Analysis of Truss Structures

- We will discuss the determinacy, stability, and analysis of three forms of statically determinate trusses: **simple**, **compound**, and **complex**.


Analysis of Truss Structures

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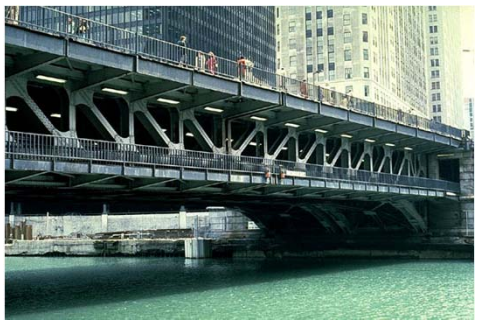
Analysis of Truss Structures



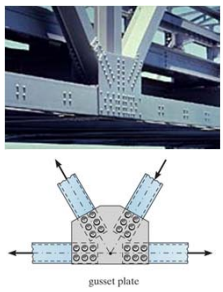
Analysis of Truss Structures

Analysis of Truss Structures

- Definition of a Truss
  - A **truss** is a structure composed of slender members joined together at their end points.
  - Planar trusses lie in a single plane.
  - Typically, the joint connections are formed by bolting or welding the end members together to a common plate, called a *gusset plate.*

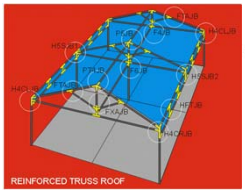
Analysis of Truss Structures

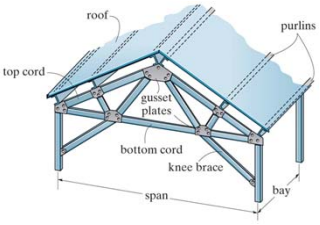
- Examples of gusset plates.



Analysis of Truss Structures

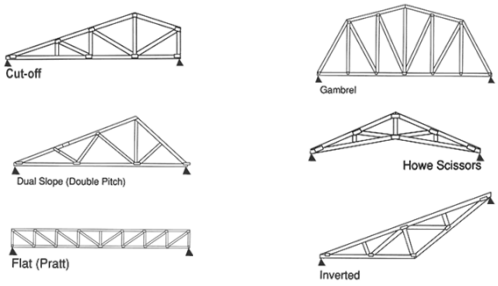
- Common Types of Trusses
  - **Roof trusses** - in general, the roof load is transmitted to the truss by a series of *purlins*. The roof truss along with its supporting columns is termed a *bent*. The space between bents is called a *bay*.





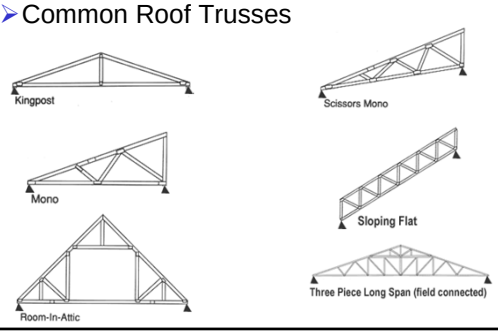
Analysis of Truss Structures

- Common Roof Trusses



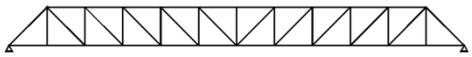
Analysis of Truss Structures

- Common Roof Trusses



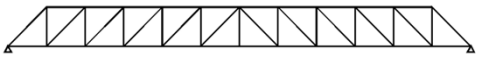
Analysis of Truss Structures

- Common Types of Trusses
  - **Pratt Truss –** This truss was patented in 1844 by two Boston railway engineers; Caleb Pratt and his son Thomas Willis Pratt.
  - The design uses vertical beams for compression and horizontal beams to respond to tension.
  - What is remarkable about this style is that it remained popular even as wood gave way to iron, and even still as iron gave way to steel.



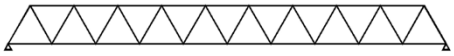
Analysis of Truss Structures

- Common Types of Trusses
  - **Howe Truss -**The relatively rare Howe truss, patented in 1840 by Massachusetts millwright William Howe.
  - It includes vertical members and diagonals that slope up towards the center, the opposite of the Pratt truss.
  - In contrast to the Pratt Truss, the diagonal web members are in compression and the vertical web members are in tension.



Analysis of Truss Structures

- Common Types of Trusses
  - **Warren Truss -**The Warren truss was patented in 1848 by its designers James Warren and Willoughby Theobald Monzani.
  - This truss and consists of longitudinal members joined only by angled cross-members, forming alternately inverted equilateral triangle-shaped spaces along its length, ensuring that no individual strut, beam, or tie is subject to bending or torsional straining forces, but only to tension or compression.

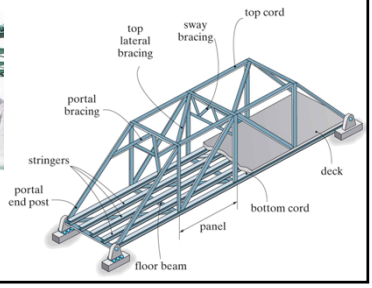


Analysis of Truss Structures

- Common Types of Trusses
  - **Bridge trusses** - the load is transmitted by the *deck* to a series of *stringers* and then to a set of *floor beams*.
  - The floor beams are supported by two parallel trusses.
  - The supporting trusses are connected top and bottom by *lateral bracing*.
  - Additional stability may be provided by *portal* and *sway* bracing

Analysis of Truss Structures

- Common Bridge Truss

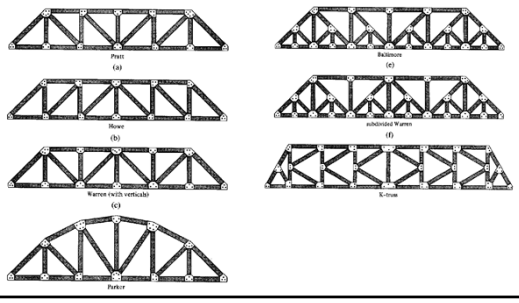


Analysis of Truss Structures

- Common Bridge Truss

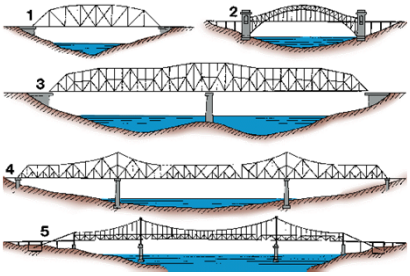
Analysis of Truss Structures

- Common Bridge Truss



Analysis of Truss Structures

- Common Bridge Truss



Analysis of Truss Structures

- Assumptions for Truss Design
  - To design both the members and connections of a truss, the *force* in each member for a given loading must be determined.
  - Two important assumptions are made in truss analysis:
    - ***Truss members are connected by smooth pins***
    - ***All loading is applied at the joints of the truss***

Analysis of Truss Structures

- ***Truss members are connected by smooth pins.***
  - The stress produced in these elements is called the *primary stress*.
  - The pin assumption is valid for bolted or welded connections if the members are concurrent.
  - However, since the connection does provide some rigidity, the bending introduced in the members is called *secondary stress*.
  - Secondary stress analysis is not commonly performed

Analysis of Truss Structures

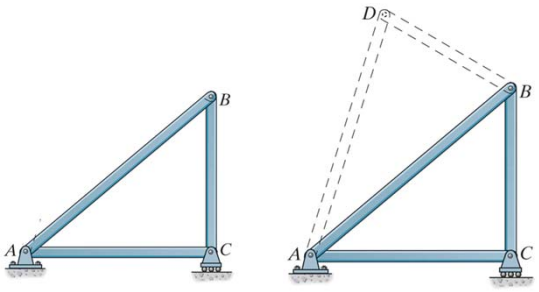
- ***All loading is applied at the joints of the truss.***
  - Since the weight of each members is small compared to the member force, the member weight is often neglected.
  - However, when the member weight is considered, it is applied at the end of each member.
  - Because of these two assumptions, each truss member is a two-force member with either a compressive (C) or a tensile (T) axial force.
  - In general, compression members are bigger to help with instability due to buckling.

Classification of Coplanar Trusses

- Simple Truss
  - The simplest framework that is rigid or stable is a triangle.
  - Therefore, a simple truss is constructed starting with a basic triangular element and connecting two members to form additional elements.
  - As each additional element of two members is placed on a truss, the number of joints is increased by one.

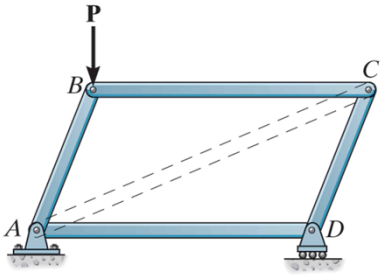
Classification of Coplanar Trusses

- Simple Truss



Classification of Coplanar Trusses

- Simple Truss



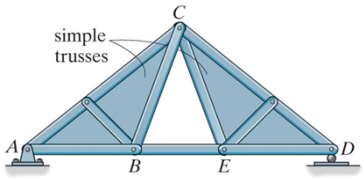
Classification of Coplanar Trusses

- Compound Truss
  - This truss is formed by connecting two or more simple trusses together.
  - This type of truss is often used for large spans.

Classification of Coplanar Trusses

- Compound Truss
  - There are three ways in which simple trusses may be connected to form a compound truss:

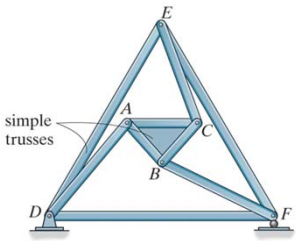
1. Trusses may be connected by a common joint and bar.



Classification of Coplanar Trusses

- Compound Truss

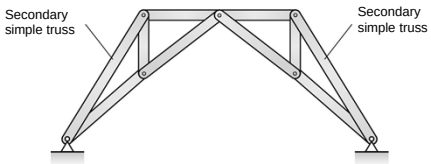
2. Trusses may be joined by three bars.



Classification of Coplanar Trusses

- Compound Truss

3. Trusses may be joined where bars of a large simple truss, called the *main truss,* have been substituted by simple trusses, called *secondary trusses*



Classification of Coplanar Trusses

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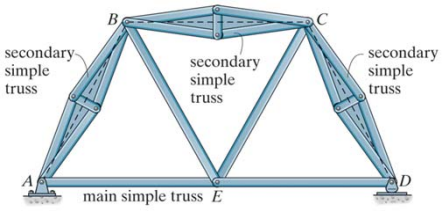
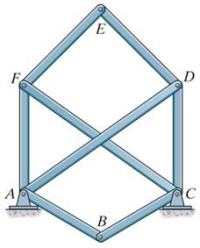


Classification of Coplanar Trusses

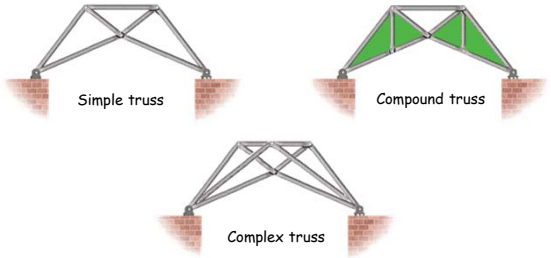
- Complex Truss

This is a truss that cannot be classified as being either simple or compound.



Classification of Coplanar Trusses

- Types of Trusses

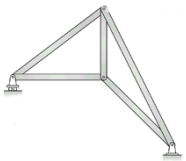


Determinacy of Coplanar Trusses

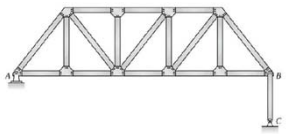
- Since all the elements of a truss are two-force members, the moment equilibrium is automatically satisfied.
- Therefore there are two equations of equilibrium for each joint, ***j***, in a truss. If ***r*** is the number of reactions and ***b*** is the number of bar members in the truss, determinacy is obtained by

b + r = 2j	Determinate
b + r > 2j	Indeterminate

Determinacy of Coplanar Trusses

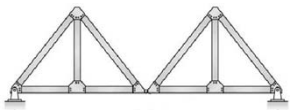


r = 3
b = 5 r+b=2j **determinate**
j = 4

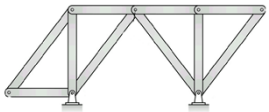


r = 4
b = 18 r+b=2j **determinate**
j = 11

Determinacy of Coplanar Trusses

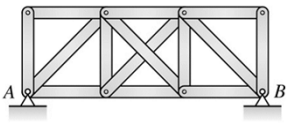


r = 4
b = 10 r+b=2j **determinate**
j = 7

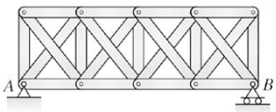


r = 4
b = 10 r+b=2j **determinate**
j = 7

Determinacy of Coplanar Trusses



r = 4
b = 14 r+b>2j **indeterminate**
j = 8



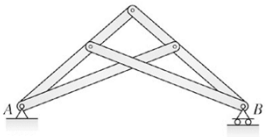
r = 3
b = 21 r+b>2j **indeterminate**
j = 10

Stability of Coplanar Trusses

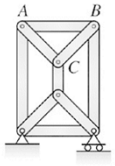
- If ***b + r < 2j***, a truss will be ***unstable***, which means the structure will collapse since there are not enough reactions to constrain all the joints.
- A truss may also be unstable if $b + r \geq 2j$. In this case, stability will be determined by inspection

b + r < 2j	***Unstable***
b + r ≥ 2j	***Unstable*** if reactions are concurrent, parallel, or collapsible mechanics

Stability of Coplanar Trusses



r = 3
b = 6 r+b<2j **unstable**
j = 5

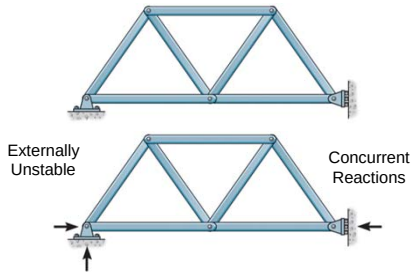


r = 3
b = 9 r+b=2j **unstable**
j = 6

Section ABC is supported by three parallel links

Stability of Coplanar Trusses

- **External stability** - a structure (truss) is externally unstable if its reactions are concurrent or parallel.

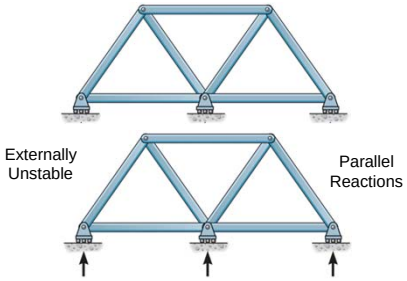


Externally Unstable

Concurrent Reactions

Stability of Coplanar Trusses

- **External stability** - a structure (truss) is externally unstable if its reactions are concurrent or parallel.



Externally Unstable

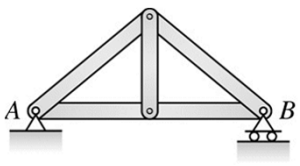
Parallel Reactions

Stability of Coplanar Trusses

- **Internal stability** - may be determined by inspection of the arrangement of the truss members.
  - A *simple* truss will always be internally stable
  - The stability of a *compound* truss is determined by examining how the simple trusses are connected
  - The stability of a *complex* truss can often be difficult to determine by inspection.
  - In general, the stability of any truss may be checked by performing a complete analysis of the structure. If a unique solution can be found for the set of equilibrium equations, then the truss is stable

Stability of Coplanar Trusses

- **Internal stability**



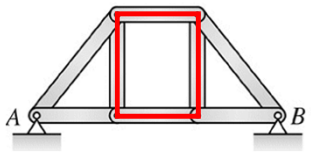
Externally stable

Internally stable

Stability of Coplanar Trusses

- **Internal stability**

Collapsible mechanism

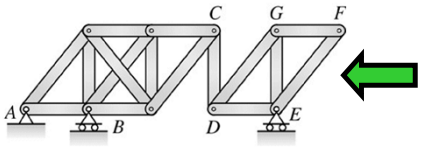


Externally stable Internally unstable

Stability of Coplanar Trusses

- **Internal stability**

Collapsible mechanism



Externally stable Internally unstable

End of Trusses - Part 1

Any questions?