Connections

- needed to:
  - support beams by columns
  - connect truss members
  - splice beams or columns

- transfer load

- subjected to
  - tension or compression
  - shear
  - bending

Bolts

- bolted steel connections

- types
  - materials
    - high strength
    - A307, A325, A492
  - location of threads
    - included
    - excluded
  - friction or bearing
    - always tightened
Bolted Connection Design

- considerations
  - bearing stress
    - yielding
  - shear stress
    - single & double
  - member
  - rupture

Bolts

- rarely fail in bearing
- holes considered 1/8” larger
- shear & tension
  \[ \frac{R_a}{\phi} \leq \frac{R_u}{\Omega} \leq \phi_v R_n \]
  - single shear or tension
    \[ R_n = F_n A_b \]
  - double shear
    \[ R_n = F_n 2A_b \]

Bolts

- bearing (\( \phi_x \))
  \[ \frac{R_a}{\phi} \leq \frac{R_u}{\Omega} \leq \phi R_n \]
  - deformation is concern
    \[ R_n = 1.2L_c t F_u \leq 2.4dt F_u \]
  - deformation isn’t concern
    \[ R_n = 1.5L_c t F_u \leq 3.0dt F_u \]
  - long slotted holes
    \[ R_n = 1.0L_c t F_u \leq 2.0dt F_u \]

L_c – clear length to edge or next hole (ex. 1¼”, 3”)
Bolts

Tension Members

- steel members can have holes
- reduced area
  \[ A_n = A_g - A_{of \ all \ holes} + t\Sigma \frac{s^2}{4g} \]
- increased stress

Effective Net Area

- likely path to “rip” across
- bolts divide transferred force too
- shear lag  \[ A_e \leq A_n U \]

Tension Members

- limit states for failure
  \[ P_a \leq \frac{P_n}{\Omega}, \quad P_u \leq \phi_t P_n \]
  1. yielding  \[ \phi_t = 0.9, \quad P_n = F_y A_g \]
  2. rupture* \[ \phi_t = 0.75, \quad P_n = F_u A_e \]

\( A_g \) - gross area
\( A_e \) - effective net area
(holes 3/16” + d)
\( F_u \) = the tensile strength of the steel (ultimate)
Framed Beam Connections

- angles
  - bolted
  - welded

Framed Beam Connections

- terms
  - coping

Framed Beam Connections

- tables for standard bolt sizes & spacings
- # bolts
- bolt diameter, angle leg thickness
- bearing on beam web

Beam Connections

- LRFD provisions
  - shear yielding
  - shear rupture
  - block shear rupture
  - tension yielding
  - tension rupture
  - local web buckling
  - lateral torsional buckling
Beam Connections

\[ R_n = 0.6 F_u A_{nv} + U_{bs} F_u A_{nt} \leq 0.6 F_y A_{gv} + U_{bs} F_u A_{nt} \]

- where \( U_{bs} \) is 1 for uniform tensile stress

block shear rupture
tension rupture

Other Bolted Connections

- truss gussets
- base plates
- splices