wood construction: connections
Connectors

- **joining**
  - lapping
  - interlocking
  - butting

- **mechanical**
  - “third-elements”

- **transfer load at a point, line or surface**
  - generally more than a point due to stresses
Wood Connectors

- **adhesives**
  - used in a controlled environment
  - can be used with nails

- **mechanical**
  - bolts
  - lag bolts or lag screws
  - nails
  - split ring and shear plate connectors
  - timber rivets
Wood Connections

• mechanical
Bolted Joints

- connected members in tension cause shear stress

- connected members in compression cause bearing stress
Tension Members

- members with holes have reduced area
- increased tension stress
- $A_e$ is effective net area

\[
 f_t = \frac{P}{A_e} \left( \text{or} \frac{T}{A_{e}} \right)
\]
Effective Net Area

- likely path to “rip” across
- bolts divide transferred force too
Single Shear

- seen when 2 members are connected

\[
f_v = \frac{P}{A} = \frac{P}{\pi \frac{d^2}{4}}
\]

Figure 5.11 A bolted connection—single shear.
(a) Two steel plates bolted using one bolt.
(b) Elevation showing the bolt in shear.
Double Shear

- seen when 3 members are connected

\[ \Sigma F = 0 = -P + 2 \left( \frac{P}{2} \right) \]

\[ f_v = \frac{P}{2A} = \frac{P}{2} = \frac{P}{2\pi d^2/4} \]

(two shear planes)

Free-body diagram of middle section of the bolt in shear.

Figure 5.12  A bolted connection in double shear.
Bearing Stress

- compression & contact
- stress limited by species & grain direction to load
- projected area

\[ f_p = \frac{P}{A_{projected}} = \frac{P}{td} \]
Bolted Joints

• **twisting**

  - shearing
  - end distance & spacing

  [Diagram of bolted joint with labels: end distance, shear strength, twisted bolt, and underwashed wood.]

  Figure 1.—Higher connection capacities can be achieved with increased fastener spacings.

  Taylor & Line 2002

• **tear out**

  - shear strength
  - end distance & spacing

[Website: www.timber.org.au]
Nailed Joints

- tension stress (pullout)
- shear stress nails presumed to share load by distance from centroid of nail pattern
Nailed Joints

- sized by pennyweight units / length
- embedment length
- dense wood, more capacity

<table>
<thead>
<tr>
<th>Side Member Thickness, ( t_s ) (in.)</th>
<th>Nail Length, ( L ) (in.)</th>
<th>Nail Diameter, ( D ) (in.)</th>
<th>Pennyweight</th>
<th>Load per Nail for Douglas Fir-Larch ( G = 0.50, Z ) (lb)</th>
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</thead>
<tbody>
<tr>
<td>Structural Plywood Side Members</td>
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<tr>
<td>( \frac{3}{8} )</td>
<td>2</td>
<td>0.113</td>
<td>6d</td>
<td>48</td>
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<td>2( \frac{1}{2} )</td>
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<td>8d</td>
<td>63</td>
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<td>3</td>
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<tr>
<td>( \frac{1}{2} )</td>
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<td>3( \frac{1}{2} )</td>
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</table>

*NDS*
Connectors Resisting Beam Shear

- plates with
  - nails
  - rivets
  - bolts
- splices
- V from beam load related to $V_{\text{longitudinal}}$

\[
\frac{V_{\text{longitudinal}}}{p} = \frac{VQ}{I} \tag{1}
\]

\[
nF_{\text{connector}} \geq \frac{VQ_{\text{connected area}}}{I} \cdot p
\]
Vertical Connectors

- isolate an area with vertical interfaces

\[ n F_{\text{connector}} \geq \frac{VQ_{\text{connected area}}}{I} \cdot p \]