

# Connections for Mass Timber Construction and New Fastening Details



Mark Gillis, P.Eng.  
Gillis & Company Timber Frames



Wood Connections



# Timber Connections

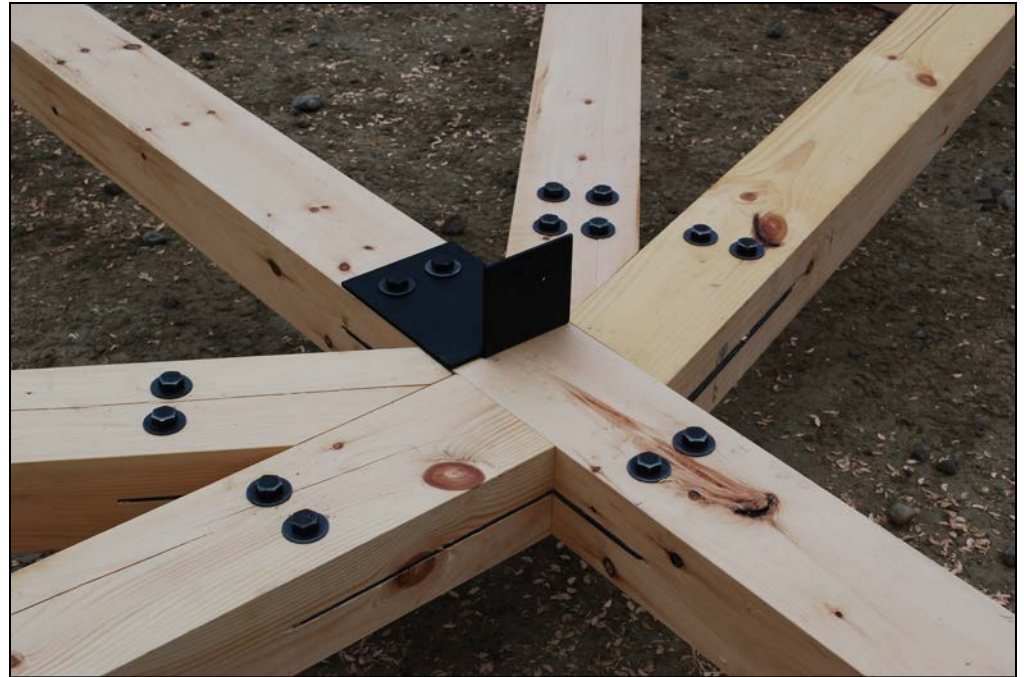
## Outline:

Wood Behaviour & Characteristics

Connection Design

Fasteners

Connection Detailing



# Wood Behaviour & Characteristics

## Compression Parallel and Perpendicular

- Hankinson Formula
- Bearing
  - Side Grain
  - End Grain

## Tension Parallel and Perp Shear

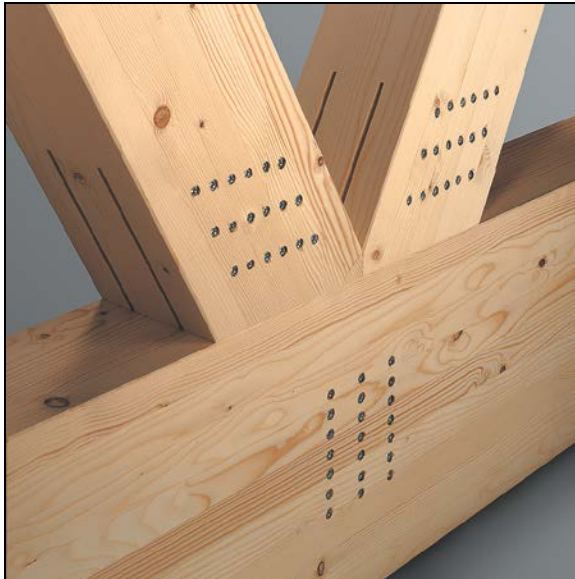
- Net Area



# Wood Behaviour & Characteristics

## Design for Ductility

- Wood = Brittle Failure = Bad!



# Connection Design

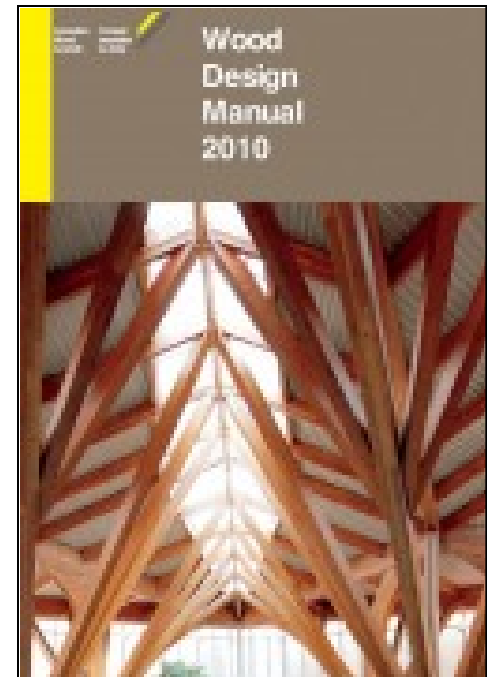
## **CSA O86.1 (2009)**

Standard for Engineering Design in Wood

## **Wood Design Manual (2010)**

Canadian Wood Council

- CSA O86.1 (2009)
- National Building Code (2010)



Wood Connections



# Connection Design

## Critical Items:

- Species
- Grade
- Moisture Content
- Angle to Grain





# Connection Design

## Wood Species

### CSA O86.1 Species Groups:

Table 5.2.1.2  
Species Combinations

Species combinations	Stamp identification	Species included in the combination
Douglas Fir-Larch	D Fir-L (N)	Douglas Fir, Western Larch
Hem-Fir	Hem-Fir (N)	Pacific Coast Hemlock, Amabilis Fir
Spruce-Pine-Fir	S-P-F	Spruce (all species except Coast Sitka Spruce), Jack Pine, Lodgepole Pine, Balsam Fir, Alpine Fir
Northern Species	North Species	Any Canadian species graded in accordance with the NLGA rules

**Notes:**

- (1) Names of species in Table 5.2.1.2 are standard commercial names. Additional information on botanical names and other common names is given in CSA Standard CAN/CSA-O141.
- (2) The NLGA Standard Grading Rules for Canadian Lumber contains many species designations not shown in Table 5.2.1.2. If the species can be identified, however, it may be possible to group it in one of the species combinations, for purposes of assigning specified strengths.



# Connection Design

## Wood Grades

### CSA O86.1 Grade Categories:

*Engineering Design in Wood (Limit States Design)*

**Table 5.2.2.1**  
**Visual Grades and Their Dimensions**

Grade category	Smaller dimension (mm)	Larger dimension (mm)	Grades
Light Framing	38 to 89	38 to 89	Construction, Standard
Stud	38 to 89	38 or more	Stud
Structural Light Framing	38 to 89	38 to 89	Select Structural No. 1, No. 2, No. 3
Structural Joists and Planks	38 to 89	114 or more	Select Structural No. 1, No. 2, No. 3
Beam and Stringer	114 or more	Exceeds smaller dimension by more than 51 mm	Select Structural No. 1, No. 2
Post and Timber	114 or more	Exceeds smaller dimension by 51 mm or less	Select Structural No. 1, No. 2
Plank Decking	38 to 89	140 or more	Select, Commercial





# Connection Design

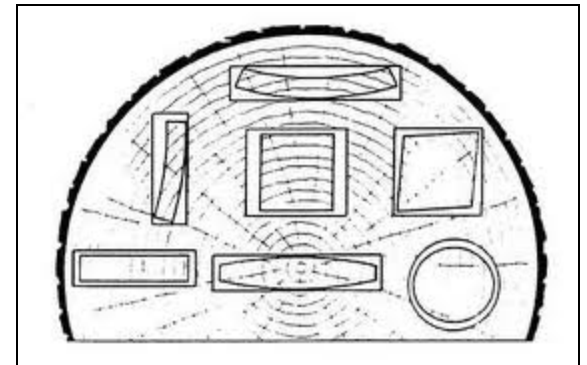
## Moisture Content – Very Important!

Green Wood (Moisture Content > 20%)

- Locally Available
- Quick Turn-Around Time
- Drying Issues:
  - Shrinkage – Net Section Reduction
  - Bowing, Cupping, Twisting
  - Checking
- Soft (Structurally)

Wet Service (low drying capacity)

- Detailing to avoid trapping water



# Connection Design

## Moisture Content – Very Important!

“Dry” Wood (Moisture Content < 20%)

- Probably NOT Locally Available for Larger Sizes
- MUCH Longer Turn-Around Time
- No Major Drying Issues



Wood Connections



# Connection Design

## Angle to Grain – Also Very Important!

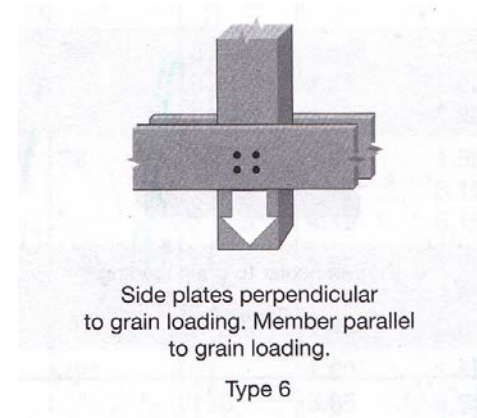
### Compression Parallel and Perpendicular

- Hankinson Formula

$$\sigma_{\alpha} = \frac{\sigma_0 \sigma_{90}}{\sigma_0 \sin^2 \alpha + \sigma_{90} \cos^2 \alpha}$$

### Tension Parallel and Perpendicular

- Hanging Loads
- Detailing

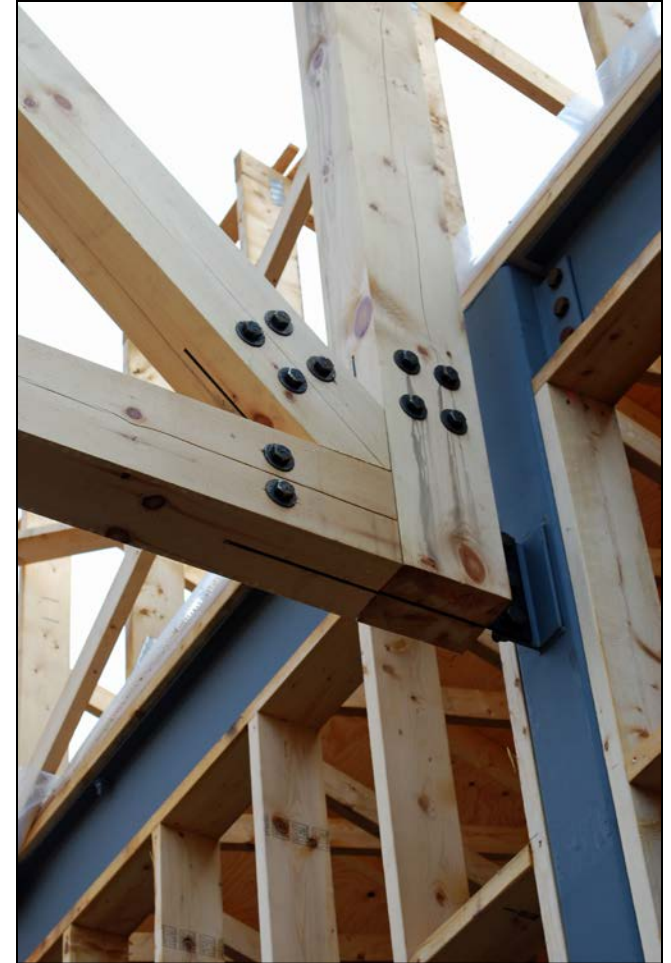


# Fasteners

## CSA O86.1 – Section 10

- Nails & Spikes
- Wood Screws
- Bolts (Threaded Rod)
- Lag Screws
- Split Rings & Shear Plates
- Timber Rivets

## Proprietary Fasteners



Wood Connections



# Fasteners

## Nails & Spikes

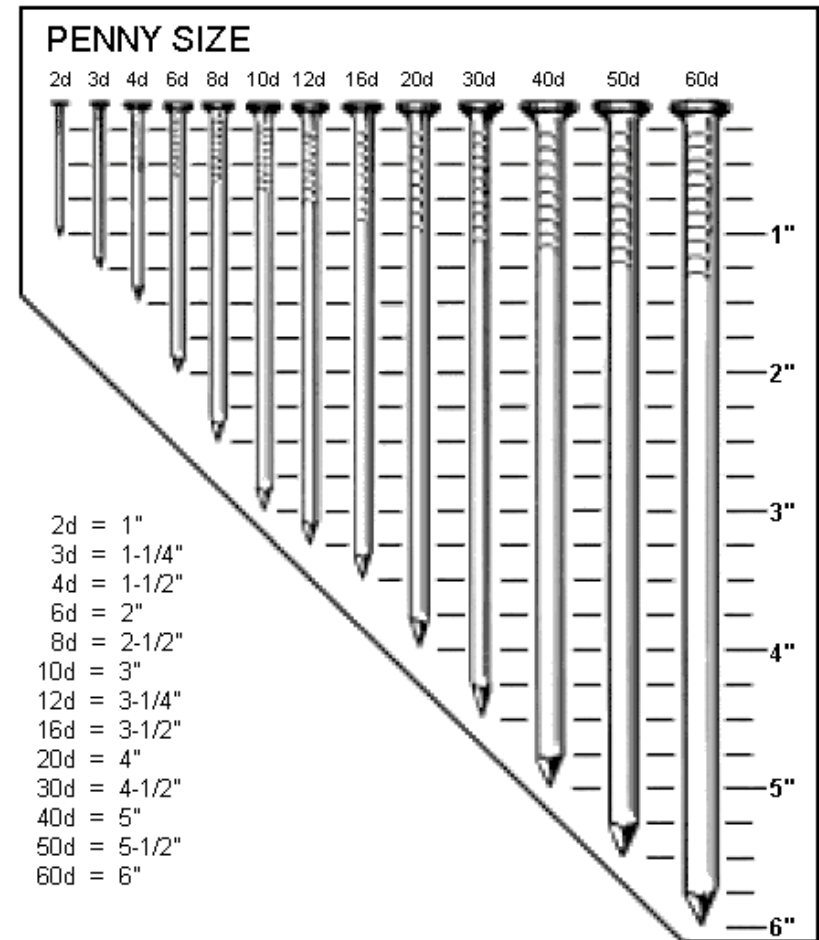


Image Courtesy of [www.leaderhome.com](http://www.leaderhome.com)



Wood Connections



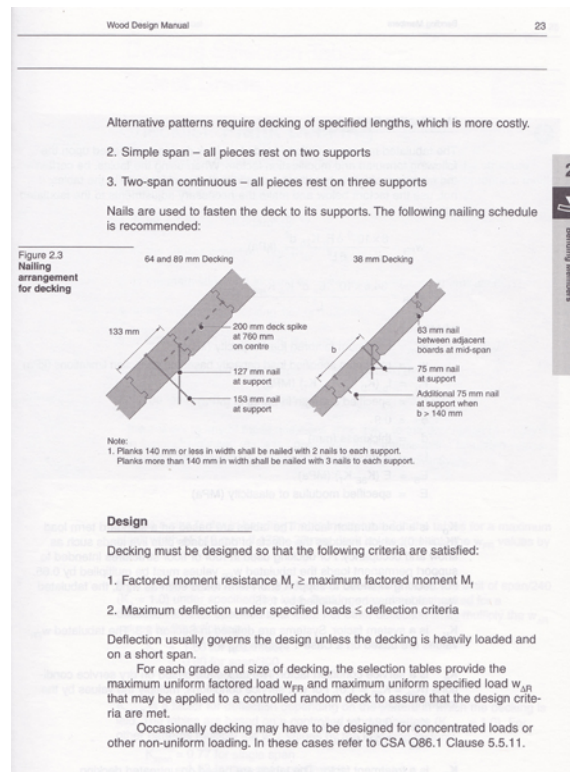


# Fasteners

## Spikes

Wood Decking - 2x6, 3x6 (Solid Sawn or Laminated)

CSA O86.1:



# Fasteners

## Wood Screws

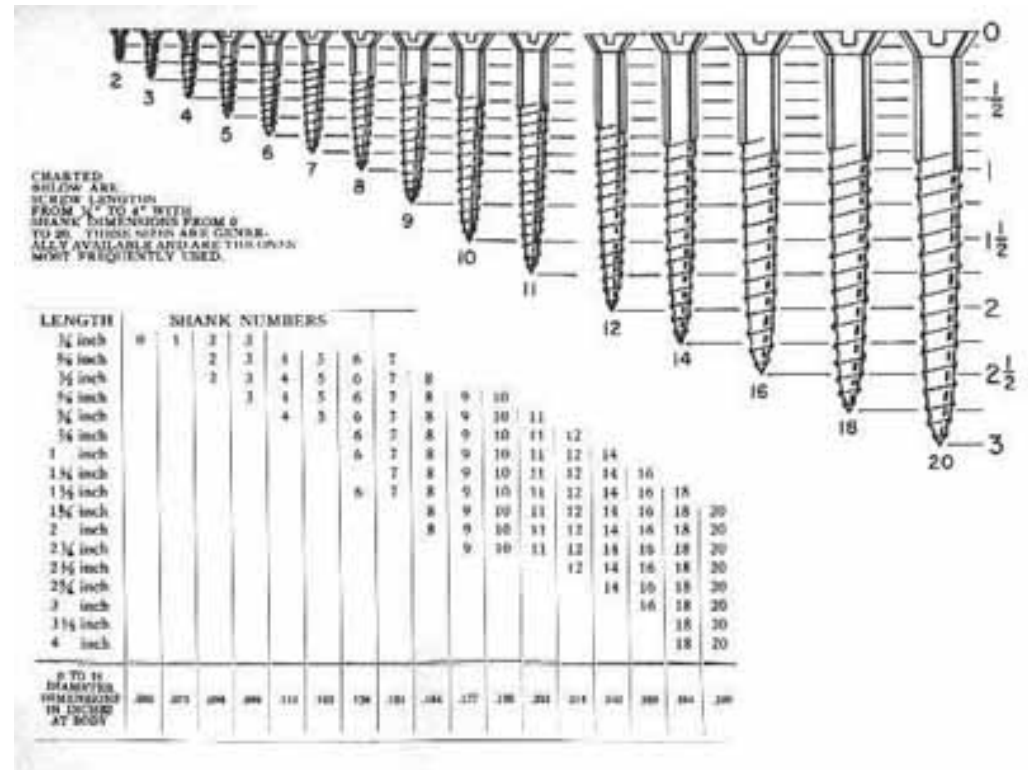
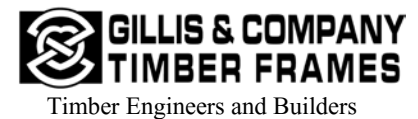


Image Courtesy of [www.driverlayer.com](http://www.driverlayer.com)



Wood Connections



# Fasteners

## Bolts/Threaded Rod

- Side vs. Internal Plates
- Finishes/Quality
- Malleable Iron Washers
- Hanging Loads



# Fasteners

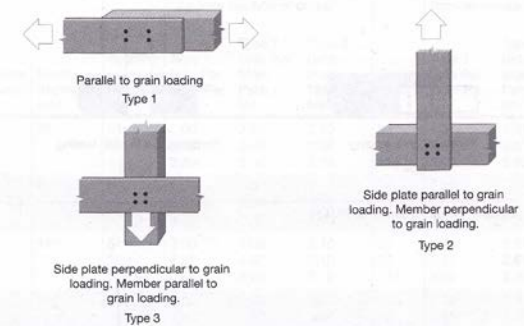
## Bolts/Threaded Rod

- Joint Configurations

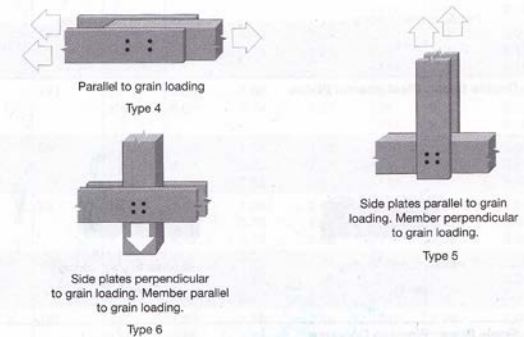
### Bolt Selection Tables

### Joint Configurations

#### Single Shear, Wood Side Plates



#### Double Shear, Wood Side Plates



# Fasteners

## Lag Screws



Image courtesy Portland Bolt



Wood Connections





# Fasteners

## Split Rings & Shear Plates

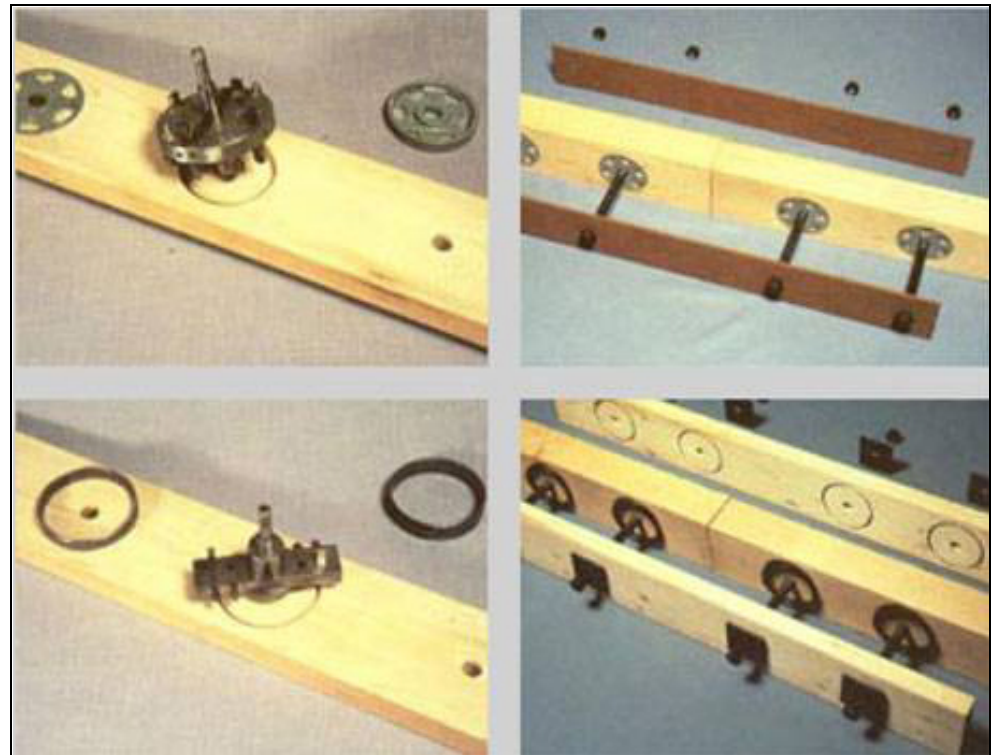


Image courtesy CWC



Wood Connections



# Fasteners

## Timber Rivets

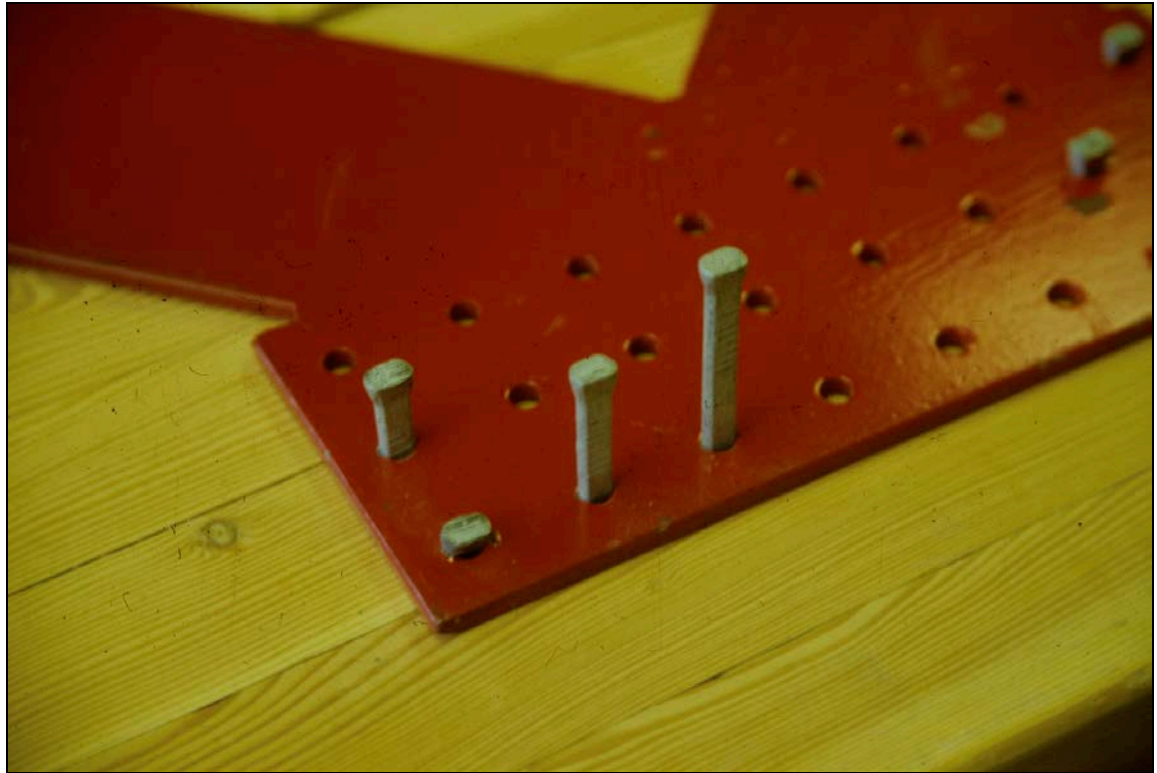


Image courtesy Specialized Timber Fasteners



Wood Connections



# Fasteners

## Proprietary Fasteners

- Timber Screws



Images courtesy GRK Fasteners

# Fasteners

## Proprietary Fasteners

- Timber Screws
- Timberlinx

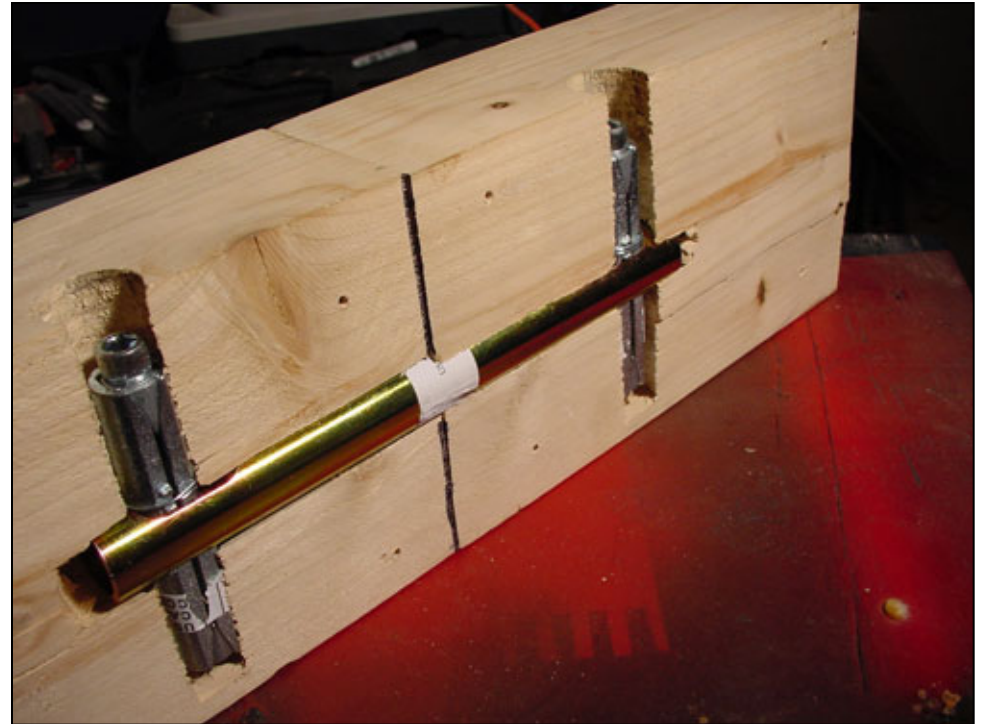


Image courtesy Timberlinx



# Fasteners

## Proprietary Fasteners

- Timber Screws
- Timberlinx
- System WS



Images courtesy SFS Intec



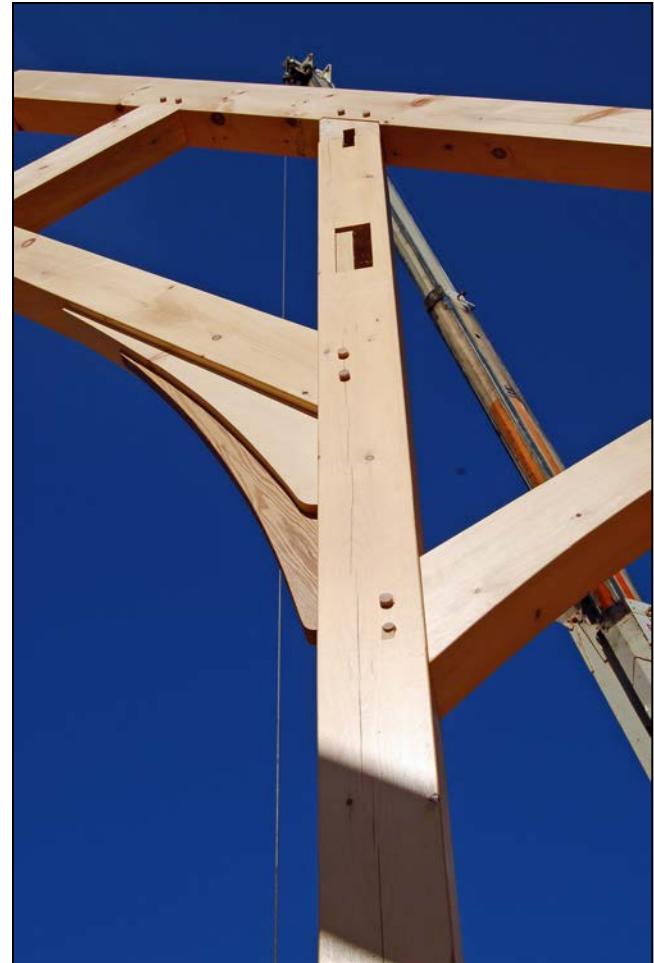
Wood Connections





# Fasteners

## Wood Joinery



Wood Connections



# Fasteners

## Wood Joinery

TFEC-1 - Standard for Design of Timber Frame Structures and Commentary

TFEC Master Spec for Timber Frame Construction  
Section 06130



[timberframeengineeringcouncil.org](http://timberframeengineeringcouncil.org)



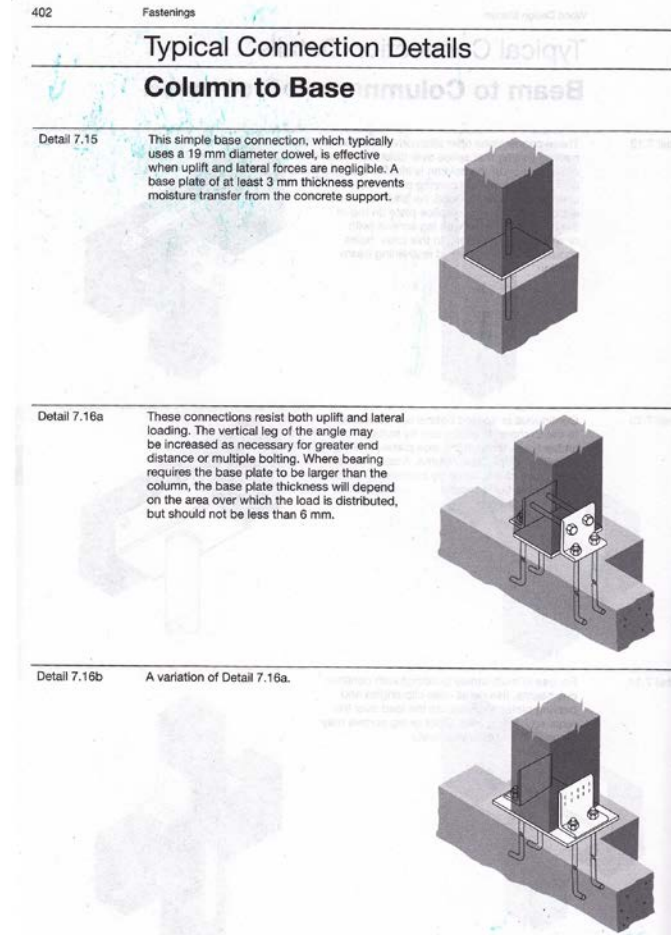
Wood Connections



# Connection Detailing

## Connection Details

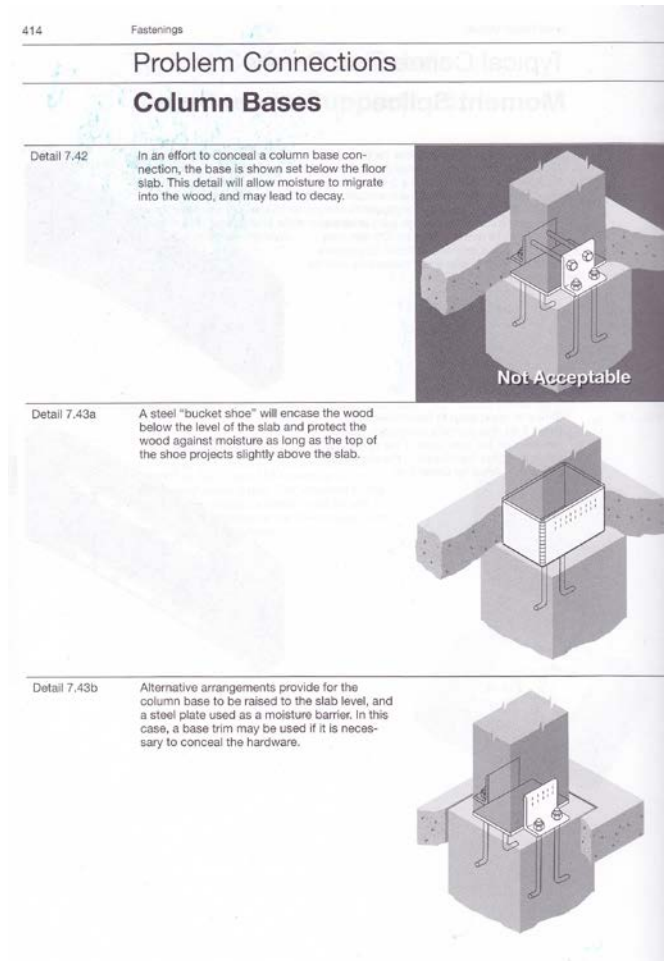
- CSA Details  
(Wood Design Manual)
- Column Bases



# Connection Detailing

## Connection Details

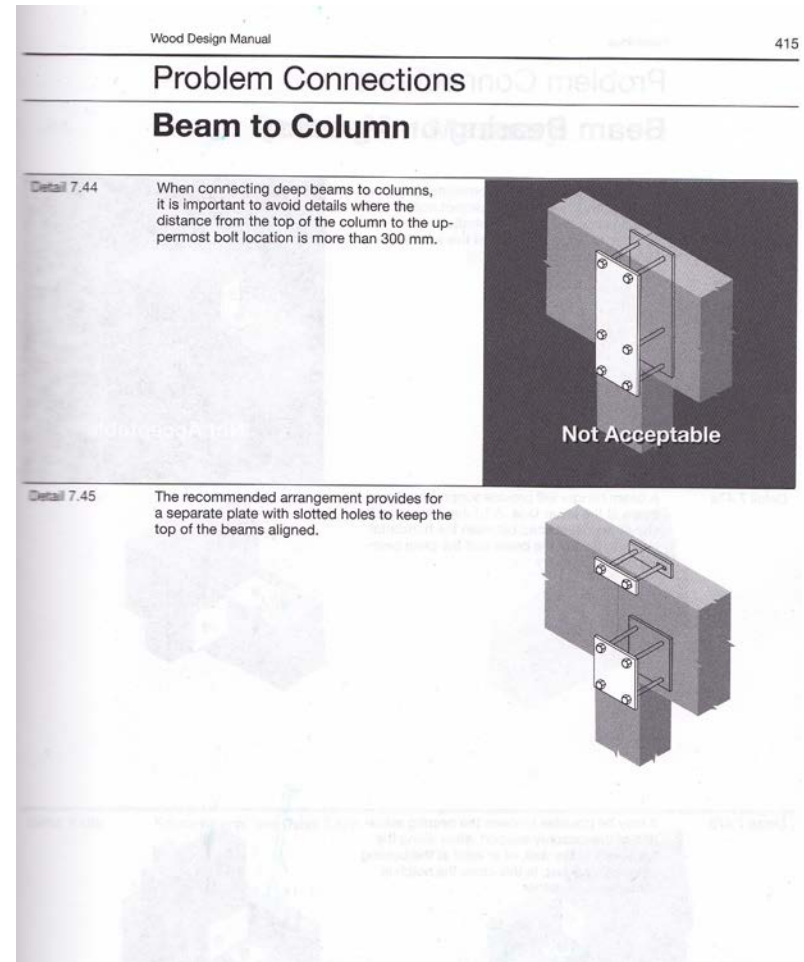
- CSA Details  
(Wood Design Manual)
- Column Bases



# Connection Detailing

## Connection Details

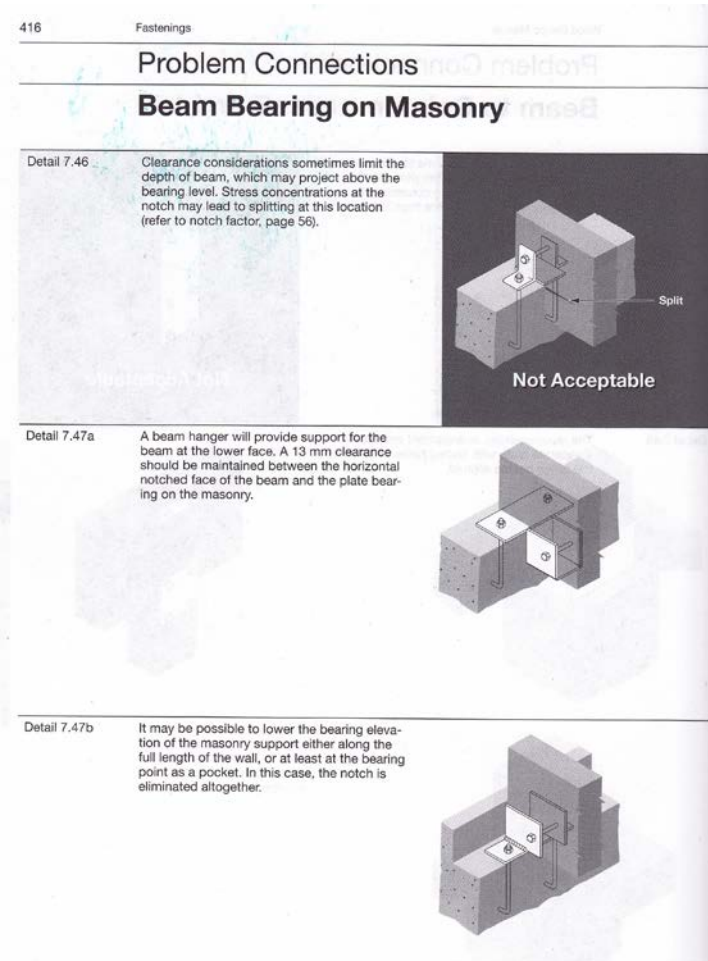
- CSA Details  
(Wood Design Manual)
- Beam-Column



# Connection Detailing

## Connection Details

- CSA Details  
(Wood Design Manual)
- Drying Effects

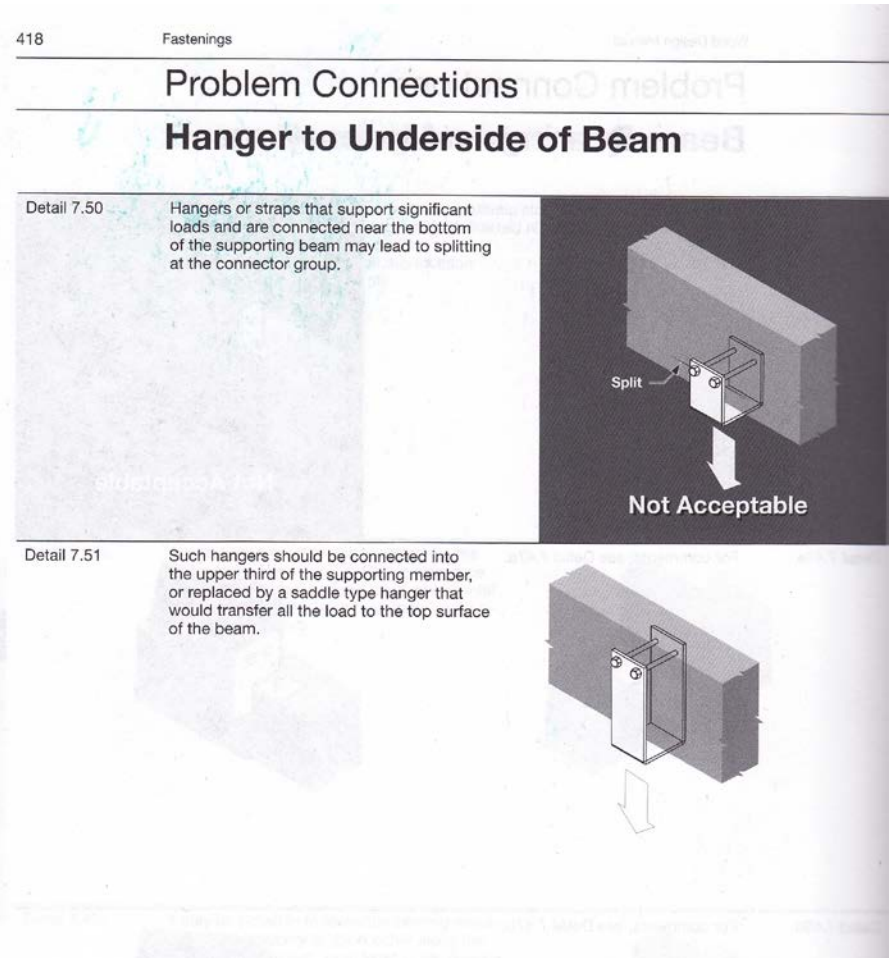




# Connection Detailing

## Connection Details

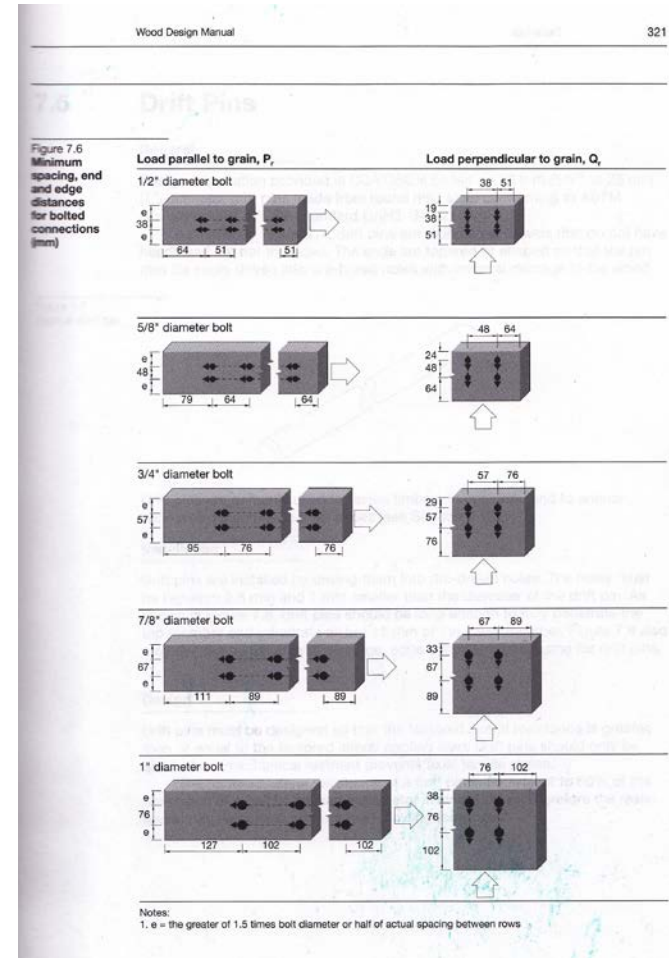
- CSA Details  
(Wood Design Manual)
- Tension Perpendicular



# Connection Detailing

## Connection Details

- CSA Details  
(Wood Design Manual)
- End and Edge Distance



# Summary

## Wood Behaviour & Characteristics

### Compression Parallel and Perpendicular

- Hankinson Formula
- Bearing
  - Side Grain
  - End Grain

### Tension Parallel and Perp Shear

- Net Area



# Summary

## Connection Design (O86.1)

Species

Grade

Moisture Content

Angle to Grain



Wood Connections



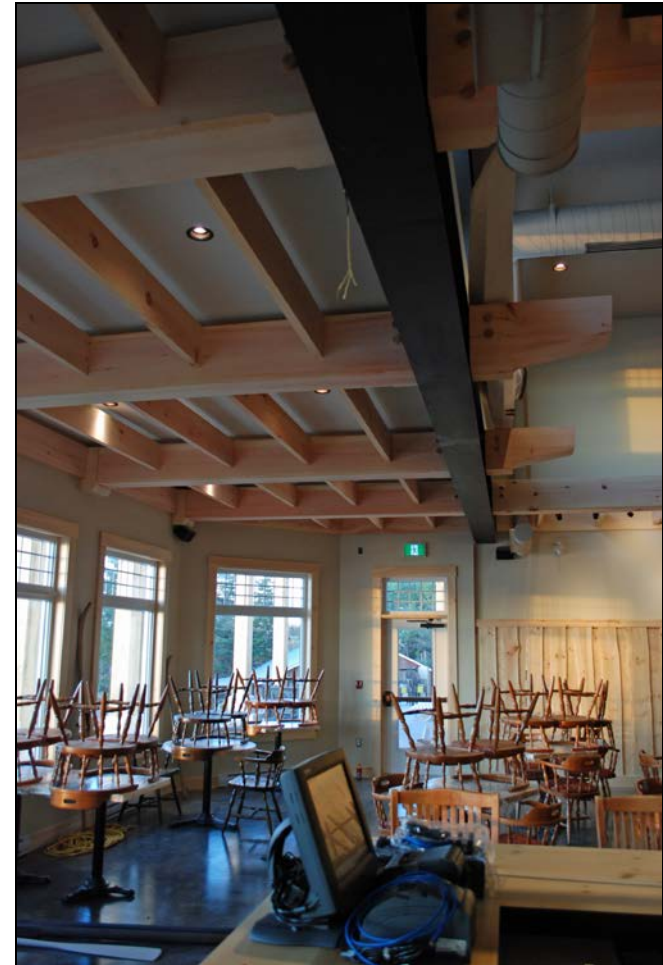
# Summary

## Fastenings

- Tons of Options

## Connection Detailing

- Wood Design Manual



Wood Connections





# Contact Me

## Mark Gillis, P.Eng.

Gillis & Company Timber Frames

6240 Summit Street

Halifax, Nova Scotia, B3L 1R7

[www.gillistimberframes.com](http://www.gillistimberframes.com)

[mark@gillistimberframes.com](mailto:mark@gillistimberframes.com)

(902) 453-2108

- Design/Build
- Consulting/Engineering
- Cost Estimating



Wood Connections





# Questions?



Wood Connections

