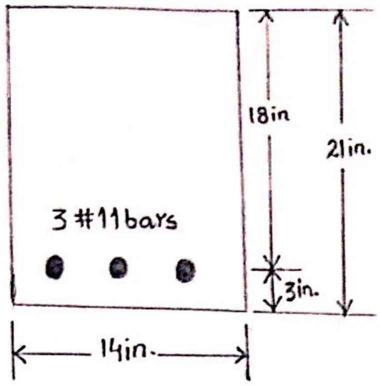
Student Name:	**Pir Zeeshan Shah**
ID:	**15341**
Module:	**4th**
Subject:	**Advance Design of Reinforce Concrete Design**
Date of submission:	**25th April 2020**
Instructor Name:	**Engr. Fawad Ahmad**

IQRA NATIONAL UNIVERISTY, PESHAWAR

Question no#1

(A) Determine the values of ϵ_t, ϕ, and ϕM_n for the sections shown below :

(i)



$F_y = 75{,}000$ psi
$f'_c = 5{,}000$ psi

Solution :

For $\epsilon_t = ?$

- $$a = \frac{A_s F_y}{0.85 f'_c b} = \frac{4.68 \times 75}{0.85 \times 5 \times 14}$$

$$\boxed{a = 5.899 \text{ in}}$$

- $$C = \frac{a}{\beta_1} = \frac{5.899}{0.85}$$

$$\boxed{C = 6.940 \text{ in}}$$

Now ϵ_t

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

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

$$\boxed{\epsilon_t = 0.00478}$$

$\epsilon_t > 0.004$

$\epsilon_t < 0.005$

Hence beam is in transition zone.

For $\phi = ?$

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

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

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

For $\phi M_n = ?$

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

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

$$= 5282.72 \text{ in-k}$$

Convert from in-k to ft-k

$$M_n = 5282.72 \cancel{\text{in}}\text{-k} \times \frac{1 \text{ ft}}{12 \cancel{\text{in}}}$$

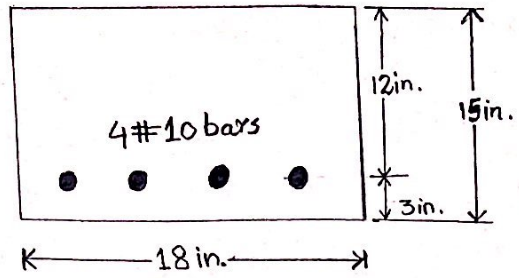
$$\boxed{M_n = 440.227 \text{ ft-k}}$$

Now

$$\phi M_n = 0.881(440.227)$$

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

(ii)



$f_y = 60{,}000$ psi

$f'_c = 40{,}00$ psi

Solution :

For $\epsilon_t = ?$

- $a = \dfrac{A_s \cdot f_y}{0.85 f'_c\, b} = \dfrac{5.06 \times 60}{0.85 \times 4 \times 18}$

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

- $c = a/\beta_1 = 4.96/0.85$

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

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 ductile ϵ_T may not be used as per ASI section 10.3.5 .

For $\phi = ?$

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

$$= 0.65\,(0.00316 - 0.002)\,\frac{250}{3}$$

$$\phi = 0.746$$

For $\phi M_n = ?$

$$M_n = A_s \times f_y (d - a/2)$$

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

$$= 2890.27 \text{ in-k}$$

Convert in-k to ft-k

$$M_n = 2890.27 \cancel{\text{in}}\text{-k} \times \frac{1 \text{ft}}{12 \cancel{\text{in}}}$$

$$\boxed{M_n = 120.428 \text{ ft-k}}$$

Now

$$\phi M_n = 0.746 \times 120.428$$

$$\boxed{\phi M_n = 89.11 \text{ ft-k}}$$

Question no 1

(B) Design a doubly reinforced beam for M_D = [first three digits of ID] ft-k and $M_L = 410$ ft-k, if $f_c' = 4000$ psi and $f_y = 6000$ psi. Appropriate diagram is must in design.

- Assume the maximum permissible beam dimensions other then done in notes or text book.

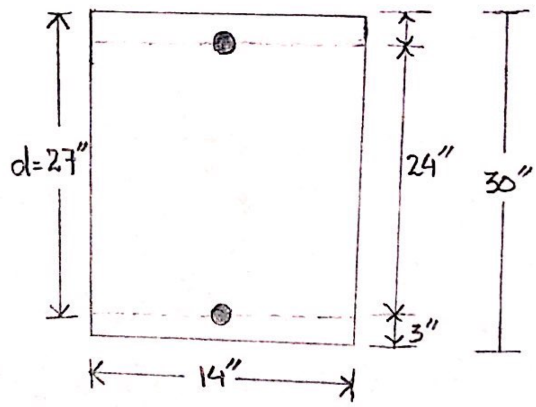
Given Data :

$M_D = 153$ ft-k

$M_L = 410$ ft-k

$f_c' = 4000$ psi

$f_y = 60{,}000$ psi



Solution :

Factored Moment :

$$M_u = 1.2 M_D + 1.6 M_L$$

$$= 1.2(153) + 1.6(410)$$

$$= 839.6 \text{ ft-k}$$

$$\boxed{M_u = 840 \text{ ft-k}}$$

Nominal Moment : (M_n)

$$M_n = M_u/\phi$$

$$= 840/0.90 \qquad \because \phi = 0.90$$

$$\boxed{M_n = 933.33 \text{ ft-k}}$$

Assuming Max-possible Tensile steel with no compression steel and computing beam nominal strength moment.

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

$$As_1 = \rho_{max}\, b\, d$$
$$= 0.0181 \times 14 \times 27$$
$$= \boxed{6.842 \text{ in}^2}$$

For

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

$$M_u = 912 \times \phi b d^2$$
$$= 912 \times 0.9 \times 14 \times (27)^2$$
$$= \frac{8377084.8 \text{ in-lb}}{12}$$
$$= \frac{698090 \text{ ft-lb}}{1000}$$

$$\boxed{M_{u_1} = 698 \text{ ft-k}}$$

- $M_{n_1} = \dfrac{M_{u_1}}{\phi} = \dfrac{698}{0.90} = 775.55$ ft-k
- $M_{n_2} = M_n - M_{n_1} = 933.33 - 698 = 235.33$ ft-k

Theoretical As' Required :

$$As' = \frac{M_{n_2}}{f_y(d-d')} = \frac{235.33 \times 12}{60(27-3)} = 1.96 \approx \boxed{2 \text{ in}^2}$$

Try 2 #9 (2.00 in^2)

$$As' f_s' = As_2 f_y$$

$$As_2 = \frac{As' f_s'}{f_y} = \frac{2 \times 60}{60} = 2 \text{ in}^2$$

$$As = As_1 + As_2$$
$$= 6.842 + 2$$
$$= \boxed{8.842 \text{ in}^2}$$

Try 8 #10 (10.12 in^2)

Note : The Theoratical value of As′ is exactly the same as the theoratical value.
The actual value of As however is higher than the theoratical value by $10.12 - 9.6 = 0.52\ in^2$.
if new bar selection for As′ is made where by the actual value of As′ exceeds the theoratical value by about this much ($0.52\ in^2$), the design will be adequate.
Select 3#8 bars ($As = 2.36\ in^2$) and Repeat the previous step.

Assuming $fs' = fy$

(1) $$\frac{(As - As')\,fy}{0.85\,fc'\,b\,\beta_1} = \frac{(10.12 - 2.36)\times 60}{0.85\times 4\times 14\times 0.85} = 11.5\ in$$

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

(2) $$\epsilon_s' = \left(\frac{c-d'}{c}\right)(0.003) = \left(\frac{11.5-3}{11.5}\right)(0.003) = 0.00217 > \epsilon_y$$

(3) $$\epsilon_t = \left(\frac{d-c}{c}\right)(0.003) = \left(\frac{27-11.5}{11.5}\right)(0.003)$$

$$= 0.00404 < 0.005$$

$$\phi \neq 0.90$$

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

$$\phi = 0.65 + (0.00404 - 0.002)\,\frac{250}{3}$$

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

$$As_2 = \frac{As'\,fs'}{fy} = \frac{236\times 60}{60} = 2.36\ in^2$$

$$As_1 = As - As_2 = 10.12 - 2.36 = 7.76\ in^2$$

$$Mn_1 = As_1\,fy\left(d - \frac{a}{2}\right) = 7.76\times 60\left[27 - \frac{0.85\times 10.74}{2}\right]$$

$$= \frac{10911.5}{12}\ in-k$$

$$\boxed{Mn_1 = 909.29\ ft\text{-}K}$$

$$M_{n2} = A_{s2} f_y (d - d')$$

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

$$M_{n2} = 3398 \text{ in-k} * \frac{1 \text{ ft}}{12 \text{ in}}$$

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

$$M_n = M_{n1} + M_{n2} = 909 + 283$$

$$\boxed{M_n = \cancel{ft}\cdot 1192 \text{ ft-K}}$$

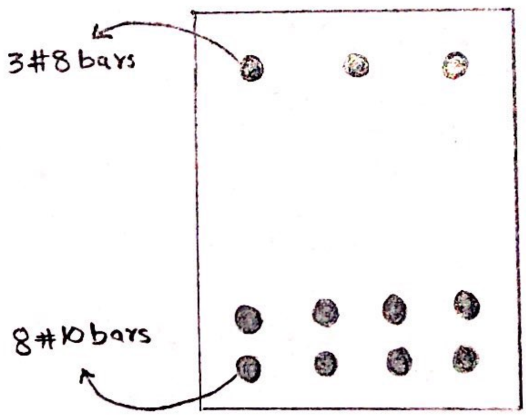
$$\phi M_n = 0.82 \times 1192$$

$$= 977 \text{ ft-k} > M_u$$

$\boxed{\text{OK}}$

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

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



Question no-2

Design a short square column for the following Condition $P_u = 153\,K$, $M_u = 15$ ft-k, $f_c' = 4000$ psi, $f_y = 60{,}000$ psi.

Place the bars uniformly around all the four faces of column. Appropriate diagram must in design.

Given Data :-

$P_u = 153\,K$.

$M_u = 15$ ft-k.

$f_c' = 4000$ Psi.

$f_y = 60{,}000$ Psi.

Solution :-

Assume the column will have average compression stress about $0.6 f_c' = 2400$ psi $= 2.4$ ksi

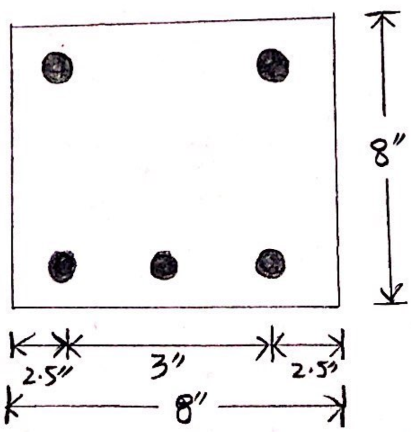
$$A_{g(req)} = 153\,K / 2.4\,ksi = P_u / 0.6 f_c'$$

$$= \boxed{63.75\ in^2}$$

Try 8 in x 8 in Column ($A_g = 64\ in^2$) with the bar arrangement.

$$e = \frac{M_u}{P_u} = \frac{(15\ \cancel{ft}\text{-}k)(12\,in/\cancel{ft})}{153\,K}$$

$$= \boxed{1.17\ in}$$



$$P_n = P_u/\phi = \frac{153}{0.65}$$

$$= \boxed{235.38\,K}$$

$$K_n = P_n / f_c' A_g = 235.38\,k / (4\,ksi)(8'' \times 8'')$$

$$= \boxed{0.919}$$

$$R_n = \frac{P_n\, e}{f_c' A_g . h} = \frac{(235.38\,k)(1.17\,in)}{(4\,ksi)(8'' \times 8'')(8'')}$$

$$= \boxed{0.1344}$$

$$\gamma = 3''/8'' = \boxed{0.375}$$

Interpolating b/w values given in graphs 6 and 7 of appendix - A.

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

$$= 0.78\ in^2$$

use 4 #4 bar = $0.78\ in^2$

Question no 3

Design a square column for a 16 inch square tied interior column that support a dead load $P_D = 153k$ and live load of $P_L = 160\,k$. The column is reinforced with #8 bars the base of footing is 5 feet below, the soil weight is $100\ lb/ft^3$. $f_y = 60{,}000$ psi and $f_c' = 3000$ psi and q_a (first four digits of ID) 1534 psf. Developement length for main bars is also to be done in footing design. Appropriate Diagram is must be in design.

Given Data :

$P_D = 153\ k$ (first Three Digits of ID)

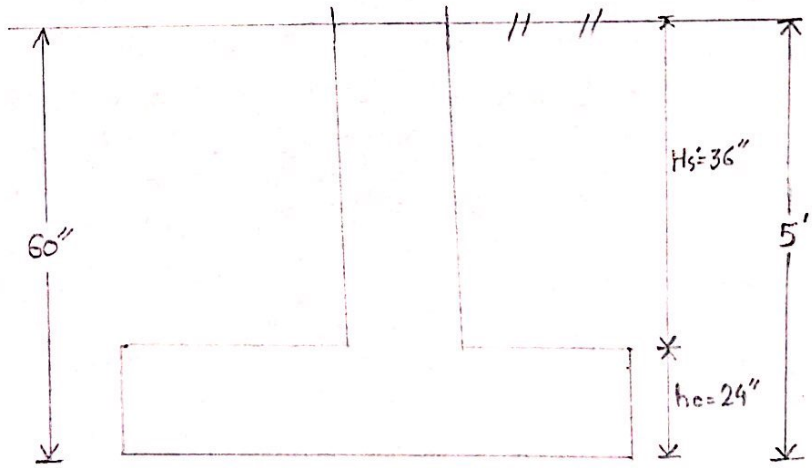
$P_L = 160\ k$

$\gamma_s = 100\ lb/ft^2$

$f_y = 60{,}000$ psi

$f_c' = 3000$ psi

$q_a = 1534$ psf (first four Digits of ID)



Assumed Data :

Unit weight of Concrete $= \gamma_c = 150\ lb/ft^3$

$h_c = 24"$

$d = 19.5"$

$H_s' = 36"$

Step # 01 :

effective soil pressure "q_e"

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

$$= 1534 - \left(\frac{24}{12} \times 150\right) - \left(\frac{36}{12}\right) \times 100$$

$$= 934\ Psf$$

$$\boxed{q_e = 0.934\ ksf}$$

Step # 02 Area of footing

$$\text{Area of footing} = \frac{P_D + P_L}{q_e}$$

$$= \frac{153 + 160}{0.934}$$

$$= \boxed{335\ ft^2}$$

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

Step # 03 Ultimate Bearing Capacity.

q_u = Ultimate Bearing Capacity

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

$$= \frac{(1.2 \times 153) + (1.6 \times 160)}{342}$$

$$\boxed{q_u = 1.28\ ksf}$$

Step # 04 Depth required for two way or punching shear

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

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

$\alpha_s = 40$ for Column where perimeter is four sided - square column.

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

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

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

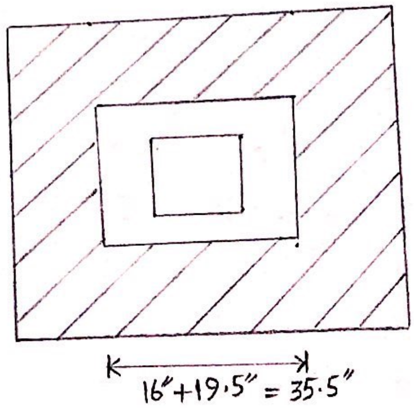
$$\boxed{b_o = 142\ in}$$

$$V_{u_2} = \cancel{433}\{A - (a+d)\} \times q_u$$

$$= \left\{335 - \left(\frac{16 + 19.5}{12}\right)\right\} \times 1.28$$

$$V_{u_2} = 433.973\ K$$

$$\boxed{V_{u_2} = 433973\ lb}$$



Two way shear

(1) $$d = \frac{V_{u2}}{\phi 4\sqrt{f_c'}\, b_o} = \frac{433973}{0.75\times 4\times\sqrt{3000}\times 142} = 18.59'' < 19.5''$$

$\boxed{\text{OK}}$

(2) $$d = \frac{V_{u2}}{\phi\left(\frac{\alpha_s d}{b_o}+2\right)\sqrt{f_c'}\, b_o} = \frac{433973}{0.75\left(\frac{40\times 19.5}{142}+2\right)\sqrt{3000}\times 142} = 9.928'' < 19.5''$$

$\boxed{\text{OK}}$

Since both value of d are less than the assumed valued of 19.5" so punching is ok

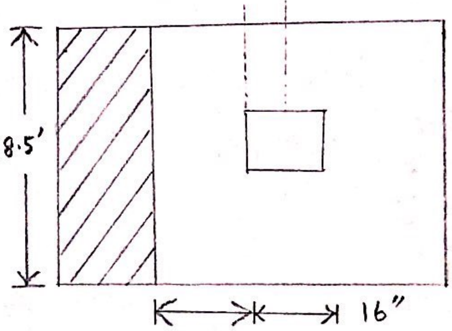
Step # 5 Depth Required for one way shear

$$\frac{L}{2}-\frac{a}{2} = \frac{18.5}{2} - \frac{16}{2}/12 = 8.58'$$

$$V_{u1} = (18.5\times 6.958)\times q_u$$
$$= (18.5\times 6.958)\times 1.28$$
$$= 164.576\text{ k}$$

$\boxed{V_{u1} = 164576\text{ lb}}$

$$\frac{L}{2}-\frac{a}{2}-d$$
$$= \frac{18.5}{2} - \frac{16''}{2} - 19.5''$$
$$= 9.25 - \frac{8}{12} - \frac{19.5}{12}$$
$$= 9.25' - 0.667' - 1.625'$$
$$= \boxed{6.958'}$$



$$d = \frac{V_u}{\phi 2\sqrt{f_c'}\, b_w} = \frac{164576}{0.75\times 2\times\sqrt{3000}\times(18.5'\times 12)}$$

$$d = 9.01'' < 19.5''$$

$\boxed{\text{Ok}}$

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

Moment :

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

$\boxed{M_u = 871\text{ ft-k}}$

$$\frac{M_u}{\phi b d^2} = \frac{871\times 1000\times 12}{0.9\times(18.5\times 12)(19.5)^2} = 137.5\text{ psi}$$

use Appendix A, Table A-12

$$\frac{M_u}{\phi b d^2} = 139.9 \qquad \rho = 0.0024$$

$< \rho_{min}$ for flexure

Then use greater of

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

(2) $\dfrac{3\sqrt{3000}}{60{,}000} = 0.00273$

So, $\rho = 0.00273$

Area of steel

$A_s = \rho bd$

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

$= 11.81\ in^2$

use Table A-4

8 #11 bars in both direction

$\boxed{A_{s\,selected} = 12.5\ in^2}$

Development length

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

ψ_t = Reinforcement location factor.

ψ_e = Coating factor.

ψ_s = Reinforcement size factor.

λ = Concrete modification factor.

$$\frac{l_d}{d_b} = \frac{3}{40}\,\frac{f_y}{\lambda\sqrt{f_c'}}\,\frac{\psi_t\psi_e\psi_s}{C_b/d_b}$$

if $\dfrac{C_b}{d_b} > 2.5$ Then use 2.5

C_b = Side Cover = 3.5"

d_b = dia of bar $= \dfrac{8}{8} = 1"$

$\dfrac{C_d}{d_b} = \dfrac{3.5}{1} = 3.5" > 2.5"$ so use $\boxed{2.5"}$

using equ (1)

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

$$\frac{l_b}{d_b}\,\frac{A_{s\,req}}{A_{s\,selected}} = 32.86 \times \frac{11.81}{12.5} = 31.04$$

$l_b = 31.04 \times d_b = 31.04 \times 1 \Rightarrow \boxed{l_b = 31"}$ $\boxed{\text{OK}}$