Solutions to Stress and Strain 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: Calculating Average Normal Stress

Problem 2: Determining Strain in a Cylindrical Bar

A cylindrical bar with an initial length of 2 m elongates by 1.5 mm under an applied load. Calculate the strain in the bar.

Solution:

Strain (ε) is given by:

$$\varepsilon = \frac{\Delta L}{L}$$

where: - $\Delta L = 1.5\,\text{mm} = 1.5 \times 10^{-3}\,\text{m}$ - $L = 2\,\text{m}$

Substituting the values:

$$\varepsilon = \frac{1.5 \times 10^{-3}}{2} = 0.00075$$

Reference: Calculating Axial Strain in a Bar

Problem 3: Axial Strain in a Concrete Column

A concrete column with a length of 3 m shortens by 2 mm under a compressive load. Determine the axial strain in the column.

Solution:

Axial strain (ε) is calculated as:

$$\varepsilon = \frac{\Delta L}{L}$$

where: - $\Delta L = -2\,\text{mm} = -2 \times 10^{-3}\,\text{m}$ (negative sign indicates shortening) - $L = 3\,\text{m}$

Substituting the values:

$$\varepsilon = \frac{-2 \times 10^{-3}}{3} = -0.00067$$

Reference: Determining Stress in Concrete and Steel under Axial Loading

Problem 4: Calculating Poisson's Ratio

A cylindrical rod with an initial diameter of 50 mm and length of 1 m is subjected to a tensile force, resulting in an elongation of 2 mm and a diameter reduction of 0.03 mm. Calculate Poisson's ratio.

Solution:

Poisson's ratio (ν) is defined as:

$$\nu = -\frac{\text{Lateral Strain}}{\text{Axial Strain}}$$

First, calculate the axial strain ($\varepsilon_{\text{axial}}$):

$$\varepsilon_{\text{axial}} = \frac{\Delta L}{L} = \frac{2 \times 10^{-3}}{1} = 0.002$$

Next, calculate the lateral strain ($\varepsilon_{\text{lateral}}$):

$$\varepsilon_{\text{lateral}} = \frac{\Delta d}{d} = \frac{-0.03 \times 10^{-3}}{50 \times 10^{-3}} = -0.0006$$

Now, determine Poisson's ratio:

$$\nu = -\frac{-0.0006}{0.002} = 0.3$$

Reference: Poisson's Ratio Example

Problem 5: Calculating Ultimate Tensile Strength

A metal specimen with a cross-sectional area of 100 mm^2 withstands a maximum load of 50 kN before failure. Determine the ultimate tensile strength (UTS) of the material.

Solution:

Ultimate tensile strength (σ_u) is calculated by:

$$\sigma_u = \frac{F_{\text{max}}}{A}$$

where: - $F_{\text{max}} = 50\,\text{kN} = 50 \times 10^3\,\text{N}$ - $A = 100\,\text{mm}^2 = 100 \times 10^{-6}\,\text{m}^2$

Substituting the values:

$$\sigma_u = \frac{50 \times 10^3}{100 \times 10^{-6}} = 500\,\text{MPa}$$

Reference: Calculating Ultimate Tensile Strength and Breaking Strength