Date: ____________

Name:-

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Reg: No. 14390

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M.S (T.E)

Date:

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Question No: 1 (Part a)

Determine the values of ϵ_t, ϕ, and M_n for following Sections.

Given Section:-

$f_y = 75,000$ psi

$f_c' = 5000$ psi

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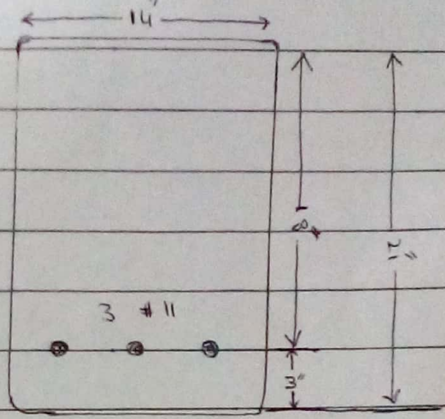

Solution:-

Now to find ϵ_t

We know that

$$\epsilon_t = \left(\frac{d-c}{c}\right)(0.003) \longrightarrow Ⓐ$$

As $$c = \frac{a}{B_1} \longrightarrow Ⓑ$$

Now to find a, we have

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

$$a = \frac{4.46 \times 75}{0.85 \times 5 \times 14}$$

$$a = 5.62 \text{ in}$$

$A_b = \frac{\pi}{4}(d^2)$

$A_b = \frac{\pi}{4}\left(\frac{11}{8}\right)^2$

$A_b = 1.48 \text{ in}^2$

Eq Ⓑ becomes

$$c = \frac{5.62}{0.80}$$

$B_1 = 0.80$ for $f_c' = 50,000$ psi

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Q.No: 1 (a) Continued

$c = 7.025$ in

Now Eq Ⓐ becomes

$$\epsilon_t = \left(\frac{18-7.025}{7.025}\right) \times 0.003$$

$$\epsilon_t = 0.00436$$

$0.004 < \epsilon_t < 0.005$
Condition Satisfied
Transition zone

Now

we have to find Φ
As we know that

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

$$\Phi = 0.65 + (0.00436 - 0.002) \times 83.33$$

$$\Phi = 0.845$$

As

we know that

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

$$M_n = 4.46 \times 75 \left(18 - \frac{5.62}{2}\right)$$

$$M_n = 5081 \text{ in-K} = 423.4 \text{ K-ft}$$

$$\Phi M_n = 0.845 \times 423.4$$

$$\Phi M_n = 357.7$$

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Q No 1 (a) Continued

Also

$$\rho = \frac{A_s}{bd}$$

$$\rho = \frac{4.46}{14 \times 18}$$

$$\rho = 0.017$$

$$\rho_{min} < \rho < \rho_{max}$$

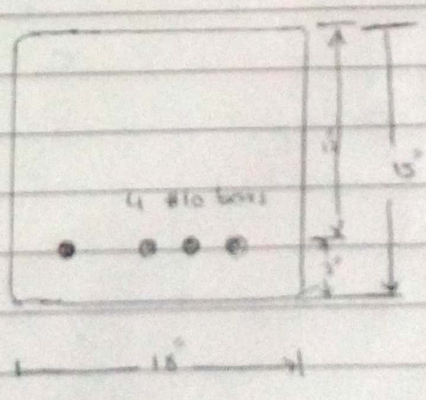
$$0.0028 < \rho < 0.0194$$

OK

Given Section:

$f_y = 60{,}000$ Psi

$f'_c = 4{,}000$ Psi



Solution:

Now to find ϵ_t

we know That

$$\epsilon_t = \left(\frac{d-c}{c}\right) \times 0.003 \longrightarrow (A)$$

As $$c = \frac{a}{\beta_1} \longrightarrow (B)$$

Now to find "a" we have

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Q. No. 1 (a) Continued

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

$$a = \frac{4.93 \times 60}{0.85 \times 4 \times 18}$$

$$a = 4.83 \text{ in}$$

Eq (B) becomes

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

for f_c 25000 – 40,000 psi
$B_1 = 0.85$

$$c = \frac{4.83}{0.85}$$

$$c = 5.68 \text{ in}$$

Now eq (A) becomes

$$\epsilon_t = \left(\frac{12 - 5.68}{5.68}\right) \times 0.003$$

$$\epsilon_t = 0.0033$$

Since the condition

$0.004 < \epsilon_t < 0.005$ is not satisfied.
So the section is not ductile.
Is Not As per ACI standards.

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Question No 1 (Part b)

Design the doubly reinforced beam

Given data

$M_D = 143$ K-ft

$M_L = 410$ K-ft   Reg: No: 14390

$f_c' = 4$ ksi

$f_y = 60,000$ psi

Solution

Factored Moment $= 1.2(M_D) + 1.6(M_L)$

$M_u = 1.2(143) + 1.6(410)$

$M_u = 171.6 + 656$

$M_u = 828$

$M_u = 828$ K-ft

Nominal Moment $= M_n = \frac{M_u}{\phi}$

$M_n = \frac{828}{0.90}$

$M_n = 920$ K-ft

Now

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

(from table A-7 - Apendix A)

$\rho_{max} = 0.0181$

$A_{s1} = \rho_{max} \times b \times d$

$A_{s1} = 0.0181 \times 15 \times 27$

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Q. No: 1 (Part b) Continued

$A_{s1} = 7.3305 \ in^2$

From table A.13, for $\rho_{max} = 0.0181$

$\frac{Mu}{\phi bd^2} = 912$ psi

$Mu_1 = 912 \times \phi bd^2$

$Mu_1 = 912 \times 0.9 \times 15 \times (27)^2$

$Mu_1 = \frac{8975448}{12}$ ~~ft~~-lb

$Mu_1 = 748$ k-ft

Now $Mn_1 = \frac{Mu_1}{\phi} \Rightarrow \frac{748}{0.9}$

$Mn_1 = 831.1$ ~~831.8~~ k-ft

$Mn_2 = Mn - Mn_1$

$Mn_2 = 920 -$ ~~831~~ 831.1

$Mn_2 = 89$ k-ft

Theoretical A_s' required

$A_s' = \frac{Mn_2}{f_y(d-d')}$

$A_s' = \frac{89 \times 12}{60(24)}$

$A_s' = 1068/1440$

$A_s' = 0.742 \ in^2$

Provide 3 #5 bars $(0.93) \ in^2$

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

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Q.No 1 (Part b) Continued

$$A_{s_2} = \frac{A_s' f_s'}{f_y}$$

$$A_{s_2} = A_s' = 0.742$$

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

$$A_s = 7.33 + 0.742$$

$$A_s = 8.24 \text{ in}^2$$

Use 14 #7 bars (8.41 in^2)

Assume

$$f_s' = f_y$$

$$c = \frac{A_s - A_s' (60)}{0.85 \times 0.85 \times 15 \times 4} \Rightarrow$$

$$c = 10.14$$

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

$$\epsilon_s = \left(\frac{10.14 - 3}{10.14}\right) 0.003$$

$$\epsilon_s = 0.0021 > \epsilon_y$$

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

$$\epsilon_t = \left(\frac{27 - 10.14}{10.14}\right) 0.003$$

$$\epsilon_t = 0.0049 < 0.005$$

So $\Phi \neq 0.90$

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Q.No 1 (Part b) Continued

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

$$\phi = 0.89$$

$$A_{s_2} = \frac{A_s' f_s}{f_y}$$

$$A_{s_2} = \frac{0.91 \times 60}{60}$$

$$A_{s_2} = 0.91$$

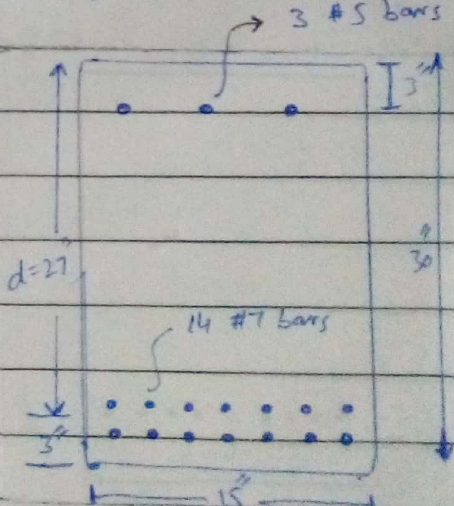
$$A_{s_1} = A_s - A_{s_2}$$

$$A_{s_1} = 8.42 - 0.91 = 7.51$$

$$M_{n_1} = A_{s_1} f_y (d - a/2)$$

$$M_{n_1} = 7.51 \times 60 \left(27 - \frac{0.85 \times 10.14}{2}\right)$$

$$M_{n_1} = 852 \text{ K-ft}$$



$$M_{n_2} = A_{s_2} f_y (d - d')$$

$$M_{n_2} = 0.91 \times 60 (27 - 3)$$

$$M_{n_2} = 109.2$$

$$M_n = M_{n_1} + M_{n_2} \Rightarrow 109.2 + 852$$

$$M_n = 961 > M_u$$

Satisfied

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Question No: 2

Design the short Square Column

Given data

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P_u = 143 Kips

M_u = 14 K-ft

f_c' = 4000 psi = 4 ksi

f_y = 60,000 psi = 60 ksi

Solution:

We will solve it by using ACI-Design Aids

Assumptions

Assume Column x-section of 12" x 12"

d' = 2.5 inch

$\gamma = (12 - 2 \times 2.5)/12$

γ = 0.60

From assumed x-section

$A_g = 12'' \times 12'' = 144 \text{ inch}^2$

Φ = 0.65 (for columns)

As we know that

$K_n = P_u / \Phi f_c' A_g$

$$K_n = \frac{143}{0.65 \times 4 \times 144}$$

K_n = 0.38 *

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Question No: 2 - Continued

Also, we know That

$$R_n = M_u \times e / \phi \times f'_c \times A_g \times h$$

$$R_n = (14 \times 12) / (0.65 \times 4 \times 144 \times 12)$$

h = y
e = x

$$R_n = 28 / 4492.8$$

$$R_n = 0.062$$

Also from figure

$$\gamma = \frac{(12-5)}{12} \text{ inch}$$

$$\gamma = \frac{7}{12} = 0.58$$

$$\gamma = 0.6$$

From these values of K_n, R_n we will find ρ from interaction charts provided by ACI-code from That

$$\rho = 0.007$$

So ⇒

$$A_{st} = 0.007 \times 144$$

$$A_{st} = 1.00 \text{ inch}^2 < 1\% \text{ of } A_g$$

ok

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Question No: 3 -- Continued

Now Reinforcement design

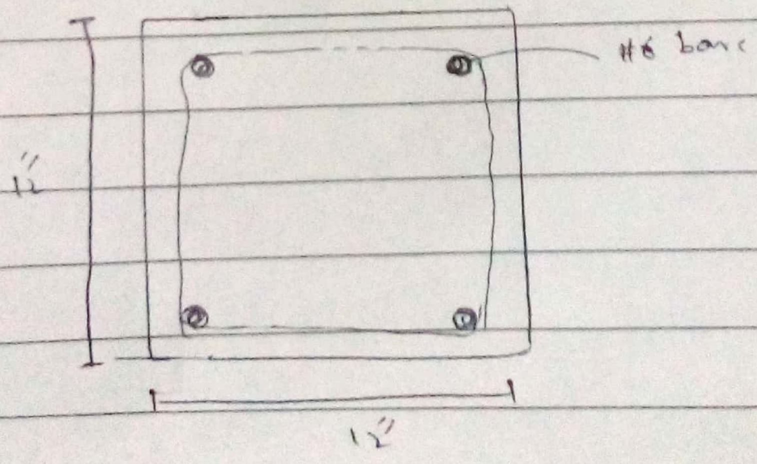
Using #6 bar

No of bars = $\frac{A_{st}}{A_b}$ ⇒ $\frac{1.44}{0.44}$

" = 4 bars

So ⇒

Provide 4 #6 bars



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Question No: 3

Design a Square Column footing for 16 in² Tied interior Column of following detail

Given data

$P_D = 143$ K Reg: No: 14390

$P_L = 160$ K

Soil weight = 100 lb/ft³

$f_y = 60,000$ psi

$f_c' = 3,000$ psi

$q_a = 1439$ Psf

Column is reinforced with #8 bars

Solution

Step 1/ Determination of allowable pressure q_n

Assume Thickness of footing = 30" = 2.5'

weight of footing / sq-ft = 2' × (1' × 1') × 150 lb/cft = 300 lb

weight of soil/surcharge = (5' − 2') (1' × 1') × 100 = 300 lb

Net allowable soil pressure = $q_a - (300 + 300)$

$q_n = 840$ Psf

$q_n = 0.840$ Ksf

Step 2/ Determination of footing size

Total load coming from column =

DL + LL ⇒ 143 + 160

= 303 K

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Q. No: 3 Continued

Area of footing = $\frac{303}{0.840}$

" = 361 Sq.-ft

having side length of 18.99'

Provide 19' x 19' footing

step 3/

Determination of resisting pressure from base

Factored Load = 1.4 (DL) + 1.7 (LL)

" = 1.4 (143) + 1.7 (160)

Factored Load = 472 K

Resisting upward pressure = $\frac{472}{19 \times 19}$

= 1.31 K/Sq.ft

step 4/

Cross check on depth of footing

Assumed depth of footing = 30" = 2.5'

d = 30" − 3 − 1.5 (8/8)

d = 25.5"

Since depth is controlled by shear,
So punching shear side length = 16" + d = 41.5" = 3.45'

So ⇒

Punching Shear = Vu = 472 − (1.31 × 3.45 × 3.45)

Vu = 456 kips

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Q. No 3 Continued

Calculating "d" from punching shear

(a) $d = \frac{Vu}{\phi[4\sqrt{fc} \times b_o}$

$d = \frac{456 \times 1000}{0.75 \times [4 \times \sqrt{3000} \times 166}$ ⇒ 16.71" ✓

(b) $d = \frac{Vu}{4 \times \sqrt{3000} \times b_o}$

$d = \frac{456000}{36368}$ ⇒ d = 12.5"

Now we find "d" on the basis of one-way shear

$L_1 = \frac{19'}{2} - \frac{18''}{12} - \frac{25.5''}{12}$

$L_1 = 9.5 - 1.5 - 2.125$

$L_1 = 5.875''$

Punching Shear = $Vu = q_{n} \times 19' \times 5.875$

$1.31 \times 19' \times 5.875$

Vu = 146.23 kips

$d = \frac{146.23}{0.75 \times 2 \times \sqrt{3000} \times 19 \times 12}$

d = 7.8"

So select the maximum "d" value out of all

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Q. No: 3 Continued

$d = 16.71''$

Total Thikness = $16.71'' + 3'' + 1.5\,(8/8)$

Total Thikness = $21.21'' > 30''$

So our assumed ~~depth~~ d is OK

$d = 25.5''$ OK

step 5/

Assessment of steel

As we know

$L_1 = \frac{19'}{2} - \frac{18''}{2 \times 12}$

$L_1 = 9.5 - 0.75$

$L_1 = 8.75$

$M_u = \frac{WL^2}{2}$

$M_u = \frac{1.31 \times (8.75)^2}{2}$

$M_u = 50.15\text{K-ft}$

$M_u = 602$ kip-inch

$R = \rho f_y \left\{ 1 - 0.59 \frac{\rho f_y}{f_c} \right\}$

$R = 0.015 \times 60{,}000 \left\{ 1 - 0.59 \times \frac{0.015 \times 60000}{3000} \right\}$

$R = 704.7$

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Q. No: 3 Continued

As we know

$$Mu = \phi A_s f_y d$$

$$A_s = \frac{Mu}{\phi f_y \times d}$$

$$A_s = \frac{50.15 \times 1000 \times 12}{0.90 \times 60,000 \times 0.888 \times 25.5''}$$

A_s = 0.492 Per-inch strip of footing

$$Spacing = \frac{12'' \times 0.44}{0.492}$$

Spacing = 10.73''

provide 5/8'' @ 10'' c-c bothways

Step 6/ Check for adequacy of steel

(a) Minimum steel for temprature = 0.0018 × b × h
= 0.432 < 0.492 ok

(b) Minimum steel for flexure = $\frac{200}{fy} \times b \times d$

" = 0.1113 in² < 0.492 ok

Step 7/

Check for bearing strength of Column

$N_1 = \phi (0.85 \times 3000 \times 16'' \times 16'')$

$N_1 = 0.75 \times 0.85 \times 3000 \times 16 \times 16$

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Q.No:3 Continued

$N_1 = 489 >$ factored load 472 k

Hence (ok)

step 8/

Load to be transferred by dowels

$(P)_{dowels} = P_u -$ bearing strength of Column

$(P)_{dowels} = 472 - 489 = -17$ kips

It means no-dowels are required,
But we will provide minimum dowels

Minimum development length =

$$L_d = \frac{0.02 \times f_y \times b\text{-}dia}{\sqrt{f_c}}$$

$$L_d = \frac{0.02 \times 60{,}000 \times 3/4''}{\sqrt{3000}}$$

$L_d = 16.43'' \approx 17''$ for 3/4 # bar