Shear.

STEP 7: CHECK FOR DEVELOPMENT LENGTH cl. 26.2.1

$$L_d = \frac{\phi \sigma_s}{4 \tau_{bd}}$$

$$= \frac{12 \times 0.87 \times 415}{4 \times 1.2}$$

$$= 902.62 \text{ mm}$$

MODULE 4

DESIGN OF COLUMNS

A member carrying direct axial load is called as column, the effective length of which exceeds 3 times of its lateral dimensions.

- If the compression member carrying the load is inclined or horizontal it is termed as strut
- The columns may be various shapes such as circular, rectangular, square etc.
- The longitudinal reinforcement bars in the columns are tied by laterally ties of suitable columns are tied by laterally ties or stirrups of suitable intervals, so that the bars does not buckle.

NAL REINFORCEMENT

1- To share the vertical compressive load
2- To provide ductility to the column.
3- To resist the tensile stresses due to eccentric load, moment or transverse load.
4- To reduce the effect of creep and shrinkage.
5- To prevent brittle failure.

FUNCTIONS OF TRANSVERSE REINFORCEMENT

1- To prevent brittle failure
2- To provide ductility to column
3- To confine the concrete thereby preventing longitudinal splitting.
4- To resist diagonal tension caused due to transverse shear.
5- To prevent longitudinal buckling of the longitudinal reinforcement.

SHORT COLUMNS AND LONG COLUMNS

A compression member is considered as short when the slenderness ratio (l/d) is less than 12 and if the slenderness ratio (l/d)

is greaterthan 12, is called as long columns.

TYPES OF COLUMNS

1. Short axially loaded columns in compression
2. Columns subjected to combined axial load & unaxial bending.
3. Columns subjected to combined axial load & biaxial bending

CLASSIFICATION BASED ON THE TYPES OF REINFORCEMENT PROVIDED

1. Columns with longitudinal steel and lateral ties.
2. Columns with longitudinal steel and helical reinforcement or spiral.

Q: A concrete column is reinforced with four bars of 20mm dia. Determine the ultimate load capacity of the column using M20 concrete and Fe 415 steel, If the size of the column is 450mm x 450mm, what will be the allowable service load in the columns.

Given:

A_{sc} = 4 No.s 20mm ϕ

$A_{sc} = 4 \times \pi/4 \times 20^2$

P_u = ?   P= ?

f_{ck} = 20N/mm²   D=450mm

f_y = 415 N/mm²

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

Min eccentricity =

$$\frac{l}{500} + \frac{D}{30}$$

Assume min. e = 20mm

$0.05D = 0.05 \times 450$

$= 22.5mm$

∴ min. e < 0.05 D

∴ The ultimate load can be computed from,

Area of concrete = Gross area − Area of steel

$A_c = A_G - A_{sc}$

$A_G = 450 \times 450$

$= 202500 mm^2$

$A_{sc} = 4 \times \pi/4 \times 20^2$

$= 1256.637 mm^2$

$A_c = A_G - A_{sc}$

$= 201243.363 mm^2$

∴ $P_u = 0.4 \times 20 \times 201243.363$

$+ 0.67 \times 415 \times 1256.637$

$= 1959352.87 N$

$= 1959.352 kN$

Allowable service load,

$$P_a = \frac{P_u}{1.5}$$

$$= \frac{1959.35}{1.5}$$

= 13.2 kN

Q. Design a short axially loaded square column 500 x 500mm for a service load of 2000 kN. Use M20 concrete & Fe 415 steel.

Soln: given

$D = 500mm$

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

$f_y = 415\ N/mm^2$

$P = 2000\ kN$

$P_u = 3000\ kN$

Min eccentricity $= \frac{l}{500} + \frac{D}{30}$

Assume min $e = 20mm$

$0.05D = 0.05 \times 500$

$= 25mm$

$\therefore$ min $e < 0.05D$

$\therefore$ the column can be designed using cl. 39.3 of IS 456 : 2000

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

Area of concrete =

Gross area − Area of steel

$A_c = 500 \times 500 - A_s$

$P_u = 0.4 \times 20 [250000 - A_{sc}] + 0.67 \times 415 A_{sc}$

$3000 \times 10^3 = 2000000 - 8 A_{sc} + 278.05 A_{sc}$

$3000 \times 10^3 = 2000000 + 270.05 A_{sc}$

$A_{sc} = 3703.01\ mm^2$

$A_{sc\,min} = \frac{0.8\ A_G}{100}$

[cl. 26.5.3.1.a of IS 456:2000]

$= \frac{0.8 \times 500 \times 500}{100}$

$= 2000\ mm^2$

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

$= \frac{6}{100} \times 500 \times 500$

$= 15000\ mm^2$

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

$\therefore$ the section is safe

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

Assume a ϕ of 25mm for longitudinal bars

$= \frac{3703.01}{\frac{\pi}{4} \times 25^2} = 7.54$

≈ 8 bars

Transverse reinforcement:

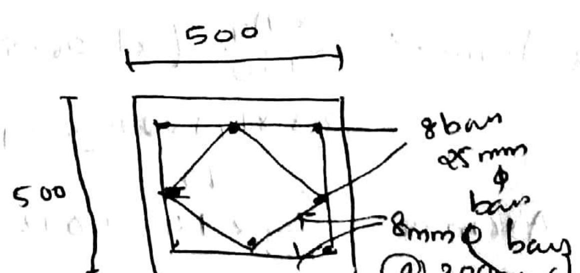
Pitch of lateral ties

[cl. 26.5.3.2.c]

(i) 500mm

(ii) $16 \times 25 = 400mm$

(iii) 300mm



Provide 8mm φ bars @ 300mm c/c.

Design a circular column of axial load 1000 kN use M_{20} concrete & Fe 415 steel

Soln: $P = 1000\,kN$

$P_u = 1000 \times 1.5 = 1500\,kN$

$f_{ck} = 20\,N/mm^2 \quad f_y = 415\,N/mm^2$

Min eccentricity $= \frac{l}{500} + \frac{D}{30}$

Assume min eccen $< 0.05D$

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

Assume % of steel,

$A_{sc} = 1\%\ A_G$

$\boxed{A_{sc} = 0.01\ A_G}$

$A_c = A_G - A_{sc}$

$= A_G - 0.01\ A_G$

$\boxed{A_c = 0.99\ A_G}$

$1500 \times 10^3 = 0.4 \times 20 \times 0.99\ A_G + 0.67 \times 415 \times 0.01\ A_G$

$1500 \times 10^3 = 7.92\ A_G + 2.78\ A_G$

$1500 \times 10^3 = 10.7\ A_G$

$A_G = 140180.36\ mm^2$

$\pi/4\ D^2 = 140180.36$

$D = 422.57 \approx 430\,mm$

$A_G = \pi/4 \times 430^2 = 145220.120\,mm^2$

$A_{sc} = 0.01 \times 145220.120$

$= 1452.20\,mm^2$

$A_{sc\,min} = \frac{0.8\ A_G}{100}$ [cl 26.5.3.1.a]

$= \frac{0.8 \times 145220.12}{100} = 1161.76\,mm^2$

$A_{sc\,max} = \frac{6}{100} \times 145220.12$

$= 8713.20\,mm^2$

Rectangle - D

$B = 0.050\,D$

$0.5D \times D = A_g$

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

∴ The section is safe

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

Assume a ϕ of ~~8mm~~ 16 16mm for longitudinal bars

$\frac{1452.20}{\frac{\pi}{4} \times 16^2} = 7.22 \approx$

8 No.s bars.

Transverse Reinforcement

Pitch of lateral ties [cl. 26.5.3.2.c]

(i) 430mm

(ii) $16 \times 16 = 256 \approx 250\,mm$

(iii) 300mm

Provide 8mm ϕ bars @ 250mm c/c

ASSIGNMENT

1) Design a rectangular column of axial load of 1500kN. Use M_{20} concrete and Fe 500 steel.

2) Design a square column of axial load of 800 kN Use M20 Concrete & Fe 500 steel