

**ARCHITECTURAL STRUCTURES:  
FORM, BEHAVIOR, AND DESIGN**

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**ARCH 331**

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**FALL 2018**

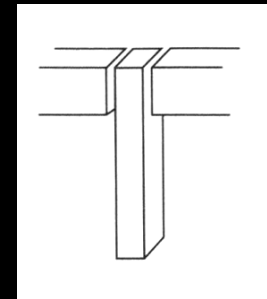
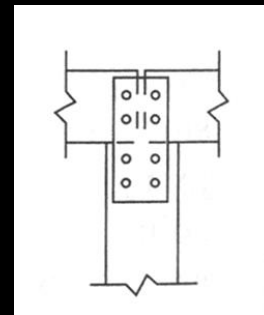
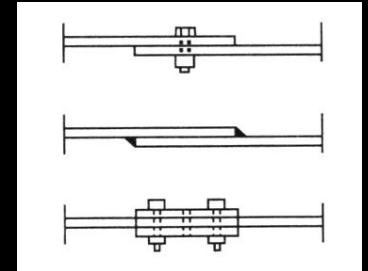
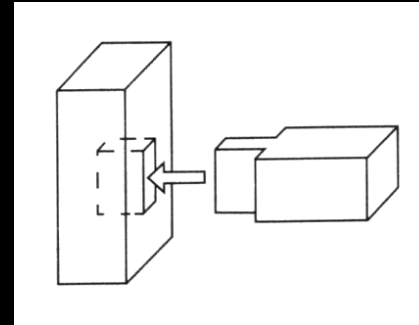
*lecture*  
**seventeen**



**wood construction:  
connections**

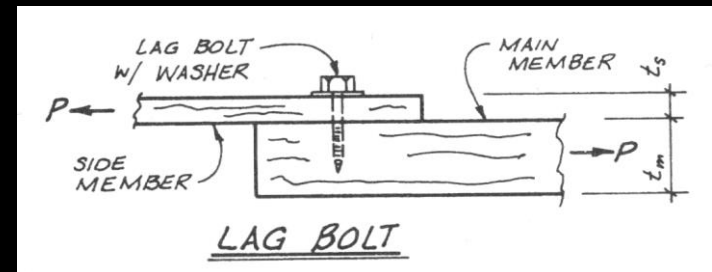
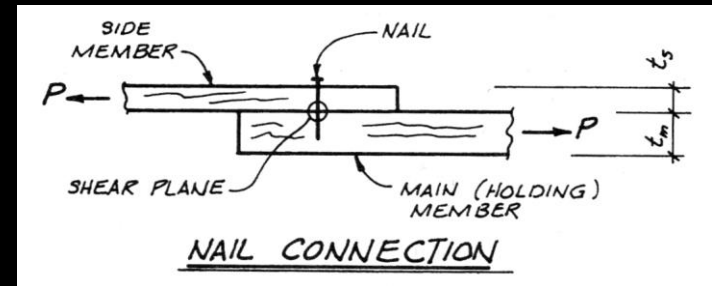
# Connectors

- *joining*
  - *lapping*
  - *interlocking*
  - *butting*
- *mechanical*
  - “*third-elements*”
- *transfer load at a point, line or surface*
  - *generally more than a point due to stresses*



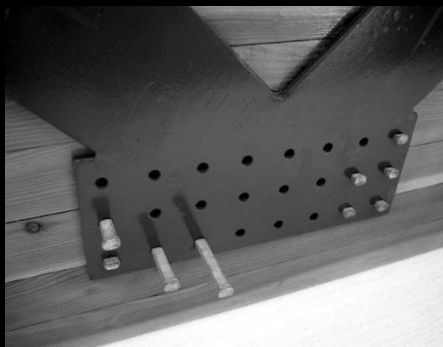
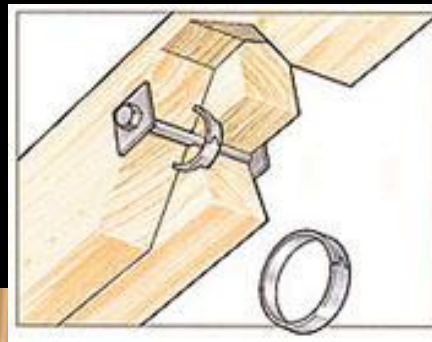
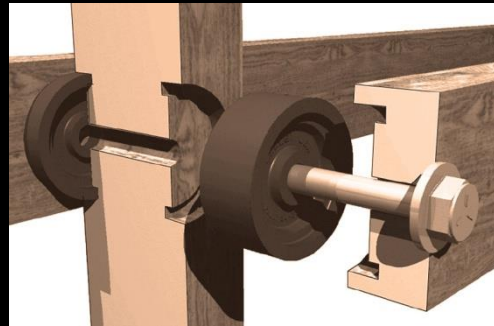
# Wood Connectors

- *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*



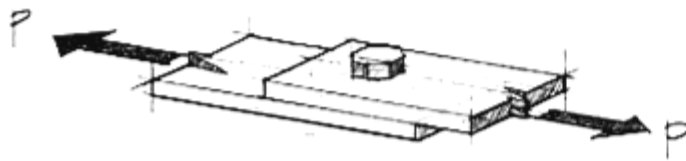
# Wood Connections

- *mechanical*

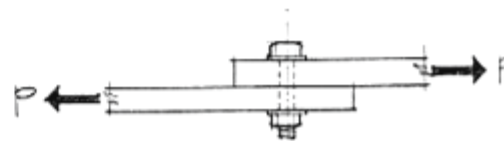


# Bolted Joints

- *connected members in tension cause shear stress*

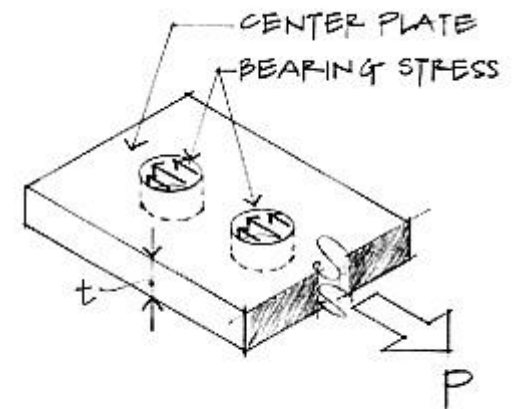


(a) Two steel plates bolted using one bolt.



(b) Elevation showing the bolt in

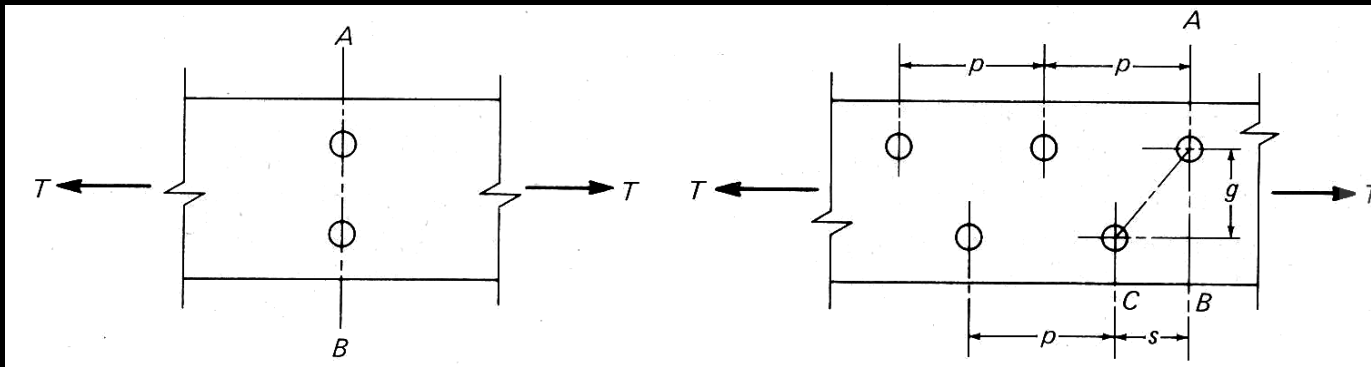
- *connected members in compression cause bearing stress*



Bearing stress on plate.

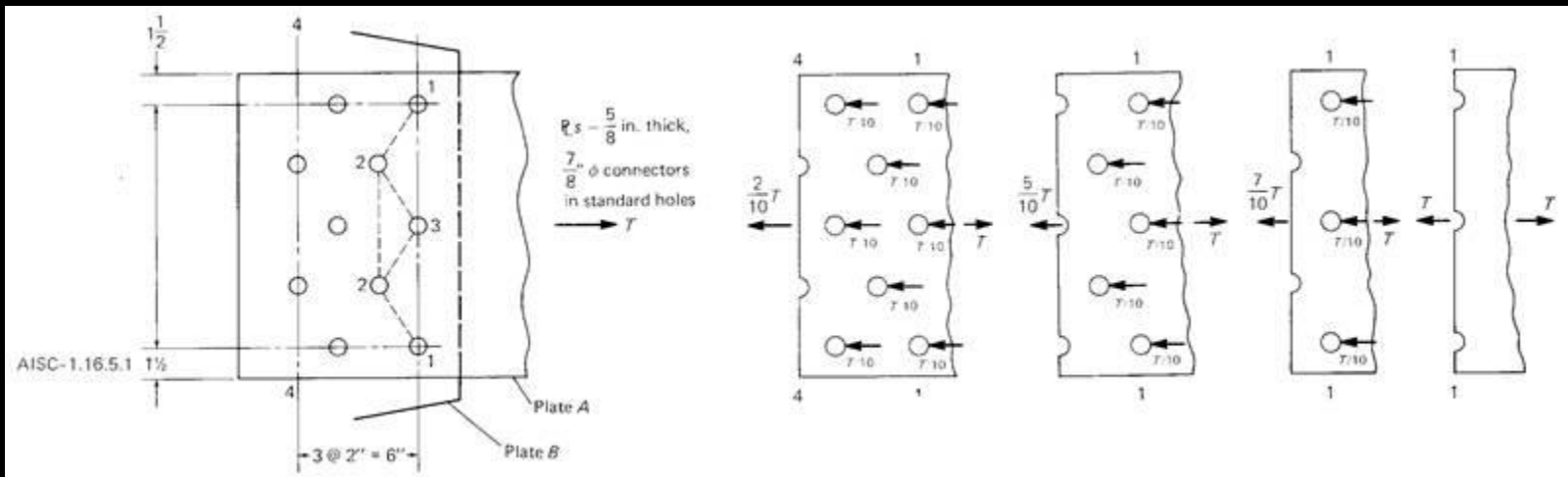
# Tension Members

- members with holes have reduced area
- increased tension stress
- $A_e$  is effective net area  $f_t = \frac{P}{A_e} \left( \text{or } \frac{T}{A_e} \right)$



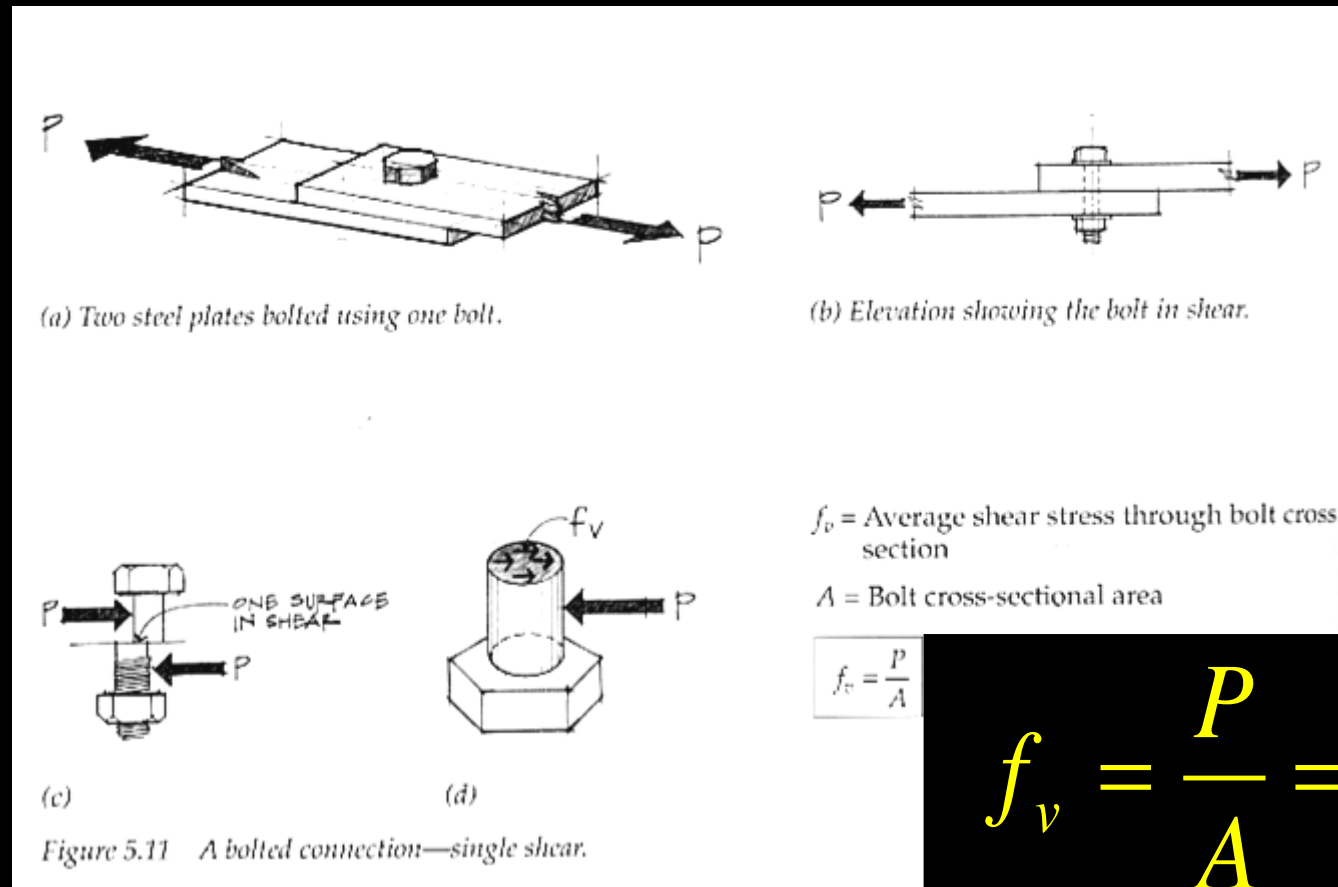
# Effective Net Area

- likely path to “rip” across
- bolts divide transferred force too



# Single Shear

- *seen when 2 members are connected*





# Double Shear

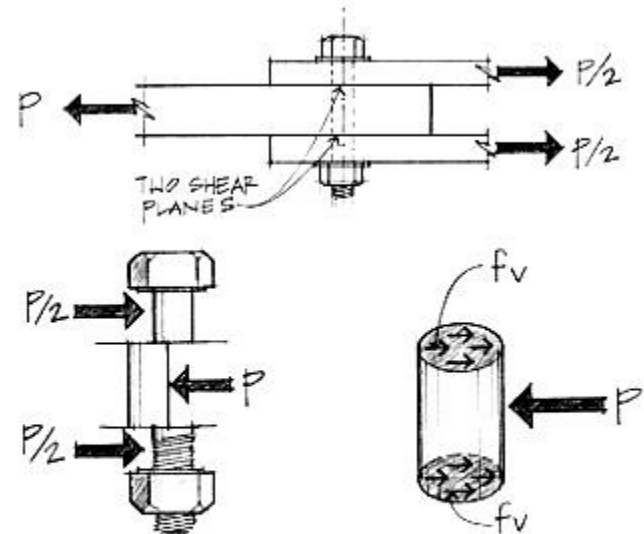
- seen when 3 members are connected

$$\Sigma F = 0 = -P + 2(P/2)$$

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

(two shear planes)

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

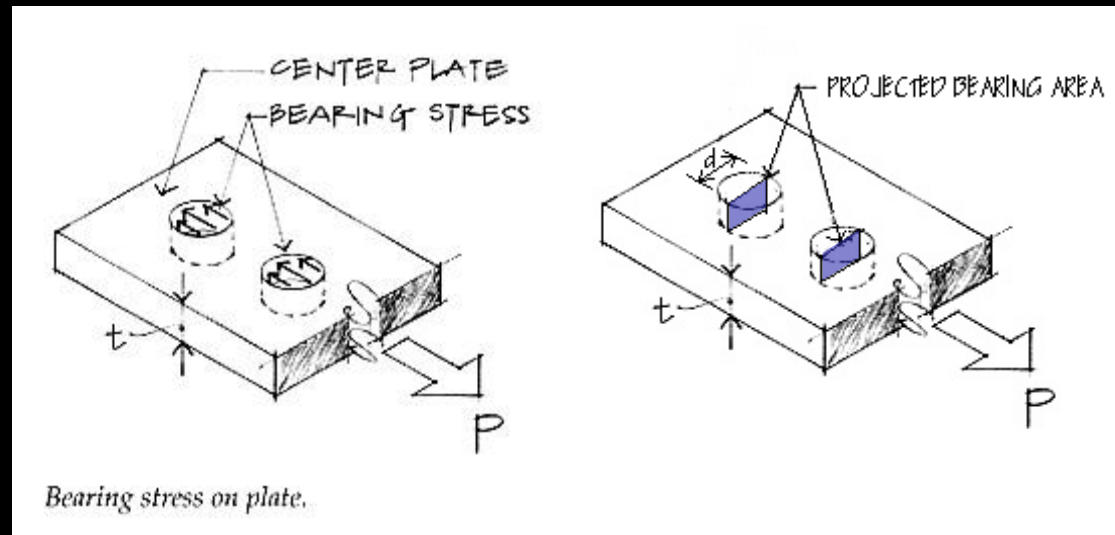


Free-body diagram of middle section of the bolt in shear.

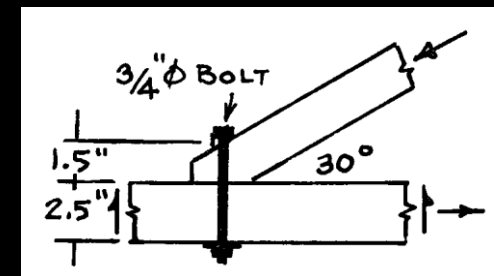
Figure 5.12 A bolted connection in double shear.

# Bearing Stress

- *compression & contact*
- *stress limited by species & grain direction to load*
- *projected area*

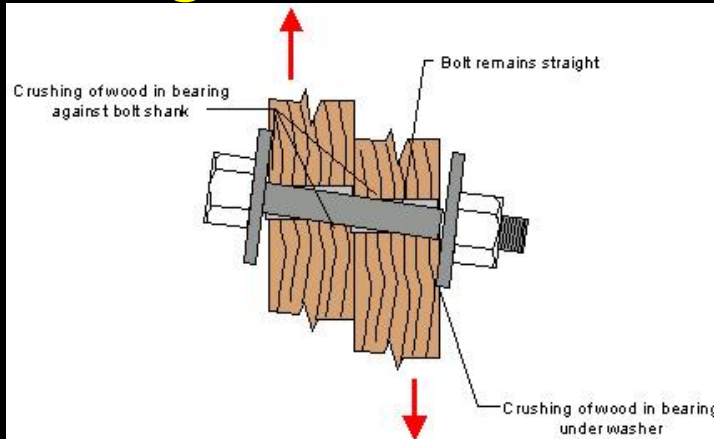


$$f_p = \frac{P}{A_{\text{projected}}} = \frac{P}{td}$$



# Bolted Joints

- *twisting*



[www.timber.org.au](http://www.timber.org.au)

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

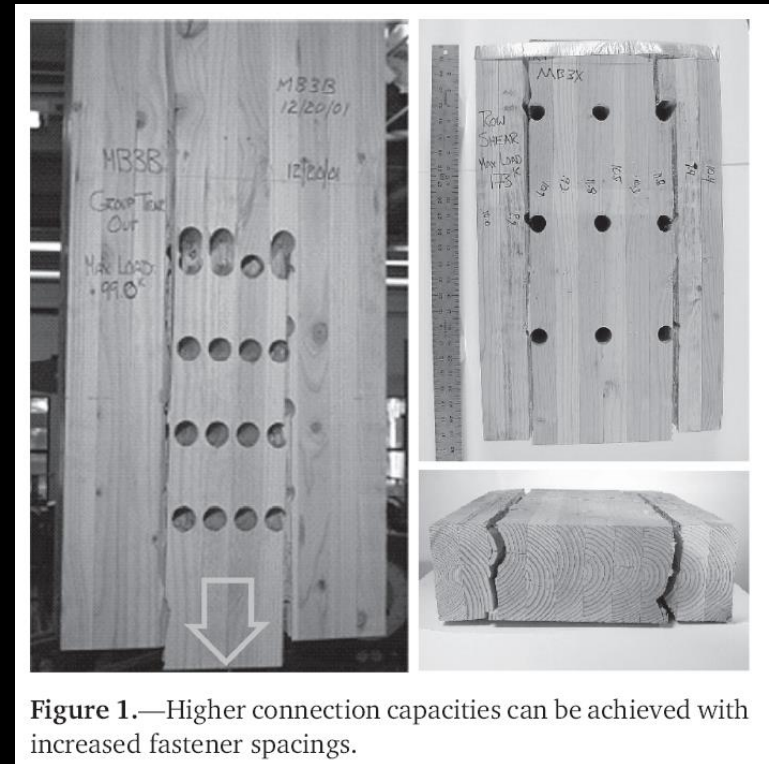
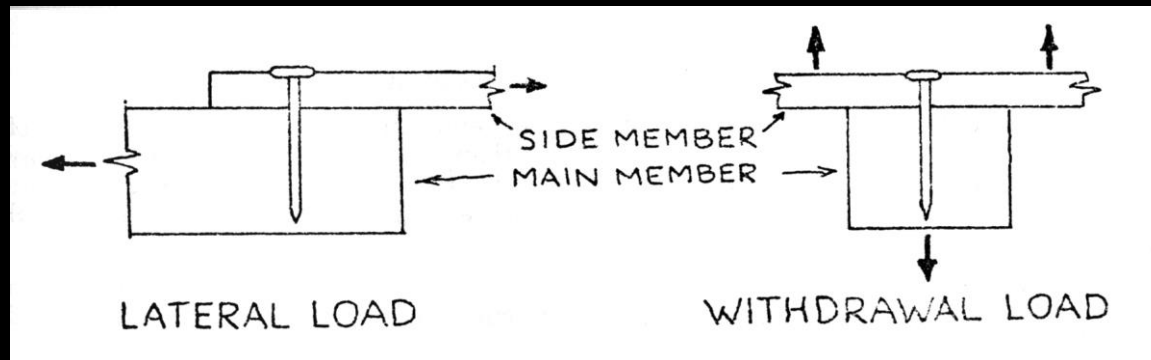


Figure 1.—Higher connection capacities can be achieved with increased fastener spacings.

*Taylor & Line 2002*

# Nailed Joints

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



# Nailed Joints

- sized by pennyweight units / length
- embedment length
- dense wood, more capacity

\*NDS

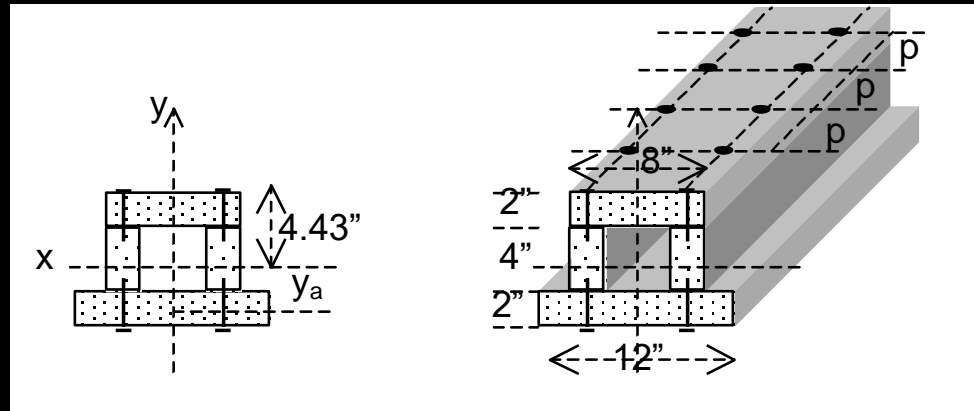
**TABLE 7.1 Lateral Load Capacity of Common Wire Nails (lb/nail)**

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)
<i>Structural Plywood Side Members</i>				
$\frac{3}{8}$	2	0.113	6d	48
	2½	0.131	8d	63
	3	0.148	10d	76
$\frac{1}{2}$	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

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

