SNS COLLEGE OF TECHNOLOGY

DEPARTMENT OF AGRICULTURAL ENGINEERING

23AGT205-STRENGTH OF MATERIALS FOR AGRICULTURAL ENGINEERING

NOTES UNIT IV

8. A Hollow Alloy Tube 5m long with external & internal diameters 40mm & 25mm respectively was found to extend 6.4mm under tensile load of 60kN. Find the buckling load for the tube when used as a column with both ends pinned. Also find the Safe load for the tube, taking Factor of Safety = 4.

Given

$L = 5m = 5000\,mm$

$D = 40\,mm$

$d = 25\,mm$

$\delta L = 6.4\,mm$

$W = 60\,kN = 60000\,N$

$FoS = 4$

Soln

Cross Sectional Area $= \frac{\pi}{4}(D^2 - d^2)$

$A = \frac{\pi}{4}(40^2 - 25^2)$

$= 766\,mm^2$

Moment of Inertia $I = \frac{\pi}{64}(D^4 - d^4)$

$$= \frac{\pi}{64}\left[40^4 - 25^4\right]$$

$$= 106500 \text{mm}^4$$

$$\text{Young's Modulus } (E) = \frac{\text{Tensile Stress}}{\text{Tensile Strain}}$$

$$= \frac{(W/A)}{(\delta L/L)}$$

$$= \frac{W}{A} \times \frac{L}{\delta L}$$

$$= \frac{60000}{766} \times \frac{5000}{6.4}$$

$$= 6.11945 \times 10^4 \text{ N/mm}^2$$

Since, column pinned at both ends,

$$L_e = L = 5000 \text{mm}$$

$$\text{Buckling Load, } P_c = \frac{\pi^2 EI}{L_e^2}$$

$$= \frac{\pi^2 \times 6.11945 \times 10^4 \times 106500}{5000^2}$$

$$= 2573 \text{N}$$

$$\text{Safe Load} = \frac{\text{Buckling Load}}{\text{FOS}} = \frac{2573}{4}$$

$$= 643.2 \text{N}$$

RANKINE'S FORMULA :

Euler's formula gives correct results only for very long columns. So, columns that are Short & Not so long will be given by empirical formula,

$$P = \frac{\sigma_c \cdot A}{1 + a \cdot \left(\frac{Le}{k}\right)^2}$$

Where, $a = \frac{\sigma_c}{\pi^2 E}$ is Rankine's constant

Values of σ_c & a for different Column Material are as follows.

S.No	Material	σ_c in N/mm^2	a
1.	Wrought Iron	250	1/9000
2.	Cast Iron	550	1/1600
3.	Mild Steel	320	1/7500
4.	Timber	50	1/750

COLUMN WITH ECCENTRIC AXIAL LOAD - BENDING STRESS

When a Column is subjected to an axial load that doesn't pass through Centroid of Cross Section is eccentric loading.

Load has both direct (axial) Component & an

Indirect (bending) Component. This creates Combined Stress (i.e) axial Compression and bending moment

Bending Stress due to eccentric load :

Let P = Applied axial load

A = Cross Sectional area

e = Eccentricity

$M = P.e$

I = MoI

y = Distance from Neutral axis

Total Stress $\sigma = \frac{P}{A} \pm \frac{M.y}{I}$

$= \frac{P}{A} \pm \frac{P.e.y}{I}$

$\therefore \sigma = \frac{P}{A} \pm \frac{Pey}{I}$

IMPACT OF ECCENTRICITY ON STRUCTURAL STABILITY :

It introduces Bending Moment that

→ Increases maximum Stress in Column

→ Reduces buckling load due to lateral deflection being amplified

→ May cause tension on one side of Column which is dangerous for materials weak in tension

1. The External & Internal diameter of a hollow cast iron column are 5cm & 4cm, respectively. If the length of this column is 3m & both of its ends are fixed, determine the Crippling load using Rankine's formula. Take value of $\sigma_c = 550 N/mm^2$ & $a = \frac{1}{1600}$ in Rankine's formula.

Given

External Diameter $D = 5cm$

Internal Diameter $d = 4cm$

Soln

Area $A = \frac{\pi}{4}[D^2 - d^2]$

$= \frac{\pi}{4}[5^2 - 4^2]$

$= 2.25\pi \times 10^2 mm^2$

$= 225\pi mm^2$

Moment of Inertia $I = \frac{\pi}{64}[D^4 - d^4]$

$= \frac{\pi}{64}[5^4 - 4^4]$

$= 5.7656\pi cm^4$

$= 5.7656\pi \times 10^4 mm^4$

$= 57656\pi mm^4$.

Least Radius of Gyration $k = \sqrt{I/A}$

$= \sqrt{\frac{57656\pi}{225\pi}}$

$= 25.625\,mm$

Length of column, $l = 3m = 3000\,mm$

As Both ends are fixed,

$$L_e = \frac{L}{2} = \frac{3000}{2}$$

$$= 1500\,mm$$

Crushing Stress, $\sigma_c = 550\,N/mm^2$

Rankine Constant, $a = \frac{1}{1600}$

Crippling Load,

$$P = \frac{\sigma_c \cdot A}{1 + a\left(\frac{L_e}{k}\right)^2}$$

$$= \frac{550 \times 225\pi}{1 + \frac{1}{1600}\left(\frac{1500}{25.625}\right)^2}$$

$$= \frac{550 \times 225\pi}{3.1415}$$

$$= 123750\,N.$$