Elements of Architectural Structures: Form, Behavior, and Design
ARCH 614
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Spring 2015

Lecture fifteen

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**

![Nail Connection Diagram](image1)

![Lag Bolt Diagram](image2)
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

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

- seen when 3 members are connected

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

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

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

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*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

![TABLE 7.1 Lateral Load Capacity of Common Wire Nails (lb/nail)](image)

<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>Structural Plywood Side Members</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\frac{3}{8}$</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>$\frac{1}{2}$</td>
<td>2</td>
<td>0.113</td>
<td>6d</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>2 1/2</td>
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<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>

*NDS*
Connectors Resisting Beam Shear

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

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

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

• isolate an area with vertical interfaces

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