Design of Steel Structures

Introduction to Structural Design of Steel

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- Load and resistance factors

Introduction to Design of Steel Structures

- **General Introduction**
  - Structural design is a systematic & iterative process that involves:
    - Identification of intended *use* & *occupancy* of a structure – by owner
    - Development of architectural plans & layout – by architect
    - Identification of structural framework – by engineer
    - Estimation of structural loads depending on use & occupancy
    - Analysis of the structure to determine member & connection design forces
    - Design of structural members & connections
    - Verification of design
    - Fabrication & Erection – by steel fabricator & contractor
    - Inspection & Approval – by state building official

Primary Responsibilities

- The primary responsibilities are:
  - Owner - primary responsibility is deciding the use & occupancy, & approving the arch. plans of the building.
  - Architect - primary responsibility is ensuring that the architectural plan of the building interior is appropriate for the intended use & the overall building is aesthetically pleasing.
  - Engineer – primary responsibility is ensuring the safety & serviceability of the structure, i.e., designing the building to carry the loads safely.

Primary Responsibilities

- Fabricator – primary responsibility is ensuring that the designed members & connections are fabricated economically in the shop or field as required.
- Contractor/Erector - primary responsibility is ensuring that the members & connections are economically assembled in the field to build the structure.
- State Building Official – primary responsibility is ensuring that the built structure satisfies the appropriate building codes accepted by the Govt.

Structural Design

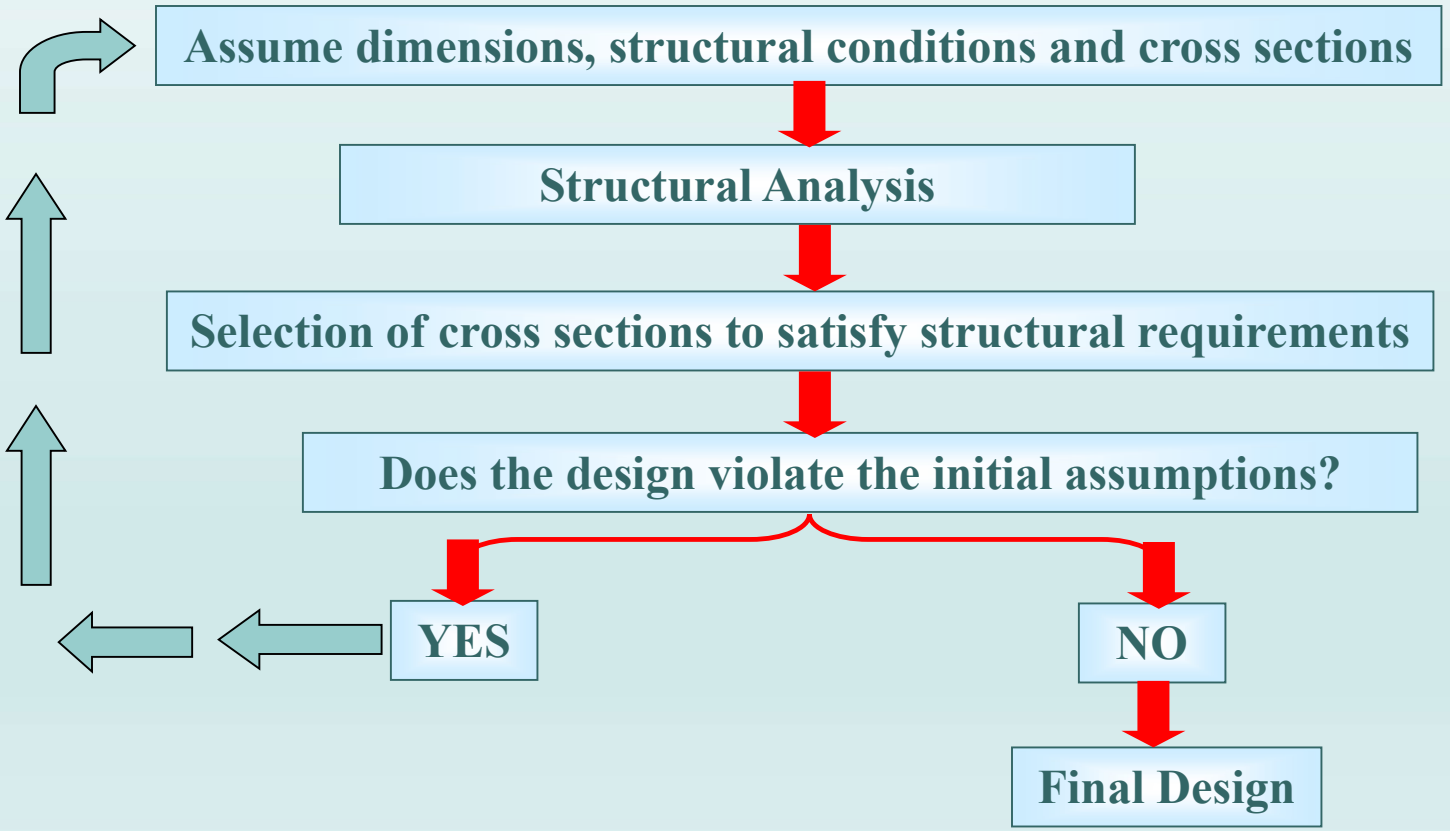
- Conceptually, from an engineering standpoint, the parameters that can be varied (somewhat) are:
  - The material of construction
  - The structural framing plan.
- The choices for material include:
  - *Steel*
  - Reinforced concrete
  - Steel-concrete composite construction.
- The choices for structural framing plan include:
  - Moment resisting frames.
  - Braced frames.
  - Dual frames
  - Shear wall frames, and so on.
- The engineer can also *innovate* a new structural framing plan for a particular structure if required.

Structural Design

- All viable material + framing plan alternatives must be considered & designed to compare the individual material + fabrication / erection costs to identify the most efficient & economical design for the structure.
- For each material + framing plan alternative considered, designing the structure consists of designing the individual structural components, i.e., the members & the connections, of the framing plan.

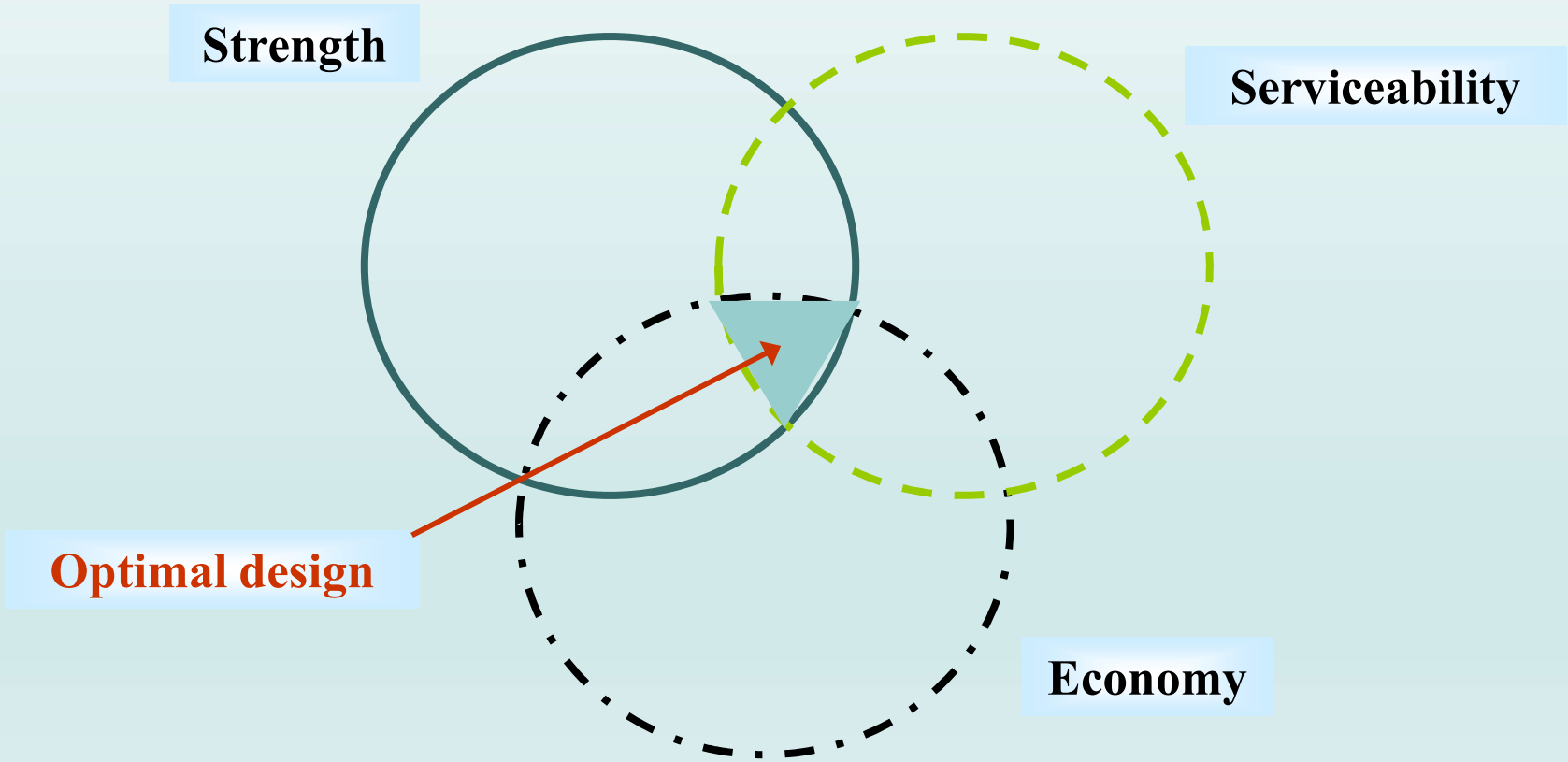
Structural Design

- Determination of dimensions and selection of cross sections.
- The design process is a loop:



Structural Design

- Optimal structural design shall achieve balance between the following requirements:



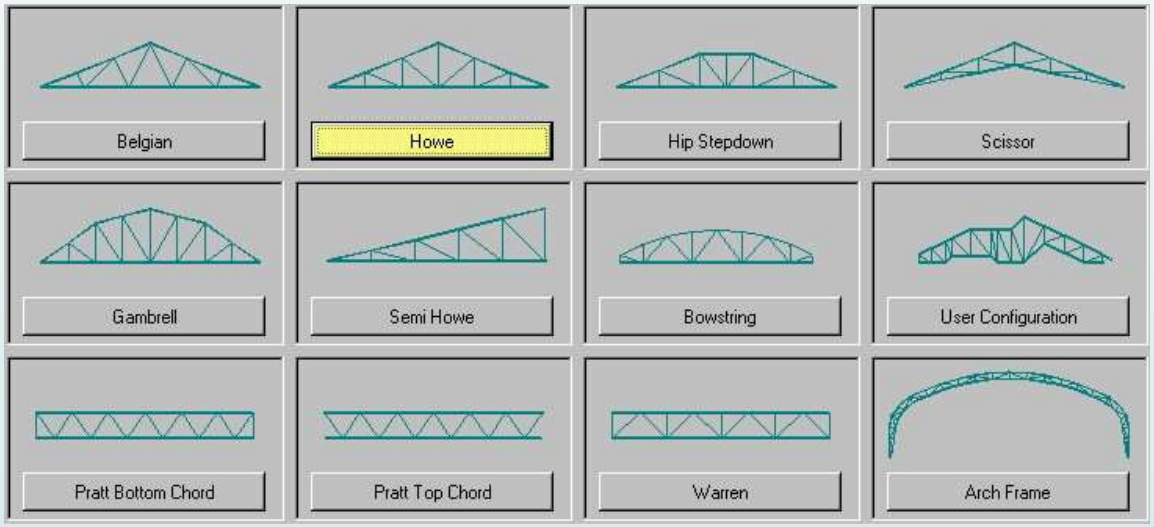
Roles and responsibilities of the structural steel designer

- Arrange and proportion the members of the structures, using engineer's intuition and sound engineering principles, so that they can be *practically* erected, have sufficient strength (*safe*), and are *economical*.

  - Practicality: Ensure structures can be fabricated and erected without problems
  - Safety: Ensure structures can safely support the loads. Ensure deflections and vibrations are controlled for occupants comfort.
  - Cost: Minimize costs without sacrifice of strength (consider labor costs in fabrication and erection, not just material costs)

Basic Structural Shapes

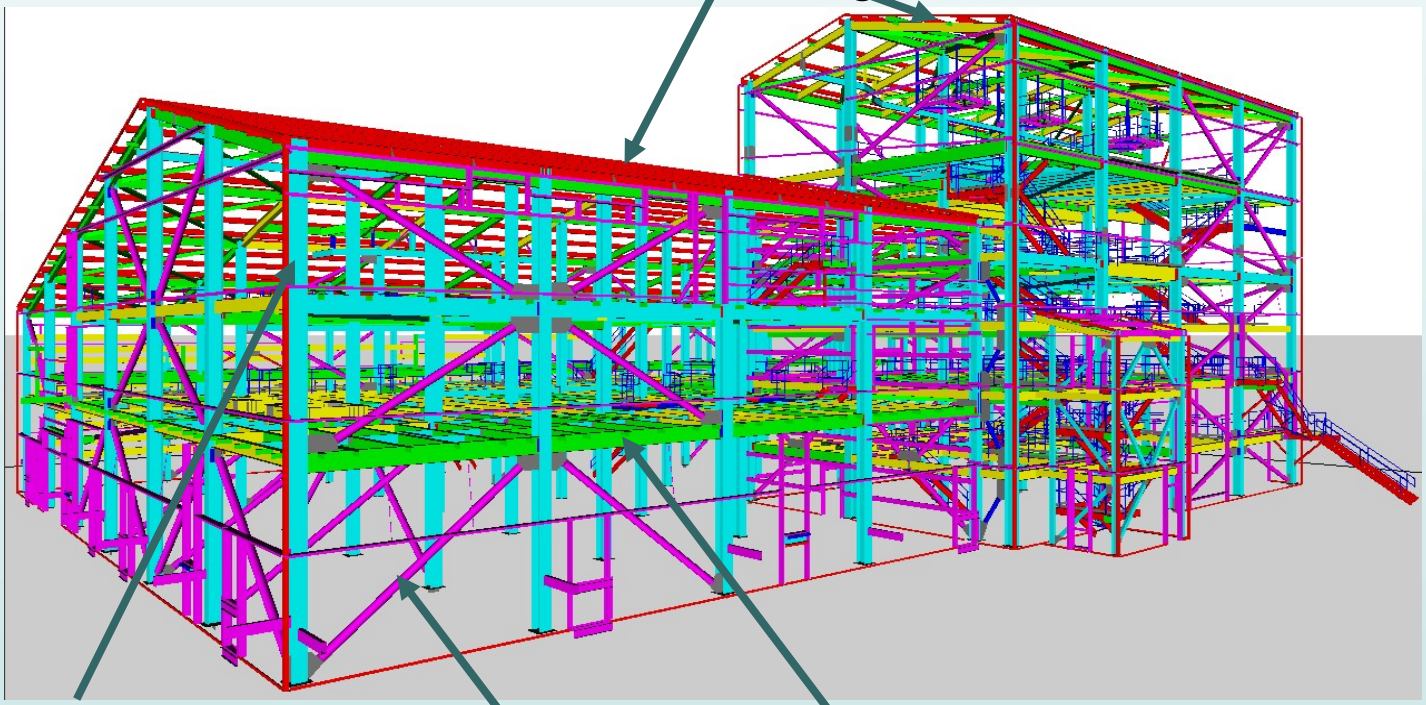
- Trusses



- Frames (Beam-Column)
  - Beams
  - Girders
  - Columns

- Space trusses/frames

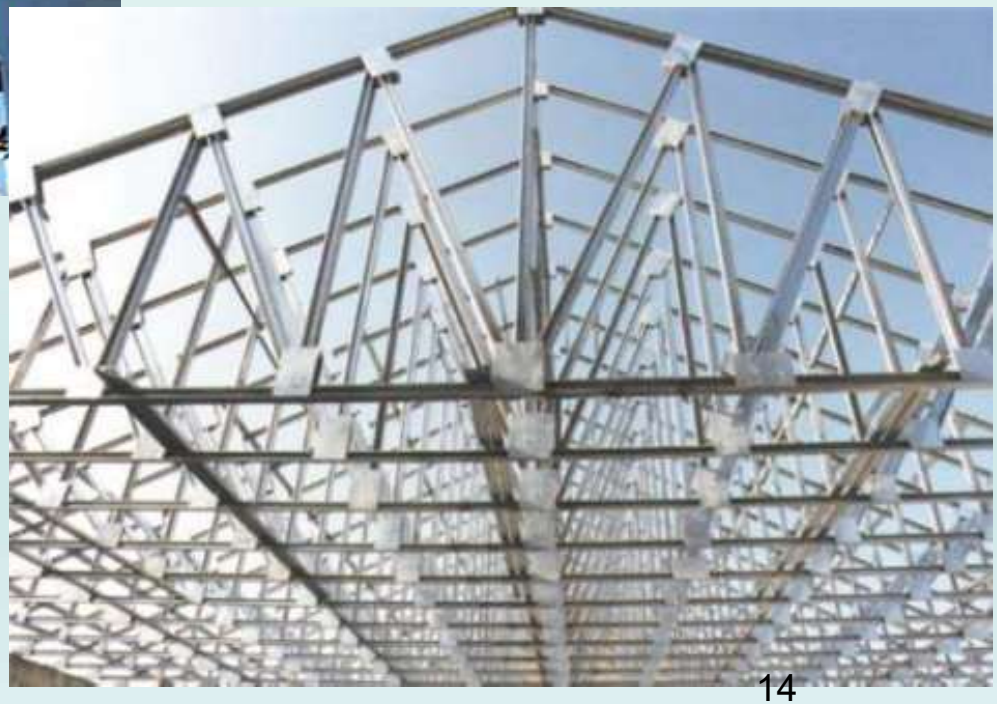
Steel Structures



Steel Structures

Industrial/Parking structures “Frames”

Steel Structures

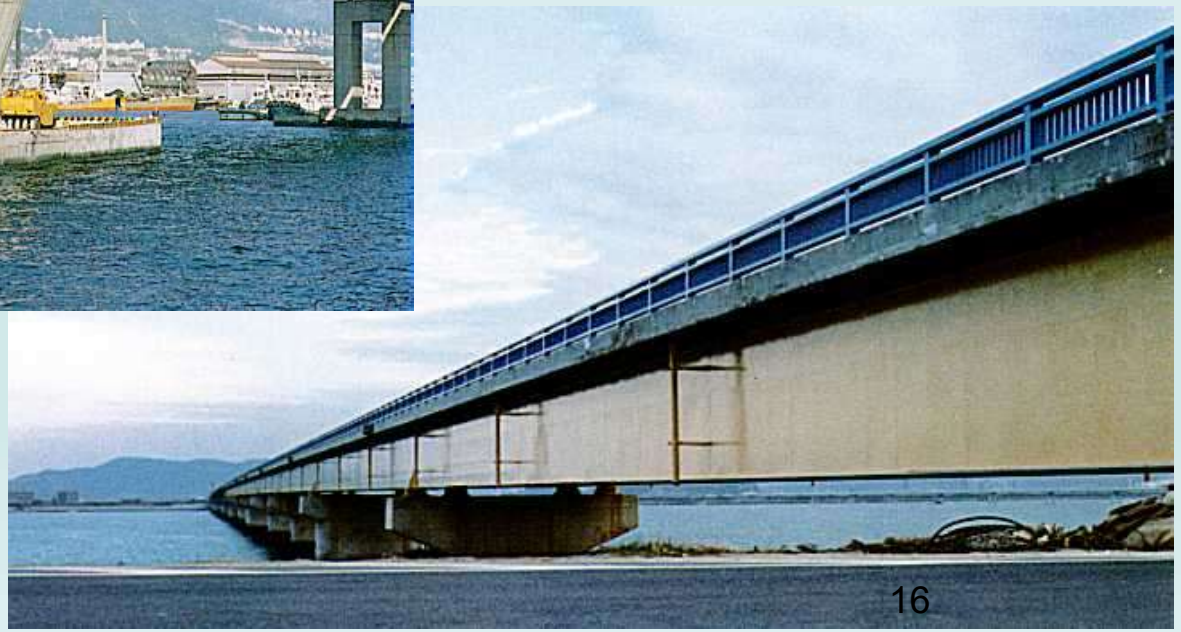


Joists/Trusses

Steel Structures

High rise buildings

Steel Structures



- Girder bridges

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- Truss bridges

Steel Structures

- Cable stayed & suspended bridges

Structural Members

- Structural members are categorized based up on the internal forces in them. For example:
  - Tension member –subjected to tensile axial force only
  - Column or compression member –subjected to compressive axial force only
  - Tension/Compression member –subjected to tensile/compressive axial forces
  - Beam member –subjected to flexural loads, i.e., shear force & bending moment only. The
  - axial force in a beam member is negligible.
  - Beam-column member – member subjected to combined axial force & flexural loads (shear
  - force, & bending moments)

Structural Members

- In trusses:
  - All the members are connected using pin/hinge connections.
  - All external forces are applied at the pins/hinges.
  - All truss members are subjected to axial forces (tension or compression) only.
- In frames:
  - The horizontal members (beams) are subjected to flexural loads only.
  - In braced frames:
    - The vertical members (columns) are subjected to compressive axial forces only.
    - The diagonal members (braces) are subjected to tension/compression axial forces only.
  - In moment frames
    - The vertical members (beam-columns) are subjected to combined axial & flexural loads.