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
  \[ R_a \leq \frac{R_n}{\Omega} \quad R_u \leq \phi v R_n \]
  - single shear or tension
  \[ R_n = F_n A_b \]
  - double shear
  \[ R_n = F_n 2A_b \]

Bolts

- bearing (\(\phi_x\))
  \[ R_a \leq \frac{R_n}{\Omega} \quad R_u \leq \phi R_n \]
  - 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”)

Table 7-1: Available Shear Strength of Bolts, kips
Table 7-2: Available Tensile Strength of Bolts, kips

Bolts

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

**Tension Members**

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

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

The Royal Ontario Museum
Toronto, Canada
Daniel Libeskind
(AISC - Steel Structures of the Everyday)