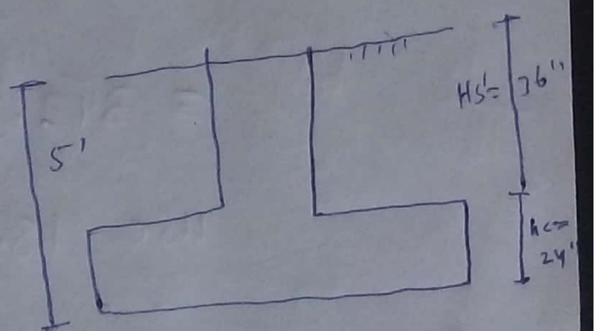
$P_L = 160k$

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

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

$f_c' = 3000\,psi$

$q_a = \cancel{5000}\ 1505\,psf$



Assumed data:

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

$h_c = 24''$

$d = 19.5''$

$H_s' = 36''$

Solution : Step # 01

Effective soil pressure 'q_e'

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

$q_e = \overset{1505}{\cancel{5000}} - \left(\frac{24}{12} \times 150\right) - \left(\frac{36}{12}\right) \times 100$

$q_e = \overset{1505}{\cancel{5000}} - 300 - 300$

$\boxed{q_e = \overset{905}{\cancel{4400}} \text{ psf} = \overset{0.905 \text{ ksf}}{\cancel{4.40 \text{ ksf}}}}$

Step # 02 = Area of footing $= \frac{P_D + P_L}{q_e}$

$= \frac{\cancel{200}\ 150 + 160}{\underset{0.905}{\cancel{440}}} = 7\cancel{0.45\ ft^2}$

$= 342.54$

use $18.5' \times 18.5'$ footing Area $= 342$

Step # 03 ultimate Bearing capicity

$q_u = \frac{1.2 P_D + 1.6 P_L}{A} = \frac{(1.2 \times 150) + (1.6 \times 160)}{342}$

$= \frac{180 + 256}{342} = \boxed{1.274 \text{ ksf}}$

Step # 4 Depth required for Two way or punching shear:

The 'd' required for Two way shear is

The largest value obtain frome The fallowing.

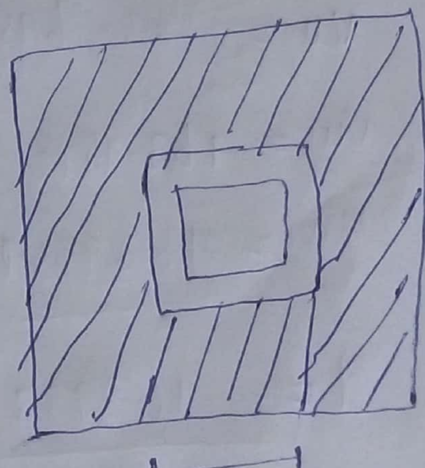
(i) $d = \dfrac{V_{u2}}{\phi 4\sqrt{f_c'}\, b_o}$

$\alpha_s = 40$ for coulumn where parameter is four sided

b_o = parameter around The punching aerea $= 4(a+d)$

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

$$\boxed{b_o = 142''}$$



$16'' + 19.5'' = 35.5''$

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

$V_{u2} = \left\{342.54 - \left(\dfrac{16+19.5}{12}\right)\right\} \times 1.274$

$V_{u2} = 432.62\ K$

$$\boxed{V_{u2} = 432620\ lb}$$

(1) (14)

$$d_1 = \frac{V_{u2}}{\phi 4\sqrt{f_c'}\, b_o} = \frac{432620}{0.75 \times 4\sqrt{3000} \times 142} = 18.5 < 19.5''$$

ok

(2)

$$d = \frac{V_{u2}}{\phi\left(\frac{\alpha_s d}{b_o} + 2\right)\sqrt{f_c'}\, b_o} = \frac{432620}{0.75\left(\frac{40 \times 19.5}{142} + 2\right)\sqrt{3000} \times 142}$$

$d = 9.928'' < 19.5''$ ok

So both value are less then 19.5''

so punching is ok

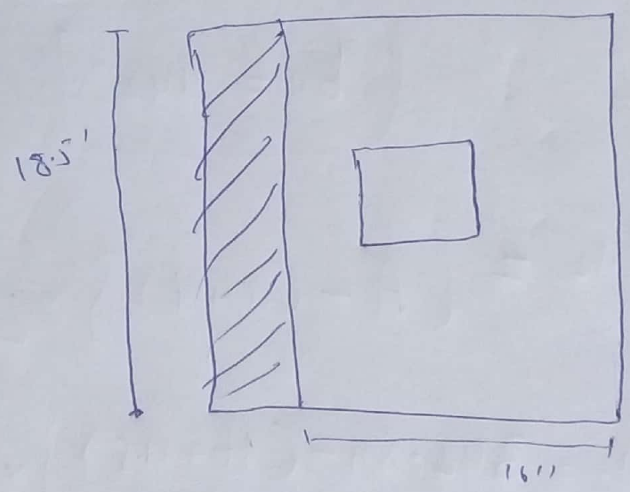
Step # 5 Depth required for one way share

$\frac{L}{2} - \frac{a}{2} = \frac{18.5}{2} - \frac{16}{2} = 8.58'$

$V_{u1} = (18.5 \times 6.958) \times 1.274$

$V_{u1} = 163.99k$

$V_{u1} = 163993\ lb$



$$d = \frac{163993}{0.75 \times 2\sqrt{3000} \times (18.5 \times 12)}$$

$d = 9' < 19.5'$ ok

$d = 19.5''$

$\frac{l}{2} - \frac{a}{2} - d$

$\frac{18.5''}{2} - \frac{16''}{2} - \frac{19.5}{12}$

$9.25 - \frac{8}{12} - \frac{19.5}{12}$

$= 9.25 - 0.667' - 1.625' = 6.958$

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use $h = 24''$ in Total depth

$$Mu = 8.58 \times 18.5 \times 1.274 \times \frac{8.58}{2}$$

$Mu = 871$ ft.k

$$\frac{Mu}{\phi b d^2} = \frac{871 \times 1000 \times 12}{0.9 (18.5 \times 12)(19.5)^2} = 137.2 \text{ psi}$$

use Appendix A Table A-12

$$\frac{Mu}{\phi b d^2} = 139.9 \quad \rho = 0.0024 < \rho_{min} \text{ for flexture}$$

Then use greater of

(1) $$\frac{153}{60{,}000} = 0.00255$$

(2) $$\frac{3\sqrt{3000}}{60{,}000} = 0.00273 \quad \text{so } \rho = 0.00273$$

Area of steel

$AS = \rho b d$

$As = 0.00273 \times (18.5 \times 12) \times 19.5$

$= 11.81 \text{ in}^2$

use Table A.4

8 #11 bars in both direction

(As selected 12.5 in²)

Development length:

$\psi_T = \psi_e = \psi_s = \lambda = 1$

$$\frac{l_d}{d_b} = \frac{3}{40} \frac{f_y}{\lambda\sqrt{f_c}} \frac{\psi_T \psi_e \psi_s}{c_b/d_b}$$

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

ψ = rienforcement Location factor

ψ = Coating factor

ψ_s = Reinforcement size factor

λ = Concrete modification factor

$$\frac{c_d}{d_b} = \frac{3.5}{1} = 3.5 > 2.5 \text{ so use } 2.5$$

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

$$\frac{l_b}{d_b} = \frac{As\ req}{As\ selected} = 32.86 \times \frac{11.81}{12.5} = 31.04$$

$l_b = 31.04\ d_b = 31.04 \times 1$

$\boxed{l_b = 31''}$ ok