

Determinacy of Structural System

Structural System

Structure is generally classified into two categories as Determinate and Indeterminate Structures

Determinate structures are analyzed just by the use of basic equilibrium equations. By this analysis, the unknown reactions are found for the further determination of stresses.

Redundant or indeterminate structures are not capable of being analyzed by mere use of basic equilibrium equations. Along with the basic equilibrium equations, some extra conditions are required to be used like **compatibility conditions** of deformations etc. to get the unknown reactions for drawing **bending moment and shear force diagrams**.

Example of determinate structures are: simply supported beams, cantilever beams, single and double overhanging beams, three hinged arches, etc.

Examples of indeterminate structures are: fixed beams, continuous beams, fixed arches, two hinged arches, portals, multistoried frames, etc.

Structural System

Most structures in the real world are statically indeterminate.

Advantage:

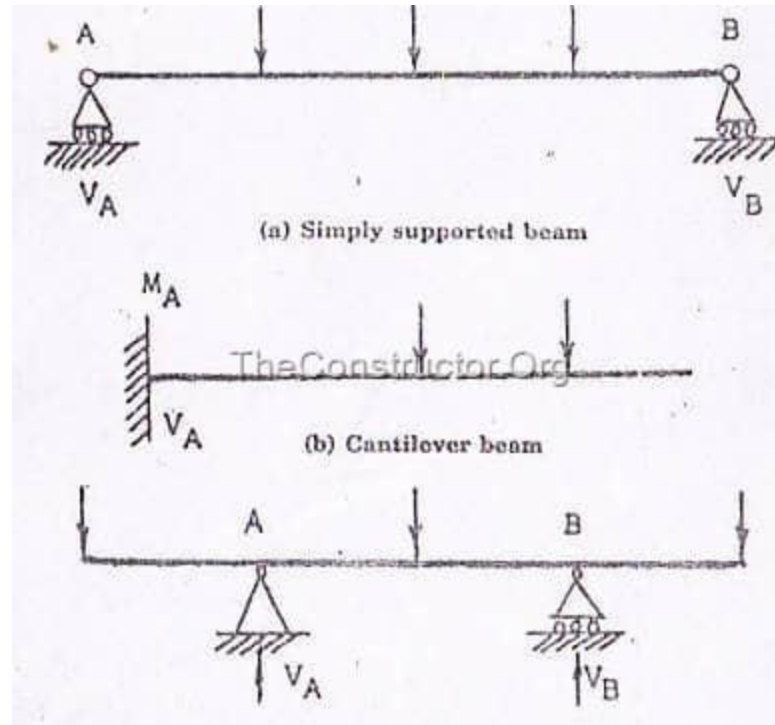
- Smaller deflections for similar members
- Redundancy in load carrying capacity (redistribution)
- Increased stability

Disadvantage:

- More material => More Cost
- Complex connections
- Initial / Residual / Settlement Stresses

Externally Indeterminate Structures

A structure is usually externally indeterminate or redundant if the reactions at the supports can not be determined by using three equations of equilibrium, i.e. . In the case of beams subjected to vertical loads only, two reactions can be determined by conditions of equilibrium.



Internally Indeterminate Structures

A truss is statically determinate internally if the total number of members

$$m=2j - 3$$

where j = number of joints.

A truss having more than $(2j - 3)$ members is statically indeterminate or redundant, the degree of indeterminacy or redundancy being equal to the number of extra members.

The internally indeterminate trusses can be analyzed by **strain energy method**.

Methods of Analysis

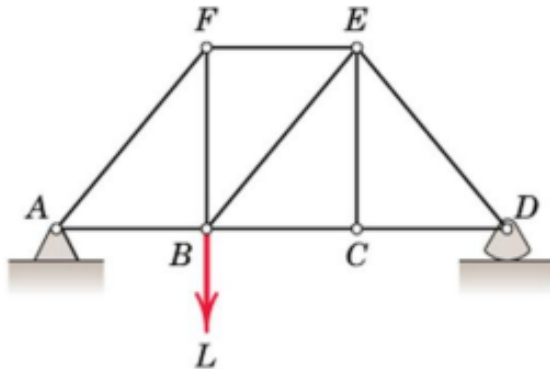
- (i) Equilibrium of forces and moments
- (ii) Compatibility of deformation among members and at supports
- (iii) Material behavior relating stresses with strains
- (iv) Strain-displacement relations
- (v) Boundary Conditions

Difference Between Determinate and Indeterminate Structures

S. No.	Determinate Structures	Indeterminate Structures
1	Equilibrium conditions are fully adequate to analyze the structure.	Conditions of equilibrium are not adequate to fully analyze the structure.
2	Bending moment or shear force at any section is independent of the material property of the structure.	Bending moment or shear force at any section depends upon the material property.
3	The bending moment or shear force at any section is independent of the cross-section or moment of inertia.	The bending moment or shear force at any section depends upon the cross-section or moment of inertia.
4	Temperature variations do not cause stresses.	Temperature variations cause stresses.
5	No stresses are caused due to lack of fit.	Stresses are caused due to lack of fit.
6	Extra conditions like compatibility of displacements are not required to analyze the structure.	Extra conditions like compatibility of displacements are required to analyze the structure along with the equilibrium equations.

Statically Indeterminate Structure

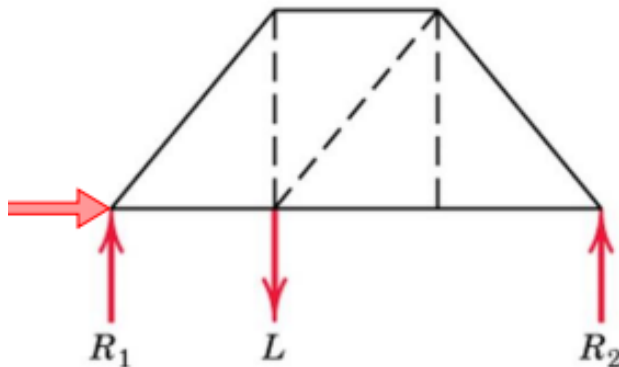
Plane Truss :: Determinacy



No. of unknown reactions = 3

No. of equilibrium equations = 3

: **Statically Determinate (*External*)**



No. of members (m) = 9

No. of joints (j) = 6

No. of unknown reactions (R) = 3

$\therefore m + R = 2j$

: **Statically Determinate (*Internal*)**

Determinacy of beam

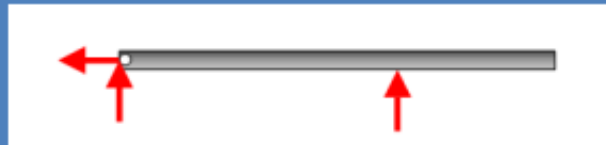
$r = 3n$, statically determinate

$r > 3n$, statically indeterminate

n = the total parts of structure members.

r = the total number of unknown reactive force and moment components

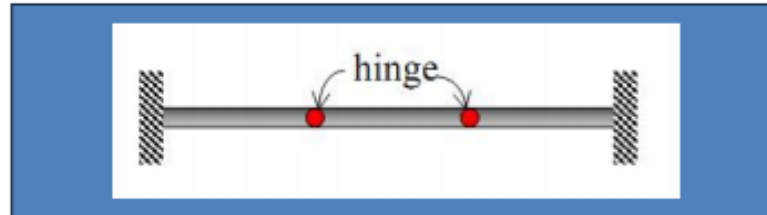
Determinacy of beam



$$r = 3, n = 1, 3 = 3(1)$$

Statically **determinate**

Determinacy of beam



$$r = 10, n = 3$$

$$10 \neq 9$$

Statically **indeterminate**

THANK YOU!!