ELEMENTS OF ARCHITECTURAL STRUCTURES:

FORM, BEHAVIOR, AND DESIGN

ARCH 614

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SPRING 2014

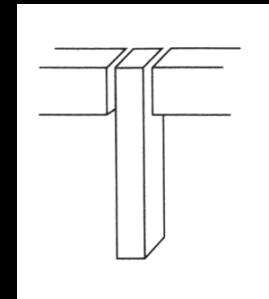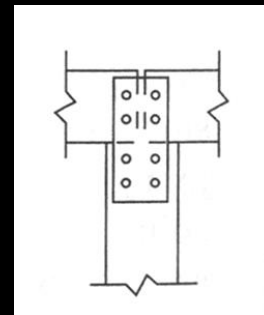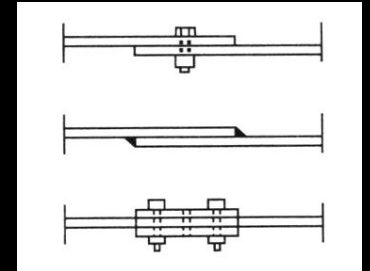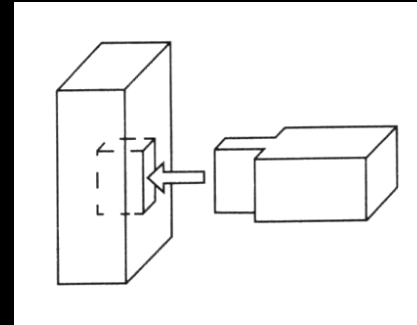*lecture*
fifteen

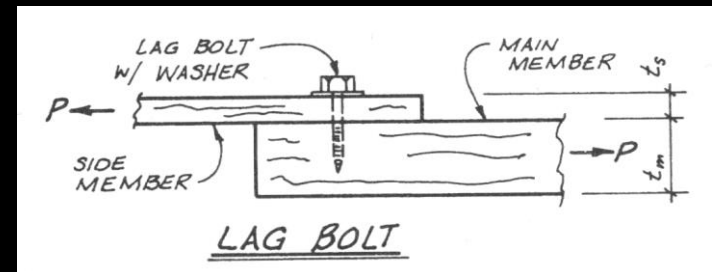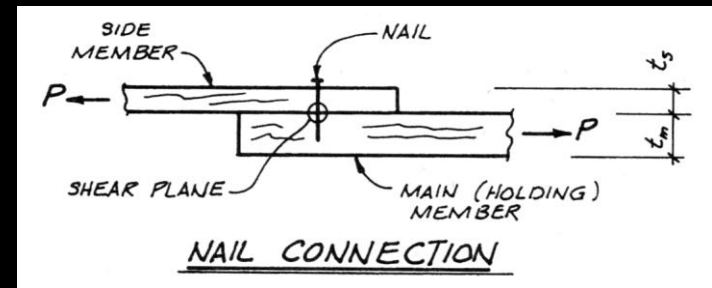# wood construction: connections

Connectors

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

- *mechanical*
  - *"third-elements"*

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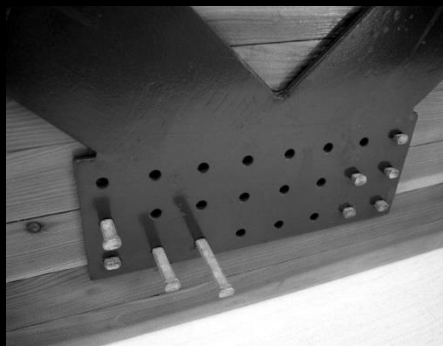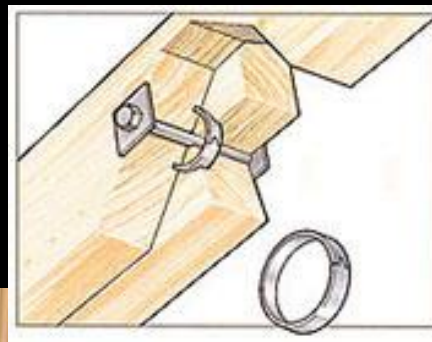 - *generally more than a point due to stresses*

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

LAG BOLT

Wood Connections

- *mechanical*
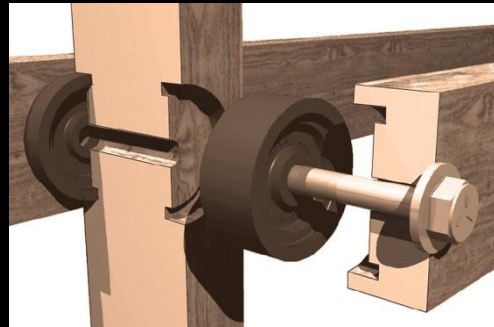
Bolted Joints

- *connected members in tension cause shear stress*
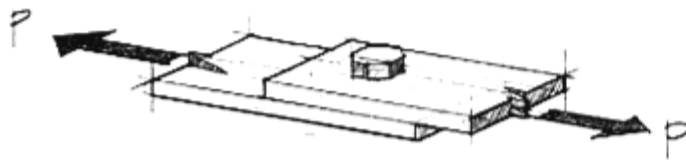
(a) Two steel plates bolted using one bolt.
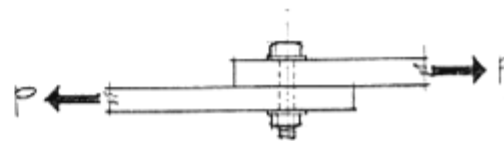
(b) Elevation showing the bolt in

- *connected members in compression cause bearing stress*

CENTER PLATE
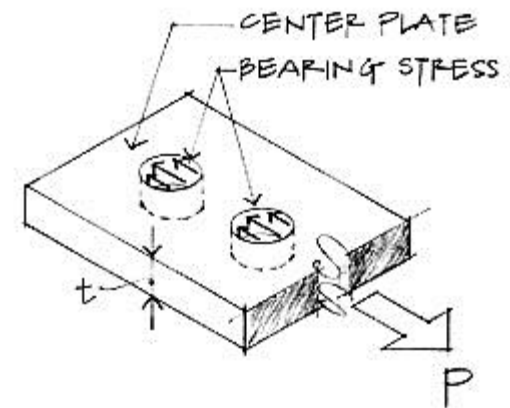
BEARING STRESS

Bearing stress on plate.

Tension Members

- *members with <u>holes</u> have reduced area*
- *increased tension stress*
- *A_e is effective net area*

$$f_t = \frac{P}{A_e} \left(or \frac{T}{A_e} \right)$$

Effective Net Area

- *likely path to "rip" across*

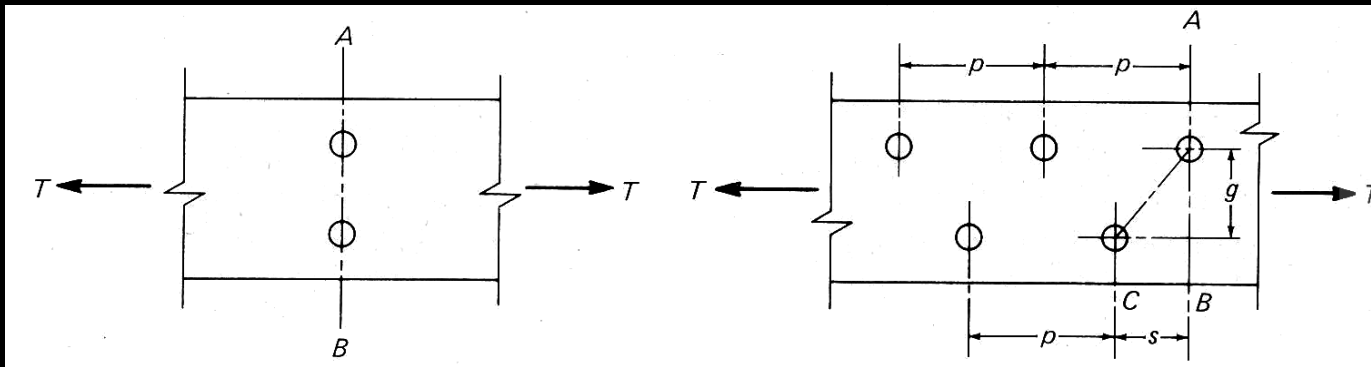- *bolts divide transferred force too*
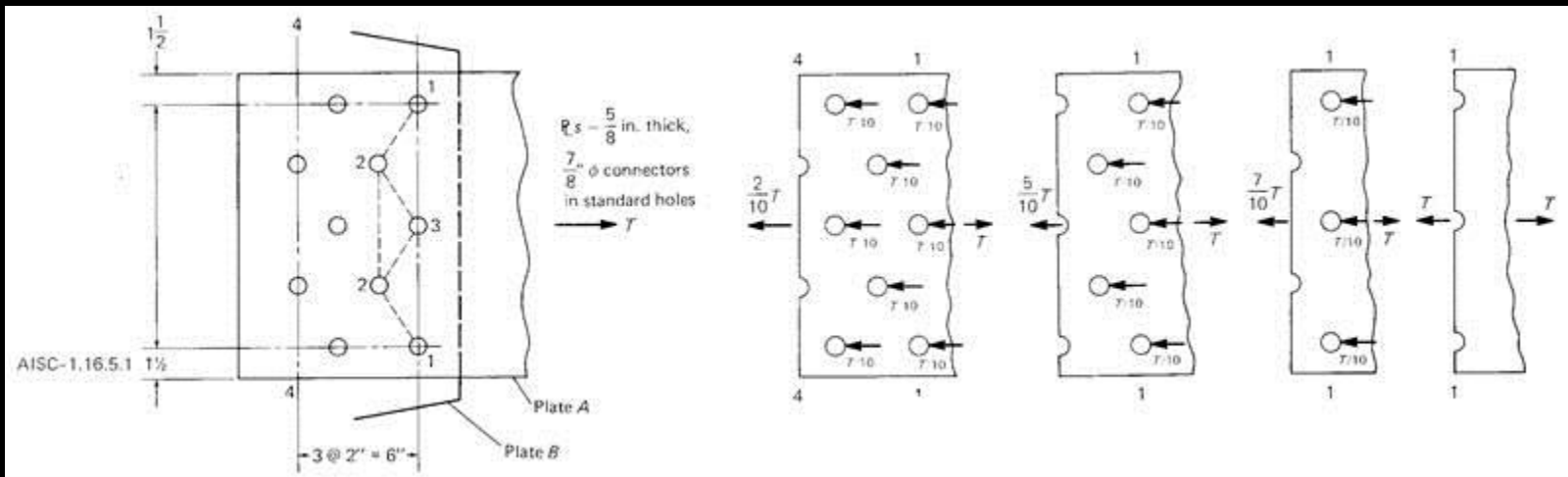
Single Shear

- *seen when 2 members are connected*

(a) Two steel plates bolted using one bolt.

(b) Elevation showing the bolt in shear.

ONE SURFACE IN SHEAR

f_v

(c)

(d)

Figure 5.11 A bolted connection—single shear.

f_v = Average shear stress through bolt cross section

A = Bolt cross-sectional area

$f_v = \dfrac{P}{A}$

$$f_v = \frac{P}{A} = \frac{P}{\pi\, d^2 / 4}$$
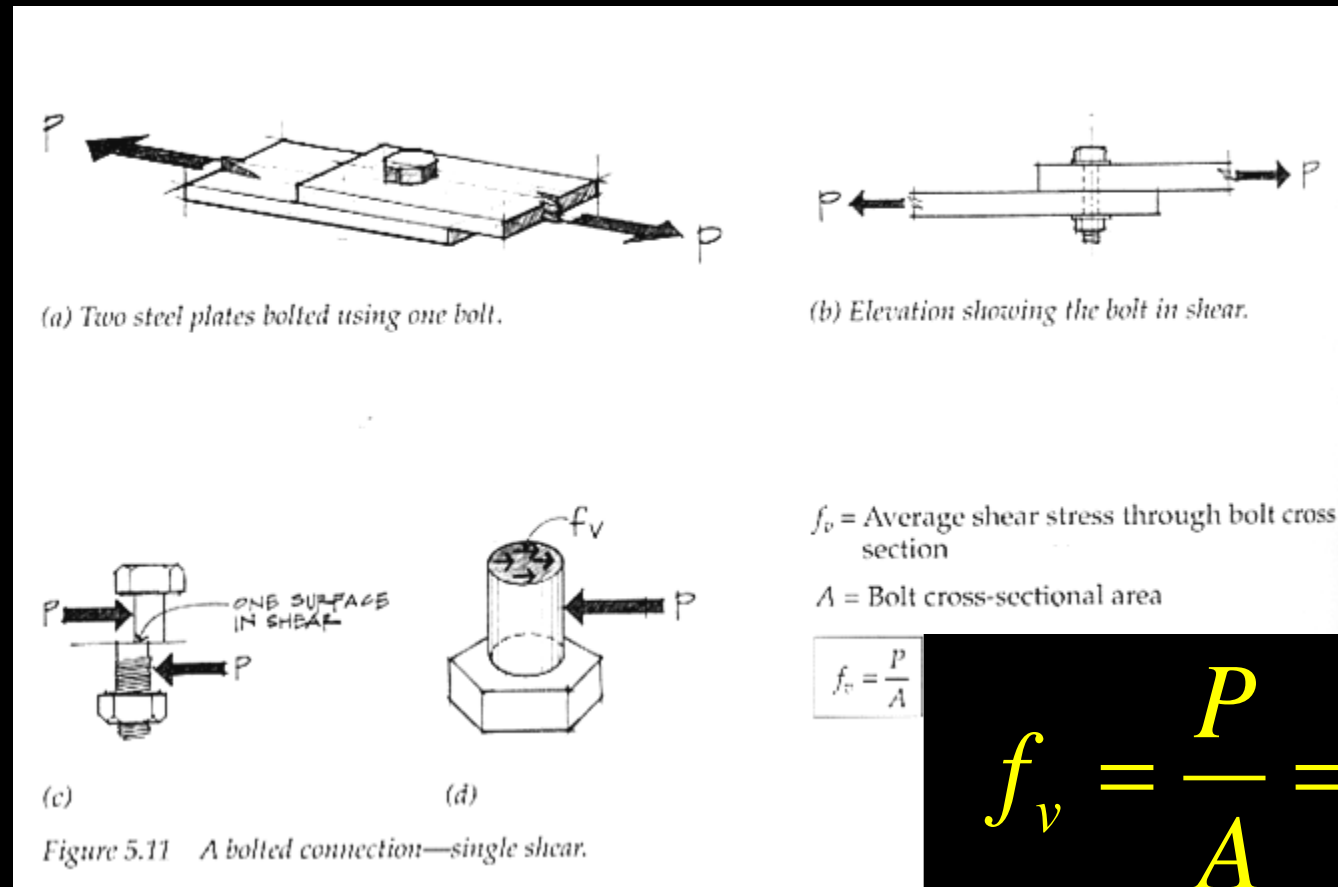
Double Shear

- *seen when 3 members are connected*

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

$$f_v = \frac{P}{2A}$$

(two shear planes)

$$f_v = \frac{P}{2A} = \frac{P/2}{A} = \frac{P/2}{\pi\, d^2/4}$$

Free-body diagram of middle section of the bolt in shear.
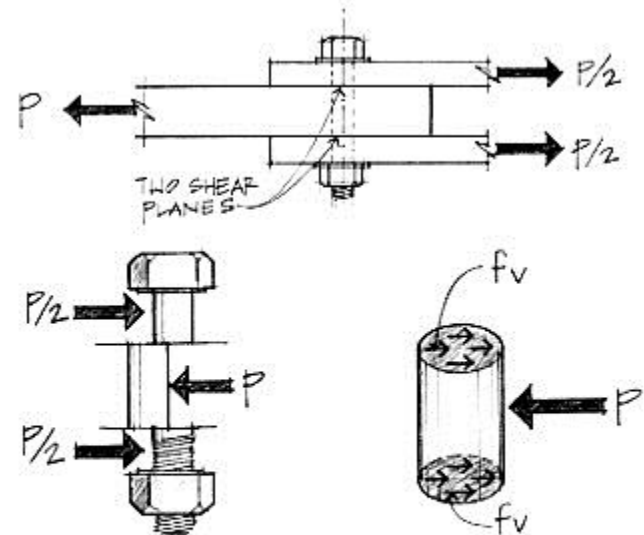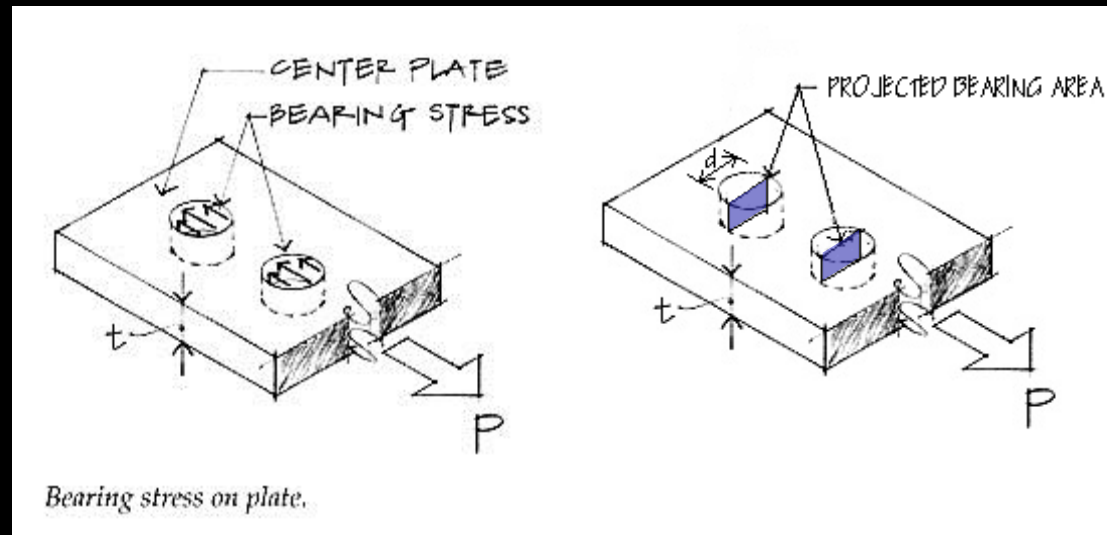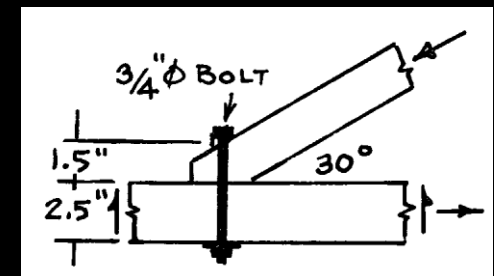
Figure 5.12   A bolted connection in double shear.

Bearing Stress

- *compression & contact*

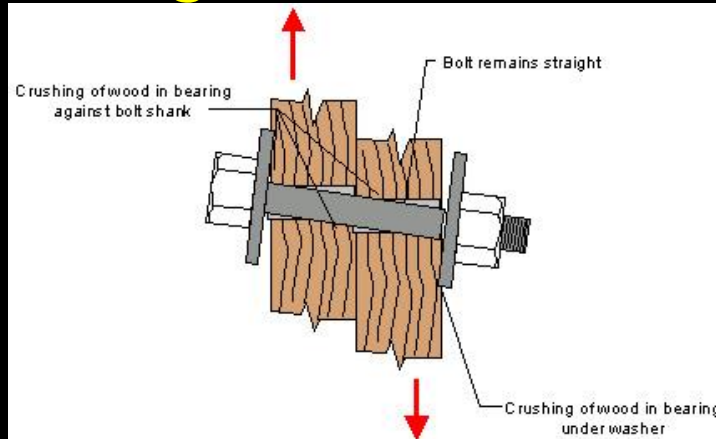- *stress limited by species & grain direction to load*

Bearing stress on plate.

- *projected area*

$$f_p = \frac{P}{A_{projected}} = \frac{P}{td}$$

Bolted Joints

- *twisting*

www.timber.org.au

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

Figure 1.—Higher connection capacities can be achieved with increased fastener spacings.
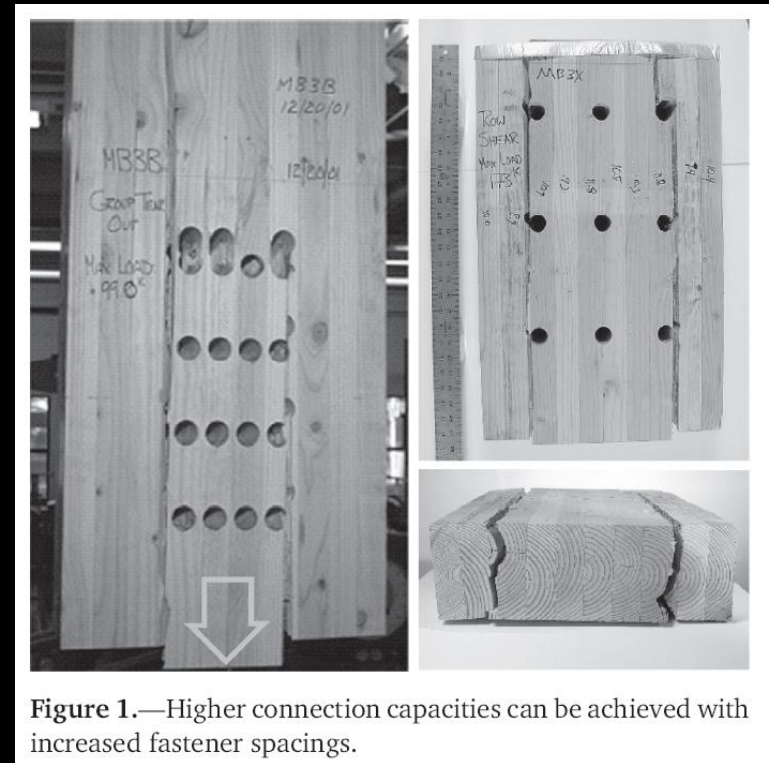
Taylor & Line 2002

Nailed Joints

- *tension stress (pullout)*

- *shear stress nails presumed to share load by distance from centroid of nail pattern*

LATERAL LOAD   SIDE MEMBER   MAIN MEMBER   WITHDRAWAL LOAD
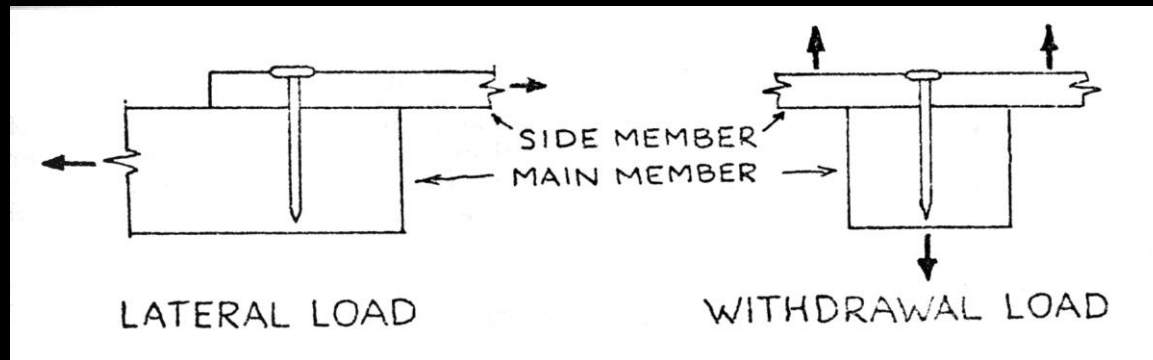
Nailed Joints

- *sized by pennyweight units / length*

- *embedment length*

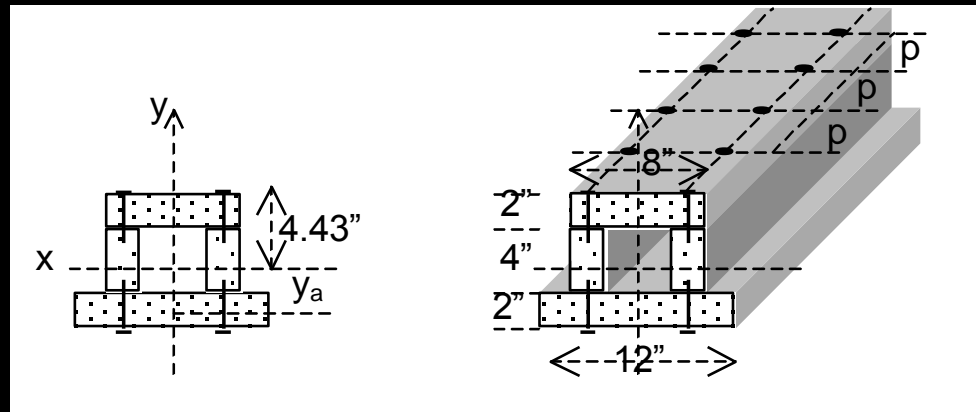- *dense wood, more capacity*

*NDS

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

Side Member Thickness, t_s (in.)	Nail Length, L (in.)	Nail Diameter, D (in.)	Pennyweight	Load per Nail for Douglas Fir-Larch $G = 0.50$, Z (lb)
Structural Plywood Side Members				
3/8	2	0.113	6d	48
	2½	0.131	8d	63
	3	0.148	10d	76
1/2	2	0.113	6d	50
	2½	0.131	8d	65
	3	0.148	10d	78
	3½	0.162	16d	92

Connectors Resisting Beam Shear

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

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

$$nF_{connector} \geq \frac{VQ_{connected\,area}}{I} \cdot p$$

Vertical Connectors

- *isolate an area with vertical interfaces*

$$nF_{connector} \geq \frac{VQ_{connected\ area}}{I} \cdot p$$