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

Welds

- welded steel connections
Bolts

- types
  - materials
    - high strength
    - A307, A325, A490
  - location of threads
    - included - N
    - excluded - X
  - friction or bearing (SC)
    - always tightened

Bolted Connection Design

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

\[
R_a \leq \frac{R_n}{\Omega} \quad R_u \leq \phi_v R_n
\]

- single shear or tension
  \[
  \phi_v = 0.75
  \]

- double shear
  \[
  R_n = F_n A_b
  \]
  \[
  R_n = F_n 2A_b
  \]

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http://www.fastenal.com
Bolts

- **bearing**
  \[ R_a \leq \frac{R_n}{\Omega}, \quad R_u \leq \phi R_n \]
  \( \phi = 0.75 \)
  - deformation is concern
    \[ R_n = 1.2 L_c t F_u \leq 2.4 dt F_u \]
  - deformation isn’t concern
    \[ R_n = 1.5 L_c t F_u \leq 3.0 dt F_u \]
  - long slotted holes
    \[ R_n = 1.0 L_c t F_u \leq 2.0 dt F_u \]
  \( L_c \) – clear length to edge or next hole (ex. 1\( \frac{1}{4} \), 3")

Welded Connection Design

- **considerations**
  - shear stress
  - yielding
  - rupture

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Welded Connection Design

- **weld terms**
  - butt weld
  - fillet weld
  - plug weld
  - throat
  - field welding
  - shop welding

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Welded Connection Design

- Table 7-5
  Available Bearing Strength at Bolt Holes Based on Edge Distance
  kips/ft, Thickness

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Welded Connection Design

• weld process
  – melting of material
  – melted filler - electrode
  – shielding gas / flux
  – potential defects

• weld materials
  – E60XX
  – E70XX
  \( F_{EXX} = 70 \text{ ksi} \)

Welded Connection Design

• shear failure assumed
• throat
  – \( T = 0.707 \times \text{weld size} \)
• area
  – \( A = T \times \text{length of weld} \)
• weld metal generally stronger than base metal (ex. \( F_y = 50 \text{ ksi} \))

Welded Connection Design

• minimum
  – table

• maximum
  – material thickness ( to \( ¼” \))
  – \( 1/16” \) less

• min. length
  – \( 4 \times \text{size min.} \)
  – \( ≥ 1 \frac{1}{2}” \)

**TABLE J2.4**

<table>
<thead>
<tr>
<th>Material Thickness of Thicker Part Jointed, in (mm)</th>
<th>Minimum Size of Fillet Welds, in (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( ½ )</td>
<td>( 3.5 )</td>
</tr>
<tr>
<td>( ¾ )</td>
<td>4.77</td>
</tr>
<tr>
<td>( 1 )</td>
<td>5.97</td>
</tr>
<tr>
<td>( 1½ )</td>
<td>7.16</td>
</tr>
<tr>
<td>( 1¾ )</td>
<td>8.35</td>
</tr>
<tr>
<td>( 2 )</td>
<td>9.55</td>
</tr>
<tr>
<td>( 2½ )</td>
<td>13.93</td>
</tr>
<tr>
<td>( 3 )</td>
<td>14.32</td>
</tr>
</tbody>
</table>

\( \text{R}_n = 0.6 F_{EXX} T l = S l \)

Welded Connection Design

• shear
  \[ R_a \leq \frac{R_n}{\Omega} \]
  \[ R_u \leq \phi R_n \]
  \[ \phi = 0.75 \]

\begin{equation}
R_n = 0.6 F_{EXX} T l = S l
\end{equation}

**Available Strengths of Fillet Welds**

- \( \text{per inch of weld (fl)} \)
  - 60XX
  - 70XX

<table>
<thead>
<tr>
<th>Weld Size (in.)</th>
<th>60XX (ksi)</th>
<th>70XX (ksi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( ½ )</td>
<td>3.55</td>
<td>4.10</td>
</tr>
<tr>
<td>( ¾ )</td>
<td>4.77</td>
<td>5.57</td>
</tr>
<tr>
<td>( 1 )</td>
<td>5.97</td>
<td>6.96</td>
</tr>
<tr>
<td>( 1½ )</td>
<td>7.16</td>
<td>8.35</td>
</tr>
<tr>
<td>( 1¾ )</td>
<td>8.35</td>
<td>9.74</td>
</tr>
<tr>
<td>( 2 )</td>
<td>9.55</td>
<td>11.14</td>
</tr>
<tr>
<td>( 2½ )</td>
<td>13.93</td>
<td>13.92</td>
</tr>
<tr>
<td>( 3 )</td>
<td>14.32</td>
<td>16.70</td>
</tr>
</tbody>
</table>

*(not considering increase in bent weld submerged arc weld process)*
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

(AISC - Steel Structures of the Everyday)
**Framed Beam Connections**

- welded moment example

![Image of welded moment example](AISC - Steel Structures of the Everyday)

**Framed Beam Connections**

- welded/bolted moment example

![Image of welded/bolted moment example](AISC - Steel Structures of the Everyday)

**Beam Connections**

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

![Diagram of beam connections](AISC - Steel Structures of the Everyday)
**Beam Connections**

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

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

**Other Connections**

- **seated beam**
- **continuous**
  - beam to column
  - beam to beam

**Other Connections**

- **splices**
- **rigid frame knees**
- **gussets & joints**
Other Connections

- base plates
  - anchor bolts
  - bearing on steel
  - bending of plate