Design the square column which is a part of a braced frame, with ends assumed to be simply supported (hinge-hinge).

$L_u = 8{,}5 m$

$M_1 = M_2 = 140 kNm$

The column bend in double curvature

$P_f = 2500 kN$

$b = h = 500 mm$

$f_c' = 25 MPa$, $f_y = 400 MPa$

cover to ties: 40 mm

* Is the column slender? $\frac{k l_u}{r} \le \frac{25 - 10(M_1/M_2)}{\sqrt{P_f / f_c' A_g}}$?

$k = 1.0$ (hinged-hinged)

$l_u = 6000 mm$

$r = 0{,}3h = 0{,}3(500) = 150 mm$

$-1 \le \frac{M_1}{M_2} \le 0$ (double curvature)

$\frac{M_1}{M_2} = \frac{-140}{140} = -1$

and $\frac{M_1}{M_2}$ should not be less than $\underline{-0.5}$

$$\frac{1.0(8500)}{150} > \frac{25 - 10(-0.5)}{\sqrt{(2500 \times 10^3 / 25 \times 500^2)}}$$

$56{,}67 > 47{,}43 \Rightarrow$ column is slender

* Compute magnified moment, M_c

$$M_c = \frac{C_m M_2}{1 - \frac{P_f}{\phi_m P_c}} \geq M_2$$

$$C_m = 0{,}6 + 0.4 \frac{M_1}{M_2} \geq 0.4$$

$C_m = 0.6 + 0.4(-0.5) = 0.4$

$\phi_m = 0.75$

$EI = 0{,}25 E_c I_g$

$EI = 0{,}25(4500\sqrt{25})\frac{500^4}{12} = 2{,}93 \times 10^{13}$ ×

$$P_c = \frac{\pi^2 EI}{(k l_u)^2} = \frac{\pi^2 (2{,}93 \times 10^{13})}{(1.0 \times 8500)^2} = 400248$$

$P_c = 4002 kN$

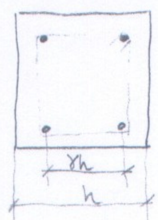
$$M_c = \frac{0.4(140)}{1 - \frac{2500}{0.75(4002)}} = 335{,}2 kNm$$

$M_c > M_2$

* Select the column reinforcement

$f_c' = 25\,MPa$, $f_y = 400\,MPa$, square column: $500^{mm} \times 500^{mm}$

Use 30M bars (at all faces)



$$\gamma = \frac{500 - 2(40 + 10 + \frac{30}{2})}{500} = 0.74$$

$$\frac{P_f}{A_g} = \frac{2500 \times 10^3}{500 \times 500} = 10\ MPa$$

$$\frac{M_c}{A_g \times h} = \frac{335.2 \times 10^6}{(500 \times 500) \times 500} = 2,68 \simeq 2,7$$

Use Table 7.4.2 $\Rightarrow \rho = 0.02$ when $\gamma = 0.70$

and Table 7.4.3 $\Rightarrow \rho = 0,015$ when $\gamma = 0,80$

Interpolate, to find ρ when $\gamma = 0.74$:

$$\frac{0.74 - 0.70}{0.80 - 0.70} = \frac{\rho - 0.02}{0.015 - 0.02} \Rightarrow 0.4 = \frac{\rho - 0.02}{-0.005} \Rightarrow 0.018$$

$$A_s = \rho A_g = 0,018\ (500 \times 500) = 4500\ mm^2$$

Use 8 - 30M $\Rightarrow A_s = 8(700) = 5600\ mm^2$