What are Structural Stability Principles?

Worksheet

Structural stability principles ensure a structure maintains equilibrium and resists sudden failure modes like buckling. For slender columns, the critical buckling load is given by Euler's formula: Pcr = EI/(KL), where stiffer, shorter, and better-restrained columns can carry more load before buckling.

Questions

1. What does Euler's formula (Pcr = EI/(KL)) calculate?

A) Beam deflection
B) Critical buckling load of a column
C) Maximum bending stress
D) Foundation bearing capacity

2. If a column's length doubles (all else equal), its critical buckling load:

A) Doubles
B) Stays the same
C) Is cut to a quarter
D) Is cut in half

3. Which end condition gives the lowest effective length factor K, and therefore the highest buckling capacity?

A) Fixed-free (K=2)
B) Pinned-pinned (K=1)
C) Fixed-fixed (K=0.5)
D) Fixed-pinned (K=0.7)

4. A column has Pcr = 600 kN and carries an actual load of 200 kN. What is its factor of safety?

A) 1.5
B) 2.0
C) 3.0
D) 4.0

5. A steel column is pinned at both ends (K=1) with E = 20010 Pa, I = 8.510 m, and L = 4 m. Find its critical buckling load.

6. If the same column were fixed at both ends (K=0.5) instead, how would the critical buckling load change?

7. A timber column has a critical buckling load of Pcr = 450 kN and carries an actual axial load of 150 kN. What is its factor of safety, and is it stable?

8. Define: What does Euler's buckling formula calculate?

9. Define: What happens to buckling capacity as column length increases?

10. Define: What does the effective length factor K represent?

Answer Key

1. B) Critical buckling load of a column - Euler's formula gives the critical axial load at which a slender column buckles.

2. C) Is cut to a quarter - Pcr 1/L, so doubling L reduces Pcr to 1/4 of its original value.

3. C) Fixed-fixed (K=0.5) - Fixed-fixed columns have K=0.5, the shortest effective length and highest buckling resistance.

4. C) 3.0 - FS = Pcr/P = 600/200 = 3.0.

5. Pcr = EI/(KL) 9.8696, E = 20010 Pa, I = 8.510 m, K = 1 (pinned-pinned), L = 4 m Pcr = 9.8696 20010 8.510 / (14) = 1.677810 / 16 1,048,600 N 1049 kN

6. With K = 0.5: (KL) = (0.54) = 4 Pcr = 1.677810 / 4 = 4,194,500 N 4195 kN Comparison: fixing both ends roughly quadruples the buckling capacity compared to pinned-pinned.

7. Factor of safety FS = Pcr / P_actual Pcr = 450 kN, P_actual = 150 kN FS = 450/150 = 3.0 - exceeds the typical minimum FS of 2.5-3 for buckling, so the column is stable under this load.

8. The critical axial load (Pcr) at which a slender column will suddenly buckle sideways: Pcr = EI/(KL).

9. It decreases sharply - Pcr is inversely proportional to length squared, so doubling length cuts capacity to a quarter.

10. How the column's end conditions affect its buckling length - e.g., K=1 for pinned-pinned, K=0.5 for fixed-fixed, K=2 for fixed-free.