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FACULTY OF ENGINEERING AND TECHNOLOGY

Department of Mechanical Engineering

MEPS102:Strength of Material

Lecture 32

Topic: Rankine formula for Column

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Empirical Formulae of Columns

- ✓Numerous column experiments indicate that the Euler formula is reliable for designing axially loaded column , provided the slenderness ratio is within the range in which the eccentricity has relatively little effect.
- ✓This range is called slender range which ranges from 120-140
- ✓At lower slenderness the failure stress would be the compressive strength of the material. This range is 0-40.
- ✓In the intermediate range (40-120) the we can use secant formula with some modifications

Rankine's Formula

- ✓ The empirical formula thus proposed covers all cases ranging from very short to very long struts

$$\frac{1}{P} = \frac{1}{P_C} + \frac{1}{P_E}$$

$$P_C = Crushing\ load\ \sigma_c A$$

$$\sigma_c = Utimate\ crushing\ load$$

$$A = cross\ sectional\ area$$

$$P_E = Buckling\ load\ by\ Euler'sformula = \frac{\pi^2 EI}{L^2}$$

$$L = equivalent\ length$$

Rankine's Formula

- For short column P_e is very large and hence $1/P_e$ is very small in comparison
- Alternative form of **Rankine Gordon formulae**

$$P = \frac{\sigma_c A}{1 + a\left(L/r\right)^2}$$

$$Value\ of\ a\ is\ found\ experimentally$$

$$r = least\ radius\ of\ gyration$$

Material	σ_c (MPa)	a for Hinged Ends
Wrought iron	255	1/9000
Cast iron	550	1/1600
Mild steel	330	1/7500
Strong timber	50	1/750

Rankine's Formula

- The above formula is for standard case of two end-hinged column. For columns with other end conditions, the value of the constant will change accordingly. However since ***a*** is a constant for a particular materials, it better to modify the Rankine's formula as

$$P = \frac{\sigma_c A}{1 + a\left({}^{L_e}/_{r}\right)^2}$$

$$L_e = equivalent\ length$$

$$\sigma_c = Allowable\ stress\ and\ a = \frac{\sigma_c}{\pi^2 E}$$

Question

1.The external and internal diameters of the hollow cast iron column are 5cm and 4cm respectively. If the length of this column is 3m and both of its ends are fixed, determine the crippling load using Rankine's formula. Take σc= 550N/mm2 and a=1/1600.

2.The hollow cylindrical cast iron column is 4m long with both ends fixed. Determine the minimum diameter of the column if it has to carry a safe load of 250KN with a FOS of 5 take internal diameter as 0.8 times the external diameter. Take σc= 550N/mm2 and a=1/1600.

Question

3. A hollow cast iron column of external diameter 250mm and internal diameter 200mm is 10m long with both ends fixed. Find the safe axial load with FOS of 4.Take σc= 550N/mm2 and a=1/1600.

4. Find the Euler's crippling load for a hollow cylindrical steel column of 40mm external diameter and 4mm thick. The length of the column is 2.5m and is hinged at both the ends. Also compute the Rankine's crippling load using constants 350MPa and 1/7500.Take E=205GPa.

5. Design the section of circular cast iron column that can safely carry a load of 1000KN. The length of the column is 6m. Rankine's constant is 1/1600, FOS 3.One end is fixed and other is free. Critical stress is 560Mpa.

Question

6. A hollow cast iron circular section column is 7.5mm long and pinned at both the end. The inner diameter of the column is 160mm and thickness of the wall is 20mm. Find the safe load by Rankine's formula, using FOS of 5.Also find the slenderness ratio and ratio of the Euler's and Rankine's critical loads. For cast iron take σc= 550N/mm2 and a=1/1600 and E=8X104N/mm2.

7. A hollow circular section 2.8m long is fixed at one end and hinged at other end. External diameter is 150mm and thickness of the wall is 15mm.Rankine's constant=1/1600 and σc= 550Mpa.Comparwe the buckling loads obtained by using Euler formula and Rankine's formula. Also find the length of the column for which both formulas gives the same load. Take E=80GPa.

Question

9. A column as shown in the figure below consists of three plates, each of thickness "t" welded together. It carries a axial load of 400 KN over an effective length of 4m.Taking σc= 320MPa, a=1/7500 and FOS= 2.5, determine the value of t.

10. The following particulars are given below

a) Diameter of the cylinder =400mm

b) Steam pressure in cylinder =0.6N/mm2

c) Distance between the piston and cross head = 1.25m.

Find the diameter of the piston rod allowing a FOS of 4.Assume that the piston is firmly fixed to the piston and the cross head. Take σc= 330N/mm2 and a=1/7500