UNIT-III

Flexibility matrix method

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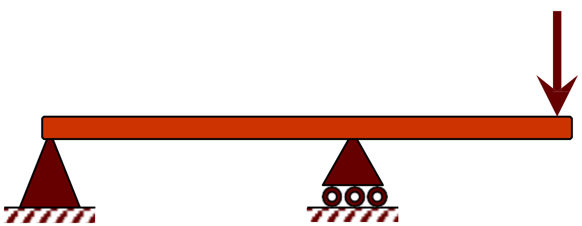
Introduction

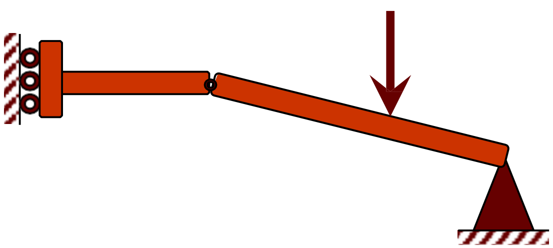
- What is statically ***DETERMINATE*** structure?
  - When all the forces (reactions) in a structure can be determined from the equilibrium equations its called statically determinate structure
  - Structure having unknown forces equal to the available equilibrium equations



No. of unknown = 3

No. of equilibrium equations = 3

3 = 3 thus statically determinate



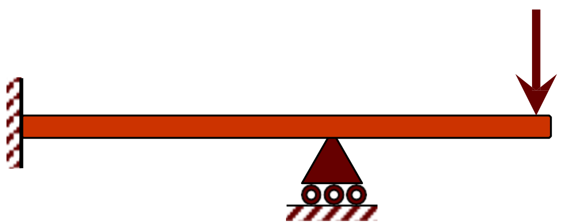
No. of unknown = 6

No. of equilibrium equations = 6

6 = 6 thus statically determinate

Introduction

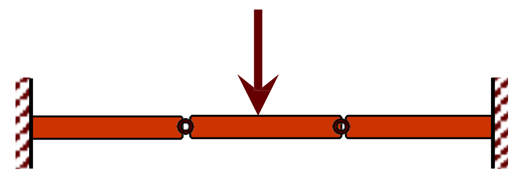
- What is statically *INETERMINATED* structure
  - Structure having more unknown forces than available equilibrium equations
  - Additional equations needed to solve the unknown reactions



No. of unknown = 4

No. of equilibrium equations = 3

4 > 3 thus statically Indeterminate



No. of unknown = 10

No. of equilibrium equations = 9

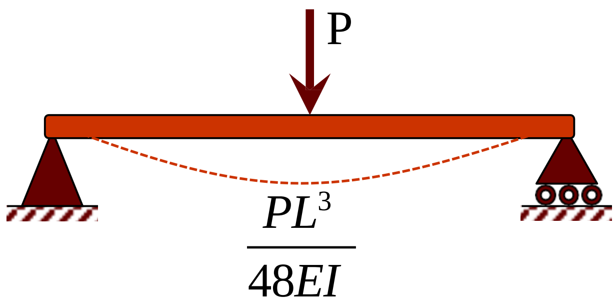
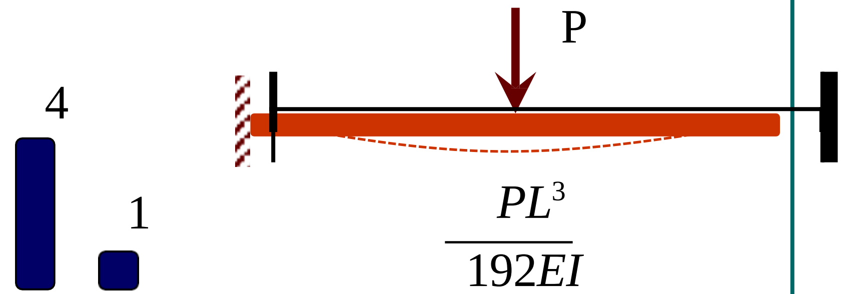
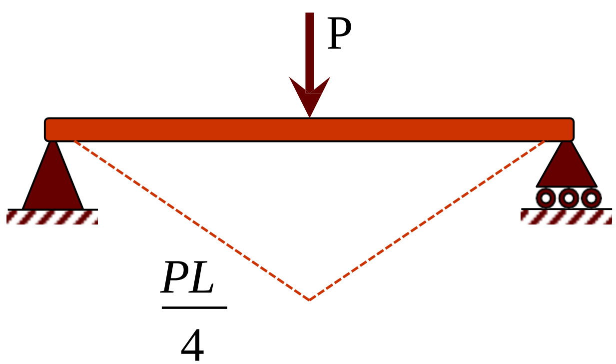
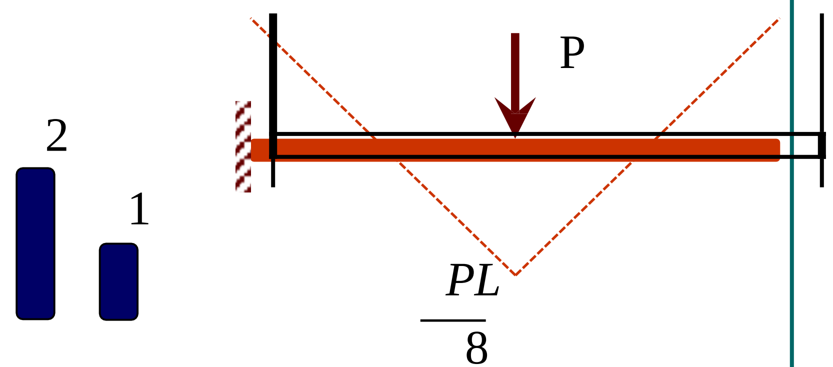
10 > 9 thus statically Indeterminate

Indeterminate Structure

Why we study indeterminate structure

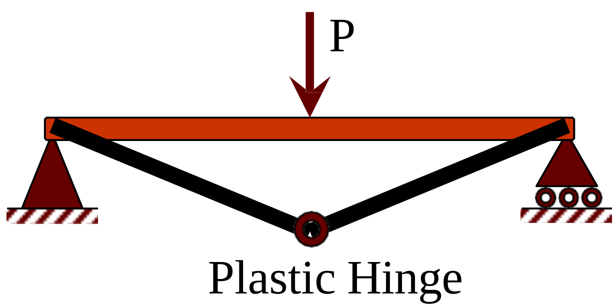
- Most of the structures designed today are statically indeterminate
- Reinforced concrete buildings are considered in most cases as a statically indeterminate structures since the columns & beams are poured as continuous member through the joints & over the supports
- More stable compare to determinate structure or in another word safer.
- In many cases more economical than determinate.
- The comparison in the next page will enlighten more

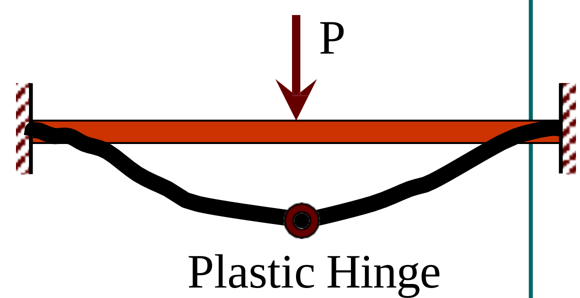
Contrast

<table>
<tr><th></th><th>Indeterminate Structure</th><th>Determinate Structure</th></tr>
<tr><td>Deflection</td><td>Considerable compared to indeterminate structure
</td><td>Generally smaller than determinate structure
</td></tr>
<tr><td>Stress</td><td>High moment caused thicker member & more material needed
</td><td>Less moment, smaller cross section & less material needed
</td></tr>
</table>

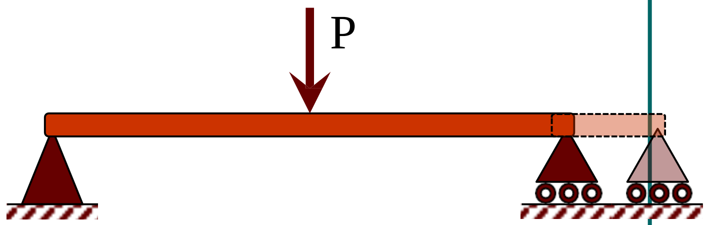
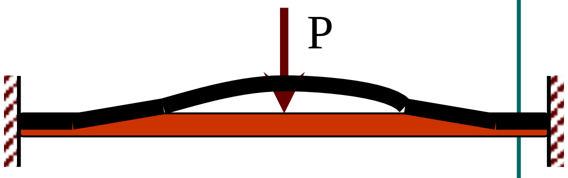
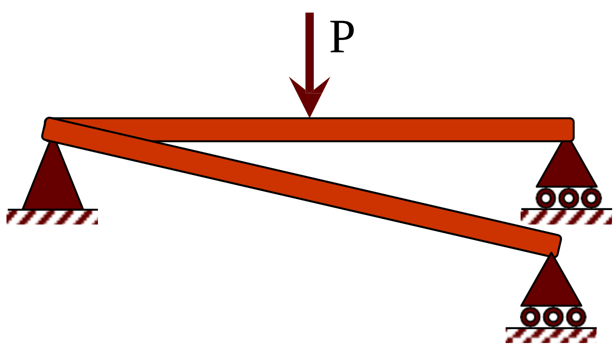
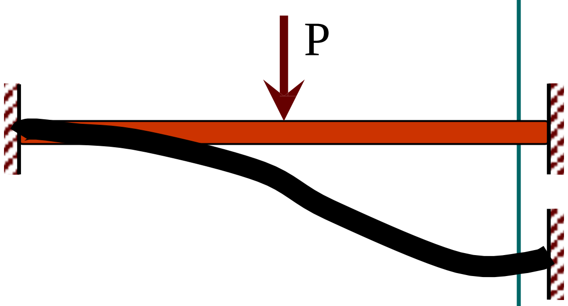
Contrast

	Indeterminate Structure	Determinate Structure
Stability in case of over load	✶Support will not develop the horizontal force & moments that necessary to prevent total collapse	✶Will develop horizontal force & moment reactions that will hold the beam
	✶No load redistribution	✶Has the tendency to redistribute its load to its redundant supports
	✶When the plastic hinge formed certain collapse for the system	✶When the plastic hinge formed the system would be a determinate structure





Contrast

	Indeterminate Structure	Determinate Structure
Temperature	No effect & no stress would be developed in the beam 	Serious effect and stress would be developed in the beam 
Differential Displacement	No effect & no stress would be developed 	Serious effect and stress would be developed 

Matrix Methods in Structural Analysis

Systematic approach for analyzing structures.
Uses matrix algebra to solve structural problems.

Two major methods:

Flexibility Matrix Method (Force Method)
Stiffness Matrix Method (Displacement Method)

Applications
Continuous beams
Trusses
Frames
Indeterminate structures

Concept of Flexibility Method

Basic Idea

Unknowns are redundant forces.

Compatibility conditions are used.

Structure is transformed into a determinate primary structure.

Advantages

Suitable for structures with few redundants.

Provides force-based solutions.

Flexibility Coefficient

f_{ij}

- Displacement at coordinate *i*
- Due to unit force applied at coordinate *j*

Flexibility Matrix

$$[F] = \begin{bmatrix} f_{11} & f_{12} \\ f_{21} & f_{22} \end{bmatrix}$$

Properties:

- Symmetric matrix
- $f_{ij} = f_{ji}$

Matrix Form

$$\{\Delta\} = [F]\{R\}$$

Where:

- $\{\Delta\}$ = displacement vector
- $[F]$ = flexibility matrix
- $\{R\}$ = redundant force vector

For compatibility:

$$\{\Delta\} = 0$$

Thus,

$$[F]\{R\} = -\{\Delta_L\}$$

Steps in Flexibility Matrix Method

1. Determine degree of static indeterminacy.
2. Select redundants.
3. Convert to primary determinate structure.
4. Compute flexibility coefficients.
5. Form flexibility matrix.
6. Apply compatibility equations.
7. Solve for redundants.
8. Determine member forces and reactions.

Analysis of Continuous Beam

Example Structure

•(Insert continuous beam diagram)

•Multiple spans

•Fixed and roller supports

Indeterminate beam

Procedure

•Select reaction as redundant.

•Remove redundant support.

•Calculate flexibility coefficients.

•Apply compatibility conditions.

Example of Settlement Analysis
Given

Continuous beam

Settlement at middle support = 20 mm

Procedure

Determine primary structure.

Calculate displacement due to loads.

Include settlement displacement.

Solve flexibility equations.

Obtain final reactions and moments.

Pin-Jointed Plane Frames

Definition

A structure composed of:

Straight members

Pin-connected joints

Loads acting at joints

Assumptions:

Members carry axial forces only.

Joints are frictionless.

Procedure for Pin-Jointed Frames

1. Identify redundants.
2. Remove redundant members.
3. Form primary determinate truss.
4. Calculate flexibility coefficients.
5. Assemble flexibility matrix.
6. Apply compatibility equations.
7. Solve redundant forces.
8. Determine member forces.

THANK YOU