Mid Term Paper.

Subject:- Advance Design of Reinforced Concrete Structure.

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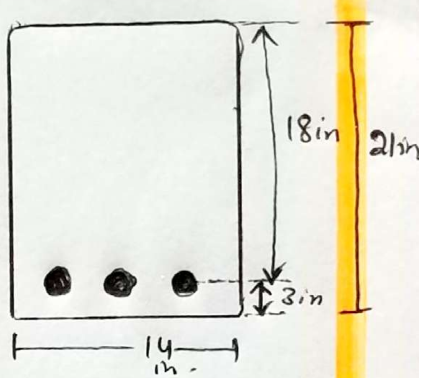
Q1 8b

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



Required (i) $\varepsilon_t = ?$ (ii) $\phi = ?$ (iii) $\phi M_n = ?$

(i) ε_t :→

$$\varepsilon_t = \frac{d-c}{c}(0.003) \quad \text{—— } (A).$$

First we will find "c"

$$a = \frac{A_s f_y}{0.85 f_c' b} = \frac{4.68 \times 75}{0.85 \times 5 \times 14} = 5.899\,in.$$

$\beta_1 = 0.80$ for $f_c' = 3000$ psi Concrete.

$$c = a/\beta_1 = \frac{5.899}{0.8} = 7.37\,in.$$

Now (A) ⇒ $\varepsilon_t = \left(\frac{d-c}{c}\right)(0.003) = \left(\frac{18-7.37}{7.37}\right)(0.003).$

$$\boxed{\varepsilon_t = 0.00432.}$$

$\varepsilon_t > 0.004$

$\varepsilon_t < 0.005$

Hence the beam in transition zone.

(ii) $\phi = ?$

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

$$\phi = 0.65 + (0.00432 - 0.002)$$

$$\boxed{\phi = 0.836.}$$

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(iii) $\phi M_n = ?$

first we check the steel.

$$\rho = \frac{A_s}{bd} = \frac{4.68}{14 \times 18} = 0.0185$$

From table "A.7" in Appendix "A"

$$\rho > \rho_{min} = 0.0028$$
$$\rho < \rho_{max} = 0.0194$$

Ok

So

$$M_n = A_s f_y (d - a/2) = 4.68 \times 75 (18 - \frac{5.898}{2})$$

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

$$M_n = 440.229 \text{ ft-k}.$$

Now

$$\phi M_n = 0.836 \times 440.229$$

$$\boxed{\phi M_n = 368.029}$$

~~The ... ~~

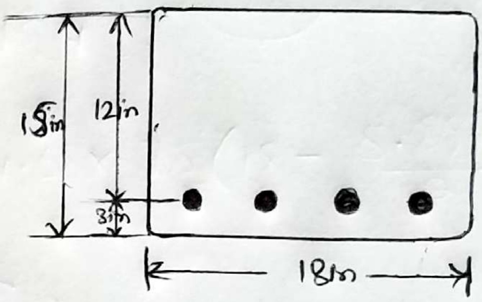
The value of strain is greater the yield strain 0.002 but less than 0.005. This indicate the beam laying in transition zone. To make more safer the value of ϕ should be calculated which change. Now the steel is well into it's yield plateau before concrete crushes.

P.T.O

→ The value of ρ is greater than ρ_{min} & less than ρ_{max}. so As per ACI Code the reinforcement is ok the steel will be yield first & give a warning sign before failure.

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

$f_c' = 4{,}000\,psi$



$$\varepsilon_t = \left(\frac{d-c}{c}\right)(0.003) \quad - (B)$$

$$\Rightarrow \quad a = \frac{A_s f_y}{0.85 f_c' b} = \frac{5.06 \times 60}{0.85 \times 4 \times 18} = 4.96\,in$$

$\beta_1 = 0.85$ for $f_c' = 4{,}000\,psi$

$$c = a/\beta_1 = \frac{4.96\,in}{0.85} = 5.835\,in.$$

Now

$$(B) \Rightarrow \quad \varepsilon_t = \left(\frac{12 - 5.835}{5.835}\right)(0.003)$$

$$\boxed{\varepsilon_t = 0.003}$$

$$\varepsilon_t \nless 0.004,$$

So the above section is not ductile & may not be used as per ACI Section 10.3.5

(B) Q

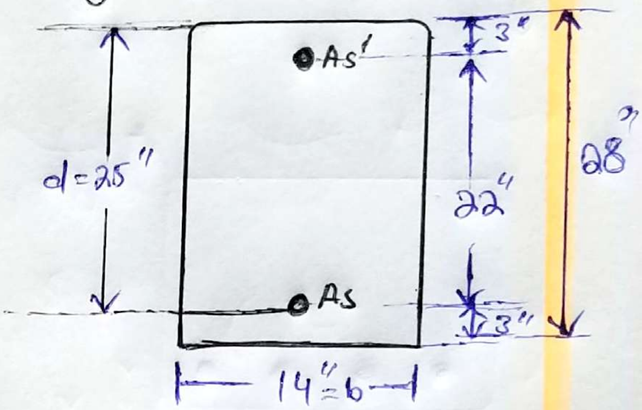
Given Data.

M_D = Reg NO = 152 ft-k. M_L = 400 ft-K

f_c' = 4,000 psi f_y = 60,000 psi.

Sol

Section:-



(1) Factored Moment:→

$$M_u = 1.2 M_D + 1.6 M_L$$

$$= 1.2 \times 152 + 1.6 \times 400 = 822 \text{ ft-k}.$$

$$\boxed{M_u = 822 \text{ ft-k}}$$

(2) Nominal Moment:-

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

$$\boxed{M_n = 913.3 \text{ ft-k}}$$

Assuming maximum possible tensile steel with no compression steel & computing Beams nominal strength moment.

ρ_{max} (from table A.7, Appendix A) = 0.0181

$A_{s_1} = \rho_{max} bd = 0.0181 \times 14 \times 25$

$\boxed{A_{s_1} = 6.335\ in^2}$

For $\rho_{max} = 0.0181$ $\quad M_u/\phi bd^2 = 912\ psi$

(From Table A.13).

$\Rightarrow M_{u_1} = 912 \times \phi bd^2 = 912 \times 0.9 \times 14 \times (25)^2$

$M_{u_1} = 7182000\ in\text{-}lb = \frac{7182000}{12}\ ft\text{-}lb$

$M_{u_1} = \frac{7182000}{12 \times 1000}\ ft\text{-}k$

$\boxed{M_{u_1} = 598.50\ ft\ k}$

Now

$M_{n_1} = \frac{M_{u_1}}{\phi} = \frac{598.5}{0.9} = 665\ ft\text{-}k$

$\boxed{M_{n_1} = 665\ ft}$

$M_{n_2} = M_n - M_{n_1} = 913.3 - 665 = 248.3$

$\boxed{M_{n_2} = 248.3\ ft\text{-}k}$

(3) Theoritical A_s' required:

$A_s' = \frac{M_{n2}}{f_y(d-d')} = \frac{248.3 \times 12}{60(25-3)} = \boxed{2.26 in^2}$

Try 3# 8 bars, $2.35 in^2$ Table A.4

Consider $f_s' = f_y$

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

$$A_{s_2} = \frac{A_s' f_s'}{f_y} = \frac{2.35 in^2 \times \cancel{60}}{\cancel{60}} = 2.35 in^2$$

$$\boxed{A_{s_2} = 2.35 in^2.}$$

$$A_s = A_{s_1} + A_{s_2} = 6.335 + 2.35 = 8.685 in^2.$$

$$\boxed{A_s = 8.685 in^2}$$ try 7 #10 bars ($8.86 in^2$)
(Table A-4)

Checking

Assuming $f_s' = f_y$.

(i) $$\frac{(A_s - A_s')f_y}{0.85 f_c' b \beta_1} = \frac{(8.685 - 2.35) \times 60}{0.85 \times 14 \times 4 \times 0.85} = 9.39 \approx 9.4 in$$

(ii) $$\varepsilon_s' = \left(\frac{c-d'}{c}\right)(0.003) = \left(\frac{9.4-3}{9.4}\right)(0.003) = 0.00206 > \varepsilon_y$$ (ok)

$$\boxed{\varepsilon_s' > \varepsilon_y}.$$

(iii) $$\varepsilon_t = \left(\frac{d-c}{c}\right)(0.003) = \left(\frac{25-9.4}{9.4}\right)(0.003)$$

$$\boxed{\varepsilon_t = 0.00497 < 0.005}$$

So calculate the value of ϕ again

because $\phi \neq 0.9$

$$\phi = 0.65 + (0.00497 - 0.002)\left(\frac{250}{3}\right)$$

$$\boxed{\phi = 0.8975}$$

$$As_2 = \frac{As' fs'}{fy} = \frac{2.35 \times 60}{60}$$

$$\boxed{As_2 = 2.35\,in^2}$$

$$As_1 = As - As_2 = \cancel{8.685}\ 8.86 - 2.35 = 6.51\,in^2$$

$$\boxed{As_1 = 6.51\,in^2}$$

$$M_{n_1} = As_1 fy\left(d - a/2\right)$$

$$= 6.51 \times 60\left(25 - \frac{0.85 \times 9.4}{2}\right) = 8204.553\,in\text{-}k$$

$$\boxed{M_{n_1} = 683.71\,ft\text{-}k}$$

$$M_{n_2} = As_2\, fy (d - d') = (2.35)(60)(25-3)$$

$$= 3102\,in\text{-}k$$

$$\boxed{M_{n_2} = 258.5\,ft\text{-}k}$$

$$M_n = M_{n_1} + M_{n_2}$$

P.T.O

$M_n = M_{n1} + M_{n2} = 683.71 + 258.5$

$\boxed{M_n = 942.21 \text{ ft-k.}}$

$\phi M_n = 0.89 \times 942.21$

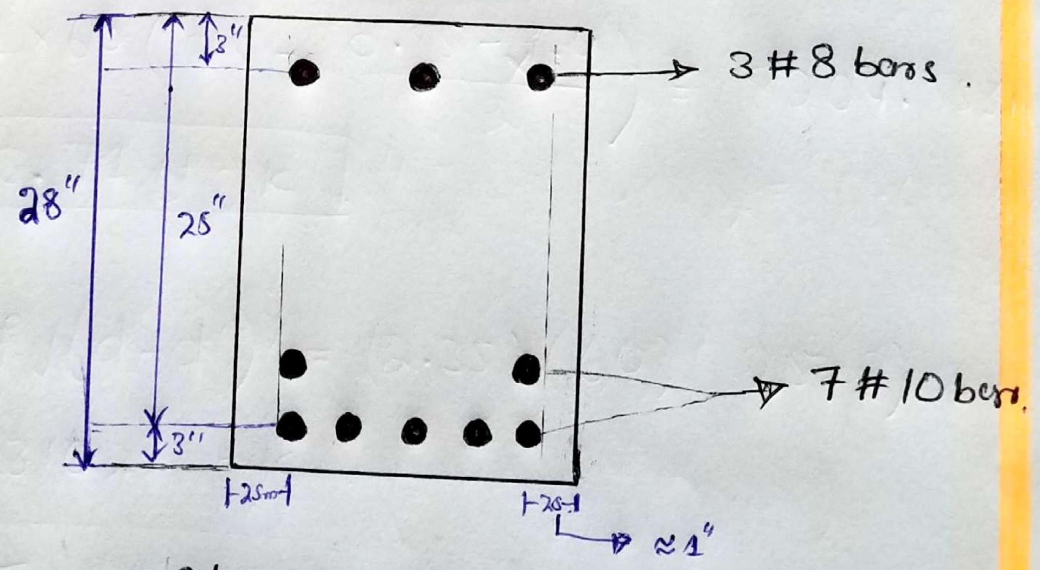
$\boxed{\phi M_n = 845.63 \text{ ft-k.}}$

& $M_u = 822$ ft-k

so $\boxed{\phi M_n > M_u}$ OK.

$A_s' = 2.35 \text{ in}^2$ (3#8 bars)

$A_s = 8.86 \text{ in}^2$. (7#10 bars) (Table A.4)



As per ACI Code Side clear Cover 25mm – 35mm.

So take 25mm Side clear Cover.

Design of Square Column.

Q2

Given data.

P = Reg No = 152K

P_u = 152K

M_u = 15 ft-K | Reg No = 15274

$f_c' = 4{,}000$ psi $f_y = 60{,}000$ psi

Sol

Short Square Column.

Assuming the Column will have an average Compression Stress = about $0.6f_c' = 0.6 \times 4000$

$= 2400$ psi $= 2.4$ ksi

$$A_{g(\text{required})} = \frac{P_u}{0.6f_c'}$$

$$\boxed{A_{g(\text{required})} = \frac{152}{2.4} = 63.34 \text{ in}^2.}$$

As per ACI recomendation the minium size of Column is 12"x12"

So Try 12"x12" (A_g = 256 in²)

Now.

$$e = \frac{M_u}{P_u} = \frac{12 \times 15}{152} = \frac{180}{152}.$$

$$\boxed{e = 1.184 \text{ in.}}$$

$$\boxed{P_n = \frac{P_u}{\phi} = \frac{152}{0.65} = 233.84\text{K}}$$

$$K_n = \frac{P_n}{f'_c A_g} = \frac{233.84}{4 \times 12 \times 12} = 0.405$$

$$\boxed{K_n = 0.405}$$

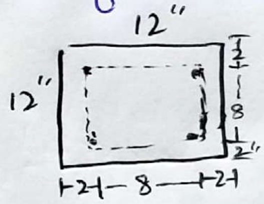
$$R_n = \frac{P_n e}{f'_c A_g h} = \frac{233.84 \times 1.184}{4 \times 12 \times 12 \times 12}$$

$$\boxed{R_n = 0.0400}$$

$$\gamma = \frac{8 \text{ in.}}{12 \text{ in}}$$

$$\boxed{\gamma = 0.667}$$

As per ACI Code.
$C.C_{min} = 40\text{mm} = 1.575\text{in}$
for Column
So select clear Cover
2" from each side.



From Graph "6" & "7" Append A.

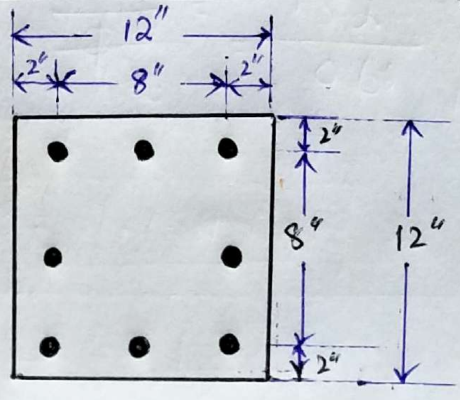
γ	0.6	$\boxed{0.667}$	0.7
ρ_g	0.025	$\boxed{0.0235}$	0.024

→ By using Interpolation we got 0.0235

$$\Rightarrow \quad A_s = (0.0235)(12)(12)$$

$$\boxed{A_s = 3.384 \text{ in}^2}$$

use 8 #6 bars $= 3.53 \text{in}^2$



Q3:

For q_a = Reg No ~~first~~ four digit = 1527 psf (which not possible) ⑪

$C = 16'' \times 16''$

$P_D = 152K$ $P_L = 160K$.

Depth 5ft. $q_a = 1527$ psf $f_y = 60$ ksi $f_c' = 3$ ksi

Sol

$h = 24''$.

$d_{avg} = 20''$

$b_o = 4(c + d_{avg}) = 4 \times (16 + 20) = 144$

Now $q_e = 1527 - 600 = 927$ psf $= 0.952$ ksf

$A_{reqd} = \frac{152 + 160}{0.952} = 328\ ft^2$

Sol Select $19ft \times 19ft$

⇒ So for $16'' \times 16''$ column $(19ft \times 19ft)$ foundation/footing is not possible.

⇒ So I solve this qustion with selecting a proper value of "q_a"

$\boxed{q_a = 3804 \text{ psf}}$

So the qustion solve on other page

Q3 -: Given Data:-

Column = 16"x16" P_D = 152K.

P_L = 160k. Depth = 5 ft Soil wgh = 100 lb/ft².

fy = 60,000 psi f c' = 3000 psi Bars = #8.

q_a = 3804psi (Selected properly)

Sol

Assum = hight of footing = h = 24" = 2'.

d avg = h − 3" − 1" = 24 − 3 − 1 = 20".

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

$\boxed{b_o = 4(16+20) = 144\,in}$.

W = Pressure of Soil + pressure of RC

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

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

$= 300 + 300 = 600$

Now

$q_e = q_a - W = 3804 - 600$.

$\boxed{q_e = 3804 - 600 = 3204\,psf}$

$$\boxed{q_e = 3.204\ \text{ksf}}$$

$$A_{reqd} = \frac{\text{Total load}}{q_e} = \frac{152+160}{3.204}$$

$$A_{reqd} = 97.37\ in^2$$

$$B \times B = A_{reqd} = 97.37\ in^2$$

$$\Rightarrow \boxed{B \approx 10 ft^2}$$

$$\Rightarrow \boxed{A = 100 ft^2}$$

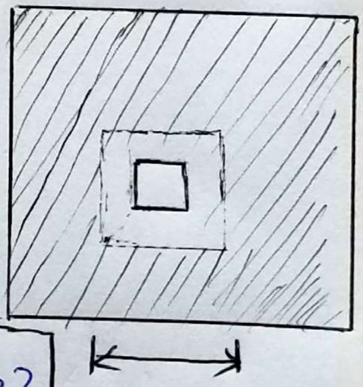
Bearing pressure

$$q_u = \frac{1.2(P_D) + 1.6(P_L)}{Area}$$

$$= \frac{1.2 \times (152) + 1.6(160)}{10 \times 10} = 4.384\ \text{ksf}$$

Now **Punching Shear**

$b_o = 144 in$



$$V_{u_2} = q_u A - q_u (C + d\text{ange})$$

$$= 4.384 \times 100 - 4.384 \left\{ \left(\frac{16+20}{12} \right) \right\}^2$$

16in + 20in = 36"

= 3'

$$\boxed{V_{u_2} = 398.944\ k}$$

Checking

$$d = \frac{V_{u_2}}{0.75 \times 4\sqrt{f_c'} \times b_o}$$

$$= \frac{398090}{0.75 \times 4\sqrt{3000} \times 144} = 17.05\,in < 20\,in$$

OK

$$d = \frac{V_{u_2}}{0.75\left(\frac{40 \times d}{b_o} + 2\right)\sqrt{f_c'} \times b_o}$$

$$= \cancel{\frac{398090}{0.75 \times \left(\frac{40 \times 20}{144}\right)}}$$

$$d = \frac{V_{u_2} = 398.944 \times 1000}{0.75\left(\frac{40 \times 20}{144} + 2\right)\sqrt{3000} \times 144}$$

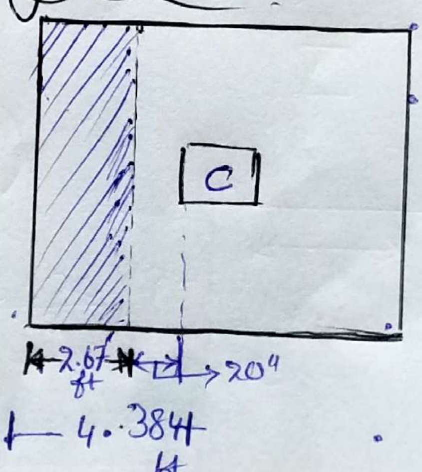
$d = 9.02\,in < 20\,in$ OK

So both "d" < 20" so punching shear is "OK"

Depth required for one way shear

$V_{u_1} = (10ft)(2.67)(4.384)$ from fig

$V_{u_1} = 117.0528$



$$d = \frac{117052}{0.75 \times 2\sqrt{3000} \times 120}$$

$d = 11.87" < 20"$ OK

$$M_u = (4.33)(10)(4.384) \times \left(\frac{4.33}{2}\right)$$

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

$$\frac{M_u}{\phi b d^2} = \frac{12 \times 411000}{0.9 \times 120 \times 20^2} = 114.1667 \text{ psi}$$

Now from Appendix "A"

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

use Large "ρ" of following

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

$$\text{or} \quad \frac{3\sqrt{3000}}{60{,}000} = 0.00274.$$

So

$$A_s = 0.0033(120)(20) = 7.2 \text{ in}^2$$

$$\boxed{A_s = 7.2 \text{ in}^2}$$

use 6 #10 bars. in Both Direction

Development length:

$$\psi_t = \psi_e = \psi_s = \lambda = 1.0$$

Assuming bars spaced 16 in on Center.
being 6in on side

C_b = bottom cover = 3.5 in.

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

Letting $K_{tr} = 0$

$$\frac{C_b + K_{tr}}{d_b} = \frac{3.5 + 0}{1.0\,in} = 3.5 > 2.5$$

used 2.5

$$\frac{l_d}{d_b} = \frac{3}{40} \cdot \frac{f_y}{\lambda \sqrt{f_c'}\ \frac{C + K_{tr}}{d_b}} = \frac{3}{4} \times \frac{60000}{(1)\sqrt{3000}} \times \frac{1 \times 1 \times 1}{2.5}$$

= 32.86 diameter.

$$\frac{l_d}{d_b}\,\frac{A_{s\,reqd}}{A_{s\,fur}} = 32.86\left(\frac{7.2}{7.59}\right) = 31.30 \text{ diameter}$$

$$l_d = 31.30(1) = 31.30 \approx 32\,in.$$

< available l_d = 4ft 6in − $\frac{20}{2}$ − 3in

= $\boxed{140\,in}$ OK.