Analysis of Truss Structures

- We will discuss the determinacy, stability, and analysis of statically determinate trusses

Analysis of Truss Structures

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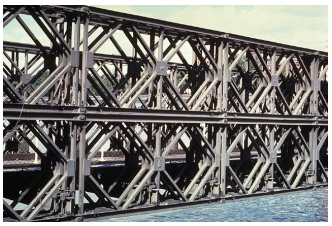

Analysis of Truss Structures

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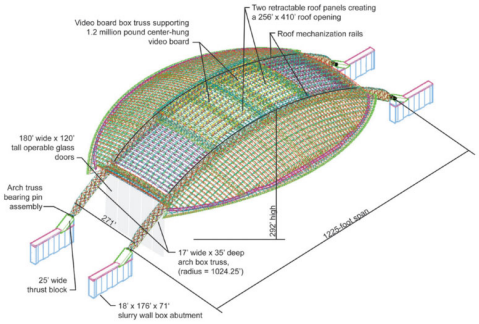

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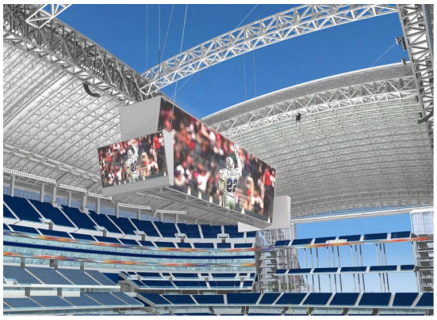

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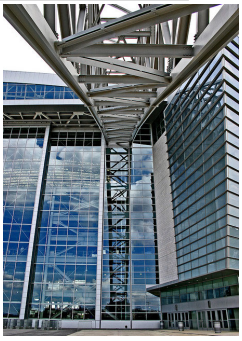
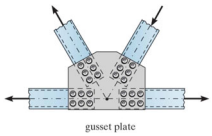


Analysis of Truss Structures

- 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*.

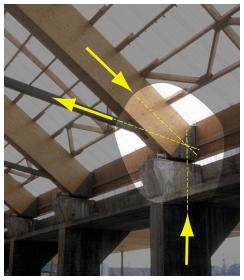
Analysis of Truss Structures

Examples of gusset plates



Analysis of Truss Structures

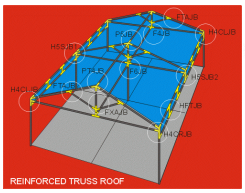
Idealized Pin Connections

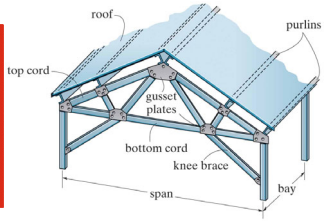


Analysis of Truss Structures

Common Roof Trusses

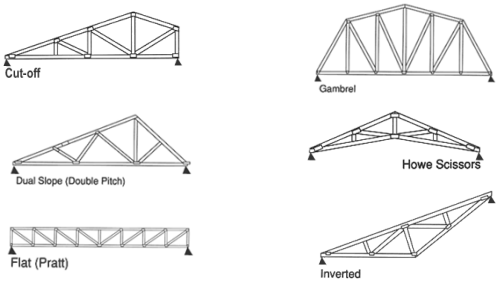
- **Roof trusses** - in general, the roof load is transmitted to the truss by a series of *purlins*. The roof truss along with its supporting columns is termed a *bent*. The space between bents is called a *bay*.





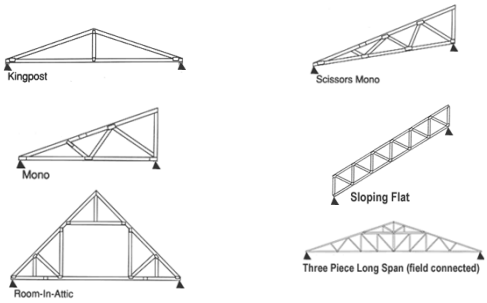
Analysis of Truss Structures

Common Roof Trusses



Analysis of Truss Structures

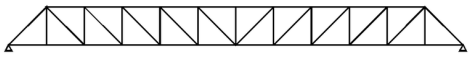
Common Roof Trusses



Analysis of Truss Structures

Common Bridge Trusses

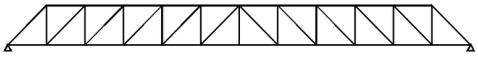
- **Pratt Truss –** This truss was patented in 1844 by two Boston railway engineers; Caleb Pratt and his son Thomas Willis Pratt.
- The design uses vertical beams for compression and horizontal beams to respond to tension.
- What is remarkable about this style is that it remained popular even as wood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



Analysis of Truss Structures

Common Bridge Trusses

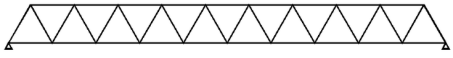
- **Howe Truss -**The relatively rare Howe truss, patented in 1840 by Massachusetts millwright William Howe.
- It includes vertical members and diagonals that slope up towards the center, the opposite of the Pratt truss.
- In contrast to the Pratt Truss, the diagonal web members are in compression and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



Analysis of Truss Structures

Common Bridge 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.



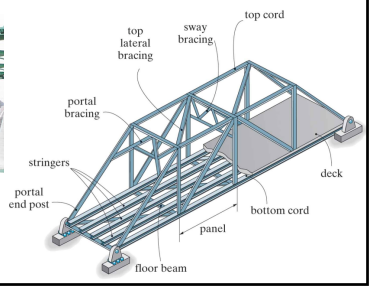
Analysis of Truss Structures

Common Bridge 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 Trusses

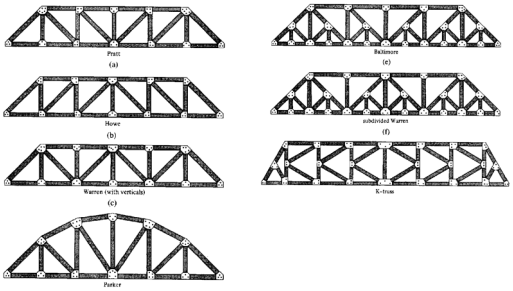


Analysis of Truss Structures

Common Bridge Trusses

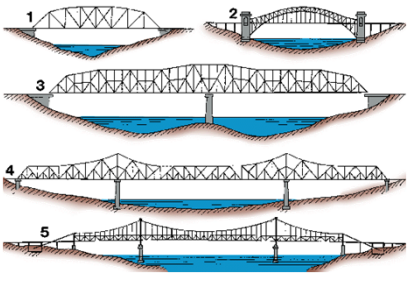
Analysis of Truss Structures

Common Bridge Trusses



Analysis of Truss Structures

Common Bridge Trusses



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.

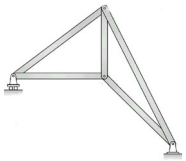
- Since the weight of each members is small compared to the member force, the member weight is often neglected.
- However, when the member weight is considered, it is applied at the end of each member.
- Because of these two assumptions, each truss member is a two-force member with either a compressive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

Determinacy of Coplanar Trusses

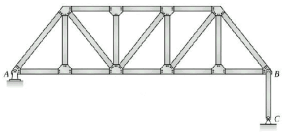
- Since all the elements of a truss are two-force members, the moment equilibrium is automatically satisfied.
- Therefore, there are two equations of equilibrium for each joint, ***j***, in a truss. If ***r*** is the number of reactions and ***b*** is the number of bar members in the truss, determinacy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

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

Determinacy of Coplanar Trusses

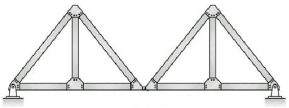


r = 3
b = 5 r+b=2j **determinate**
j = 4

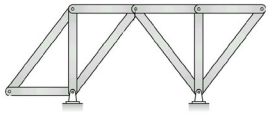


r = 4
b = 18 r+b=2j **determinate**
j = 11

Determinacy of Coplanar Trusses

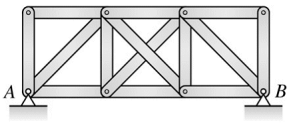


r = 4
b = 10 r+b=2j **determinate**
j = 7

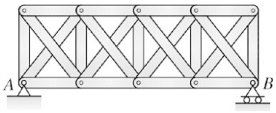


r = 4
b = 10 r+b=2j **determinate**
j = 7

Determinacy of Coplanar Trusses



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



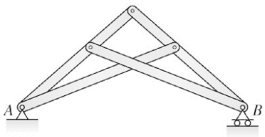
r = 3
b = 21 r+b>2j **indeterminate**
j = 10

Stability of Coplanar Trusses

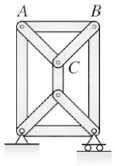
- If ***b + r < 2j***, a truss will be ***unstable***, which means the structure will collapse since there are not enough reactions to constrain all the joints.
- A truss may also be unstable if ***b + r ≥ 2j***. In this case, stability will be determined by inspection

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

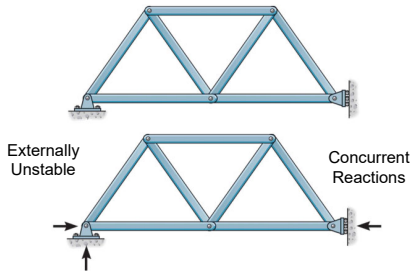


r = 3
b = 9 r+b=2j **unstable**
j = 6

Section ABC is supported by three parallel links

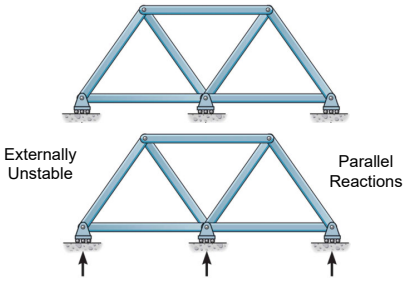
Stability of Coplanar Trusses

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



Stability of Coplanar Trusses

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



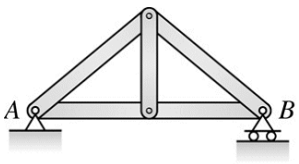
Stability of Coplanar Trusses

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



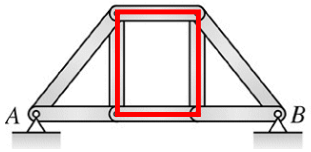
Externally stable

Internally stable

Stability of Coplanar Trusses

Internal stability

Collapsible mechanism



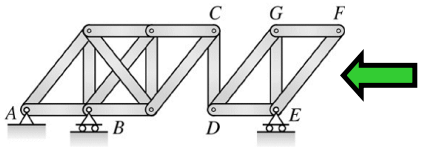
Externally stable

Internally unstable

Stability of Coplanar Trusses

Internal stability

Collapsible mechanism



Externally stable

Internally unstable

End of Trusses - Part 1

Any questions?