Solutions to Structural Engineering Problems

Civil Engineering Licensure Exam - Day 49

March 7, 2025

Section A: Multiple Choice Questions (MCQs)

1. The Ultimate Load Design Method in structural engineering is also known as:

Answer: (a) Load Factor Design Method

Video Explanation: Ultimate Load Method — Reinforced Cement Concrete

2. The modulus of elasticity of concrete is influenced by:

Answer: (a) Aggregate properties, mix proportions, and curing conditions

Video Explanation: What is the Modulus of Elasticity of Concrete?

3. In structural design, the term 'service load' refers to:

Answer: (a) The actual loads expected during the structure's use

Video Explanation: Intro to Structural Analysis - Loads and LRFD

4. The primary purpose of using safety factors in structural design is to:

Answer: (a) Account for uncertainties in load estimations and material strengths

Video Explanation: Intro to Structural Analysis - Loads and LRFD

5. The Limit State Design approach ensures that structures are:

Answer: (a) Safe and serviceable under all expected loads

Video Explanation: Ultimate Load Method — Reinforced Cement Concrete

Section B: Problem-Solving

1. A reinforced concrete beam has a width of 300 mm and an effective depth of 500 mm. If the factored bending moment is 150 kN·m, determine the required area of tensile reinforcement assuming $f'_c = 25$ MPa and $f_y = 415$ MPa.

Solution:

Using the flexural reinforcement formula:

$$A_s = \frac{M_u}{\phi f_y d}$$

where: - $M_u = 150 \times 10^6$ N·mm - $\phi = 0.9$ - $f_y = 415$ MPa - $d = 500$ mm

$$A_s = \frac{150 \times 10^6}{0.9 \times 415 \times 500} \approx 805.3\,\text{mm}^2$$

Video Explanation: Calculate the Steel Reinforcement for a Concrete Beam

2. A rectangular open channel is 3 m wide and carries a flow of 12 m^3/s at a depth of 1.5 m. Determine the Froude number.

Solution:

The Froude number (Fr) is given by:

$$Fr = \frac{V}{\sqrt{gh}}$$

where: - $V = \frac{Q}{A} = \frac{12}{3 \times 1.5} = 2.67$ m/s - $g = 9.81$ m/s^2 - $h = 1.5$ m

$$Fr = \frac{2.67}{\sqrt{9.81 \times 1.5}} \approx 0.69$$

Video Explanation: What is the Modulus of Elasticity of Concrete?

3. A steel column with an effective length of 3 m has a radius of gyration of 50 mm. Calculate its slenderness ratio.

Solution:

The slenderness ratio (λ) is calculated as:

$$\lambda = \frac{L_{\text{eff}}}{r}$$

where: - $L_{\text{eff}} = 3\,\text{m} = 3000\,\text{mm}$ - $r = 50\,\text{mm}$

$$\lambda = \frac{3000}{50} = 60$$

Video Explanation: Intro to Structural Analysis - Loads and LRFD

4. A soil sample has a liquid limit of 50 and a plastic limit of 20. Determine the plasticity index.

Solution:

The plasticity index (PI) is:

$$PI = LL - PL$$

where: - $LL = 50$ - $PL = 20$

$$PI = 50 - 20 = 30$$

Video Explanation: Ultimate Load Method — Reinforced Cement Concrete

5. A simply supported beam has a span of 5 m and carries a uniformly distributed load of 25 kN/m. Determine the maximum bending moment.

Solution:

For a simply supported beam under uniform load:

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

where: - $w = 25$ kN/m - $L = 5$ m

$$M_{\max} = \frac{25 \times 5^2}{8} = 78.125\,\text{kN} \cdot \text{m}$$

Video Explanation: Intro to Structural Analysis - Loads and LRFD