Axially Loaded Columns

Analysis

Calculated load / Nominal strength, $P_n = 0.85 f_c' (A_g - A_{cr}) + f_y A_{st}$

Ultimate strength $P_u = K\varphi \left(0.85 f_c' (A_g - A_{cv}) + f_y A_{st}\right)$

Columns:	φ	K
spiral	0.75	0.85
Tied	0.65	0.80

Design Tied Columns:

(i) Load Calculation: $TL = 1.2 \times DL + 1.6 \times LL = P_u$

(ii) Column Dimension: $\rho = \frac{A_{st}}{A_g}$: Assum, $\rho = 1\% - 5\%$ [ACI]

$\therefore A_{st} = \rho A_g$

$\therefore P_u = \varphi K \left[0.85 f_c' (A_g - A_{cr}) + f_y A_{st})\right]$

$\therefore A_g = \boxed{}$

$b = \sqrt{A_g}$

$\therefore A_g = b \times b$

(iii) Steel Calculation:

$A_{st} = \rho \times \boxed{A_g}$

(iv) Tie calculation:

Let's choose #3 bar,

$s_1 = 16 \times$ dia of longitudinal bar

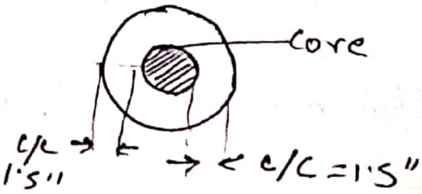
$s_2 = 48 \times$ tie bar dia

$s_3 =$ Least dimension

Spiral Columns:

(i) —— (iii) like before

(iv) Spiral Calculation:



$D_{core} = Dia_{col} - 1.5 \times 2$

$A_{cr} = \frac{\pi \times D_{core}^2}{4}$

$\rho_{sp(min)} = 0.45 \left(\frac{A_g}{A_{g\,core}} - 1 \right) \frac{f_c'}{f_y}$

choose #3 bar,

$S = \frac{4 A_{sp}}{\rho_{sp} D_{core}}$

Analysis

MMI Problem: 01: Determine the allowable design axial load on a 12" square short tied column reinforced with four #9 bars. Tied are #3 spaced at 12". Use $f_c' = 4$ ksi and $f_y = 60$ ksi.

Sol^n:

$A_g = 12^2 = 144$ in^2

$A_{st} = 4 \times 1 = 4$ in^2

For tied columns, $\phi = 0.65$, $k = 0.80$

∴ Allowable axial load,

$P_u = \phi k [0.85 f_c' (A_g - A_{st}) + f_y A_{st}]$

$= 0.65 \times 0.80 [0.85 \times 4 \times (144 - 4) + 60 \times 4]$

$= 372.32$ kip

Ans:

MMI Problem2: Design the allowable design axial load on a 16 in dia short spinal column reinforced with six #8 are spaced at 12". Use $f_c' = 4$ ksi, $f_y = 60$ ksi.

Sol^n:

$A_g = \frac{\pi}{4} \times 16^2 = 64\pi$ in^2

$A_{st} = 6 \times 0.79 = 4.74$ in^2

∴ for spiral columns, $\phi = 0.75$ $k = 0.85$

Allowable design axial load,

$P_u = \phi k [0.85 f_c' (A_g - A_{st}) + f_y A_{st}]$

$= 0.75 \times 0.85 \times [0.85 \times 4 \times (64\pi - 4.74) + 60 \times 4.74]$

$= 606.83$ kip

Ans

Design

mmP Problem: Design a Tied column to support an axial load of 400k and live load of 232k. Using $f_c' = 5000 psi$, $f_y' = 60000 psi$. Assume steel ratio as 5%. Design necessary ties.

Tied Column

Soln:

(i) Load Calculation: $TL = 1.2 \times 400 + 1.6 \times 232 = 851.2 k$

(ii) Column Dimension:

$$\rho = \frac{A_{st}}{A_g}$$

$$\Rightarrow A_{st} = \rho A_g = 0.05 \times A_g$$

Now, $P_u = \phi k [0.85 f_c' (A_g - A_{st}) + f_y A_{st}]$

$$\Rightarrow 851.2 = 0.65 \times 0.80 [0.85 \times 5 \times (A_g - 0.05 A_g) + 60 \times 0.05 A_{st}]$$

$\therefore A_g = 218.91 \ in^2$

Assuming a square column, $b = \sqrt{218.91} = 14.79 \ in \approx 15 in$

$\therefore$ Now, $A_g = 15^2 = 225 \ in^2$

(iii) Steel Calculation: $A_{st} = \rho A_g = 0.05 \times A_g = 0.05 \times 225$
$= 11.25 \ in^2$

$\therefore$ Providing 9 # 10 bars.

(iv) Tie calculation:

Let's choose #3 bar as tie.

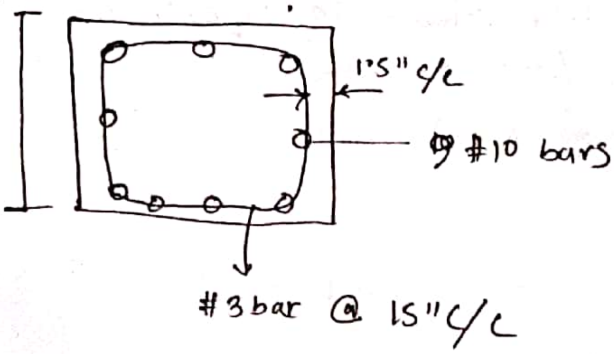
S_1 = 16x dia of longitudinal bars = $16 \times 10/8 = 20"$

S_2 = 48 x tie bar dia = $48 \times 3/8 = 18"$

S_3 = least dim = 15"

$\therefore$ Providing # 3 bar @ 15" c/c

Working Diagram:



Answer:

mm2 Problem: Design a spiral circular column to support an axial dead load of 475 kip and a live load of 250k using $f_c' = 4$ ksi, $f_y = 60$ ksi steel ratio 3%. Design necessary spirals.

Spiral Column

Soln:

(i) load calculation: $TL = 1.2 \times 475 + 1.6 \times 250 = 970k$

(ii) Column Dimension: $\rho = \frac{A_{st}}{A_g} \Rightarrow A_{st} = 0.03 A_g$

$$970 = 0.75 \times 0.85 \times \{0.85 \times 4 (A_g - 0.03 A_g) + 60 \times 0.03 A_g\}$$

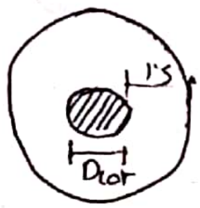
$\therefore A_g = 298.46 \text{ in}^2$

$\therefore$ Dia, $D = \sqrt{\frac{4 \times 298.46}{\pi}} = 19.5"$

(iii) Steel Calculation: $A_{st} = 0.03 A_g = 0.03 \times 298.46 = 8.953 \text{ in}^2$

$\therefore$ Providing 9#9.

(iv) Spiral Calculation:



$\therefore D_{core} = D_{col} - 2 \times 1.5 = 19.5 - 2 \times 1.5$
$= 16.5"$

$\therefore A_{core} = \frac{\pi \times 16.5^2}{4} = 213.82 \text{ in}^2$

$$\rho_{sp(min)} = 0.45 \left(\frac{A_g}{A_{cr}} - 1 \right) \times \frac{f_c'}{f_y}$$

$$= 0.45 \times \left(\frac{218.46}{213.8} - 1 \right) \times \frac{4}{60}$$

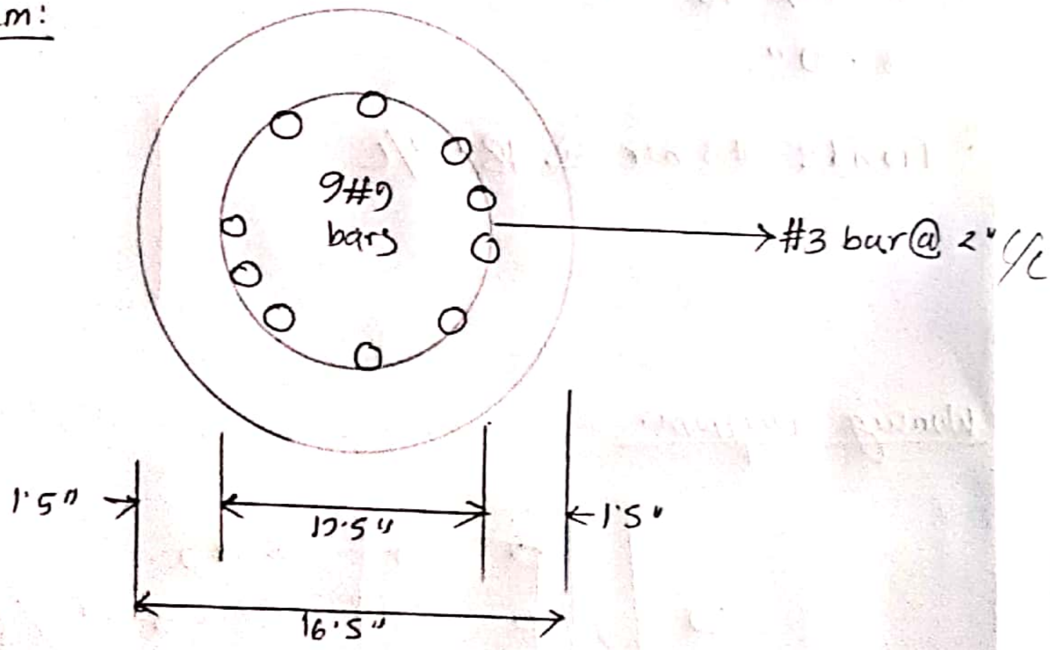
$$= 0.0118$$

$\therefore$ Now, Choosing #3 bar,

$$S = \frac{4A_{sp}}{\rho_{sr} D_{core}} = \frac{4 \times 0.11}{0.0118 \times 16.5} = 2.25''$$

$\therefore$ Provide #3 bar @ 2" c/c → Spacing কমিয়ে পূর্ণ সংখ্যায় রূপান্তর করা হলো

Working Diagram:



Problem: A column section is 20"x30" is reinforced with $\rho_g = 1\%$. Design the tie.

Soln:

Column dimension is given, thus load calculation not needed.

Steel Calculation:

$$\rho_s = \frac{A_s}{A_g} = 0.01$$

$$\therefore A_s = A_g \times 0.01 = 20 \times 30 \times 0.01$$
$$= 6 \text{ in}^2$$

$\therefore$ providing 6 #9 bars.

Tie calculation:

Let's choose #3 bars as tie,

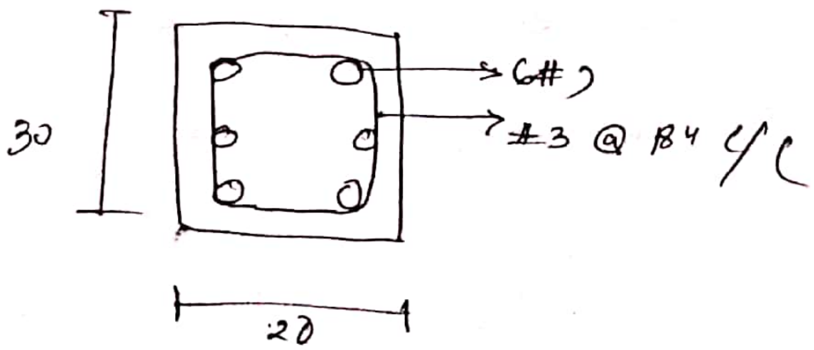
$$\therefore S_1 = 16 \times 9/8 = 18"$$

$$S_2 = 48 \times 3/8 = 18"$$

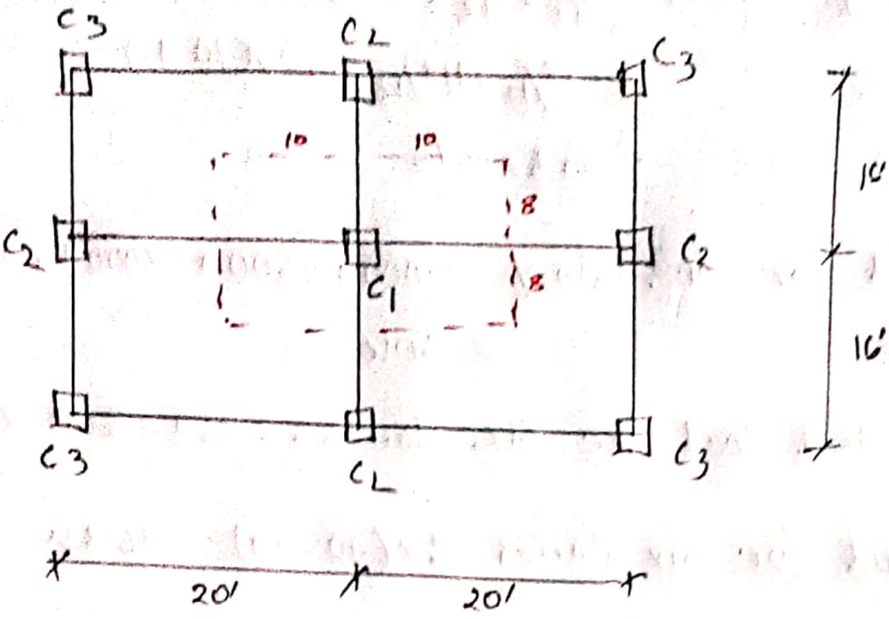
$$S_3 = 20"$$

$\therefore$ Provide #3 bar @ 18" c/c

Working Diagram:



Problem: Plan of a six storied building:



Design column 1. Assume thickness of slab = 6", beam size = 12"x18", partition wall = 5", floor finish = 30 psf, Live load = 40 psf, $f_c' = 3$ ksi, $f_y = 60$ ksi.

Solution:

(1) Load Calculation: Loaded area for column 1 = (8+8) × (10+10)
= 320 sq.ft

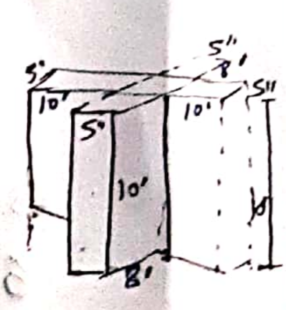
Assume, Height of each story = 10' (floor to ceiling)

∴ ~~Load on column from~~ weight of slab = $\frac{t}{12} \times 150 = \frac{6}{12} \times 150 = 75$ psf

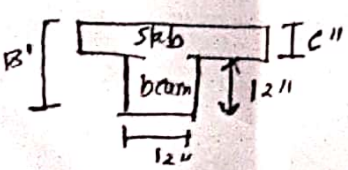
load on column from slab = Area × 75 = 320 × 75 = 24000 lb

load on column from floor finish = 320 × 30 = 9600 lb

weight of partition wall = $\left(\frac{5}{12} \times 120\right) \times (10 \times 20 + 10 \times 16)$ (120 = unit weight of masonry wall)
= 18000 lb



weight of beam = $\left(\frac{18-6}{12} \times 150\right) \times \left(\frac{12}{12} \times 20 + \frac{12}{12} \times 16\right)$
= 5400 lb



Assuming, Column section = 18×18

∴ weight of column = $\left(\frac{18}{12} \times \frac{18}{12} \times 150\right) \times$ height

$= 18/12 \times 18/12 \times 150 \times (10-1)$ → beam

$= 3037.5$ lb

Total load for one story = 24000 + 9600 + 18000 + 5400 + 3037.5

= 60k

∴ Total dead load for six stories = 6×60 = 360 k

Live load for six stories = 6×(40×30) = 76.8 k

∴ TL = 1.2 × 360 + 1.6 × 76.8 = 554.88 k

__For tied column:__

Assume, $\rho_s = 3\%$ [ACI: (1 − 8)%]

∴ $A_{st} = 0.03 A_g$

∴ $P_u = \phi k [0.85 f_c' (A_g - A_{st}) + f_y A_{st}]$

⇒ 554.88 = 0.65 × 0.80 × [0.85 × 3 × (18×8 −

∴ $A_{st} = 0.03 \times 18 \times 18 = 9.72$ in²

∴ 10 #9 bars.

অথবা

$P_u = \phi k [0.85 f_c' (A_g - A_{st}) + f_y A_{st}]$

⇒ $P_u = \phi k [0.85 f_c' (A_g - \rho_s A_g) + f_y \rho_s A_g]$

⇒ $P_u = \phi k A_g [0.85 f_c' + \rho_s (f_y - 0.85 f_c')]$

⇒ 554.88 = 0.65 × 0.80 × 18² × [0.85×3 + ρ_s (60 − 0.85×3)]

∴ $\rho_s = 0.013 > 0.01$

∴ $A_{st} = 0.013 \times 18^2 = 4.212$

∴ 6 #8 bars.

Tie Design: choosing #3 bars,

$S_1 = 16 \times 8/8 = 16$

$S_2 = 48 \times 3/8 = 18$

$S_3 = 18"$

∴ Providing #3 bar at 16" c/c.

Working Diagram: