CE-601 SDD (RCC-1)

Notes - Dr. D.K. Jain 24.3.2020 Teaching/Learning from Home

Example 1. Design a short column, square in section, to carry an axial load of 2000 kN using M20 grade concrete and (i) Mild steel (ii) Fe 415 grade steel

Solution:-

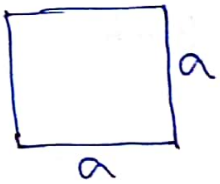
Factored load $P_u = 2000 \times 1.5 = 3000$ kN

Since length is not given, no need to calculate $e_{min.}$ & since it is a short axial column, so

$$P_u = 0.4 f_{ck} \cdot A_c + 0.67 f_y \cdot A_{sc} \quad \text{---(1)}$$

(i) **Mild steel :-** $f_y = 250$ N/mm^2

Let us provide a square column with sides = a



For economy, provide min. steel

min. steel = 0.8 %

$$\therefore A_{sc} = \frac{0.8}{100} \times a \times a = 0.008\, a^2$$

filling values in formula eq^n (1), we get

$$\left(\frac{3000}{\times 1000}\right) = 0.4 \times 20 \times a \times a\,(1 - 0.008) + 0.67 \times 250 \times 0.008^2$$

$A_c = (A_g - A_{sc})$
$= (A_g - 0.008 A_g)$
$= A_g (1 - 0.008)$
$= a \times a (1 - 0.008)$

$$\therefore a = 568.7 \text{ mm.}$$

Provide column of size 600 mm × 600 mm

Gross area provided = $600 \times 600 = 360000\ mm^2$

Gross area required = $568.7 \times 568.7 = 323419.7\ mm^2$

Area of Longitudinal steel = 0.008×323419.7

$= 2587\ mm^2$

provide reinf. bars $4-20\ \phi = 1257\ mm^2$

$+\ 8-16\ \phi = 1600\ mm^2$

$2856\ mm^2 > 2587\ mm^2$

so, OK.

Dia & Pitch of Lateral Ties:-

Dia $\phi_T \geq \frac{(\phi_L)_{max}}{4} = \frac{20}{4} = 5\ mm.$

$\geq 6\ mm.$

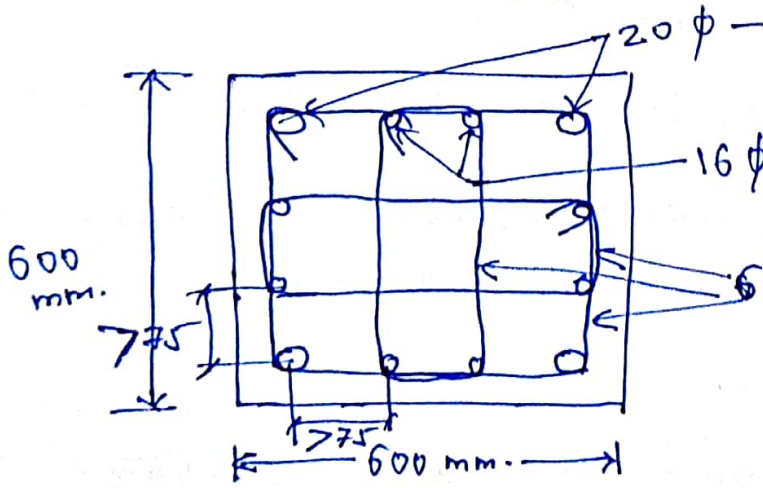
So, provide ~~8 mm.~~ 6 mm. ϕ bars (in mild steel, min dia = ~~6 mm~~ = 6 mm)

Pitch $p \leq$ Least lateral dimension $= 600\ mm.$

$\leq 16 (\phi_L)_{min.} = 16 \times 16 = 256\ mm.$

$\leq 300\ mm.$

So, adopt a pitch of 250 mm. c/c



Spacing of bars > 75 mm so extra ties provided

(ii) Fe 415 grade steel $f_y = 415\ N/mm^2$

putting values in eqn (1), we get

$$3000 \times 1000 = 0.4 \times 20 \times a^2 (1 - 0.008) + 0.67 \times 415 \times 0.008\, a^2$$

$\therefore a = 543.4$ mm.

Adopt column size = 550 mm. × 550 mm.

Gross area of concrete provided = 550×550

Gross area of concrete required = 543.4×543.4

~~$= 2953\ mm^2$~~

$= 295284\ mm^2$

$\therefore$ Area of longitudinal steel = 0.008×295284

$= 2362\ mm^2$

provide reinf. bars $8 - 20\phi = 8 \times 314 = 2512\ mm^2$

$> 2362\ mm^2$

so, OK

Lateral ties :—

(1) Dia $\phi_T \geq \frac{(\phi_L)_{max}}{4} = \frac{20}{4} = 5$ mm.

≥ 6 mm

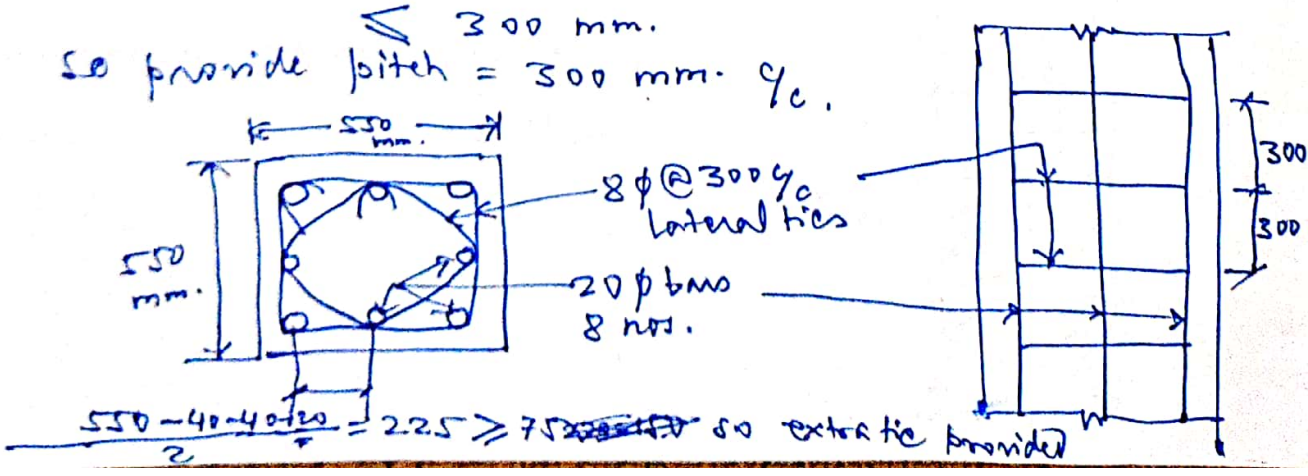
provide 8 mm. dia ties (for Fe415 steel min. dia = 8mm)

(2) Pitch $p \leq$ least lateral dimension = 550 mm.

$\leq 16 (\phi_L)_{min} = 16 \times 20 = 320$ mm.

≤ 300 mm.

so provide pitch = 300 mm. c/c.



Example 2:- Design a short circular column to carry same load i.e. 2000 kN with M20 grade concrete & Fe415 grade steel.

here $A_g = \frac{\pi}{4} D^2$

filling values in formula (equation (1)), we get,

$$3000 \times 1000 = 0.4 \times 20 \times \left(\frac{\pi}{4} \times D^2\right)(1 - 0.008) + 0.67 \times 415 \times 0.008 \times \frac{\pi}{4} \times D^2$$

$\therefore D = 613$ mm.

Provide $D = 625$ mm.

Area of steel $= 0.008 \times \frac{\pi}{4} \times 613^2 = 2361 \text{ mm}^2$

Provide 8 - 20 ϕ bars, area $= 8 \times 314 = 2512 > 2361$

so, ok.

Lateral ties:-

① Dia $\geq \frac{(\phi_L)_{max}}{4} = \frac{20}{4} = 5$ mm.

≥ 6 mm.

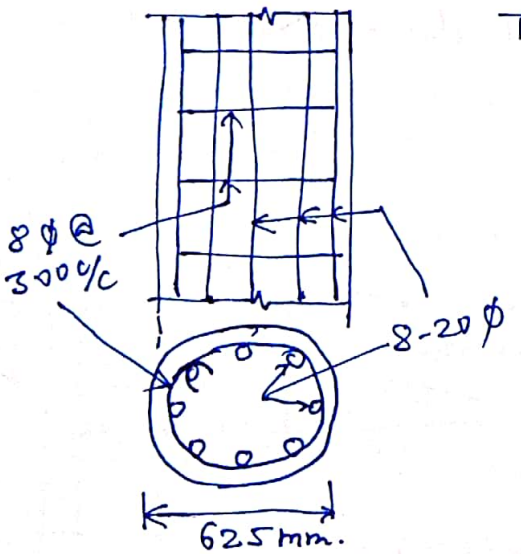
provide 8 mm. dia ties (for Fe415 steel, min dia = 8 mm)

② Pitch $\leq$ least lateral dimension $= D = 625$ mm.

$\leq 16 (\phi_L)_{min} = 16 \times 20 = 320$ mm.

≤ 300 mm.

So, provide pitch = 300 mm.



These are normal ties not spiral ties

Circular Columns with spiral ties has different design procedure which shall be taken up seperately.

Example 3 :- Design the reinforcement in a column of size 400 mm. x 600 mm subjected to an axial working load of 1800 kN. The column has an unsupported length of 2m. and it is braced against side sway in both the directions & restrained against rotation also. Adopt M20 grade concrete and Fe 415 grade steel.

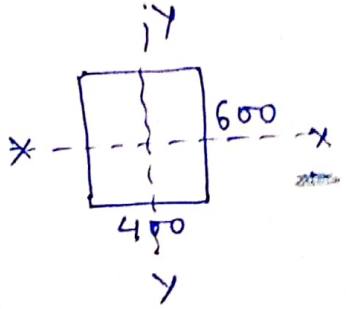
Solution :-

Column end condition is given as braced against side sway & restrained against rotation at both ends which means both ends are fixed

$\therefore$ Eff. length $l_{ex} = l_{ey} = 0.65\ l$ --- Ann. E Table 23 P. 94 IS 456

$= 0.65 \times 2$

$= 1.3$ m.



Slenderness ratios :-

$$\frac{l_{ex}}{D} = \frac{1.3 \times 1000}{600} = 2.17 < 12$$

and, $$\frac{l_{ey}}{b} = \frac{1.3 \times 1000}{400} = 3.25 < 12$$

So, it is a short column

Minimum eccentricity $e_{min} = \frac{\text{unsupported length}}{500} + \frac{\text{lateral dimension}}{30}$

bending about x-x axis $e_{min} = \frac{2000}{500} + \frac{600}{30} = 24$ mm. $< 0.05 \times 600 = 30$ mm.

bending about y-y axis $e_{min} = \frac{2000}{500} + \frac{400}{30} = 17.33$ mm. $< 0.05 \times 400 = 20$ mm.

$\therefore e_{min} < 0.05 \times$ lateral dimention in both direction. Therefore, strength of column is given by;

$A_c = A_g - A_{sc}$

$P_u = 0.4 f_{ck} \cdot A_c + 0.67 f_y \cdot A_{sc}$

or, $1800 \times 1.5 = 0.4 \times 20 \times (400 \times 600 - A_{sc}) + 0.67 \times 415 \times A_{sc}$

$\therefore A_{sc} = 2888.35 \text{ mm}^2$

Min. steel = $0.8\% = \frac{0.8}{100} \times 400 \times 600 = 1920 \text{ mm}^2$

$2888.35 > 1920$ so, OK.

No. of 20 mm. dia bars = $\frac{2888.35}{314} = 9.2$

provide 10 bars of 20 mm dia

Lateral ties:-

① Diameter $\geq \frac{(\phi_L)_{max}}{4} = \frac{20}{4} = 5 \text{ mm.}$

$\geq 6 \text{ mm.}$

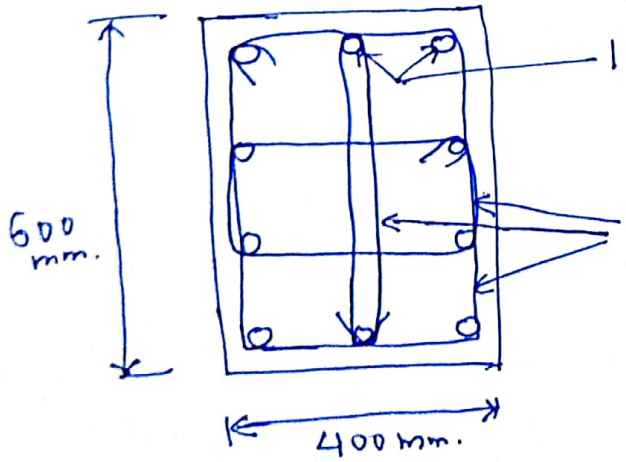
provide 8 mm. ϕ ties (min. dia for Fe 415 HYSD bars = 8 mm)

② Pitch $<$ least lateral dimension $= 400 \text{ mm.}$

$< 16 (\phi_L)_{min.} = 16 \times 20 = 320 \text{ mm.}$

$< 300 \text{ mm.}$

so, provide pitch = 300 mm.



spacing between main bars > 75 so middle bars are tied in other direction also using additional ties