Department of Civil Engineering
Katihar Engineering College, Katihar

Subject: Design of Concrete Structure - I
Topic: Design of Column.
Lecture: 04
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P-2. Design a circular column with helical reinforcement subjected to an axial load of 2500 kN. Dia of column is 600 mm, M25 & Fe415 steel are used. Use WSM. Effective length of column is 8.5 m.

Solution.

$P = 2500\ kN$

Dia of column $= 600\ mm$

$\sigma_{sc} = 190\ N/mm^2$

$\sigma_{cc} = 6\ N/mm^2$

$L_{eff} = 8500\ mm$

(1) Slenderness Ratio (λ) $= \dfrac{\text{Effective length}}{\text{Least Lateral Dimension}}$

$= \dfrac{8500}{600} = 14.16 > 12$ (long column)

(2) Load Carrying Capacity

$P = C_r \times 1.05 (\sigma_{sc} A_{sc} + \sigma_{cc} A_c)$

$$\text{Reduction coefficient } (C_r) = 1.25 - \frac{L_{eff}}{48 \cdot D_c}$$

$$= 1.25 - \frac{8500}{48 \times \cancel{600}\, D_c}$$

$$\text{Diameter of Core } (D_c) = D_g - 2 \times \text{clear cover}$$

$$= 600 - 2 \times 40$$

$$= 520 \text{ mm}$$

$$P = 1.05 \times C_r (\sigma_{sc} A_{sc} + \sigma_{cc} \times A_c)$$

$$2500 \times 10^3 = 1.05 \left(1.25 - \frac{8500}{48 \times 520}\right) \times \left(190 \times A_{sc} + 6 \times \left[\frac{\pi}{4} \times 600^2 - A_{sc}\right]\right)$$

$$2500 \times 10^3 = 0.9549 (190 A_{sc} - 6 A_{sc} + 1696460.03)$$

$$A_{sc} = 5008 \text{ mm}^2$$

$$\% \text{ of steel} = \frac{5008}{\frac{\pi}{4} \times 600^2} \times 100 = 1.77\%$$

Provide 25 mm diameter bar

$$\text{No of bars} = \frac{5008}{\frac{\pi}{4} \times 600^2} = 10.2$$

$$\simeq 11 \text{ Nos}$$

(3) Design of helical reinforcement:

$$0.36 \frac{f_{ck}}{f_y}\left(\frac{A_g}{A_c} - 1\right) \leq \frac{V_h}{V_c}$$

(a) $D_g = 600$ mm

$A_g = \frac{\pi}{4} \times 600^2 = 282743.34$ mm²

(b) $D_c = 600 - 2 \times 40 = 520$ mm

$A_c = \frac{\pi}{4} \times 520^2 = 212372$ mm²

(c) $V_c = 1000 \times A_c$

$= 1000 \times 212372$

$= 212372000$ mm³

(iv) $\underline{\underline{V_h}}$.

$D_h = D_c - \phi_h$

$= 520 - 8 = 512$ mm

$$V_h = \frac{1000}{p} \times \pi D_h \times \frac{\pi}{4} \times \phi_h^2$$

$$= \frac{1000}{p} \times \pi \times 512 \times \frac{\pi}{4} \times 8^2$$

$$= \frac{80851799}{p}$$

$V_h = 80851799/p$

$$0.36\frac{f_{ck}}{f_y}\left(\frac{A_g}{A_c}-1\right) \leq \frac{V_h}{V_c}$$

$$\frac{0.36\times25}{415}\left(\frac{282743}{212372}-1\right) \leq \frac{80851799}{p\times212372000}$$

$$7.186\times10^{-3} \leq \frac{0.38}{p}$$

$$p \leq 52.98\ mm$$

$$p = 52.98\ mm$$

pitch.

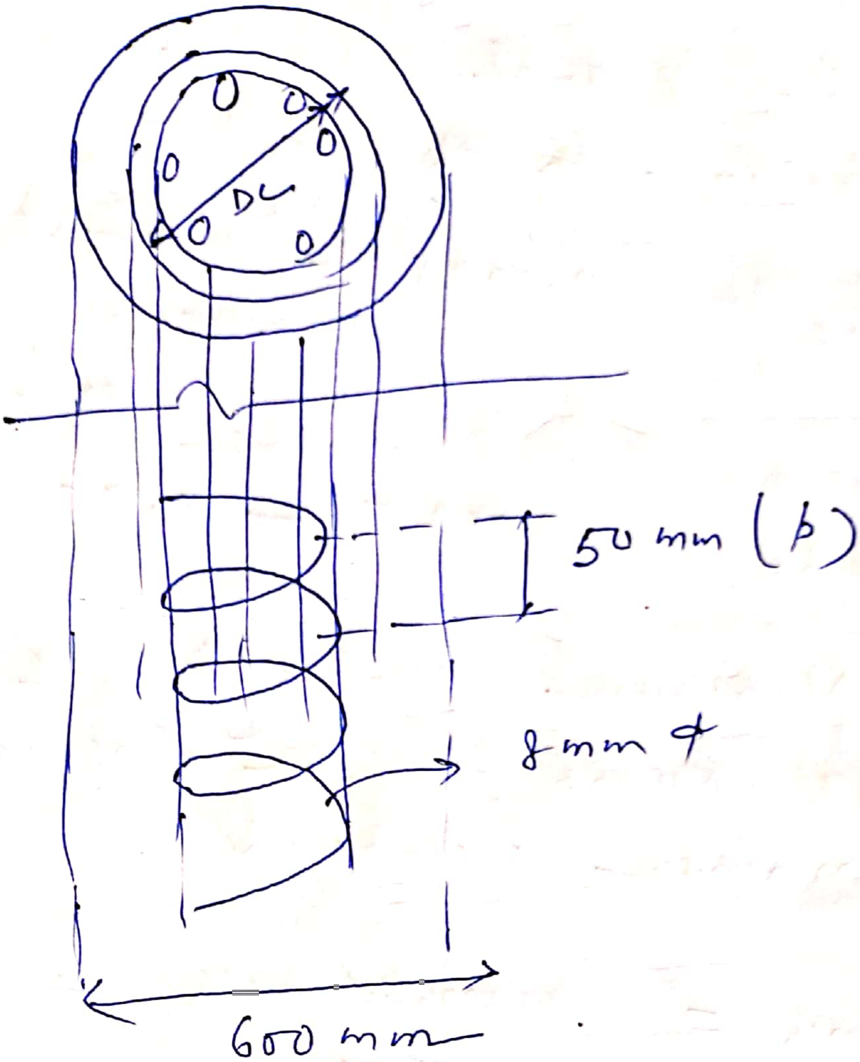
(i) $p \not> 75\,mm$

(ii) $p \not> \frac{A_c}{6} = \frac{520}{6} = 86\,mm$

(iii) $p \not< 25\,mm \rightarrow ok$

(iv) $p \not< 3\phi_h = 3\times8 = 24\,mm$ ok

Provide 8 mm @ 50 mm pitch.



⇒ Design of column by Limit state method

Assumptions:

All assumptions are discussed for beam (flexural members) are also valid for compression member

(1) Max^m compressive strain in concrete in case of direct compression = 0.002.

In bending compression = 0.0035.

(2) The max^m compressive strain at highly compressed extreme fibre in case

the column is subjected to axial compression & bending and when there is no tension in the section is

$\epsilon_{hc} = 0.0035 - 0.75$ times the strain at least compressed extreme fibre

$$\boxed{\epsilon_{hc} = 0.0035 - 0.75\,\epsilon_{Lc}}$$

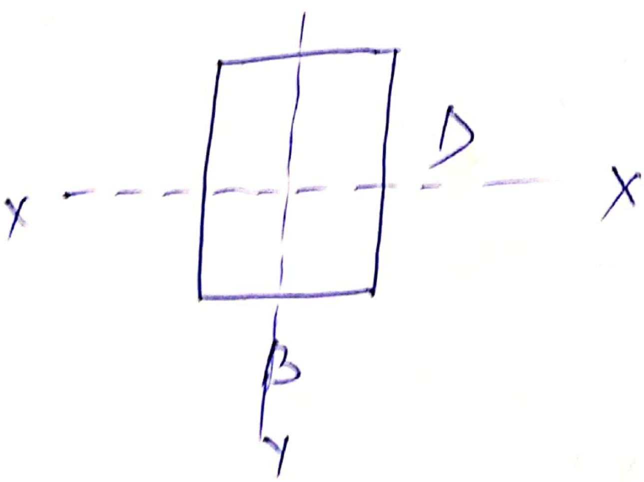
Minimum eccentricity (Cl 39.2)

All columns shall be designed for a minimum eccentricity.

$$e_{min} = \frac{\text{Unsupported length}}{500} + \frac{\text{Lateral dimension}}{30}$$

or 20 mm

whichever is more



About X-X

$$e_{min} = \left(\frac{L}{500} + \frac{D}{30}\right)$$

or 20 mm

whichever is more

About Y-Y axis

$$e_{min} = \left.\begin{array}{l} \frac{L}{500} + \frac{B}{30} \\ \text{OR} \quad 20\text{ mm} \end{array}\right\} \text{ Whichever is more}$$

A/c to IS 456: 2000 Cl 39.3 Short axially loaded columns can be designed using the following Equation

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

If minm eccentricity doesn't exceed 0.05 times the lateral dimension

To used this formula (1) following four condition are to be satisfied

(i) It should be short column.

$$\text{Slenderness ratio } (\lambda) = \frac{L_{ex}}{D} \text{ and } \frac{L_{ey}}{B} < 12$$

(ii) The column is subjected to only Axial load and No bending moment.

(iii) Minm Eccentricity

$$e_{min\,x-x} = \left.\begin{array}{l} \frac{L_x}{500} + \frac{D}{500} \\ \text{or } 20\text{ mm} \end{array}\right\} \text{ whichever is more} \leq 0.05 D$$

(iv) Minimum eccentricity about Y-Y axis

$$e_{min\,Y-Y} = \frac{L_y}{500} + \frac{B}{30} \quad \text{or} \quad 20\,mm \quad \text{whichever is more} \quad \leq 0.05B$$

<Happy Learning>