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

Bolts

• types
  – materials
    • high strength
    • A307, A325, A492
  – location of threads
    • included - N
    • excluded - X
  – bearing or friction (SC)
    • 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
    \[ R_n = F_n 2A_b \]

- bearing (\( \phi_x \))
  \[ R_a \leq \frac{R_n}{\Omega} \quad R_u \leq \phi v R_n \]
  - deformation is concern
    \[ R_n = 1.2L_c tF_u \leq 2.4dtF_u \]
  - deformation isn’t concern
    \[ R_n = 1.5L_c tF_u \leq 3.0dtF_u \]
  - long slotted holes
    \[ R_n = 1.0L_c tF_u \leq 2.0dtF_u \]
  \( L_c \) – clear length to edge or next hole (ex. 1¼”, 3”)

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Bolts

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Bolts

Tension Members

- steel members can have holes
- reduced area
- increased stress

$$A_n = A_g - A_{of \ all \ holes} + \sigma \sum \frac{s^2}{4g}$$

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
  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

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

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

Other Bolted Connections

- truss gussets
- base plates
- splices

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