Connections

- needed to:
  - support beams by columns
  - connect truss members
  - splice beams or columns
- transfer load
- subjected to
  - tension or compression
  - shear
  - bending

Connections in steel structures:

- 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

Bolts

- rarely fail in bearing
- holes considered 1/8” larger
- shear & tension
  \[ R_a \leq \frac{R_n}{\phi_v} \]
  \[ R_u \leq \phi_v R_n \]
  - single shear or tension \( \phi_v = 0.75 \)
  - double shear
    \[ R_n = F_n A_p \]
    \[ R_n = F_n 2A_p \]
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
    \[ R_n = 1.0 L_c t F_u \leq 2.0 dt F_u \]
  \[ L_c - \text{clear length to edge or next hole (ex. 1\frac{1}{4}'', 3'')} \]

Welded Connection Design

- considerations
  - shear stress
  - yielding
  - rupture

Welded Connection Design

- weld terms
  - butt weld
  - fillet weld
  - plug weld
  - throat
  - field welding
  - shop welding
Welded Connection Design

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

- **weld materials**
  - E60XX
  - E70XX
  - $F_{EXX} = 70$ ksi

Welded Connection Design

- **shear failure assumed**
- **throat**
  - $T = 0.707 \times$ weld size
- **area**
  - $A = T \times$ length of weld
- **weld metal generally stronger than base metal** (ex. $F_y = 50$ ksi)

Welded Connection Design

- **minimum**
  - table

- **maximum**
  - material thickness (to $\frac{1}{4}"$)
  - $1/16"$ less

- **min. length**
  - $4 \times$ size min.
  - $\geq 1 \frac{1}{2}"$

Welded Connection Design

<table>
<thead>
<tr>
<th>TABLE J2.4</th>
<th>Minimum Size of Fillet Welds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Thickness of Thicker Part Joined, in. (mm)</td>
<td>Minimum Size of Weld, in. (mm)</td>
</tr>
<tr>
<td>$\frac{3}{16}$ (5)</td>
<td>$<em>a</em> (8)$</td>
</tr>
<tr>
<td>$\frac{1}{4}$ (6)</td>
<td>$<em>a</em> (8)$</td>
</tr>
<tr>
<td>$\frac{5}{32}$ (4)</td>
<td>$<em>a</em> (8)$</td>
</tr>
</tbody>
</table>

- $^a$ See Section 2.2 for maximum size of fillet welds.

Welded Connection Design

- **shear**
  - $R_u \leq \frac{R_n}{\Omega}$
  - $R_u \leq \phi R_n$
  - $\phi = 0.75$

  $R_n = 0.6 F_{EXX} Tl = S_l$

  - table for $\phi S$

Welded Connection Design
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

(AISC - Steel Structures of the Everyday)

Framed Beam Connections

• welded/bolted moment example

(AISC - Steel Structures of the Everyday)

Framed Beam Connections

• 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
**Beam Connections**

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

- 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

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**Figure 5-1**: Black Shear Hinge; Load State (Image by J.A. Strefler and R. Fare, courtesy of Georgia Institute of Technology)

**Figure 5-14**: Beam to Column Joint State (Image by A.J. Ingleson and B. Jost, courtesy of Georgia Institute of Technology)

**The Royal Ontario Museum**: Toronto, Canada

(AISC - Steel Structures of the Everyday)

*Steel Bolts & Welding 25*

Lecture 18

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*Steel Bolts & Welding 26*

Lecture 21

ARCH 331

*Steel Bolts & Welding 28*

Lecture 21

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Other Connections

• base plates
  – anchor bolts
  – bearing on steel
  – bending of plate