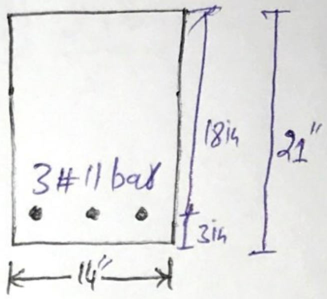
Subject :- "Advance Design of Reinforced Concrete Structure".

P-1

ID :- 15533

Instructor :- Engr. Fawad Ahmad.

Q1 (A) :-



Solution :

$$a = \frac{A_s f_y}{0.85 f_c b}$$

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

$$\boxed{a = 5.899m}$$

⇒ Now finding $C = ?$

$$C = a/B_1$$

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

$$\boxed{C = 6.940m}$$

⇒ $E_t = ?$

$$E_t = \frac{d - c}{c}(0.003).$$

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

$$\boxed{E_t = 0.00478}$$

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$E_t > 0.004$

$E_t < 0.005$

Hence beam is in transition zone.

(2) $\Rightarrow$ $\phi = ?$

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

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

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

(3) $\Rightarrow$ $\phi M_n = ?$

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

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

$M_n = 5282.72$ in-K

Convert it from in-K to ft-K

$$M_n = 5282.72 \, \cancel{in} - K \times \frac{1 ft}{12 \cancel{in}}$$

$$\boxed{M_n = 440.227 \text{ ft-K}}$$

Now

$$\phi M_n = 0.881 \times 440.227.$$

$$\boxed{\phi M_n = 387.84 \text{ ft-K}}$$

Q1 Solution:-

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$$\epsilon_t = ?$$

$$a = \frac{A_s f_y}{0.85 \times f_c' \times b}$$

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

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

$$c = a/\beta_1$$

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

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

Now, $\epsilon_t = \frac{d-c}{c}(0.003)$

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

$$\boxed{\epsilon_t = 0.00316}$$

$$\epsilon_t = 0.00316 < 0.004.$$

Section is not ductive & may not be used as for ACI Section 10.3.5.

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Question # 01 (b)

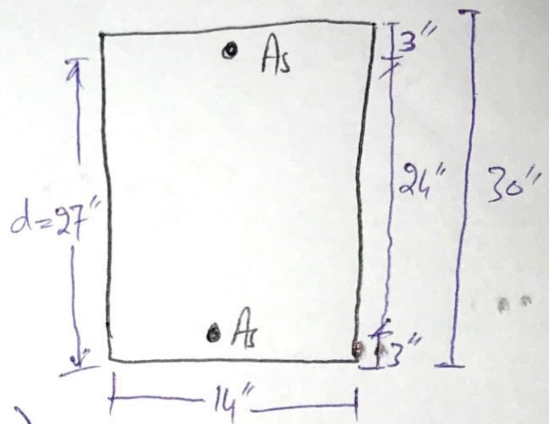
Given data:-

$M_D = 155$ ft-K

$M_L = 410$ ft-K

$f_c = 4000$ psi

$f_y = 60000$ psi



Solution:- (1) Factored Moment:-

$M_u = 1.2 M_D + 1.6 M_L$

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

$M_u = 186 + 656$

~~$M_u = 834.8$ ft-K~~

$\boxed{M_u = 842 \text{ ft-K}}$

(2) Nominal moment $M_n = ?$

$M_n = M_u/\phi$

$= 842/0.90$

$\boxed{M_n = 927.77 \text{ ft-K}}$

Assuming Max possible Tensile steel with No compression steel & computing beam nominal stress moment.

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ρ_{max} (from Appendix A, Table A-7) $= 0.0181$

$A_{s1} = \rho_{max}\, bd$

$= 0.181 \times 14 \times 27$

$\boxed{A_{s1} = 6.842\ in^2}$

For,

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

$M_{u1} = 912 \times \phi b d^2$

$= 912 \times 0.9 \times 14 \times (27)^2$

$$M_{u1} = \frac{8377084.8}{12}\ in-lb$$

$= 698090\ ft-lb$

$$= \frac{698090}{1000}$$

$\boxed{M_{u1} = 698\ ft-K}$

$$M_{n1} = M_{u1}/\phi = \frac{698}{0.9}$$

$\boxed{M_{n1} = 775.55\ ft-K}$

$M_{n2} = M_n - M_{u1} = 927.77 - 698$

$\boxed{M_{n2} = 229.77\ ft-K}$

Theoritical A_s' Required.

$$A_s' = \frac{M_{n2}}{f_y(a-d)}$$

$$= \frac{229.77 \times 12}{60(27-3)}$$

$$= 1.96 \simeq 2\ in^2$$

Try 2 #9 ($2.00\ in^2$).

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

$$A_{s2} = \frac{A_s' f_s'}{f_y} = \frac{2 \times 60}{60}$$

$$\boxed{A_{s2} = 2\ in^2}$$

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

$$= 6.842 + 2$$

$$\boxed{A_s = 8.842\ in^2}$$ Try 8 #10 ($10.00\ in^2$).

Note: The actual value of A_s' is exactly the same as theoritical value. The actual value of A_s however is higher than the theoritical value by $10 - 12 - 9.6\ in^2$

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Assuming, $f_s' = f_y$

$$\frac{(A_s - A_s')f_y}{0.85 f_c'} = \frac{(10.12-2.36)\times 60}{0.85\times 4\times 14\times 0.85}$$

$$\boxed{C = 11.5 \text{ in}}$$

$$\varepsilon_s' = \left(\frac{c-d}{c}\right)(0.003).$$

$$= \frac{11.5-3}{11.5}\times(0.003).$$

$$\Rightarrow \varepsilon_s' = 0.00217 > f_y$$

$$\Rightarrow \varepsilon_t = \left(\frac{d-c}{c}\right)(0.003).$$

$$= \left(\frac{27-11.5}{11.5}\right)(0.003).$$

$$= 0.00404 < 0.005$$

$$\phi \neq 0.90$$

$$\phi = 0.65 + (\varepsilon_t - 0.002)\,250/3$$

$$= 0.65 + (0.0404 - 0.002)\,250/3.$$

$$\boxed{\phi = 0.82}$$

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ID=15533 P(8)

$$A_{s2} = \frac{A_s' f_s'}{f_y} = \frac{2.36 \times \cancel{60}}{\cancel{60}}$$

$$\boxed{A_{s2} = 2.36 \text{ in}^2}$$

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

$$= 10.12 - 2.36$$

$$\boxed{A_{s1} = 7.76 \text{ in}^2}$$

$$M_{n1} = A_{s1} f_y \left(d - a/2\right)$$

$$= 7.76 \times 60 \left[27 - \frac{0.85 \times 10.74}{2}\right].$$

$$M_{n1} = 10912.5 \text{ in-k}$$

$$M_{n1} = \frac{10912.5}{12}$$

$$\boxed{M_{n1} = 909.29 \text{ ft-k}}$$

$$M_{n2} = A_{s2} f_y \left(d - d'\right).$$

$$= (2.36)(60)(27-3).$$

$$= 3398 \text{ in-k}$$

$$\boxed{M_{n2} = 283 \text{ ft-k}}$$

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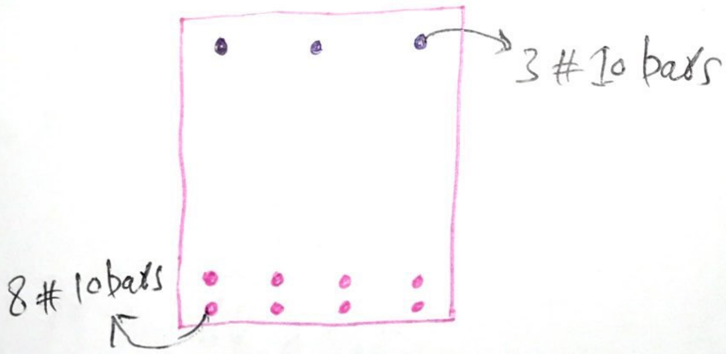
ID=15533 P(9)

$$M_n = M_{n_1} + M_{n_2}$$
$$= 909 + 283$$
$$\boxed{M_n = 1192 \text{ ft-K}}$$

$$\phi M_n = 0.82 \times 1192$$
$$= 977 \text{ ft-K} > M_u \text{ (OK)}$$

$A_s' = 2.36 \text{ in}^2$ (3 #8 bars).

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



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ID = 15533

P (10).

Given Data of Question #02:-

$P_u = 155\,K.$

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

$f_c' = 4000\,psi$

$f_y = 60000\,psi$

Solution:- Assume that the column will have Average Compression stress is about $0.6 f_c' = 2400\,psi$
$= 2.4\,Ksi$

$A_g = P_u / 0.6 f_c'$

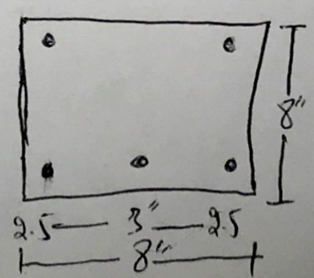
$= 155/2.4$

$\boxed{A_g = 64.08\,in^2}$

Try 8 in x 8in column ($A_g = 64\,in^2$) with the bar Arrangement

$e = M_u/P_u \Rightarrow \dfrac{(14\,\cancel{ft}\text{-}K)(12\,in/ft)}{155}$

$\boxed{e = 1.08\,in}$



$$P_n = P_u / \phi$$

$$= 155 / 0.65$$

$$\boxed{P_n = 238.46}$$

$$K_n = P_n / f_c' A_g$$

$$= \frac{238.46}{4 \times (8 \times 8)}$$

$$\boxed{K_n = 0.936}$$

$$R_n = \frac{P_n e}{f_c' \times A_g \times h}$$

$$= \frac{(238.46)(1.08)}{4 \times (8 \times 8)(8)}$$

$$\boxed{R_n = 0.236}$$

$$\gamma = 3'' / 8''$$

$$\boxed{\gamma = 0.375}$$

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

$$\boxed{A_s = 0.78 in^2}$$ use $4 \# 4 = 0.78 in^2$.

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(15533) P(12)

Question #3:-

Given data:-

$P_D = 155\ K$

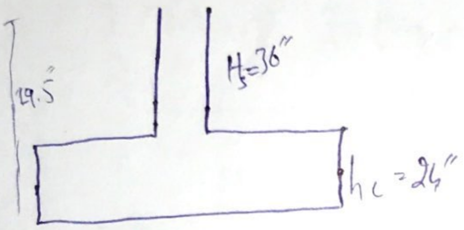
$P_L = 160\ K$.

unit weight of Soil = $\gamma_s = 100\ lb/ft^3$

$f_y = 60000\ psi$

$f_c' = 3000\ psi$

$q_a = 1553\ psi$



Assumed data:-

unit weight of Concrete = $150\ lb/ft^2$

$h_c = 24''$

$d = 19.5''$

$H_s = 36''$

Solution:-

STep 1:- Effective soil pressure "q_e"

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

$$= 1553 - \left(\frac{24}{12} \times 150\right) - \left(36/12\right) \times 100$$

$$= 843\ Psf$$

$$\boxed{q_e = 0.843\ ksf}$$

STep#2 :- Area of footing

$$= \frac{P_D + P_L}{q_e}$$

$$= \frac{155 + 160}{0.843}$$

$\boxed{\text{Area of footing} = 338\ ft^2}$

Use $18.5' \times 18.5'$ footing Area $= 342\ ft^2$

STep # 03 :- ultimate bearing Capacity.

$$q_u = \frac{1.2 P_D + 1.6 P_L}{\text{Area of footing}}$$

$$= \frac{1.2(155) + 1.6(160)}{342}.$$

$\boxed{q_u = 1.36\ ksf}$

STep # 04 :- Depth required for two way or punching shear
The "d" required for the two way shear is the largest value obtained from the expression.

P.T.O.

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(i) $d = \dfrac{V_{u_2}}{\phi 4 \sqrt{f_c}\, b_o}$

$\alpha_s = 40$ for column where parameter is four sided square column.

(ii) $d = \dfrac{V_{u_2}}{\phi \left(\dfrac{\alpha_s d}{b_o} + 2\right) \sqrt{f_c}\, b_o}$

b_o = Parameter around the punching area

$b_o = 4(a+d)$.

$b_o = 4(16+19.5)$.

$\boxed{b_o = 142 \text{ in}}$

$V_{u_2} = \{A - (a+d)\} \times q_u$

$= \left\{338 - \left(\dfrac{16+19.5}{12}\right)\right\} \times 1.36$

$\boxed{V_{u_2} = 456.973 \text{ K}}$ lb

$\boxed{V_{u_2} = 456973 \text{ lb}}$

(1) $d = \dfrac{V_{u_2}}{\phi \times 4 \sqrt{f_c'}\, b_o}$

$d = \dfrac{456973}{0.75 \times 4 \times \sqrt{3000} \times 142}$

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$d = 18.86'' < 19.5''$ ok

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

$$= \frac{456973}{0.75\left(\frac{40\times 19.5}{142}+2\right)\sqrt{3000}\times 142}$$

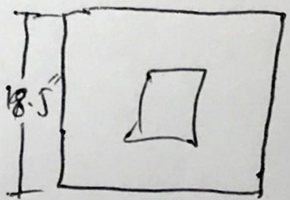
$d = 10.126'' < 19.5''$ oK

Since both values of "d" are less than the assumed value of 19.5", putting is ok.

Step # 5:- Depth required for one-way shear.

$V_{u_1} = (18.5\times 6.958)\times 1.28$

$\boxed{V_{u_1} = 164576\text{ lb}}$



$d = 19.5''$

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

$= \frac{18.5}{2} - \frac{16''}{2} - 17.5$

$= 6.958.$

$$d = \frac{V_u}{\phi\times 2\sqrt{f_c}\times b_w}$$

$$= \frac{164576}{0.75\times 2\times\sqrt{3000}\times(18.5\times 12)}$$

$\boxed{d = 9.81''} < 19.5''$ oK

Use $h = 24''$ in total depth.

Moment:-

$$M_u = 8.58 \times 18.5 \times 1.28 \times \frac{8.58}{2}$$

$$M_u = 871 \text{ ft-K}$$

$$\frac{M_u}{\varphi b d^2} = \frac{871 \times 1000 \times 12}{0.9 \times (18.5 \times 12)(19.5)^2}$$

$$= 137.5 \text{ psi} \qquad \rho = 0.0024 < \rho_c \text{ min.}$$

Now use greater of.

① $\dfrac{155}{60000} = 0.0025$

② $\dfrac{3\sqrt{3000}}{60000} = 0.00273.$

so $\rho = 0.00273$

Area of steel:-

$$A_s = \rho b d$$

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

$\boxed{A_s = 11.81 \text{ in}^2}$ use table A 4.

8 #11 bars in both direction (A_s selected $= 12.5 \text{ in}^2$)

Development length:-

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

$$\frac{l_d}{d_b} = \frac{3}{40}\frac{f_y}{\lambda\sqrt{f_c}}\ \frac{\psi_t \psi_e \psi_s}{C_b/d_b} \rightarrow eq\ 1.$$

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

C_b = side corner = 3.5"

d_b = dia of bars = $8/8 = 1$

$$\frac{cd}{db} = \frac{3.5}{1} = 3.5 > 2.5$$

using equation 1.

$$\frac{l_b}{d_b} = 3/40 \times \frac{60000}{\sqrt{3000}} \times \frac{1\times1\times1}{2.5} = 32.86$$

$$\frac{l_b}{d_b} = \frac{A_s\ \text{required}}{A_s\ \text{selected}} = 32.86 \times \frac{11.81}{12.5} = 81.84.$$

$l_b = 32.3 \times d_b.$

$= 32.3 \times 1$

$\boxed{l_b = 31"}$ ok