Solutions to Steel Structures Problems

Civil Engineering Licensure Exam - Day 46

March 7, 2025

Section A: Multiple Choice Questions (MCQs)

1. The primary function of a steel beam in a structure is to:
Answer: (a) Resist bending and shear forces
Video Explanation: Elastic and Plastic Moment Capacity of Steel Beam

2. The slenderness ratio of a steel column is defined as:
Answer: (a) The ratio of effective length to the radius of gyration
Video Explanation: Slenderness Ratio — Design of Steel Structures

3. In bolted steel connections, the failure mode due to excessive tension in the bolts is called:
Answer: (a) Bolt rupture
Video Explanation: Bearing, Tearout, and Shear Load Capacity Calculations

4. The plastic section modulus Z_p is used in steel beam design to determine:
Answer: (a) The plastic moment capacity of the beam
Video Explanation: Plastic Moment Capacity for a Beam's Cross-section

5. The lateral-torsional buckling of a steel beam occurs when:
Answer: (a) The compression flange is not laterally braced
Video Explanation: Elastic and Plastic Moment Capacity of Steel Beam

Section B: Problem-Solving

1. A W-section steel beam has a plastic section modulus of $500 \times 10^3\,\text{mm}^3$. If the yield strength of steel is 250 MPa, determine the plastic moment capacity of the beam.
Solution:

$$M_p = Z_p \times f_y$$

$$M_p = (500 \times 10^3) \times (250) = 125 \times 10^6 \text{ N} \cdot \text{mm} = 125 \text{ kN} \cdot \text{m}$$

Video Explanation: Calculating Plastic Moment Capacity and Shape Factor

2. A steel column has an effective length of 3.5 m and a radius of gyration of 100 mm. Determine the slenderness ratio.

Solution:

$$\lambda = \frac{L_{\text{eff}}}{r} = \frac{3500}{100} = 35$$

Video Explanation: Slenderness Ratio — Design of Steel Structures

3. A bolted steel connection consists of four M20 bolts in double shear. If the allowable shear stress of the bolts is 140 MPa, determine the total shear capacity of the connection.

Solution:

$$A = \frac{\pi d^2}{4} = \frac{\pi (20)^2}{4} = 314.16 \text{ mm}^2$$

$$\text{Shear capacity per bolt} = 2 \times \tau_{\text{allow}} \times A = 2 \times 140 \times 314.16 = 87.97 \text{ kN}$$

$$\text{Total shear capacity} = 4 \times 87.97 = 351.88 \text{ kN}$$

Video Explanation: Bearing, Tearout, and Shear Load Capacity Calculations

4. A steel beam carries a uniform load of 25 kN/m over a simply supported span of 6 m. Determine the maximum bending moment.

Solution:

$$M_{\max} = \frac{wL^2}{8} = \frac{25 \times 6^2}{8} = 112.5 \text{ kN} \cdot \text{m}$$

Video Explanation: Maximum Bending Moment of a Simply Supported Beam with a UDL

5. A steel column is subjected to an axial load of 800 kN. If the cross-section of the column has an area of 400 cm^2, determine the axial stress in the column.

Solution:

$$\sigma = \frac{P}{A}$$

$$A = 400 \text{ cm}^2 = 400 \times 10^{-4} \text{ m}^2$$

$$\sigma = \frac{800 \times 10^3}{400 \times 10^{-4}} = 20 \text{ MPa}$$

Video Explanation: Axial Stress in Steel Columns