Solutions to Axial, Shear, and Flexural Stresses Problems

Civil Engineering Licensure Exam – Mock Exam

February 24, 2025

Problem 1: Axial Stress in a Steel Rod

A steel rod with a cross-sectional area of 150 mm^2 is subjected to an axial tensile force of 60 kN. Determine the axial stress in the rod.

Solution:

Axial stress (σ) is calculated using the formula:

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

where: - $F = 60\,\text{kN} = 60 \times 10^3\,\text{N}$ - $A = 150\,\text{mm}^2 = 150 \times 10^{-6}\,\text{m}^2$

Substituting the values:

$$\sigma = \frac{60 \times 10^3}{150 \times 10^{-6}} = 400\,\text{MPa}$$

Reference: Axial Stress - Everything you NEED to Know

Problem 2: Maximum Bending Stress in a Simply Supported Beam

A simply supported beam of span 5 m carries a central concentrated load of 20 kN. Determine the maximum bending stress if the beam has a rectangular cross-section of 200 mm width and 300 mm depth.

Solution:

The maximum bending moment (M_{max}) for a simply supported beam with a central load is:

$$M_{\text{max}} = \frac{P \times L}{4} = \frac{20 \times 10^3 \times 5}{4} = 25 \times 10^3\,\text{N} \cdot \text{m}$$

The section modulus (S) for a rectangular section is:

$$S = \frac{b \times d^2}{6} = \frac{200 \times (300)^2}{6} = 3 \times 10^6\,\text{mm}^3 = 3 \times 10^{-3}\,\text{m}^3$$

The maximum bending stress ($\sigma_{\max}$) is:

$$\sigma_{\max} = \frac{M_{\max}}{S} = \frac{25 \times 10^3}{3 \times 10^{-3}} = 8.33 \times 10^6 \,\text{Pa} = 8.33 \,\text{MPa}$$

Reference: Bending Stress Example - Rectangular Cross Section

Problem 3: Maximum Shear Stress in an I-Section Beam

A beam with an I-section has a moment of inertia of 8×10^6 mm^4 and is subjected to a shear force of 40 kN. Determine the maximum shear stress if the width of the web is 10 mm and the first moment of area Q is 6×10^5 mm^3.

Solution:

Shear stress (τ) in a beam is given by:

$$\tau = \frac{V \times Q}{I \times t}$$

where: - $V = 40 \times 10^3$ N - $Q = 6 \times 10^5 \,\text{mm}^3$ - $I = 8 \times 10^6 \,\text{mm}^4$ - $t = 10 \,\text{mm}$

Substituting the values:

$$\tau = \frac{40 \times 10^3 \times 6 \times 10^5}{8 \times 10^6 \times 10} = 0.3 \,\text{MPa}$$

Reference: Shear Stress Example in an I Beam

Problem 4: Maximum Flexural Stress in a Concrete Beam

A concrete beam has a section modulus of 500 mm^3 and is subjected to a maximum bending moment of 25 kN·m. Determine the maximum flexural stress.

Solution:

Flexural stress (σ) is calculated using:

$$\sigma = \frac{M}{S}$$

where: - $M = 25 \times 10^3 \,\text{N} \cdot \text{m} = 25 \times 10^6 \,\text{N} \cdot \text{mm}$ - $S = 500 \,\text{mm}^3$

Substituting the values:

$$\sigma = \frac{25 \times 10^6}{500} = 50 \times 10^3 \,\text{Pa} = 50 \,\text{MPa}$$

Reference: ARE 5.0 Structures - Flexural Stress Equation F = M/S

Problem 5: Maximum Shear Stress in a Rectangular Beam

A rectangular beam of 100 mm width and 250 mm depth is subjected to a shear force of 30 kN. Determine the maximum shear stress using the shear formula.

Solution:

The maximum shear stress ($\tau_{\max}$) in a rectangular section is:

$$\begin{aligned}\tau_{\max} &= \frac{3}{2} \times \frac{V}{A} = \frac{3}{2} \times \frac{V}{b \times d} \\ &= \frac{3}{2} \times \frac{30 \times 10^3}{100 \times 250} = 1.8\,\text{MPa}\end{aligned}$$

Reference: Topic 7.3 - Shear Stresses in Rectangular Beams