lecture
seventeen

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.

\( f_v \) = Average shear stress through bolt cross section
\( A \) = Bolt cross-sectional area
Double Shear

- seen when 3 members are connected

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

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

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

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

- **twisting**

- **tear out**
  - shear strength
  - end distance & spacing

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

*Taylor & Line 2002*
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

*NDS

**TABLE 7.1 Lateral Load Capacity of Common Wire Nails (lb/nail)**

<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>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structural Plywood Side Members</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/8</td>
<td>2</td>
<td>0.113</td>
<td>6d</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>2 1/2</td>
<td>0.131</td>
<td>8d</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.148</td>
<td>10d</td>
<td>76</td>
</tr>
<tr>
<td>1/2</td>
<td>2</td>
<td>0.113</td>
<td>6d</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>2 1/2</td>
<td>0.131</td>
<td>8d</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.148</td>
<td>10d</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>3 1/2</td>
<td>0.162</td>
<td>16d</td>
<td>92</td>
</tr>
</tbody>
</table>
Connectors Resisting Beam Shear

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

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

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

- isolate an area with vertical interfaces

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