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

<table>
<thead>
<tr>
<th>Hole Type</th>
<th>Edge Distance (in.)</th>
<th>( f_c ) (psi)</th>
<th>( f_y ) (ksi)</th>
<th>( f_t ) (ksi)</th>
<th>( f_r ) (ksi)</th>
<th>( f_d ) (ksi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD-5/8</td>
<td>3/16</td>
<td>17,900</td>
<td>55</td>
<td>36</td>
<td>48</td>
<td>72</td>
</tr>
<tr>
<td>HD-3/4</td>
<td>3/16</td>
<td>23,500</td>
<td>55</td>
<td>36</td>
<td>48</td>
<td>72</td>
</tr>
<tr>
<td>HD-1</td>
<td>3/16</td>
<td>23,500</td>
<td>55</td>
<td>36</td>
<td>48</td>
<td>72</td>
</tr>
</tbody>
</table>

**Tension Members**

- **steel members can have holes**
- **reduced area**

\[
A_n = A_g - \sum A_{of all holes} + \tau \frac{S}{4g}
\]

- **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**

\[
P_a \leq \frac{P_u}{\Omega} \quad P_u \leq \phi P_n
\]

1. **yielding** \( \phi = 0.9 \) \( P_n = F_y A_g \)
2. **rupture** \( \phi = 0.75 \) \( P_n = F_u A_e \)

- \( A_g \) - 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

Beam Connections

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

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

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

\( \phi = 0.75 \)

Other Bolted Connections

- truss gussets
- base plates
- splices

block shear rupture
tension rupture