Solutions to Beams and Frames Problems

Civil Engineering Licensure Exam – Mock Exam

February 24, 2025

Problem 1: Simply Supported Beam with a Central Load

A simply supported beam of length 6 m carries a point load of 10 kN at the center. Determine the reactions at the supports and construct the shear force and bending moment diagrams.

Solution:

For a simply supported beam with a central point load P, the reactions at both supports are:

$$R_A = R_B = \frac{P}{2} = \frac{10}{2} = 5 \text{ kN}$$

The shear force diagram (SFD) has a value of $+5$ kN from the left support to the center, then -5 kN from the center to the right support.

The bending moment diagram (BMD) is triangular, peaking at the center with a maximum moment:

$$M_{\max} = R_A \times \frac{L}{2} = 5 \times 3 = 15 \text{ kN} \cdot \text{m}$$

Reference: Shear and Moment Diagrams - Simple Beam with 1 Concentrated Force

Problem 2: Cantilever Beam with Uniform Load

A cantilever beam of length 5 m is subjected to a uniformly distributed load of 4 kN/m. Determine the reactions at the fixed end and construct the shear force and bending moment diagrams.

Solution:

The total load on the beam:

$$w \times L = 4 \times 5 = 20 \text{ kN}$$

The reaction at the fixed end counteracts this load, resulting in a vertical reaction of 20 kN upward.

The maximum moment at the fixed end is:

$$M_{\max} = w \times L \times \frac{L}{2} = 4 \times 5 \times \frac{5}{2} = 50 \text{ kN} \cdot \text{m}$$

Reference: Shear and Moment Diagrams - Cantilever Beam with Uniform Load

Problem 3: Simply Supported Beam with Triangular Load

A simply supported beam carries a triangular load varying from 0 at the left end to 8 kN/m at the right end over a span of 6 m. Determine the reactions at the supports.

Solution:

The total equivalent load is:

$$W = \frac{1}{2} \times 8 \times 6 = 24 \text{ kN}$$

This acts at a centroid location:

$$x = \frac{2}{3} \times 6 = 4 \text{ m from the left end}$$

Using static equilibrium equations, the reactions at the supports are calculated.

Reference: Shear and Moment Diagrams - Simply Supported Beam with Triangular Load

Problem 4: Simply Supported Beam with Concentrated Moment

A beam with a span of 8 m carries a concentrated moment of 20 kN·m at its midpoint. Draw the shear force and bending moment diagrams.

Solution:

For a simply supported beam with a concentrated moment at the center:

- The shear force remains zero throughout. - The bending moment diagram is a step function, with a constant moment of 20 kN·m between supports.

Reference: Shear and Moment Diagrams - Simply Supported Beam with Moment

Problem 5: Propped Cantilever Beam with Uniform Load

A propped cantilever beam of length 6 m has a uniform distributed load of 5 kN/m. Determine the reactions at the fixed and roller supports.

Solution:

The total load is:

$$W = 5 \times 6 = 30 \text{ kN}$$

Using equilibrium equations, reactions at the fixed and roller supports are determined.

Reference: Shear and Moment Diagrams - Propped Cantilever Beam