ARCHITECTURAL STRUCTURES:
FORM, BEHAVIOR, AND DESIGN
ARCH 331
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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

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

- seen when 3 members are connected

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

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

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

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

Taylor & Line 2002

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>TABLE 7.1 Lateral Load Capacity of Common Wire Nails (lb/nail)</th>
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<tbody>
<tr>
<td>Side Member Thickness, $t_s$ (in.)</td>
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<tr>
<td>Structural Plywood Side Members</td>
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Connectors Resisting Beam Shear

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

$$
\frac{V_{\text{longitudinal}}}{I} = \frac{VQ}{p}
$$

$$
nF_{\text{connector}} \geq \frac{VQ}{I} \cdot \frac{\text{connected area}}{I} \cdot p
$$
Vertical Connectors

- isolate an area with vertical interfaces

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