

Determinate and Indeterminate Structures

A determinate structure is a structure that is stable, and all support reactions can be calculated with the help of equilibrium equations only. And there is no need for compatibility conditions in the determinate structure. The bending moment and shear force of a determinate structure is independent of the material property, while it will depend on the case of an indeterminate structure.

An indeterminate structure is a structure that is also stable, but it has more unknown forces than the total number of available equilibrium equations. For analyzing an indeterminate structure, compatibility equations are required along with the equilibrium equations. Compatibility equations may be a deformation equation, slope equation, etc.

Statically Determinate and Indeterminate Structures

Statically Determinate Structures

These structures can analyze with the help of equilibrium equations alone without any help of compatibility equations.

Statically Indeterminate Structures

These are the structures for which compatibility conditions and equilibrium equations are required for their analysis. Both determinate and indeterminate structures are stable. An indeterminate structure is stable until all degree of indeterminacy is less than zero.

Difference Between Statically Determinate and Indeterminate Structures

The indeterminacy and stability of a structure will depend upon whether the structure is determinate or indeterminate, so it will be important to understand the difference between them. A statically determinate structure is stable and can be determined from equilibrium equations alone. However, a statically indeterminate structure has more unknown forces than available equilibrium equations.

Only equilibrium equations are required to analyze a determinate structure, and it is sufficient to find unknowns of the member. But compatibility conditions are also required for the analysis of indeterminate structures, along with the equilibrium equations for finding the unknowns of the structure.

Terms in Determinate and Indeterminate Structures

To understand the determinate and indeterminate structures, it is required to know the terms used. These terms are described below in detail.

Redundant: Indeterminate structures effectively have more unknowns than can be solved using the three equilibrium equations (or six equilibrium equations in 3D). These extra unknowns are called redundant reactions.

Stable/Unstable structure: A stable structure will not collapse when disturbed. Stability may also be defined as "The power to recover equilibrium." In general, there are many ways that a structure may become unstable, including the buckling of compression members and yielding/rupture of members; however, for linear structural analysis, the main concern is instability caused by insufficient reaction points or poor layout of structural members.

Internally Stable: An internally stable structure would maintain its shape if all the support reactions were removed. An internally unstable structure may remain stable with sufficient external support reactions.

What is the Degree of Indeterminacy?

The degree of indeterminacy equals the number of redundant reactions available in the structure. It helps to identify the determinate and indeterminate structures. An indeterminate structure with 2 redundant may be said to be statically indeterminate to the second degree. The degree of indeterminacy can be either external determinacy or internal determinacy, which are explained below.

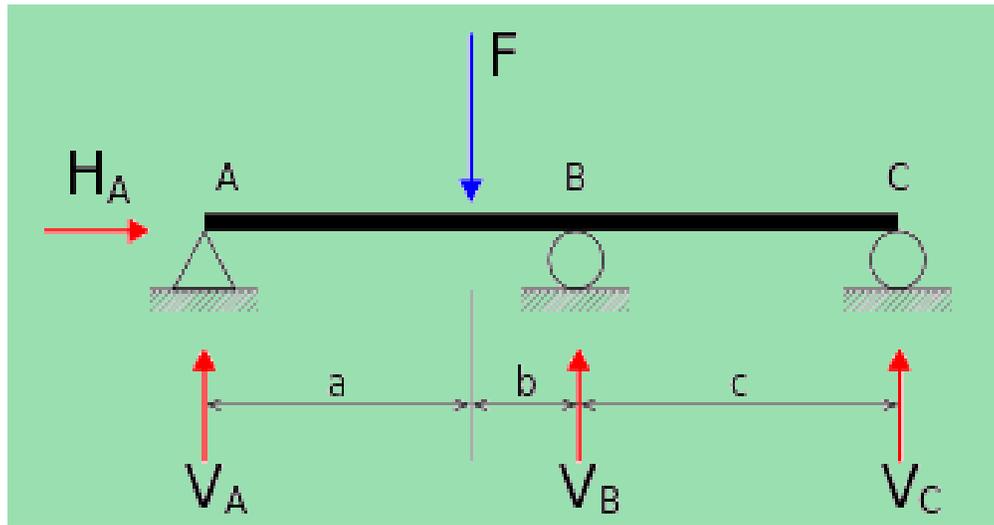
External Determinacy: The ability to calculate all of the external reaction component forces by using only static equilibrium. A structure that satisfies this requirement is the externally statically determinate. Conversely, a structure for which the external reactions component forces cannot be calculated using only equilibrium is an externally statically indeterminate structure.

Internal Determinacy: The ability to calculate the external reaction components and internal forces using only static equilibrium. A structure that

satisfies this requirement is the internally statically determinate. A structure for which the internal forces cannot be calculated using only equilibrium is an internally statically indeterminate structure.

Examples of Determinate and Indeterminate Structures

As it is already discussed that Determinate structure is a structure that does not require compatible conditions for solving their unknown forces. In contrast, in an indeterminate structure, compatibility equations along with equilibrium equations are required. Determinate and indeterminate structures can be classified based on the degree of determinacy of the structure. So let's understand the determinate and indeterminate structures with the help of an example.



Here, In this structure, vertical loading is given over a beam, So it's necessary to understand that in the case of vertical loading, only two equilibrium equations can be used because in such cases there is no sign of horizontal equilibrium.

So, In this case,

the Total number of support reactions = 3 (i.e. V_A , V_B , V_C)

And the total number of equilibrium equations available = 2

Hence, degree of static determinacy = $3 - 2 = 1$

So, the above structure is a statically indeterminate structure of degree one.