Solutions to Structural Stability and Determinacy Problems

Civil Engineering Licensure Exam – Mock Exam

February 24, 2025

Problem 1: Determinacy of a Truss

A truss has 10 joints and 19 members. Determine if the truss is statically determinate or indeterminate.

Solution:

To assess the determinacy of a planar truss, we use the formula:

$$m = 2j - 3$$

where m is the number of members and j is the number of joints.

For this truss:

$$19 = 2(10) - 3 \Rightarrow 19 = 20 - 3 = 17$$

Since $19 \neq 17$, the truss is **statically indeterminate**.

Reference: Structural Stability and Determinacy with Example Problems

Problem 2: Degree of Static Determinacy of a Beam

A beam is simply supported at both ends and has an intermediate hinge. Determine the degree of static determinacy.

Solution:

A simply supported beam typically has two supports providing three reactions (two vertical and one horizontal). The presence of an intermediate hinge introduces an additional equation of condition. Therefore, the degree of static indeterminacy (DSI) is calculated as:

$$\text{DSI} = \text{Reactions} - \text{Equilibrium Equations} - \text{Additional Conditions} = 3 - 3 - 1 = -1$$

A negative DSI indicates that the structure is **statically determinate** and has one degree of internal redundancy.

Reference: Structural Theory — Determinacy and Stability

Problem 3: Stability of a Frame

A frame consists of 4 members and 4 joints, with 3 support reactions. Determine if the structure is determinate, indeterminate, or unstable.

Solution:

For a planar frame, the determinacy can be assessed using:

$$m + r = 2j$$

where m is the number of members, r is the number of reactions, and j is the number of joints.

For this frame:

$$4 + 3 = 2(4) \Rightarrow 7 = 8$$

Since $7 \neq 8$, the structure is **unstable**.

Reference: Determinacy and Stability

Problem 4: Degree of Static Indeterminacy of a Continuous Beam

A continuous beam has three spans with fixed ends. Calculate the degree of static indeterminacy.

Solution:

Each fixed end provides two reactions (vertical and moment). For a continuous beam with three spans and fixed ends at both extremities:

$$\text{Total Reactions} = 2(\text{left}) + 2(\text{right}) + 2(\text{interior supports}) = 2 + 2 + 2 = 6$$

The number of equilibrium equations available is 3 (vertical, horizontal, and moment). Therefore, the degree of static indeterminacy (DSI) is:

$$\text{DSI} = \text{Total Reactions} - \text{Equilibrium Equations} = 6 - 3 = 3$$

Thus, the beam is **statically indeterminate to the third degree**.

Reference: Structural Theory 1: Stability Determinacy of Beams and Frames

Problem 5: Determinacy of a Planar Structure

A planar structure has 6 joints, 13 members, and 3 external reactions. Determine if the structure is statically determinate, indeterminate, or unstable.

Solution:

Using the determinacy equation for planar structures:

$$m + r = 2j$$

Substituting the given values:

$$13 + 3 = 2(6) \Rightarrow 16 = 12$$

Since $16 \neq 12$, the structure is **statically indeterminate**.
Reference: SA76: Stability and Determinacy of Structures (Example 2)