ARCHITECTURAL STRUCTURES:
FORM, BEHAVIOR, AND DESIGN
ARCH 331
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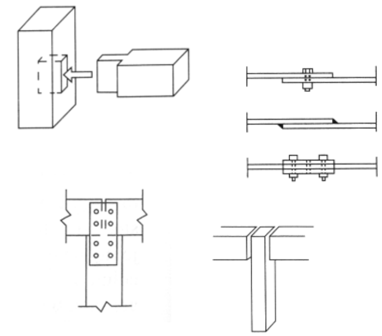
SUMMER 2018

lecture
fourteen

wood construction: connections

Connectors

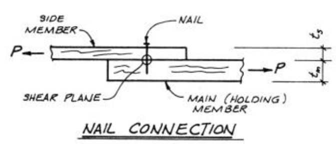
- joining
  - lapping
  - interlocking
  - butting
- mechanical
  - "third-elements"

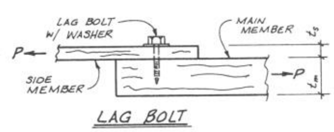


- transfer load at a point, line or surface
  - generally more than a point due to stresses

Wood Connectors

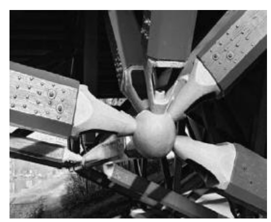
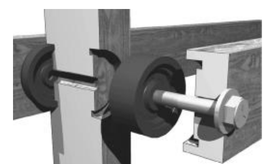
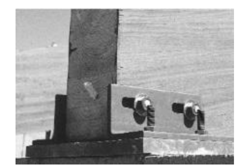
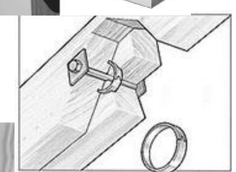
- adhesives
  - used in a controlled environment
  - can be used with nails
- mechanical
  - bolts
  - lag bolts or lag screws
  - nails
  - split ring and shear plate connectors
  - timber rivets

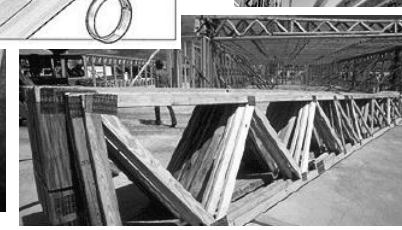




Wood Connections

- mechanical

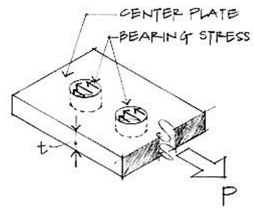



Bolted Joints

- 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

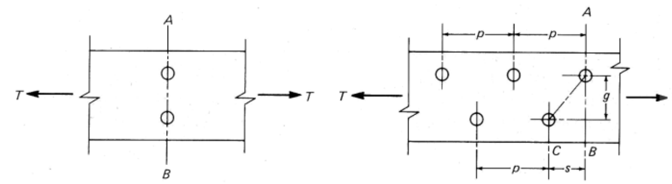


Bearing stress on plate.

Tension Members

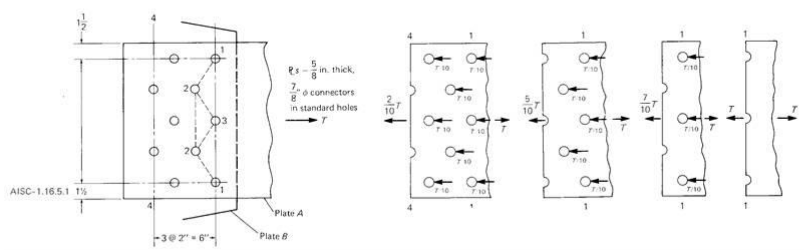
- members with <u>holes</u> have reduced area
- increased tension stress
- A_e is effective net area

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



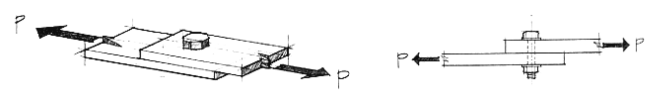
Effective Net Area

- likely path to "rip" across
- bolts divide transferred force too

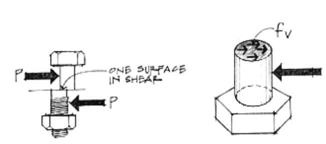


Single Shear

- seen when 2 members are connected



(a) Two steel plates bolted using one bolt. (b) Elevation showing the bolt in shear.



(c) (d)

Figure 5.11 A bolted connection—single shear.

f_v = Average shear stress through bolt cross section

A = Bolt cross-sectional area

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

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

Double Shear

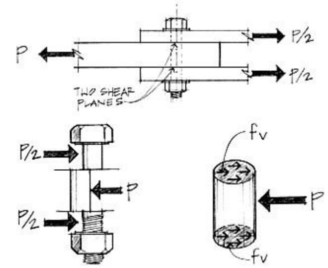
- seen when 3 members are connected

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

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

(two shear planes)

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

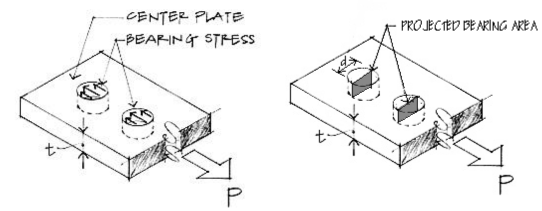


Free-body diagram of middle section of the bolt in shear.

Figure 5.12 A bolted connection in double shear.

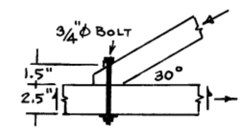
Bearing Stress

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



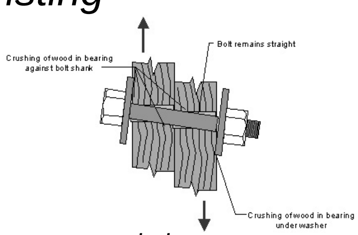
Bearing stress on plate.

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



Bolted Joints

- twisting



www.timber.org.au

- tear out
  - shear strength
  - end distance & spacing

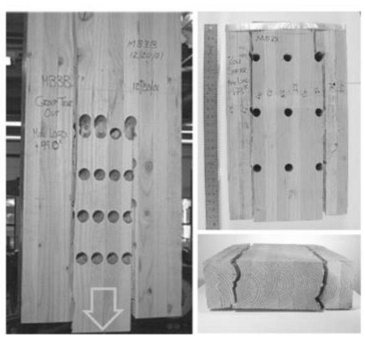
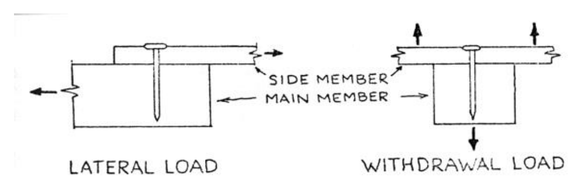


Figure 1.—Higher connection capacities can be achieved with increased fastener spacings.

Taylor & Line 2002

Nailed Joints

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



Nailed Joints

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

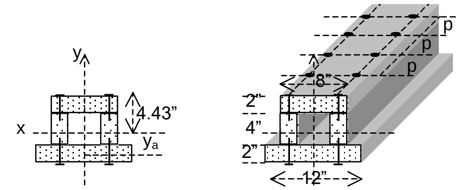
**NDS*

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				
	2	0.113	6d	48
⅜	2½	0.131	8d	63
	3	0.148	10d	76
	2	0.113	6d	50
½	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*

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