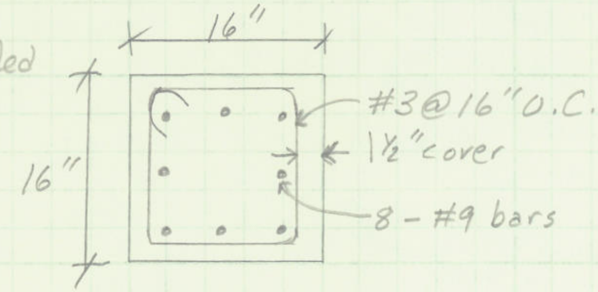
David Dammon
HW 9
ENCE 4359

(1.) Find the maximum design axial load strength for the tied column cross section shown in the Figure. Check the ties. Assume a short column. Use $f'_c = 4\,ksi$ & $f_y = 60\,ksi$ for both longitudinal steel & ties.

Assume concentrically loaded



$A_{st} = 8.00\,in^2$

$$\phi P_n = 0.80\,\phi\left[0.85 f'_c (A_g - A_{st}) + f_y A_{st}\right]$$

$$= (0.80)(0.65)\left[(0.85)(4\,ksi)(256 - 8.0)\,in^2 + (60\,ksi)(8.0\,in^2)\right]$$

$$\boxed{\begin{array}{l} \phi P_n = 688.064\,k \\ \hline P_n = 1{,}059\,k \end{array}}$$

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(2) Design a square tied column to carry axial service loads $D_L = 320k$ & $L_L = 190k$. There is no identified applied moment. Assume that the column is short. Use ρ_g of about 0.03, $f'_c = 4\,ksi$ & $f_y = 60\,ksi$.

$$P_u = 1.2(320k) + 1.6(190k) = 688\,k$$

$$\phi P_n = P_u = 0.80\,\phi\left[0.85 f'_c (A_g - A_{st}) + f_y A_{st}\right]$$

→ Estimate A_{st} @ 30% A_g ($\rho_g = 30\%$)

$$688k = 0.80(0.65)\left[(0.85)(4ksi)(A_g - 0.03A_g) + 60ksi(0.03A_g)\right]$$
$$688k = 0.52\left[3.4(.97A_g) + (1.8\,A_g)\right]$$
$$1323.1\,k = \left[3.298\,kA_g + 1.8\,kA_g\right]$$
$$A_g = 259.53\,in^2$$

→ Use $16'' \times 16'' = 256\,in^2$

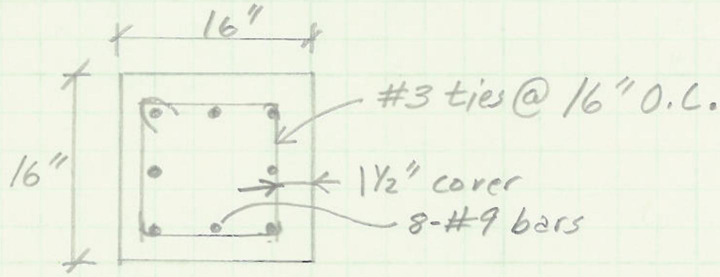
$$688k = (0.80)(0.65)\left[(0.85)(4\,ksi)(256 - A_{st}) + (60ksi)(A_{st})\right]$$
$$A_{st} = 7.998\,in^2$$

→ Use 8-#9 = $8.00\,in^2$

→ Design ties (Assume #3 ties since #9 bars are Used)

$$\text{Max Spacing} = \min \begin{cases} 16d_b = 16(1) = 16'' \leftarrow \\ 48\,d_b(\text{tie}) = 48(0.375) = 18'' \\ \text{least column dim} = 16'' \leftarrow \end{cases}$$

→ Use #3 bar tie @ 16" O.C.



Name:Korey Clement Email:korey_clement@yahoo.com (korey.clementbb@gmail.com) Work Phone:5044534785

PROB #9.8

Using 6 #10 Bars ($A_{st} = 7.59 \text{ in.}^2$)

$$\phi P_n = 0.85\,\phi\left[0.85 f'_c (A_g - A_{st}) + f_y A_{st}\right]$$
$$= (0.85)(0.70)\left[(0.85)(4)(452.4 - 7.59) + (60)(7.59)\right]$$
$$= \boxed{1254.8 \text{ k}}$$

✓ J.C.M.S.

PROB #9.9

Using 6 #10 bars ($A_{st} = 7.60 \text{ in.}^2$)

$$\phi P_n = 0.80\,\phi\left[0.85 f'_c (A_g - A_{st}) + f_y A_{st}\right]$$
$$= (0.80)(0.65)\left[(0.85)(3)(720 - 7.60) + (60)(7.60)\right]$$
$$= \boxed{1181.8 \text{ k}}$$

✓ J.C.M.S.

#2 ⇒

PROB #9.10

$$P_u = (1.2)(300) + (1.6)(500) = 1160 \text{ k}$$
$$\phi P_n = P_u = 0.80\,\phi\left[0.85 f'_c (A_g - A_{st}) + f_y A_{st}\right]$$
$$1160 = (0.80)(0.65)\left[(0.85)(4)(A_g - 0.02A_g) + (60)(0.02A_g)\right]$$
$$A_g = 492.2 \text{ in.}^2 \quad (\text{USE } 22 \times 22 = 484 \text{ in.}^2)$$
$$1136 = (0.80)(0.65)\left[(0.85)(4)(484 - A_{st}) + 60 A_{st}\right]$$
$$A_{st} = 10.34 \text{ in.}^2 \quad \text{USE } 8\#11 \; (A_{st} = 12.50 \text{ in.}^2)$$

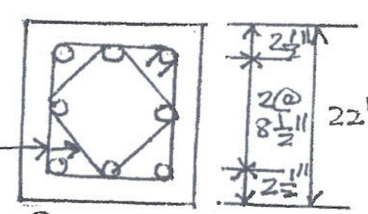
Design of Ties (Assuming #4 bars) since #11 bars used

Spacing (a) $48 \times \frac{1}{2} = 24''$

(b) $16 \times 1.41 = 22.56$ ←

(c) Least dimension $= 22''$

use #4 Ties @ 22″ →



✓ J.C.M.S.

Address:3007 Delambert St. - Chalmette - LA - us (United States) Zip Code:70043

Name:Korey Clement Email:korey_clement@yahoo.com (korey.clementbb@gmail.com) Work Phone:5044534785

PROB #9.5

Using 12 #10 bars (A_{st} = 15.19 in.^{2})

$$\phi P_n = 0.80\phi\left[0.85 f'_c (A_g - A_{st}) + f_y A_{st}\right]$$

$$= (0.80)(0.65)\left[(0.85)(4)(576 - 15.19) + (60)(15.19)\right]$$

$$= \boxed{1465.4\ k}$$

r g c m

PROB #9.6

Using 6 #9 bars (A_{st} = 6.00 in.^{2})

$$\phi P_n = 0.80\phi\left[0.85 f'_c (A_g - A_{st}) + f_y A_{st}\right]$$

$$= (0.80)(0.65)\left[(0.85)(4)(225 - 6) + (60)(6)\right]$$

$$= \boxed{574.4\ k}$$

r g c m

#1

PROB #9.7

Using 8 #8 bars (A_{st} = 6.28 in.^{2})

$$\phi P_n = 0.80\phi\left[0.85 f'_c (A_g - A_{st}) + f_y A_{st}\right]$$

$$= (0.80)(0.65)\left[(0.85)(4)(216 - 6.28) + (60)(6.28)\right]$$

$$= \boxed{566.7\ k}$$

r g c m

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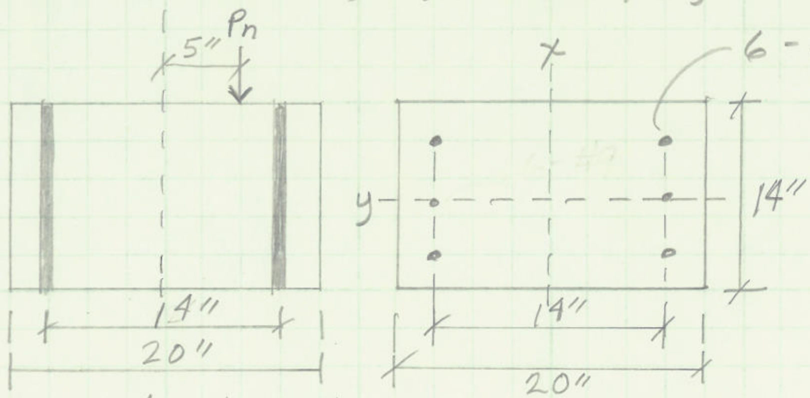
3) Find the axial load strength ϕP_n & the moment strength ϕM_n for the column cross section with six #9 bars, as shown in the Figure. Eccentricity $e = 5in$, & $f'_c = 4$ ksi & $f_y = 60$ksi.



→ Assume bending about one axis only

$$\frac{e_x}{h} = \frac{5''}{20''} = 0.25$$

$$\rho_g = \frac{A_{st}}{b\ h} = \frac{6.00 in^2}{(14'')(20'')} = 0.0214$$

$$\gamma = \frac{b}{h} = \frac{14''}{20''} = 0.7$$

→ Use graph 3 where $\gamma = 0.7$ Let $K_N = 0.8$ therefore

$$R_n = K_n \frac{e_x}{h} = (0.80)(0.25) = 0.2 \ \& \ \rho_g = 0.0214$$

Use $R_n = 0.2$ & $K_n = 0.8$ draw a straight line from origin. Find where $\rho_g = 0.0214$ on this line
Find $K_n = 0.63$

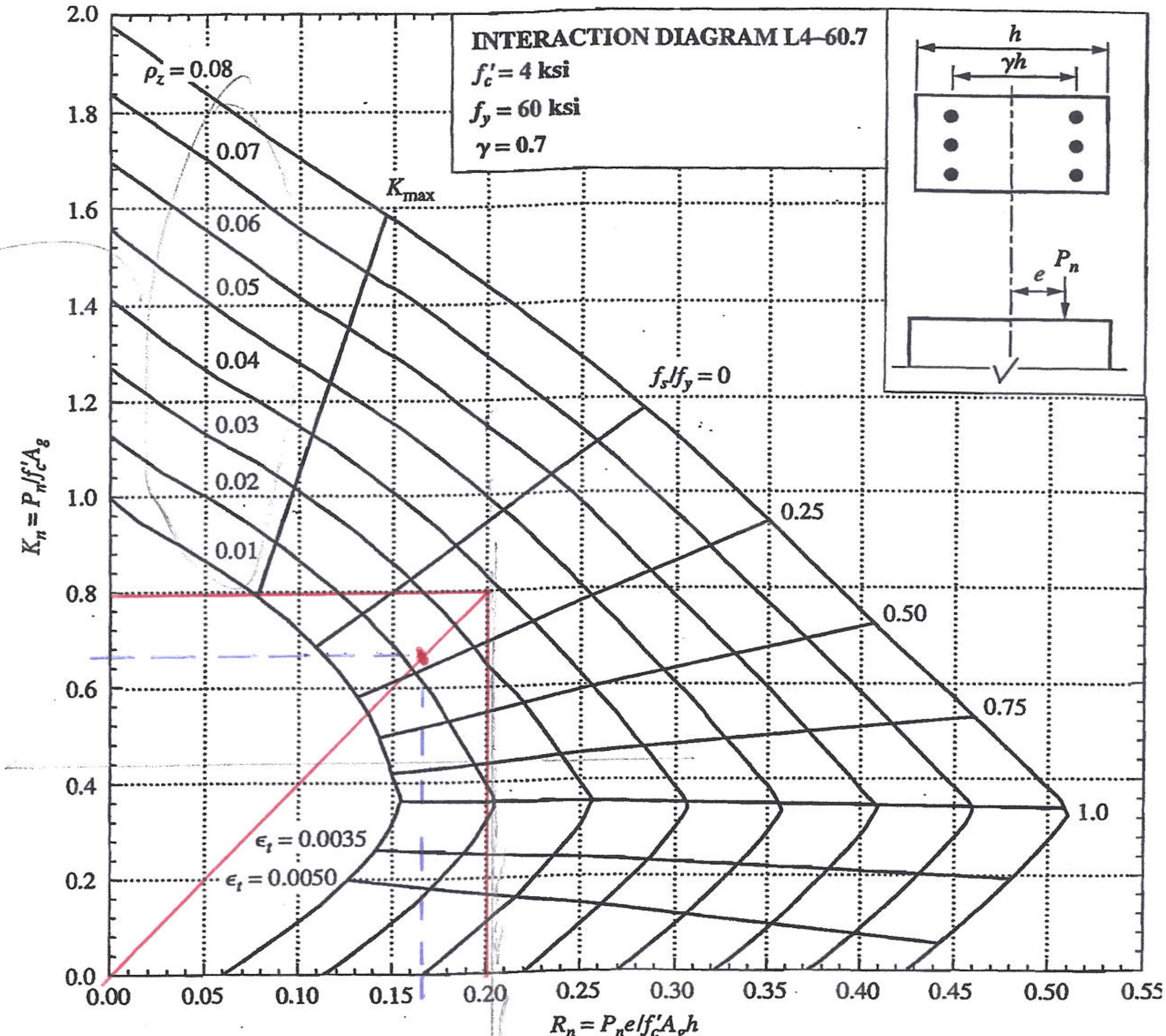
$$P_n = K_n f'_c A_g = (0.63)(4\ ksi)(14'' \times 20'') = 705.6\ k$$

$$\phi P_n = (0.65)(705.6\ k) = 458.6\ k$$

$$M_{n_x} = (P_n)(e_x) = (705.6\ k)(5'') = 3528\ in\text{-}k \text{ or } 294\ ft\text{-}k$$

$$\phi M_n = (0.65)(294\ ft\text{-}k) = 191.1\ ft\text{-}k$$

$\phi = 0.65$ for compression controlled tied reinforcement



Graph 3 Column interaction diagrams for rectangular tied columns with bars on end faces only.

Name:Korey Clement Email:korey_clement@yahoo.com (korey.clementbb@gmail.com) Work Phone:5044534785

PROB# 10.11

$$\frac{e}{h} = \frac{12}{21} = 0.571$$

$$e_g = \frac{8.00}{(15)(21)} = 0.0254$$

$$\gamma = \frac{15}{21} = 0.714$$

A straight line is plotted from the origin of Appendix A Graph 3 to values of k_n and R_n selected so $R_n = k_n \frac{e}{h}$. Here we let $k_n = 0.80$ and $R_n = k_n \frac{e}{h} = (0.80)(0.571) = 0.456$. Then with $e_g = 0.0254$ and $\frac{e}{h}$ constant on our plotted straight line we read $k_n = 0.40$

3

Repeating these same steps with Appendix A Graph 4 we read $k_n = 0.42$. Interpolating between these k_n values we get

γ	0.700	0.714	0.800
k_n	0.40	0.401	0.42

$$P_n = k_n f'_c A_g = (0.401)(4)(15 \times 21) = 505\ k$$

$$\phi P_n = (0.65)(505) = 328\ k$$

$\phi = 0.65$ since f_s/f_y is above 1.0

Address:3007 Delambert St. - Chalmette - LA - us (United States) Zip Code:70043

(4) Design a square-tied reinforced concrete column to support a design load $P_u = 1{,}300k$ & $M_u = 550$ ft-k
$f'_c = 4$ ksi & $f_y = 60$ ksi

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$\phi P_n = P_u = 0.80\,\phi\left[0.85 f'_c (A_g - A_{st}) + f_y (A_{st})\right]$

→ Estimate Ast @ 30% Ag ($\rho_g = 30\%$)

$1{,}300k = (0.80)(0.65)\left[0.85(4ksi)(A_g - 0.03A_g) + 60ksi(0.03A_g)\right]$
$1{,}300k = 0.52\left[3.4(.97A_g) + 1.8A_g\right]$
$2{,}500k = 3.298k\,A_g + 1.8k\,A_g$
$A_g = 490.39\,in^2$

→ Use $22'' \times 22'' = 484\,in^2$

$1{,}300k = 0.80(0.65)\left[0.85(4ksi)(484 - A_{st}) + 60ksi\,A_{st}\right]$

→ $A_{st} = 15.095\,in^2$ Use 8 #14 $= 18.0\,in^2$

→ Check $\rho_g = \frac{A_s}{bh} = \frac{18.0}{484} = .037$

Code [10.9.1] $0.01 \le \rho_g \le 0.08$ ∴ $0.037 \times 2 = 0.074$ (lapping)
∴ OK ✓

→ Design ties (Assume #4 ties with #14 bars)

Max Spacing = min $\begin{cases} 16 d_b = 16(1.693) = 27.1'' \\ 48\, d_b(tie) = 48(\frac{1}{2}) = 24'' \\ \text{least column dim} = 22'' \leftarrow \end{cases}$

Use #4 tie @ 22" o.c.