UNIT IV DESIGN OF COLUMNS

Types of columns –Axially Loaded columns – Design of short Rectangular Square and circular columns –Design of Slender columns- Design for Uniaxial and Biaxial bending using Column Curves

Axially Loaded columns

Assumptions

- The maximum compressive strain in concrete in axial compression is taken as 0.002.
- The maximum compressive strain at the highly compressed extreme fibre in concrete subjected to axial compression and bending and when there is no tension on the section shall be 0.0035 minus 0.75 times the strain at the least compressed extreme fibre.
- Plane sections normal to the axis remain plane after bending.
- The maximum strain in concrete at the outermost compression fibre is taken as 0.0035 in bending.
- The relationship between the compressive stress distribution in concrete and the strain in concrete may be assumed to be rectangle, trapezoid, parabola or any other shape which results in prediction of strength in substantial agreement with the results of test.
- An acceptable stress strain curve is given in IS:456-200. For design purposes, the compressive strength of concrete in the structure shall be assumed to be 0.67 times the characteristic strength. The partial safety factor y of 1.5 shall be applied in addition to this.
  The tensile strength of the concrete is ignored.

Short Axially Loaded Members in Compression

The member shall be designed by considering the assumptions given and the minimum eccentricity. When the minimum eccentricity as per 25.4 does not exceed 0.05 times the lateral dimension, the members may be designed by the following equation:

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

P_u = axial load on the member,
f_{ck} = characteristic compressive strength of the concrete,
A_c = area of concrete,
f_y = characteristic strength of the compression reinforcement, and
A_s = area of longitudinal reinforcement for columns.

P.1.Design the reinforcement in a column of size 400 mm x 600 mm subjected to an axial load of 2000 kN under service dead load and live load. The column has an unsupported length of 4.0 m and effectively held in position and restrained against rotation in both ends. Use M 25 concrete and Fe 415 steel.

Solution:

Step 1: To check if the column is short or slender

Given l = 4000 mm, b = 400 mm and D = 600 mm. Table 28 of IS 456 = lex = ley = 0.65(l) = 2600 mm. So, we have

lex/D = 2600/600 = 4.33 < 12

ley/b = 2600/400 = 6.5 < 12

Hence, it is a short column.

Step 2: Minimum eccentricity

$ex\ min$ = Greater of (lex/500 + D/30) and 20 mm = 25.2 mm

$ey\ min$ = Greater of (ley/500 + b/30) and 20 mm = 20 mm

0.05 D = 0.05(600) = 30 mm > 25.2 mm (= $ex\ min$)

0.05 b = 0.05(400) = 20 mm = 20 mm (= $ey\ min$)

Hence, the equation given in cl.39.3 of IS 456 (Eq.(1)) is applicable for the design here.

Step 3: Area of steel

$Pu = 0.4\ fck\ Ac + 0.67\ fy\ Asc$

3000(103) = 0.4(25){(400)(600) – Asc} + 0.67(415) Asc which gives,

Asc = 2238.39 mm2

Provide 6-20 mm diameter and 2-16 mm diameter rods giving 2287 mm2 (> 2238.39 mm^2) and p = 0.953 per cent, which is more than minimum percentage of 0.8 and less than maximum percentage of 4.0. Hence, o.k.

Step 4: Lateral ties

The diameter of transverse reinforcement (lateral ties) is determined from cl.26.5.3.2 C-2 of IS 456 as not less than (i) θ/4 and (ii) 6 mm. Here, θ = largest bar diameter used as longitudinal reinforcement = 20 mm. So, the diameter of bars used as lateral ties = 6 mm.

The pitch of lateral ties should be not more than the least of

(i) the least lateral dimension of the column = 400 mm

(ii) sixteen times the smallest diameter of longitudinal reinforcement bar to be tied = 16(16) = 256 mm

(iii) 300 mm