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

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

(a) Two steel plates bolted using one bolt.

(b) Elevation showing the bolt in shear.

\[f_v = \text{Average shear stress through bolt cross section}
\]

\[A = \text{Bolt cross-sectional area}
\]

\[f_v = \frac{P}{A}
\]

Figure 5.11 A bolted connection—single shear.
Double Shear

- seen when 3 members are connected

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

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

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

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

*NDS

<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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</table>
Connectors Resisting Beam Shear

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

\[
\frac{V_{\text{longitudinal}}}{p} = \frac{VQ}{I} \quad \text{and} \quad nF_{\text{connector}} \geq \frac{VQ_{\text{connected area}}}{I} \cdot p
\]
Vertical Connectors

- isolate an area with vertical interfaces

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