column 4.6m high held in position at both ends and restrains against rotation at one end to carry a axial load of 1200 kN and its diameter is restricted to 450mm. M_{20} concret Fe415 steel

Soln: $l = 4.6m$

$P = 1200$ kN

$D = 450$ mm

$f_{ck} = 20\ N/mm^2$

$f_y = 415\ N/mm^2$

using fixed length & directly apply

for the given end conditions the effective length of the compression member is

$l_{eff} = 0.80l$

[Table 28 of IS 456: 2000]

$= 0.8 \times 4.6$

$= 3.68$ m

$= 3680$ mm

• eccentricity min

$e_{min} = \frac{l}{500} + \frac{D}{30}$ min 20

[from cl. 25.4]

$e_{min} = \frac{3680}{500} + \frac{450}{30}$

$= 22.36$ mm > 20

$0.05D = 0.05 \times 450$

$= 22.50$

$e_{min} < 0.05D$

$22.36 < 22.5$

$e_{min} < 0.05D$ ∴ the column can be designed using cl 39.3.

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

~~1200×10~~ $P_u = 1200 \times 1.5 \times 10^3$

$= 1800 \times 10^3$ N

$\therefore A_c = [A_g - A_{sc}]$

$1800 \times 10^3 = 0.4 \times 20 [A_g - A_{sc}] + 0.67 \times 415 \times A_{sc}$

$1800 \times 10^3 = 0.4 \times 20 \left[\frac{\pi}{4} \times 450^2 - A_{sc}\right] + 0.67 \times 415 \times A_{sc}$

$A_{sc} = 1953.915 mm^2$

Check: [cl 26.5.3]

$A_{sc\,min} = 0.8\%$ of c/s Area

$= \frac{0.8}{100} \times \frac{\pi}{4} \times 450^2$

$A_{sc} = 1272 mm^2$

$A_{sc\,max} = 6\%$ of c/s A

$= \frac{6}{100} \times \frac{\pi}{4} \times 450^2$

$= 9542 mm^2$

$A_{sc\,min} < A_{sc} < A_{sc\,max}$

No. of bars $= \frac{A_{sc}}{\text{Area of 1 bar}}$

Assume 20 mm ϕ bar

No. of bars $= \frac{1953.95}{\pi/4 \times 20^2}$

$= 6.2$

≈ 7 No.s

Provide 7 No.s 20mm ϕ bars as longitudinal reinforcement

Transverse reinforcement — pg: 49

Pitch of lateral ties

[cl 26.5.3.2.(c)]

Assume 8mm ϕ lateral ties

Pitch :-

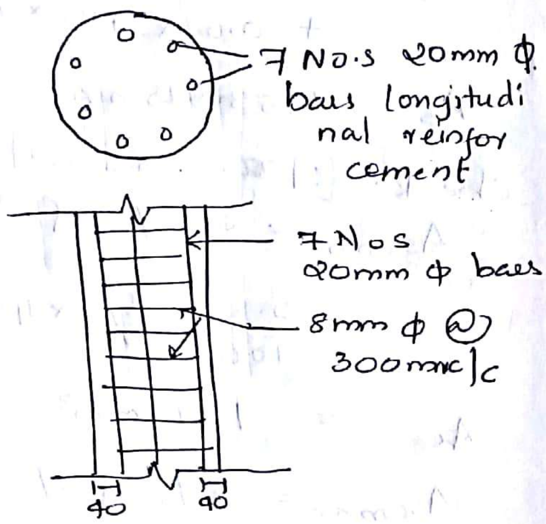
(i) least lateral dimension

(i) 450 mm

(ii) $16\phi = 16 \times 20 = 320$

(iii) 300 mm

Provide 8mm ϕ stirrup 300mm c/c



~~Provide 4 Nos 20mm ϕ bars~~ as longitudinal reinforcement

Q: Design a circular column with helical reinforcement to carry a axial load of 1000 kN use M20 concrete Fe 415 steel

Soln: Given

$P = 1000$ kN

$f_{ck} = 20$ N/mm^2

$f_y = 415$ N/mm^2

Assume e_{min} is less than $0.05D$

NOTE

Strength of compression member with helical reinforcement is 1.05 times the strength of similar member with lateral ties.

Therefore

~~$P_u = 1000 \times 1.5$~~

$$P_u = \frac{P \times 1.5}{1.05}$$

$$= \frac{1000 \times 1.5}{1.05}$$

$= 1428.57$ kN

$= 1428.57 \times 10^3$ N

From cl. 39.3

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

Assume % of steel provide is 1% of gross cross sectional area

$\therefore A_{sc} = \frac{1}{100} \times A_G$

$A_{sc} = 0.01 A_G$

Area of concrete.

$= A_G - A_{sc}$

$= A_G - 0.01 A_G$

$A_c = 0.99 A_G$

~~$P_u = 0.4$~~

$1428.57 \times 10^3 =$

$0.4 \times 20 \times 0.99 A_G +$

$0.67 \times 415 \times 0.01 A_G$

$\therefore A_G = 133504.974$ mm^2

$\frac{\pi}{4} D^2 = A_G$

$133504.974 = \pi/4 \, D^2$

∴ Actual Gross Area

$A_g = \frac{\pi}{4} \times 420^2$

$= 138544.236 \, mm^2$

$A_{sc} = 0.01 \, A_g$

$= 0.01 \times 138544.236$

$= 1385.44 \, mm^2$

Check

$A_{sc_{min}} = 0.8\%$ of A_g

$= \frac{0.8 \times 138544.236}{100}$

$= 1108.35 \, mm^2$

$A_{sc_{max}} = \frac{0.6 \times 138544.236}{100}$

$= 8312.64 \, mm^2$

∴ No. of bars $= \frac{A_{sc}}{\text{Area of 1 bar}}$

Assume 16mm ϕ bars

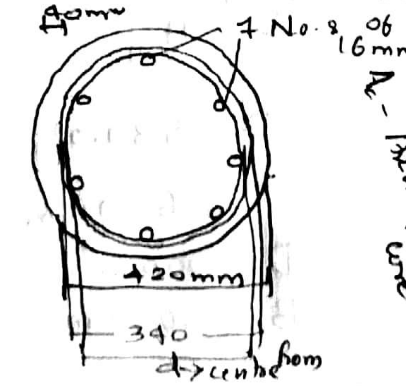
$= \frac{1385.44}{\pi/4 \times 16^2}$

$= 6.89$

≈ 7 bars.

Provide 7 Nos of 16mm ϕ bars as longitudinal reinforcement.

Transverse reinforcement



outside of the helix

Outside diameter of helix =

$420 - 2 \times 40$

$= 340 \, mm$

Area of core $= \frac{\pi}{4} \times 340^2$

$= 90792.02 \, mm^2$

Area of core excluding longitudinal bars -

$A_k = \frac{\pi}{4} \times 340^2 - 7 \times \frac{\pi}{4} \times 16^2$

$= 89384.6 \, mm^2$

Vol. of the core measured to 1mm A_k length

$= A_k \times 1$

$= 89384.6 \, mm^3$

Vol. of helix per mm of column

$= \boxed{\underbrace{\left(\frac{\pi d}{s}\right)}_{\text{height}} \underbrace{\left(\frac{\pi}{4} \times \phi_s^2\right)}_{\text{Area}}}$

diameter of the helix to d the centre.

$= 340 - 8 = 332 \, mm$

{Assume ϕ of helix = 8mm}

Volume of helix =

$\frac{\pi \times 332}{s} \left(\frac{\pi}{4} \times 8^2\right)$

From Cl. 39.4.1 (71 page)

$\frac{\text{Vol. of helical reinfor}}{\text{Vol. of core}} = \frac{0.36\left(\frac{A_g}{A_k} - 1\right) f_{ck}}{f_y}$

$\frac{\frac{\pi \times 332}{s} \times \frac{\pi}{4} \times 8^2}{89384.6} = \frac{0.36\left[\frac{138544.2}{893846} - 1\right] \times 20}{415}$

$S = 61.469 mm$

hoop → stirrup (Ring, square, circular)

Pitch

cl.26.5.3.2.(d)

(i) $S < 75mm$ ✓

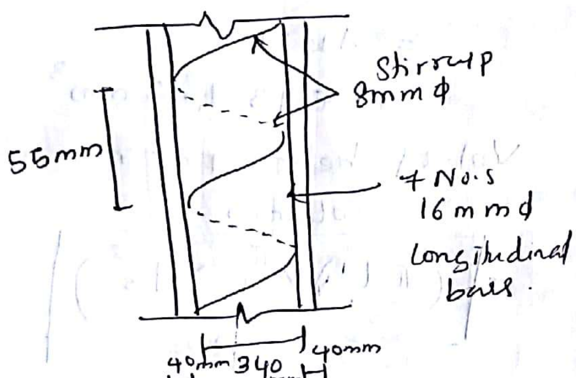
(ii) $S < \frac{1}{6} \times 340 = 56.6$ → max. (so we can take 61.469)

$(S > \frac{1}{6} \times 340)$ ×

(iii) $S > 25mm$ ✓

(iv) $S > 3 \times \phi_s = 3 \times 8 = 24$ ✓

provide helical reinforcement of 8mm ϕ @ 55 mm c/c



18.11.19 MONDAY

Q: Design a rectangular column of 4.5m unsupported length restrain a position & direction of both ends. To carry a axial load of 1200kN. Use M20 concrete & Fe 415 steel

Soln: Given:

Unsupported length = 4.5m

$P = 1200 kN$

$f_{ck} = 20 N/mm^2$

$f_y = 415 N/mm^2$

$P_u = 1200 \times 1.5$

$= 1800 kN$

Assume

$e_{min} = \frac{l}{500} + \frac{D}{30} > 20$ (emin min 20 or 20mm)

lateral dimension

Assume $e_{min} < 0.05D$

[cl.39.3 of IS 456:2000]

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

Assume 1% of reinforcement as 1% Gross area.

$A_{sc} = \frac{1}{100} A_G$

$A_c = A_G - A_{sc}$

$= A_G - 0.01 A_G$

$A_c = 0.99 A_G$

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

$1800 \times 10^3 =$

$0.4 \times 20 \times 0.99 A_G + 0.67 \times 415 \times 0.01 A_G$

$A_G = 168216.4385$

Rectangular $B \times D = A_G$

$[B = 0.5 \text{ to } 0.67] D$

Assume $B = \frac{D}{2}$

$\frac{D}{2} \times D = A_G$

$\frac{D^2}{2} = A_G$

$D = 580.02$

$\approx 600mm$

$D = 600mm$

$B = 300mm$

Actual gross area = B×D

$A_g = 600 \times 300$

$= 180000 \, mm^2$

$A_{sc} = 0.01 \times 180000$

$= 1800 \, mm^2$

[C] 26.

$A_{sc\,min} = \frac{0.8}{100} \times 600 \times 300$

$= 1440$

$A_{sc\,max} = \frac{6}{100} \times 600 \times 300$

$= 10800$

Assume 20mm ϕ bars

No.of bars = $\frac{A_{sc}}{\text{Area of 1bar}}$

$= \frac{1800}{\pi/4 \times 20^2} = 5.7$

unsupported length
an
effective length

≈ 6 Nos

Check for slendernous ratio :-

Table 28 (Cl E-3) Pg.99

$\frac{l}{d} > 12$ ⇓ long colu

$l_{eff} = 0.65 \, l$

$= 0.65 \times 4.5$

$\frac{l}{d} < 12$ ⇓ Short columns

$= 2.925 \, mm$

$= 2925 \, m$

$\frac{l_{eff}}{D} = \frac{2.925}{600} = 4.875 \times 10^3$

$\frac{l_{eff}}{B} = \frac{2.925}{300} = 9.75 \times 10^3$

$\frac{l_{eff}}{D} < 12$

$\frac{l_{eff}}{B} < 12$

∴ It is a short column.

Check for eccentricity :-

In x direction

$\frac{l}{500} + \frac{B}{30} = \frac{2925}{500} + \frac{300}{30}$

$= 15.85$

e_{min} (x dirn) 20

$0.05 \, B = 0.05 \times 300$

$= 15$

$e_{min} > 0.05 \, B$

In y direction ⇒

$\frac{l}{500} + \frac{D}{30} = \frac{2925}{500} + \frac{600}{30}$

$= 25.85$

$0.05 D = 0.05 \times 600 = 30$

$e_{min} < 0.05 \, D$

Since the equation is not strictly applicable the Column is to be redesigned

we have,

$0.05 B = 20$

$B = 400 \, mm$

$B \times D = 180000$

$D = 450 \, mm$

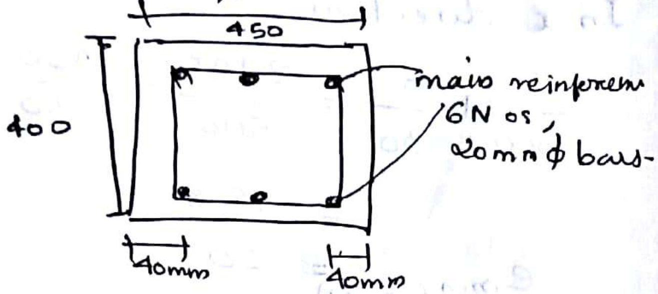
cl. 26.5.3.2

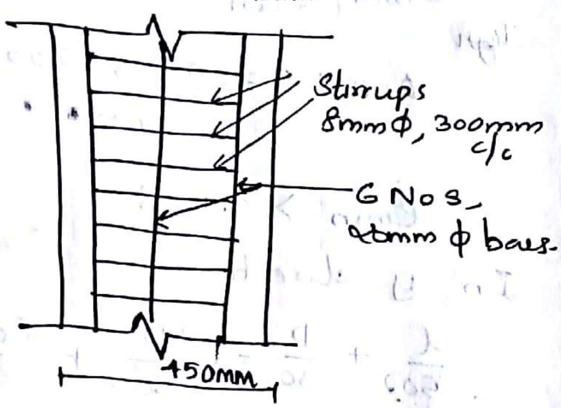
(i) least lateral dimension = 400

(ii) $16\phi = 16 \times 20 = 320$

(iii) 300mm

provide 8mm ϕ bars @ 300mm c/c





MODULE 4

ISOLATED FOOTING

ISOLATED FOOTING FOR AXIALLY LOADED COLUMNS

ISOLATED FOOTING FOR UNIFORM DEPTH FOR RCC COLUMN

Design a isolated footing of uniform thickness for a RCC column having a vertical load of 600kN and having a base of size foot 300mm. The safe bearing capacity of soil is 120 kN/m². Use M20 concrete & Fe 415 steel.

$W = 600$ kN ... kN/m²

$b = 500$ mm, $d = 500$ mm } column.

$f_{ck} = 20$ N/mm² $f_y = 415$ N/mm²

Step 1: Dimension of the section

Let w' be the selfweight of the column 10% of super imposed load.

$W' = 10\% \, W$

$= 600 \times \frac{10}{100} = 60$ kN

Total load $= 600 + 60 = 660$ kN

Area $= \frac{\text{Load}}{\text{Pressure}}$

$= \frac{660}{120}$

$= 5.5 \, m^2$

So provide a square column of size $B^2 = 5.5$

$B = 2.34$

$B = 2.4$ m

Provide a square footing of 2.4×2.4 m

Net upward pressure $= \frac{\text{Actual load}}{\text{Area}} = \frac{600}{2.4 \times 2.4}$

$= 104.17$ kN/m²