Solutions to Stresses and Strains in Materials Problems

Civil Engineering Licensure Exam – Mock Exam

February 24, 2025

Problem 1: Stress in a Steel Rod

A steel rod with a cross-sectional area of 100 mm^2 is subjected to an axial tensile force of 50 kN. Determine the stress in the rod.

Solution:

Stress (σ) is calculated using the formula:

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

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

Substituting the values:

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

Reference: How to calculate steel rod applied tensile stress, lateral strain, final diameter while subjected to axial load

Problem 2: Strain in a Bar Under Axial Force

A 2 m long bar extends by 1.5 mm under an axial force. Determine the strain in the material.

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:

$$\varepsilon = \frac{1.5 \times 10^{-3}}{2} = 0.00075\,(\text{dimensionless})$$

Reference: Simple Stress Strain Calculations - Example 1

Problem 3: Strain from Modulus of Elasticity

A steel bar with a modulus of elasticity of 200 GPa is subjected to a stress of 100 MPa. Determine the strain.

Solution:

Using Hooke's Law:

$$\sigma = E \cdot \varepsilon \implies \varepsilon = \frac{\sigma}{E}$$

where: - $\sigma = 100\,\text{MPa} = 100 \times 10^6\,\text{Pa}$ - $E = 200\,\text{GPa} = 200 \times 10^9\,\text{Pa}$

Substituting the values:

$$\varepsilon = \frac{100 \times 10^6}{200 \times 10^9} = 0.0005\,(\text{dimensionless})$$

Reference: How to Calculate Young's Modulus from a Stress Strain Curve in Excel

Problem 4: Determining Poisson's Ratio

A cylindrical rod of diameter 20 mm experiences a lateral strain of 2×10^{-5} when subjected to an axial strain of 1×10^{-3}. Determine Poisson's ratio.

Solution:

Poisson's ratio (ν) is defined as:

$$\nu = -\frac{\text{lateral strain}}{\text{axial strain}}$$

Given: - Lateral strain $= 2 \times 10^{-5}$ - Axial strain $= 1 \times 10^{-3}$

Substituting the values:

$$\nu = -\frac{2 \times 10^{-5}}{1 \times 10^{-3}} = -0.02$$

Since Poisson's ratio is typically positive, the negative sign indicates that the lateral strain is in the opposite direction to the axial strain.

Reference: Poisson's Ratio Example

Problem 5: Compressive Stress in a Concrete Column

A concrete column is subjected to an axial compressive force of 2000 kN. If the column has a cross-sectional area of 0.2 m^2, determine the compressive stress.

Solution:

Compressive stress (σ) is calculated as:

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

where: - $F = 2000\,\text{kN} = 2000 \times 10^3\,\text{N}$ - $A = 0.2\,\text{m}^2$
Substituting the values:

$$\sigma = \frac{2000 \times 10^3}{0.2} = 10 \times 10^6\,\text{Pa} = 10\,\text{MPa}$$

Reference: Reinforced Concrete Column in Compression - Example