CEEN 4316:
Structural Steel Design

Background Information

Fall 2023

Dr. Bailey

- What is the role of codes, such as the AISC code, in structural design?
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Role of Codes

- Various codes are applied during the design and construction of a building or other large-scale infrastructure project.
- Structural engineers have a responsibility to the public to abide by code provisions.
- When structures fail during service or construction, the codes provide protection to the engineer. You must be able to prove that you met or exceeded code specifications in your design.

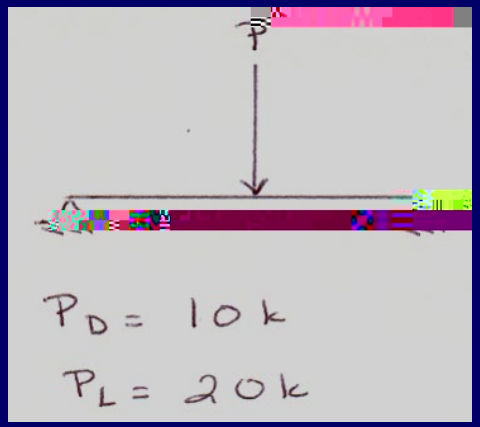
Role of Codes

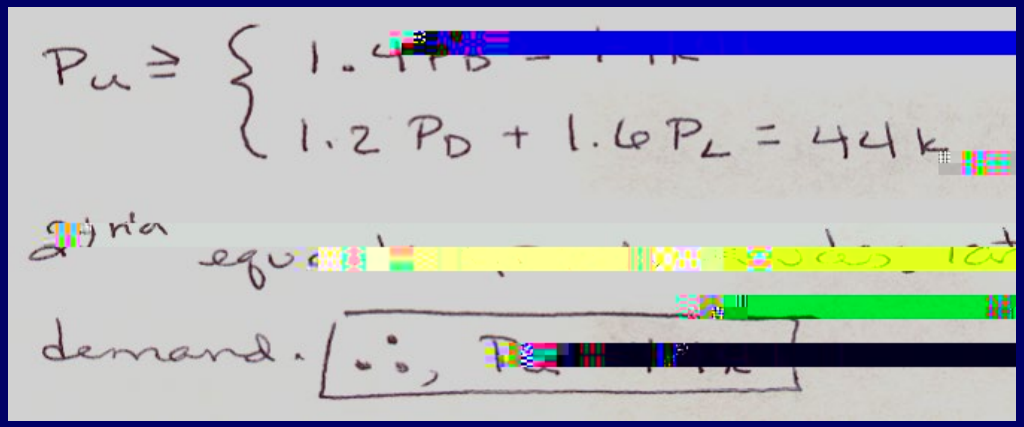
- Building Codes: (Ex. International Building Code, IBC)
  - Adopted by government entities (cities, states, etc.) or specified in contract documennts.
  - Describe minimum requirements for construction – from plumbing to structural safety.
- Loading Standards: (Ex. ASCE 7)
  - ASCE 7 is included in or referenced by many building codes.
  - Describes minimum external loads a building must withstand.
- Design Specifications: (Ex. AISC manual or ACI code)
  - Industry standards of “good practice” in structural design.
  - Explains how to design individual structural members to withstand external loads calculated with ASCE 7.

Overview of Design Process

External Loads

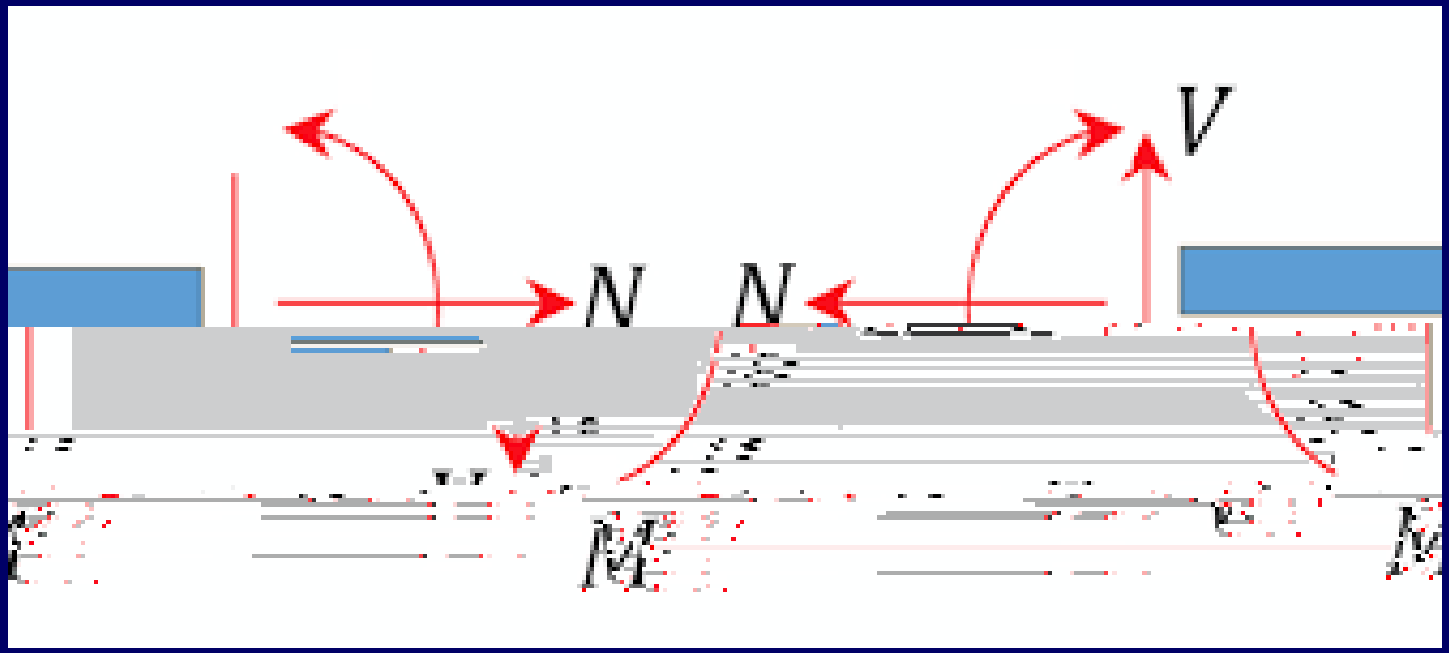
- ASCE 7 load combinations are used to determine the governing load effect on a member– i.e., the most load a member is likely to experience in its lifetime.





- As structures grow more complex, so do the loads applied to them. Multiple load combinations may need to be considered for a structure.

Internal Forces



https://pressbooks.library.upei.ca/statics/chapter/3-types-of-internal-forces/

Internal Forces

Pics from Google images, January 2017.

Trusses:

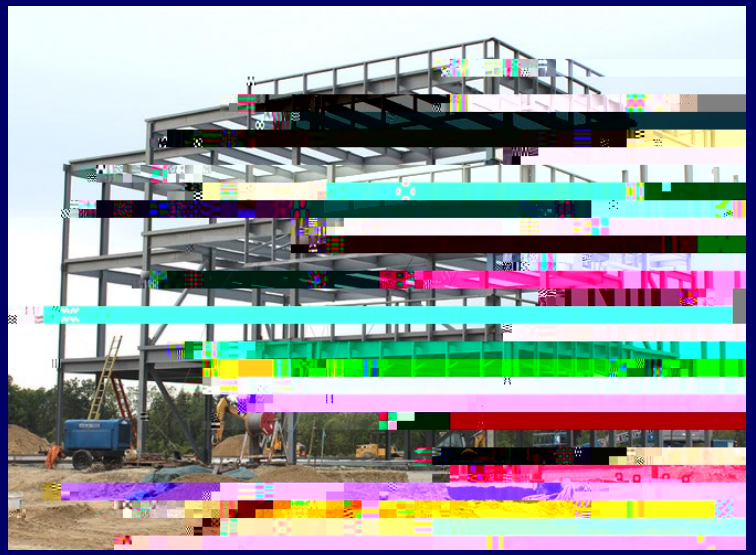
- Members arranged in triangular patterns.
- Members act in tension or compression (axial load only).
- Structure acts like a beam with sections of web missing, so that it is lighter than an equivalently sized beam.
- Used most often for roofs and bridges.

Internal Forces

Frames

- Beams and columns arranged (usually on a rectangular grid) to carry bending loads.
- Connections may be rigid (carry moment) or pinned (carry only shear and axial forces).
- Used in most buildings.

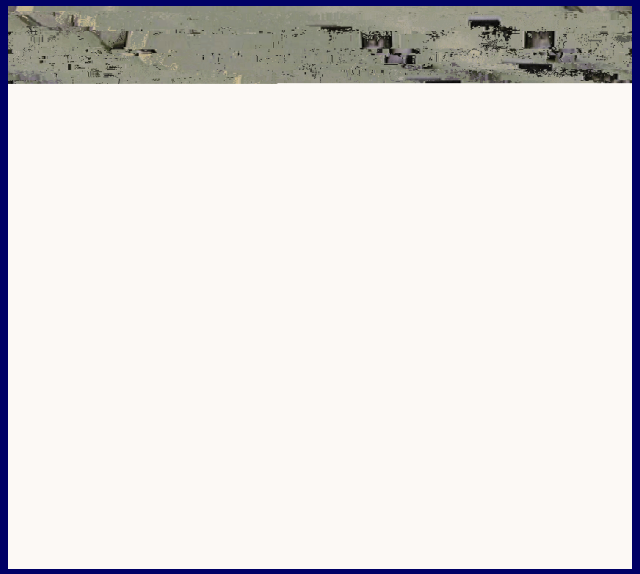
Pics from Google images, January 2017.



Different members within a structure will react differently to the same applied load:

Internal Forces

- Horizontal truss member is in TENSION. It will fracture or yield.
- Diagonal truss member is in COMPRESSION. It will buckle.
- When selecting steel cross-sections for these members, we must consider the expected failure modes.

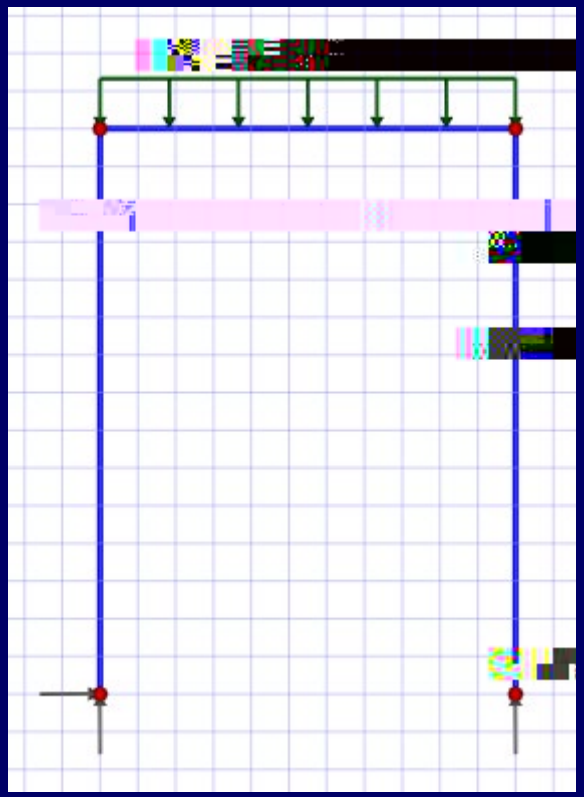


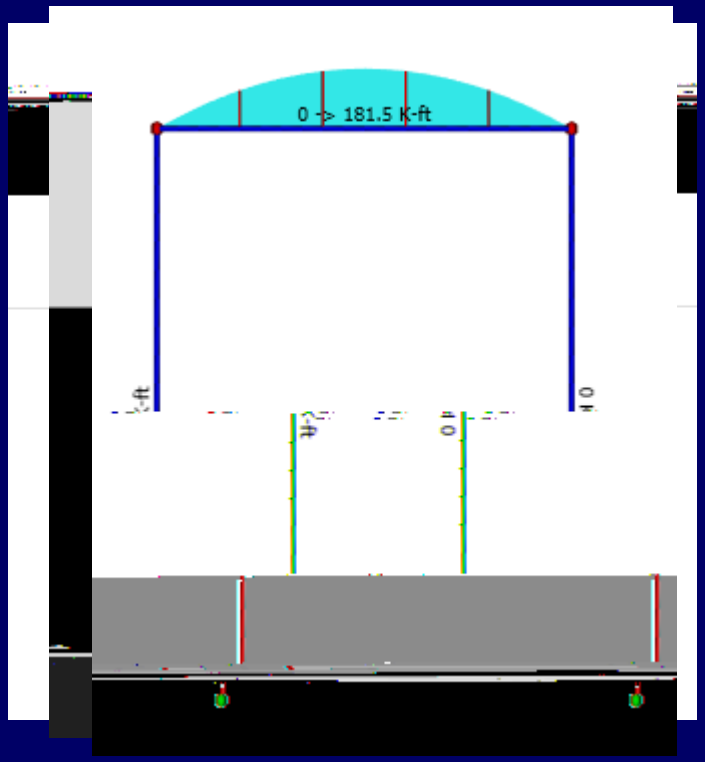
External Loads + Internal Forces

- External loads are factored to determine largest amount of

External Loads + Internal Forces

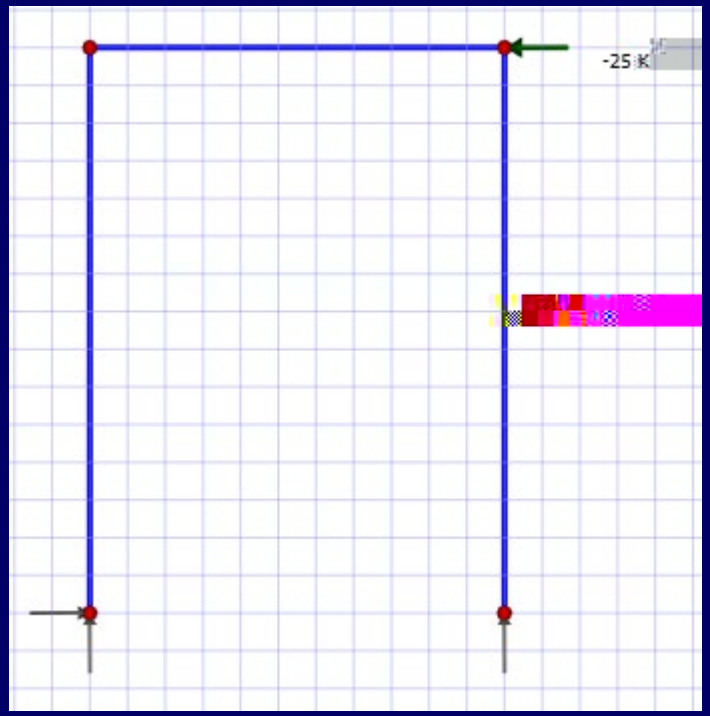
Frame with moment bearing joints subject to gravity load.

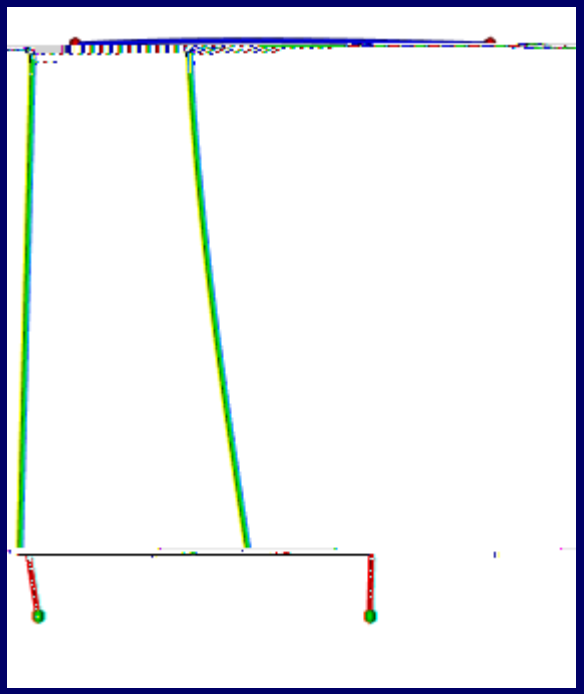




External Loads + xd

Frame with moment bearing joints subject to lateral load.





External Loads + Internal Forces

- Roller supported column always has compressive load only.
- Beam acts in bending with the gravity load, and then acts as a beam-column (compression + bending simultaneously) with the lateral load.
- Pinned column acts in compression only with the gravity load and then acts as a beam-column with the lateral load.
- Expected failure modes change as loads change.
- Different load combinations consider different load sources!

Design Philosophies

- In structural steel, there are two governing design philosophies. Both seek to satisfy the design equation:

$$Q_i < R$$

- Q = load effect; any load creating force or stress in a structural member.
- R = member resistance; the capacity of a structural member to resist the applied load.
- Both design methods strive to select members with enough resistance to withstand the sum of all loads acting on the member while in service (Q_i).

Design Philosophies

- Allowable Stress Design (ASD):
  - Compares stresses due to applied loads to theoretical maximums.
  - Uses one factor of safety to make sure stresses stay below theoretical maximums.
- Governing ASD Equation:

$$Q_i / \quad < R / FS$$

  - = relevant cross-sectional property (A or I)
  - FS = factor of safety

Design Philosophies

- Load and Resistance Factor Design (LRFD):

Course Goal

- We will be designing structural steel components (truss