Problems of Practices
Of
Mechanics of Solids
14- Elastic Stability of Columns

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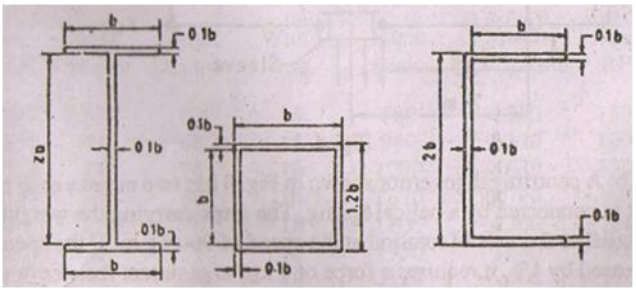
1. The cross-sections of three pin-ended columns of same length and material for which Euler critical load theory is applicable are shown in Fig. 3. The wall thickness of sections in all the three cases is equal to 0.1*b*. The areas of the three cross-sections are also same. Compare the Euler critical loads for the three sections. Which is the best cross-section of the three?



2. A vertical column 6 m high is fixed at the base and a clockwise moment of 1.4 kNm is applied at the top of the column, a horizontal force *P* is applied to the column at a height of 3 m above the base so as to give a CCW moment.
Determine the value of force *P* so that the horizontal deflections at the top of the column and at the point of application of *P* shall be equal (i) when the deflections

are on the same side (ii) when the deflections are on the opposite sides of the vertical line through the foot of the column.

3. Euler's critical load for a column with both ends hinged is found as 40 kN. What would be the change in critical load, if its both ends are fixed?

4. The link of a mechanism is subjected to axial compressive force. It has solid circular cross-section with diameter 9 mm and length 200 mm. The two ends of the link are hinged. It is made of steel having yield strength = 400 kN/mm^2 and elastic modulus = 200 kN/mm^2. Calculate the critical load that the link can carry. Use Johnson's equation.

5. A hollow cast iron column of 300 mm external dia and 220 mm internal dia is used as a column 4 m long with both ends hinged. Determine the safe compressive load the column can carry without buckling using Euler's formula and Rankine's formula.

$E = 0.7 \times 10^5$ N/mm^2, Factor of safety = 4, Rankine constant $a = 1/1600$, Crushing stress $\sigma_c = 567$ N/mm^2.

6. A hollow column, 400 mm external diameter and 300 mm internal diameter, is hinged at both ends. If the length of column is 5 m, $E = 0.75 \times 10^5$ N/mm^2, factor of safety 5, Rankine's constant 1/1600 and crushing stress 587 N/mm^2, find the safe load the column can carry without buckling. Use Euler's and Rankine formulae.

7. A hollow cylinder C.I. column, 3 m long has its internal is and external diameters as 80 mm and 100 mm respectively.

Calculate the safe load using Rankine Formula; is (i) both ends are hinged and (ii) both ends' are fixed. Take crushing strength of material as 600 N/mm^2, Rankine constant 1/1600 and factor of safety 3.

8. A long strut AB of length l is of uniform section throughout. A thrust P is applied at the ends eccentrically on the same side of the centre line with eccentricity at the end B twice than that at the end A. Show that the maximum bending moment occurs at a distance x from the end A, where

$$\tan kx = \frac{2 - \cos kl}{\sin kl} \text{ and } k = \sqrt{\frac{P}{EI}}$$

9. Determine the rise in temperature in order to induce buckling in a 1.0 meter long circular rod of diameter 40 mm. Assume the rod to be pinned at its ends and the coefficient of thermal expansion is 20×10^{-6} /°C. Assume also uniform heating of the rod.

10. Distinguish between strut and column. Name two important buckling equations indicating the range of slenderness-ratio for their applicability.

11. What is the value of Euler's buckling load for an axially loaded pin-ended (hinged at both ends) strut of length 'l' and flexural rigidity 'EI'? What would be the order of Euler's buckling load carrying capacity of a similar strut but fixed at both ends in terms of the load carrying capacity of the earlier one?

12. Find the crippling load for a hollow C.I. column of 300 mm external diameter, thickness of metal 40 mm and 8 m long, if both ends are fixed. Take $\sigma_c = 550$ N/mm^2. Use Rankine's formula. Take $a = 1/1600$.

13. A both ends hinged cast iron hollow cylindrical column 3 m in length has a critical buckling load of P kN. When the column is fixed at both the ends, its critical buckling load rises by 300 kN more. It ratio of external diameter to internal diameter is 1.25 and $E = 100$ GPa, determine the external diameter of the column.

14. A straight bar of alloy 1 m long and 12 mm × 6 mm in section is loaded as a column till it buckles. Assuming Euler formula for pinned-ends to apply, estimate the maximum central deflection before the material attains its yield point, at 260 MPa. E = 80 GN/m^2.

15. Two long columns are made of identical lengths 'l' and flexural rigidities 'EI'. Column 1 is hinged at both ends whereas for column 2 one end is fixed and the other end is free.

(i) Write the expression for Euler's buckling load for column 1.

(ii) What is the ratio of Euler's buckling load of column 1 to that of column 2?

16. The critical buckling load of a cast iron hollow cylindrical column 3 m in length when hinged at both the ends is equal to P kN. When the column is fixed at both the ends, its critical load increases to (P + 300) kN. If the ratio of external diameter to internal diameter is 1.25 and E = 100 GPa, determine the external diameter of the column.

17. Compare the flexural strengths of the following three beams of equal weight.

1. I-section 300 mm x 150 mm with flanges 20 mm thick and web 12 mm thick.
2. Rectangular section having depth twice the width.
3. Solid circular section.

18. A square bar 20 mm × 20 mm in section, 1.5 m long, is freely supported at its ends in a horizontal position and is loaded with a central load of 200 N. The central deflection due to concentrated load is found to be 5 mm.

If the same bar is placed vertically (both ends hinged) and loaded centrally along its axis, what load is likely to cause the bar to buckle?

19. A column of 6 m length is fixed at both ends. It is of rectangular cross-section of 20 cm × 10 cm. Determine the Euler's crippling load on the column, if E = 200 GPa.