Solutions to Stress Analysis Problems

Civil Engineering Licensure Exam – Mock Exam

February 24, 2025

Problem 1: Calculating Normal Stress

A steel rod with a cross-sectional area of 150 mm^2 is subjected to an axial tensile force of 45 kN. Determine the normal stress in the rod.

Solution:

Normal stress (σ) is calculated using the formula:

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

where: - $F = 45\,\text{kN} = 45 \times 10^3\,\text{N}$ - $A = 150\,\text{mm}^2 = 150 \times 10^{-6}\,\text{m}^2$

Substituting the values:

$$\sigma = \frac{45 \times 10^3}{150 \times 10^{-6}} = 300\,\text{MPa}$$

Reference: Normal Stress - YouTube

Problem 2: Determining Maximum Bending Stress

A simply supported beam of length 4 m carries a uniformly distributed load of 2 kN/m. The beam has a rectangular cross-section with a width of 100 mm and a height of 200 mm. Calculate the maximum bending stress.

Solution:

The maximum bending moment ($M_{\max}$) for a simply supported beam with a uniformly distributed load is:

$$M_{\max} = \frac{wL^2}{8}$$

where: - $w = 2\,\text{kN/m} = 2 \times 10^3\,\text{N/m}$ - $L = 4\,\text{m}$

Substituting the values:

$$M_{\max} = \frac{2 \times 10^3 \times 4^2}{8} = 4 \times 10^3\,\text{N} \cdot \text{m}$$

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

$$S = \frac{b \times d^2}{6} = \frac{100 \times (200)^2}{6} = 666.67 \times 10^3\,\mathrm{mm}^3 = 666.67 \times 10^{-6}\,\mathrm{m}^3$$

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

$$\sigma_{\max} = \frac{M_{\max}}{S} = \frac{4 \times 10^3}{666.67 \times 10^{-6}} = 6\,\mathrm{MPa}$$

Reference: Maximum Bending Stress - YouTube

Problem 3: Principal Stresses Using Mohr's Circle

At a point in a loaded member, the state of stress is such that $\sigma_x = 80\,\mathrm{MPa}$ (tensile), $\sigma_y = 40\,\mathrm{MPa}$ (compressive), and $\tau_{xy} = 30\,\mathrm{MPa}$. Determine the principal stresses using Mohr's Circle.

Solution:

The center (C) and radius (R) of Mohr's Circle are calculated as:

$$C = \frac{\sigma_x + \sigma_y}{2} = \frac{80 - 40}{2} = 20\,\mathrm{MPa}$$

$$R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} = \sqrt{\left(\frac{80 + 40}{2}\right)^2 + 30^2} = 58.31\,\mathrm{MPa}$$

The principal stresses (σ_1 and σ_2) are:

$$\sigma_1 = C + R = 20 + 58.31 = 78.31\,\mathrm{MPa}$$

$$\sigma_2 = C - R = 20 - 58.31 = -38.31\,\mathrm{MPa}$$

Reference: Understanding Stress Transformation and Mohr's Circle - YouTube

Problem 4: Maximum Shear Stress Using Mohr's Circle

Given the same state of stress as in Problem 3, determine the maximum shear stress using Mohr's Circle.

Solution:

The maximum shear stress ($\tau_{\max}$) is equal to the radius of Mohr's Circle:

$$\tau_{\max} = R = 58.31\,\mathrm{MPa}$$

Reference: Mohr's Circle - Absolute Max Shear Stress - YouTube

Problem 5: Combined Stresses Using Mohr's Circle

A point in a structural member is subjected to a normal stress $\sigma = 50\,\text{MPa}$ (tensile) and a shear stress $\tau = 25\,\text{MPa}$. Use Mohr's Circle to determine the resulting principal stresses.

Solution:

For combined stresses, the principal stresses can be found using Mohr's Circle as demonstrated in the reference video.

Reference: Mohr's Circle - Simple Combined Loading - Example 2 - YouTube