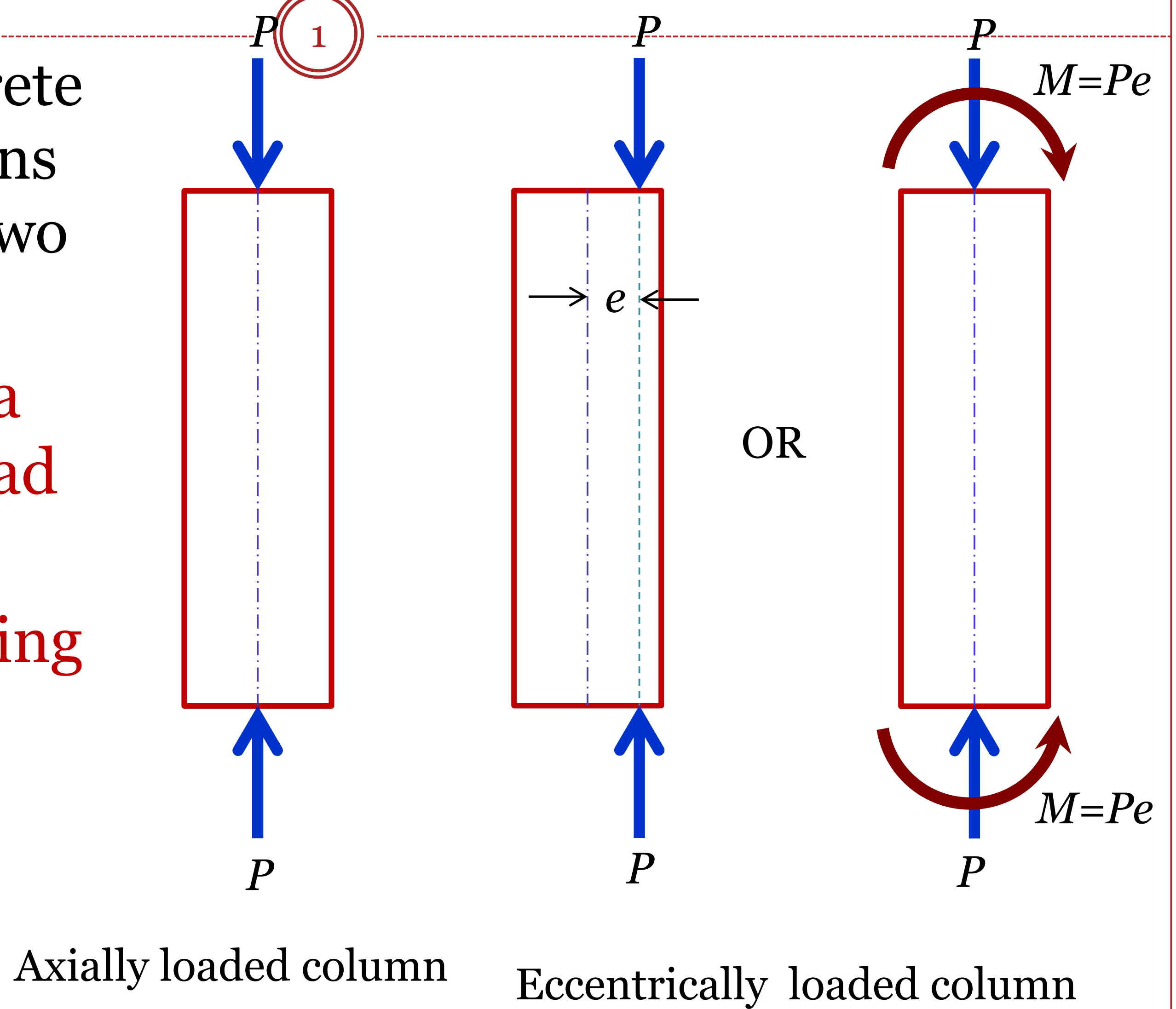
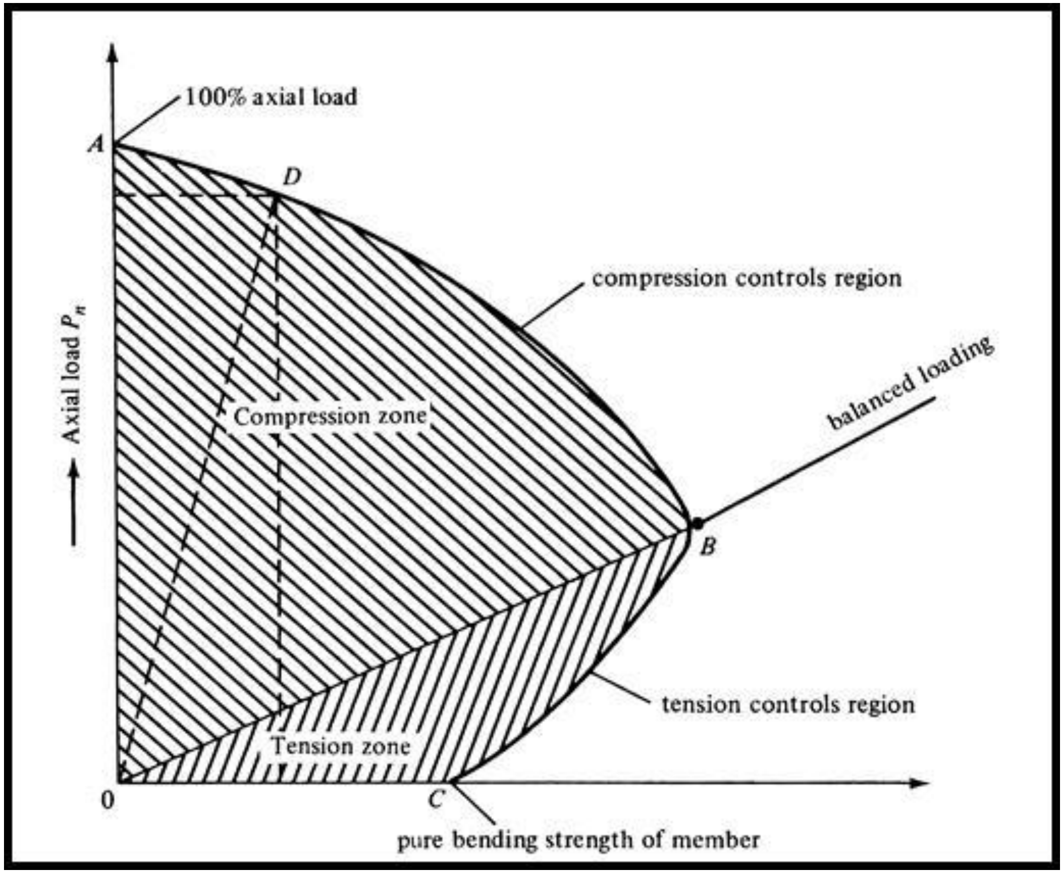
Design of Short Columns

- Reinforced Concrete (RC) short columns are divided into two categories:
  - Columns with a purely Axial load (no moment)
  - Columns carrying eccentric loads



Description of Interaction Diagram



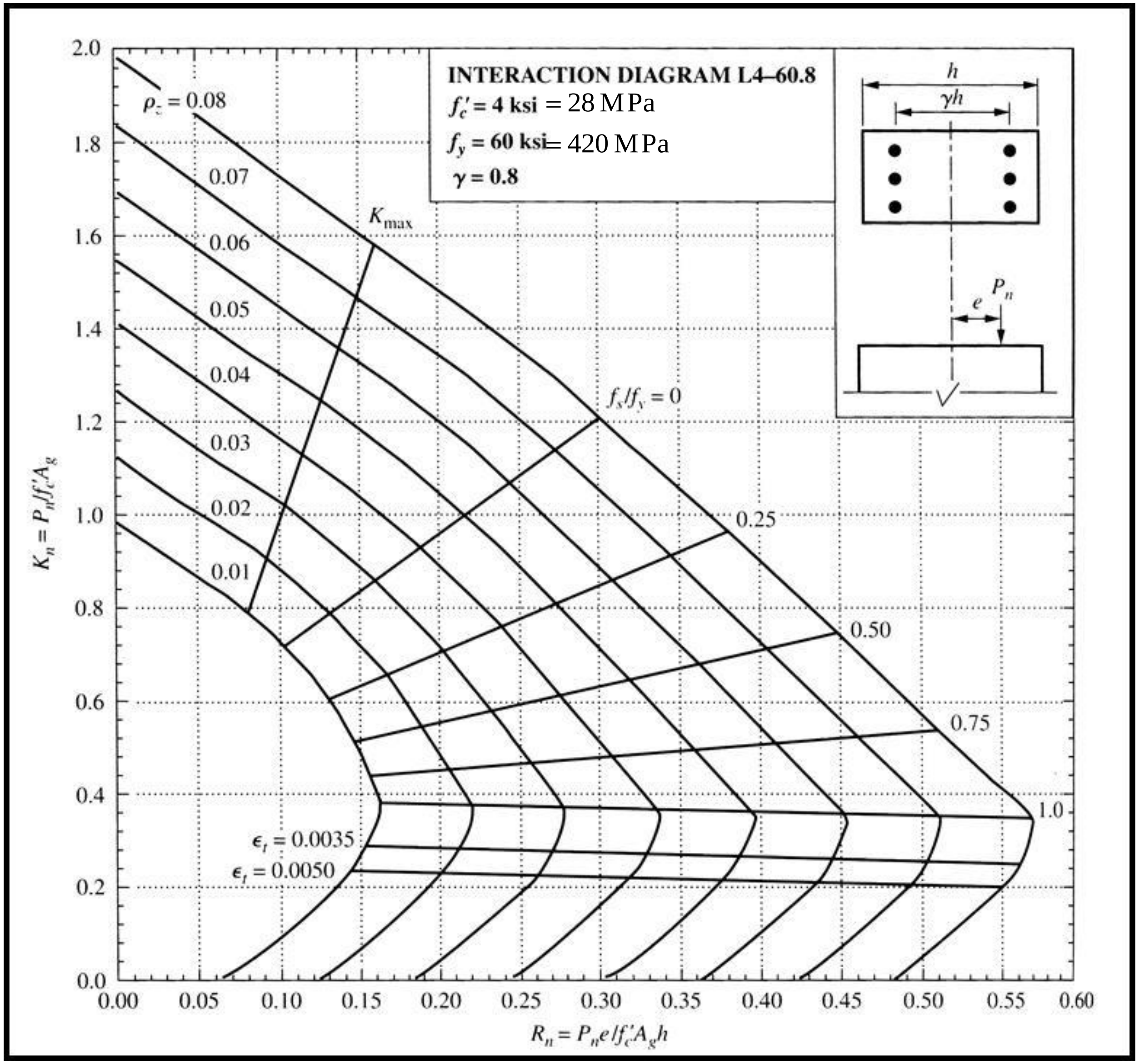
Normalized Interaction Diagrams

If the diagrams are plotted with ordinates of K_n (instead of P_n) and R_n (instead of M_n), defined below, the resulting normalized diagram can be used with any system of units.

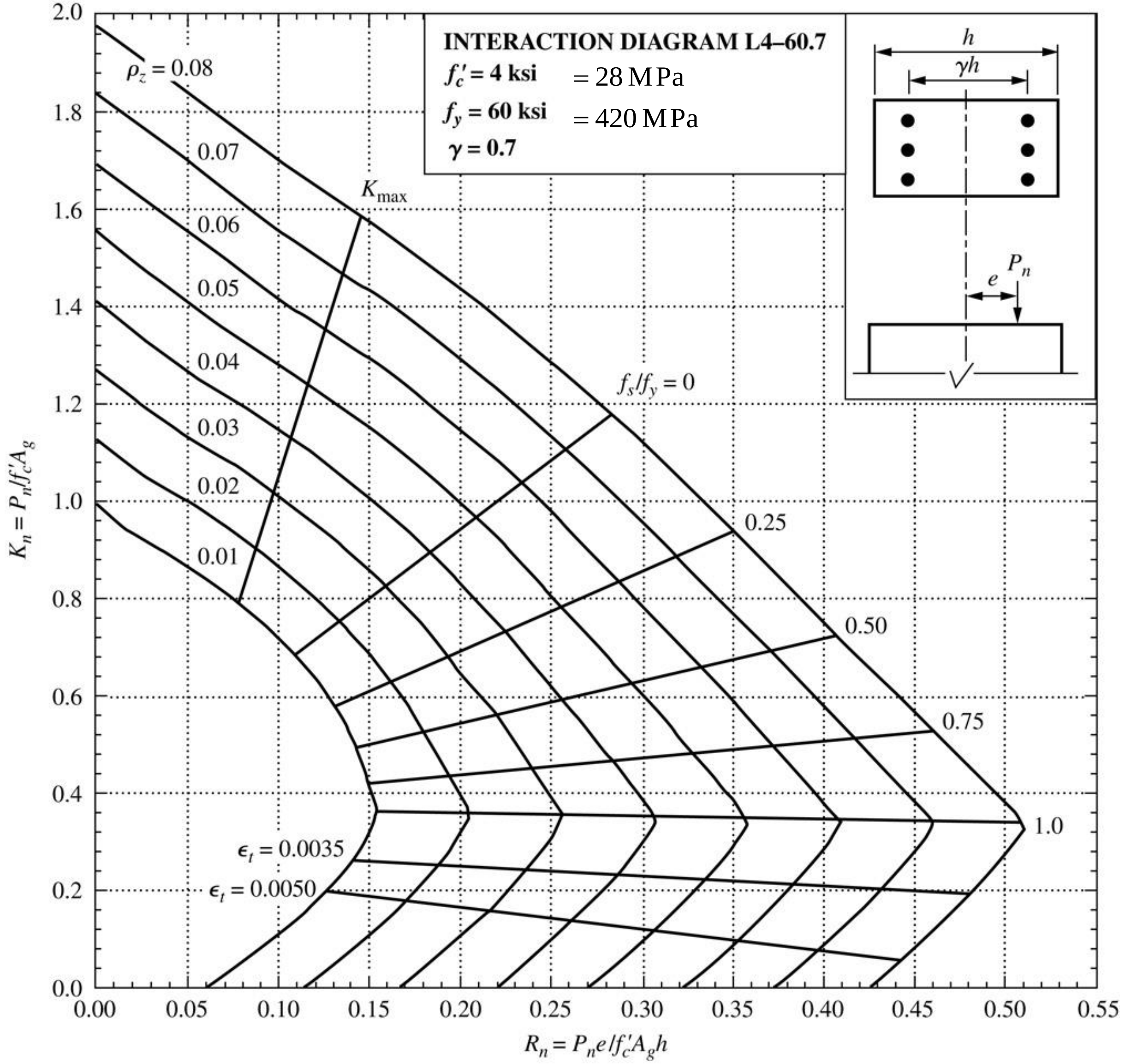
$$K_n = \frac{P_n}{f_c^{'} A_g}$$

$$R_n = \frac{P_n e}{f_c^{'} A_g h}$$

A sample Column Interaction Diagram



γ = distance from *the center of the bars on one side of the column* to the *center of the bars on the other side of the column* divided by *h*.


INTERACTION DIAGRAM L4–60.7
f'c = 4 ksi = 28 MPa
fy = 60 ksi = 420 MPa
γ = 0.7
h
γh
e
Pn
ρz = 0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
Kmax
fs/fy = 0
0.25
0.50
0.75
1.0
εt = 0.0035
εt = 0.0050
Kn = Pn/f'cAg
Rn = Pne/f'cAgh
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55

Problem-1

Design a short square tied column for the following loads: P_u = 2700 kN and M_U = 112 kNm. Place the bars uniformly around all four faces of the column. The concrete strength is 28 MPa and the steel is Grade 420. If Vu = 56 kN, check the designed column for shear.

Solution

Column Dimensions

$$A_{g(trial)} \geq \frac{P_u}{0.40(f_c^{'} + f_y \rho_t)}$$

Assume:

$\rho_t = 2\%$

$$A_g = h^2 \Rightarrow h = \sqrt{A_g} = 430\,\mathbf{mm}$$

$$\textbf{Select a } \underline{\underline{\mathbf{400 \times 400\ mm\ column}\ (A_g = 160000\ \mathbf{mm^2})}}$$

$$\phi P_n = P_u = 2700\ \text{kN} \Rightarrow P_n = 2700/\phi = 2700/0.65 = 4153.9\ \text{kN}$$

$$\phi M_n = M_u = 112\ \text{kNm} \Rightarrow M_n = 112/\phi = 112/0.65 = 172.3\ \text{kNm}$$

$$M_n = P_n e \Rightarrow e = \frac{M_n}{P_n} = \frac{172.3}{4153.9} = 0.04147\ \text{m} \Rightarrow e = 41.47\ \text{mm}$$

Parameters required to use the interaction diagrams

$$K_n = \frac{P_n}{f_c^{'} A_g} = \frac{4153.9 \times 1000}{28 \times (400 \times 400)} = 0.927$$

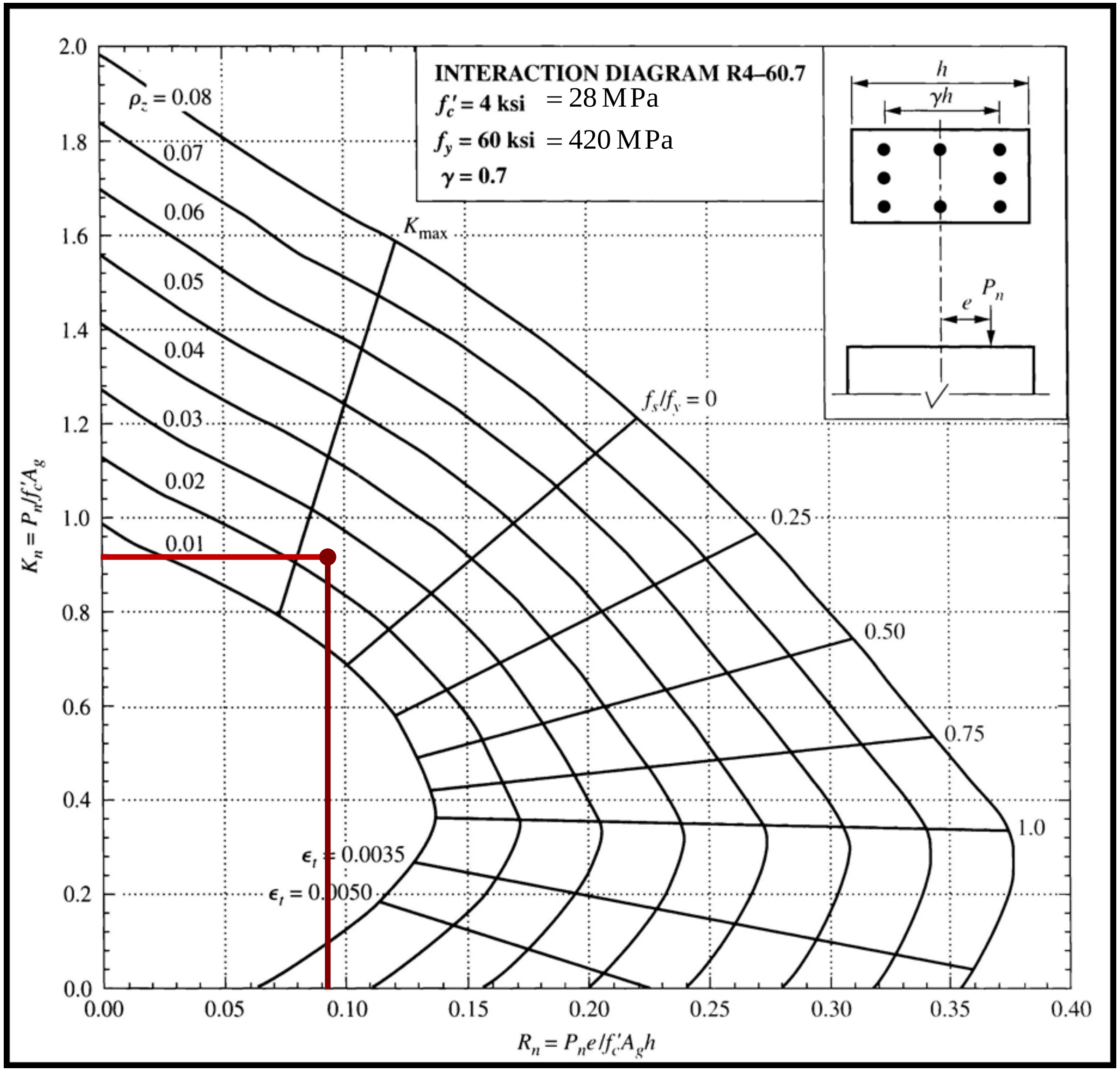
$$R_n = \frac{P_n e}{f_c^{'} A_g h} = \frac{4153.9 \times 1000 \times 41.47}{28 \times (400 \times 400) \times 400} = 0.096$$

Let us assume the effective cover = 60 mm

$$\text{Effective cover} = \text{Clear cover} + d_s + 0.5 d_b = 60 \text{ mm (say)}$$

$$\gamma = \frac{\gamma h}{h} = \frac{h - 2 \times \text{Effective cover}}{h}$$

$$\Rightarrow \gamma = \frac{400 - 2 \times 60}{400} = 0.7$$



$K_n = 0.927$

$R_n = 0.096$

$\gamma = 0.70$

$\rho_g = 0.024$

Point is in

the compression zone

$\Rightarrow \phi = 0.65$ OK.

Contd.

$$\rho_g = \frac{A_s}{A_g} \Rightarrow A_s = \rho_g A_g = \rho_g bh$$

$$\Rightarrow A_s = 0.024 \times 400 \times 400 = 3840\ \text{mm}^2$$

$$\text{Number of bars} = \frac{A_s}{A_b} = \frac{3840}{491} = 7.8 \approx 8\ \text{bars}$$

$$\underline{\underline{\text{Use } 8\text{-}25\ \text{mm bars} \left(A_s = 8 \times 491 = 3928\ \text{mm}^2\right)}}$$

Contd.

Design of Ties (Assuming 10 mm ties)

$\underline{\text{Minimum Tie Size}} = 10$ mm for long. bars of size less than 32 mm. $\underline{\underline{\text{OK}}}$

$\underline{\text{Spacing}}$: Vertical spacing (pitch) of ties shall not exceed :

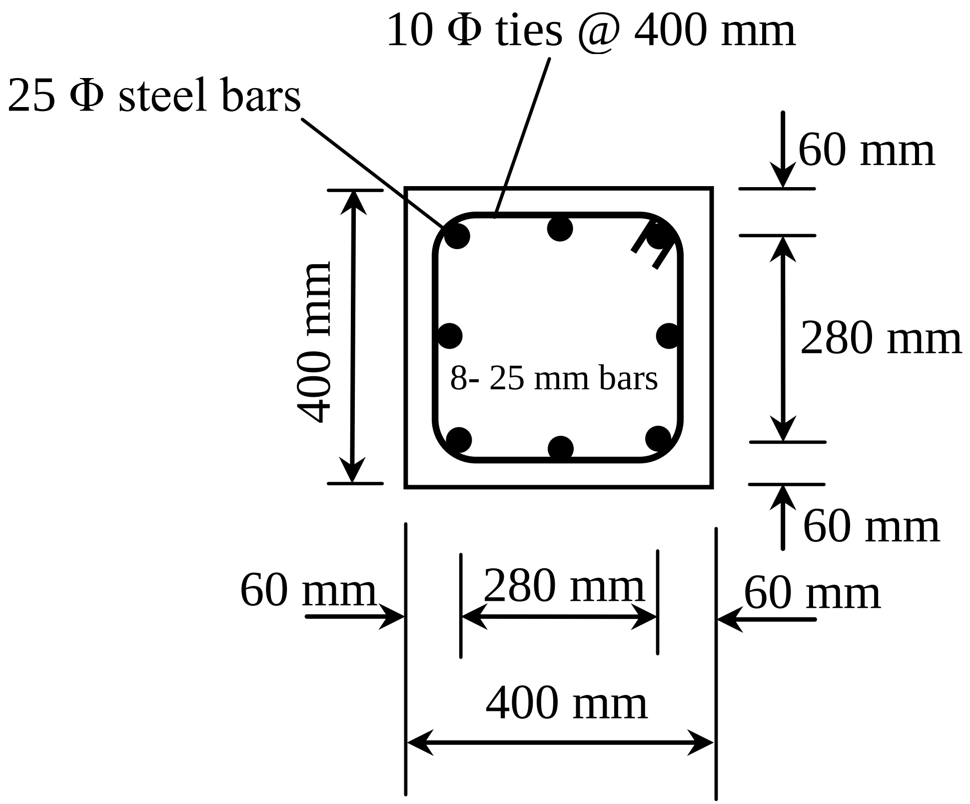
(a) $16 \times$ longitudinal bar diameter $= 16 \times 25 = 400$ mm

(b) $48 \times$ tie bar diameter $= 48 \times 10 = 480$ mm

(c) Least dimension of the column section $= 400$ mm

$\underline{\underline{\text{Use 10 mm ties at 400 mm c/c}}}$

Sketch of the Column Cross section

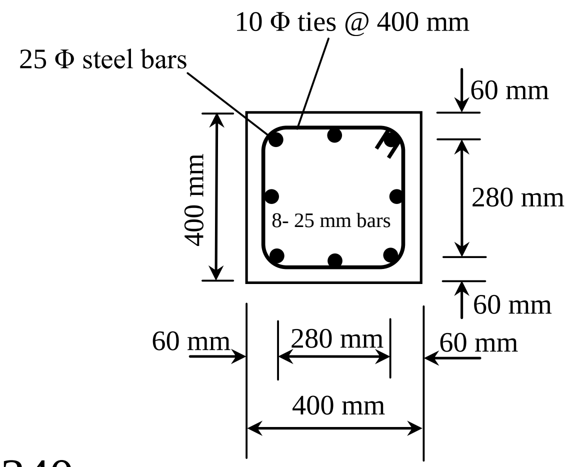


Check for shear

$$V_u = 56\,\text{kN}$$

$$d = h - (\text{cover} + \frac{d_b}{2} + d_s) = 400 - 60 = 340\,\text{mm}$$

$$b_w = 400\,\text{mm}$$



$$V_c = \left(1 + \frac{P_u}{14A_g}\right)\frac{\sqrt{f_c'}}{6}b_w d = \left(1 + \frac{2700 \times 1000}{14 \times (400 \times 400)}\right)\frac{\sqrt{28}}{6} \times 400 \times 340$$

$$\Rightarrow V_c = 264512\,\textbf{N} = 264.5\,\textbf{kN}$$

$$0.5\phi V_c = 0.5 \times 0.75 \times 264.5 = 99.2\,\text{kN}$$

Since $0.5\phi V_c > V_u (= 56\,\text{kN})$ OK