





## WOOD CONNECTIONS I

**Michelle Kam-Biron, S.E.**  
Wood Products Council - WoodWorks!


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## Learning Objectives

- Techniques for Efficient, Durable and Structurally Safe Connections
- Common Fastener Types
- Resources Available


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## Learning Objectives

- Techniques for Efficient, Durable and Structurally Safe Connections
  1. Wood is strong in Compression
  2. Wood does not like loads perpendicular to grain
  3. Wood likes load spread out
  4. Wood moves in response to varying environment

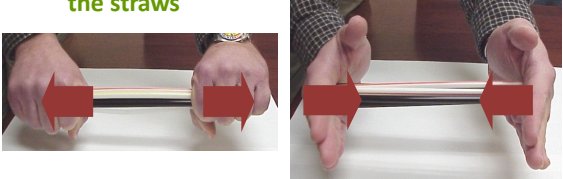
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## Basic Concepts

**Model wood cells as a bundle of straws**

- Bundle is very strong parallel to axis of the straws



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## Compression Parallel to Grain



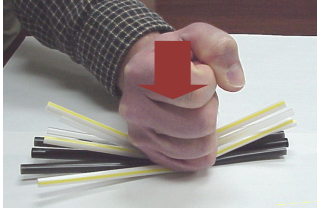
- Wood likes compression parallel to grain – makes connecting wood very easy

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**Basic Concepts**

Model wood cells as a bundle of straws

- Bundle relatively weak under perpendicular load



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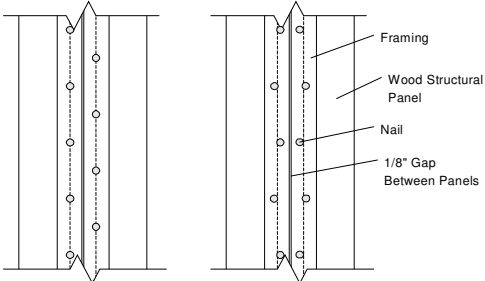
**Material Properties of Wood**

- Splitting happens because wood is relatively weak perpendicular to grain
  - Nails too close (act like a wedge)



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**Staggered Nailing**



Nailing not staggered      Nailing staggered

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**Material Properties of Wood**



Splitting occurs parallel to grain

Staggering

Splitting will not occur perpendicular to grain, no matter how close nails are

Staggering a line of nails parallel to wood grain minimizes splitting

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**Material Properties of Wood**

- Staggered nailing in tightly nailed shear wall helps prevent splitting of framing



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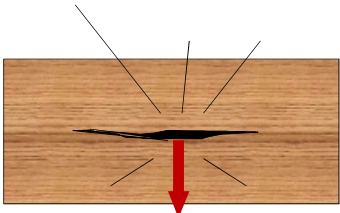
**Basic Concepts**

Wood and tension perpendicular to grain

- The evil of wood connections

Initiators:

- Hanging load
- Notches
- Large diameter fastener
- Restraint by connector detail



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### Hanger to Beam

Load suspended from lower half of beam

- Tension perpendicular to grain
- May cause splits

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### Hanger to Beam

Full wrap sling option

- Load supported in upper half of beam
- Extended plates puts wood in compression when loaded

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### Notching

Problem	Solution
Tension perpendicular to grain	

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### Beam to Concrete

#### Notched beam bearing

- Tension perpendicular
- May cause splitting
- Differential moisture uptake
- Reseal end grain

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### Beam to Concrete

#### Notched Bearing Wall

- Alternative to beam notch

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### Beam to Concrete

#### Sloped Beam

- Not fully supported
- May split
- Exposed end grain

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**Beam to Concrete**

**Sloped Beam**

- Notched concrete wall
- Alternative to beam notch

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**Beam to Masonry**

**Application**

- Bearing plate under beam
- Prevent contact with masonry

Capillary break

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**Sawn Lumber Notching**

**Fig. 1: Placement of Cuts in Floor Joists**

- Outer third of span only
- Avoid tension edge

max. length =  $D/3$   
 $D/6$  max.  
 $D$  = actual dimension  
 $D/6$  max.  
 $D/3$  max.  
 $D/4$  max. at ends  
 2" min. from top and bottom of joist  
 outer 1/3 of span  
 Notching not permitted in middle 1/3 of span  
 outer 1/3 of span  
 Cuts or notches can be reduced by using a gradual tapered notch instead of a square-cornered notch.

WWPA Technical Note A-11 "Notching and Boring Guide"

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**LVL Notching and Drilling\*\***

**Field Notching and Drilling of Laminated Veneer Lumber (Tech Note EWS G535)**

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**Possible Reinforcement for an End Notch**

**A REINFORCEMENT TECHNIQUE TO MINIMIZE CRACK PROPAGATION AT END BEARING NOTCHES**

Lag screw extends past the neutral axis into the upper portion of beam

0.9d minimum

Depth of notch  $\leq$  0.1d or 3 inches, whichever is less

Bearing length

Washer

Potential crack zone

Use one or more fully threaded lag screws

Ref. APA Technical Note EWS S560


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**Field Notching and Drilling of Glued Laminated Timber Beams**

Tech Note EWS S560

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**Vertical Holes**



**Rule of thumb:**  
**Strength reduction**  
 = 1.5 x Hole diameter/beam width

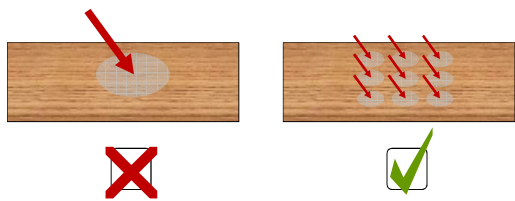
Example:  
 • 6" Beam width  
 • 1" diameter vertical hole  
 Reduction =  $(1.5 \times 1")/6"$   
 Reduction = 0.25  
 Beam is 75% of original strength

APA Tech Note EWS S560

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**Connecting Wood**

**Wood likes to take on load spread over its surface**

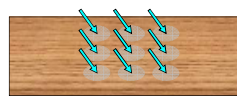


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**Connecting Wood**

**Mechanical fasteners**

- Keep 'em small
- Use lots of them
- Keep scale of fastener small relative to wood member



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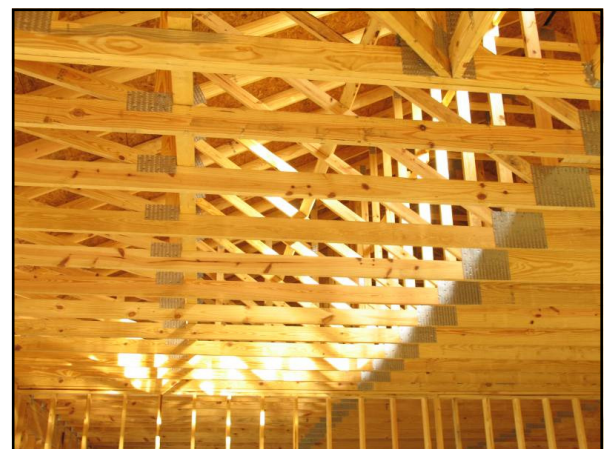
**Concentrated at a single fastener – wood is more prone to split and crush**



**Connection Techniques**



Steel bolts and plates in heavy trusses



**Connecting Wood**

■ A single bolt connecting many members but...wait a minute...

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**Connecting Wood**

■ Looks can be deceiving...

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**Connecting Wood**

Wood, like other materials, moves in varying environments

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**Connection Serviceability**

- Temperature
- Humidity and moisture

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**Connection Serviceability**

- Temperature
- Humidity and moisture
  - Ambient conditions
  - Contact with cementitious materials

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**Connection Serviceability**

**Ambient Conditions and wood EMC**

6% average moisture content  
8% average moisture content  
11% average moisture content

Figure 12-1. Recommended average moisture content for interior use of wood products in various areas of the United States.

USDA Wood Handbook Free download – Forest Products Lab  
<http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr113/fplgtr113.htm>

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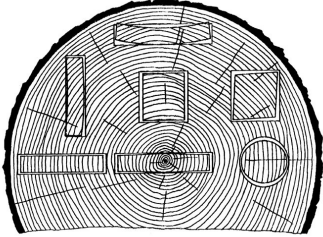
Table 12-1. Equilibrium moisture content of wood, exposed to outdoor atmosphere, in several U.S. locations in 1997

State	City	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
AK	Juneau	18.0	16.0	15.1	13.9	13.0	12.0	12.1	12.1	12.1	12.1	12.1	12.1
AL	Mobile	13.9	13.1	13.2	13.4	13.4	13.2	14.2	14.4	13.9	13.0	13.7	14.0
AZ	Flagstaff	11.8	11.4	10.9	9.1	8.9	7.8	8.2	10.0	10.7	10.8	10.8	11.2
AZ	Phoenix	8.6	8.6	7.9	6.1	6.1	6.0	6.2	10.0	10.6	7.9	8.3	8.5
AR	Little Rock	10.4	10.2	10.9	11.1	11.1	11.1	11.3	11.3	11.9	11.7	11.3	11.0
CA	Fresno	10.4	10.4	10.6	9.5	9.2	7.9	8.9	9.6	10.3	10.3	10.4	10.5
CA	Los Angeles	12.2	13.0	13.8	13.8	14.4	14.8	15.0	15.1	14.5	13.8	12.8	12.1
CO	Denver	10.7	10.5	10.2	9.4	10.2	9.5	9.4	9.6	9.2	8.9	11.0	11.0
DC	Washington	11.8	11.6	11.3	11.1	11.0	11.7	11.7	11.7	12.3	12.6	12.5	12.2
FL	Miami	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
GA	Savannah	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
IL	Chicago	16.2	13.7	13.4	12.5	12.2	12.4	12.8	13.3	13.3	12.9	14.0	14.0
IN	Indianapolis	16.1	14.6	13.8	12.8	12.6	12.8	13.0	13.4	14.2	13.7	14.8	15.2
IA	Des Moines	16.0	13.9	13.5	12.6	12.5	12.5	13.1	13.4	13.7	13.7	14.8	14.9
KS	Wichita	13.9	13.4	12.4	12.4	12.2	12.3	11.5	11.8	12.6	12.4	13.2	13.9
KY	Louisville	13.7	13.2	12.6	12.6	12.6	12.6	13.3	13.7	14.1	14.3	15.2	15.4
LA	New Orleans	14.9	14.3	14.0	14.2	14.1	14.8	15.2	15.3	14.8	14.0	14.2	15.0
ME	Burlington	13.1	12.7	12.1	12.6	13.0	13.0	13.4	13.4	13.8	14.6	14.8	15.2
MD	Baltimore	14.7	14.1	13.5	12.6	12.2	12.3	12.8	13.3	13.7	13.5	14.4	15.1
MI	Ann Arbor	13.7	13.0	13.0	12.6	12.5	12.5	13.2	13.5	13.8	14.2	14.4	14.4
MS	Memphis-Bilbao	14.1	14.1	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
MN	Minneapolis	16.1	14.4	13.7	12.8	14.1	13.8	14.6	14.6	14.6	14.1	14.3	14.0
MO	St. Louis	14.8	14.1	13.2	12.8	12.8	12.8	13.0	13.3	13.7	13.1	14.2	14.4
MT	Billings	16.7	15.1	14.8	14.6	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1
NE	Omaha	16.5	14.8	14.0	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
NH	Portland	16.7	15.1	14.8	14.6	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1
NJ	Atlantic City	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
NV	Reno	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3
NY	Albany	16.4	14.8	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
OR	Portland	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
RI	Providence	16.4	14.8	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
SC	Columbia	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
TN	Memphis	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1
TX	Austin	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
UT	Salt Lake City	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8
VA	Richmond	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1
WA	Seattle	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
WI	Madison	16.1	14.4	13.7	12.8	14.1	13.8	14.6	14.6	14.6	14.1	14.3	14.0
WV	Charleston	16.7	15.1	14.8	14.6	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1
WY	Cheyenne	16.7	15.1	14.8	14.6	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1

**Moisture Changes In Wood**

- Causes dimensional changes perpendicular to grain

Growing tree is filled with water

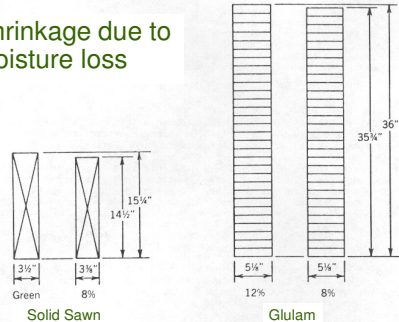


As wood dries, it shrinks perp. to grain

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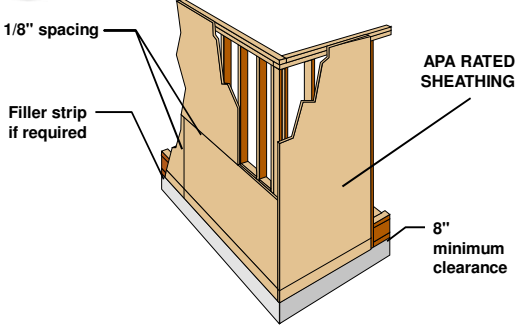
**Connection Serviceability**

- Shrinkage due to moisture loss



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**Wall Sheathing Sheathing Expands**



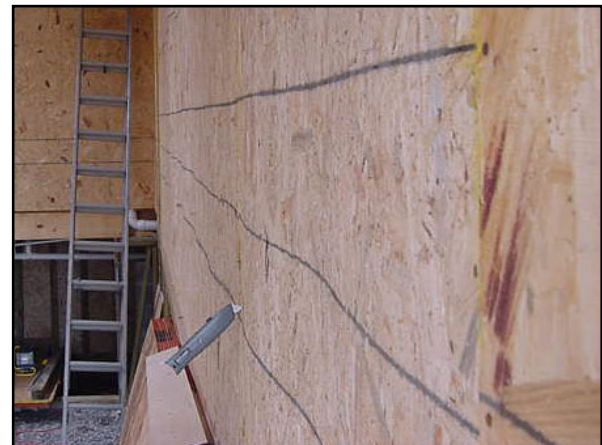
1/8" spacing

Filler strip if required

APA RATED SHEATHING

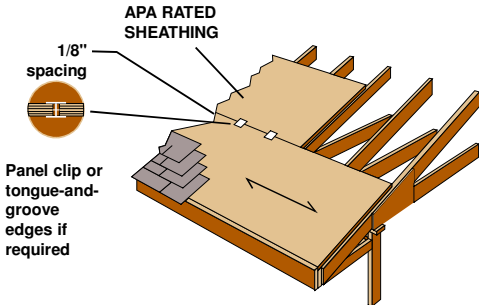
8" minimum clearance

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**Roof Sheathing Expands!**

with Moisture NOT Temperature

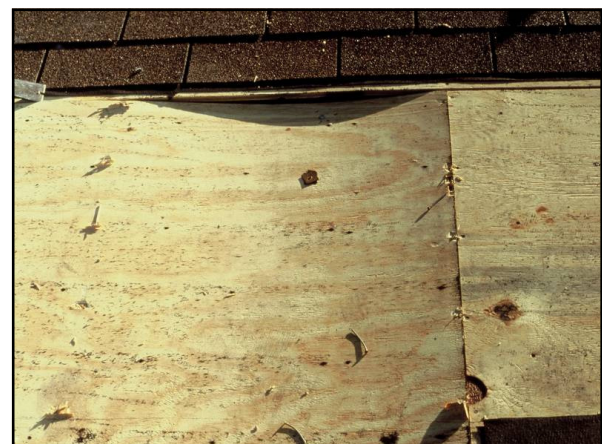


APA RATED SHEATHING

1/8" spacing

Panel clip or tongue-and-groove edges if required

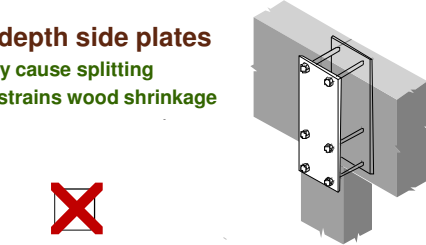
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**Beam to Column**

**Full-depth side plates**

- May cause splitting
- Restrains wood shrinkage

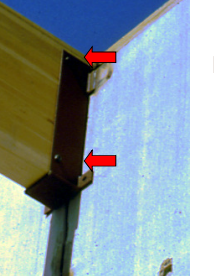


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**Beam to Column**

**Smaller side plates**

- Transmit force
- Allow wood movement




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**Beam Bearing**

**Slotted connections**

- Allows for shrinkage and movement under load

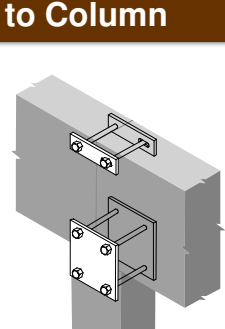


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**Beam to Wall**

**Problem**

- shrinkage
- tension perp




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**Beam to Wall**

**Solution:**

- allows shrinkage

Slotted hardware



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**Beam to Beam**

**Beam hangers**

- Fasteners in top of supported beam
- Wood shrinkage
- May split
- Not recommended

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**Beam to Beam**

**Beam hangers**

- Fasteners in bottom of supported beam
- Wood shrinkage allowed
- Prevents lateral movement

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**Beam to Beam**

**Weld bracket**

- Bucket-style
- Dapped support beam

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**Beam to Beam**

**Deep Members**

- Through bolted
- Shear plates
- Clip angles resist rotation
- Allow shrink/swell movement

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**Connecting Wood**

**CANTILEVER BEAM CONNECTION – NO TENSION TIE**

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**Connecting Wood**

**CANTILEVER BEAM CONNECTION – INDEPENDENT TENSION TIE**

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**Connection Serviceability**

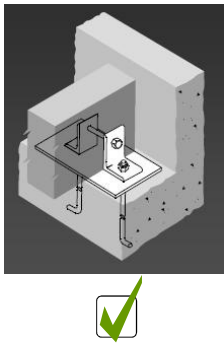
- Temperature
- Humidity and moisture
  - Ambient conditions
  - Contact with cementitious materials
    - Per 2304.11.2.5 Girder ends - 1/2" air space on top, sides and end.

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**Beam to Concrete**

**Beam on Wall**

- Prevent contact with concrete
- Provide lateral resistance and uplift

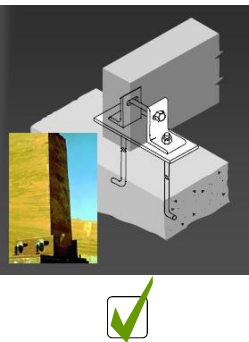


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**Beam to Concrete**

**Beam on Wall**

- Prevent contact with concrete
- Provide lateral resistance and uplift
- Slotted to allow longitudinal movement
- Typical for sloped beam




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**Beam to Masonry**

**Application**

- Need 1/2" air gap between wood and masonry




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**Beam to Masonry**

**Application**

- Bearing plate under beam
- Prevent contact with masonry by maintaining 1/2" space at end of beam.




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**Column to Base**

**Problem**

- No weep holes in closed shoe
- Moisture
- Decay



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**Column to Base**

**Bearing plate**

- Anchor bolts in bearing plate
- Slotted column end

**Floor slab poured over connection**

- Can cause decay
- Not recommended

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**Column to Base**

- Where's the *plate*?
- Grout substituted
- Moisture may wick into wood

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**Column to Base**

**Bearing plate**

- Anchor bolts in bearing plate
- Slotted column end

**Angle brackets**

- Anchor bolts in bracket

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**Arch Base to Support**

**ISSUE:**

- End grain sitting in puddle
- Moisture may wick into wood

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**Arch Base to Support**

- Glulam arches with closed shoe
- No provision such as weep holes to remove moisture

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**Connection Serviceability**

**Issue:**

- Direct water ingress
- No weep holes

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**Arch Base to Support**

**Good connection**

- Avoids tension perp
- Avoids decay







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**Connection Serviceability**

■ Issue: direct water ingress  
Water is absorbed most quickly through wood end grain

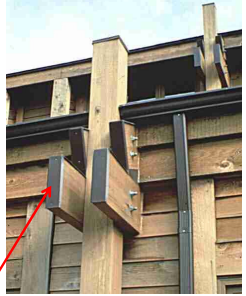

No end caps or flashing

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**Connection Serviceability**

Issue: direct water ingress

- Re-direct the water flow around the connection
- Preservative treated glulam
- End caps and flashing must allow for air flow and drying

end caps and flashing

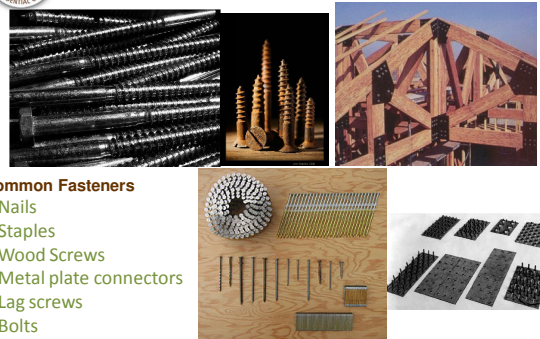
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**Summary of Techniques**

- Transfer loads in compression bearing whenever possible.
- Avoid the use of details that induce tension perpendicular-to-grain stresses in the member.
- Multiple fasteners instead of fewer fasteners
  - Reduce stress concentration
  - Improve redundancy
- Avoid eccentricity in joint details.
- Allow for dimensional changes in the wood due to potential in-service moisture cycling.
- Avoid moisture entrapment at connections.
- Do not place the wood in direct contact with masonry or concrete.
- Minimize exposure of end grain.

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**Mechanical Connectors**



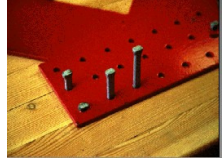


**Common Fasteners**

- Nails
- Staples
- Wood Screws
- Metal plate connectors
- Lag screws
- Bolts

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**Mechanical Connectors**

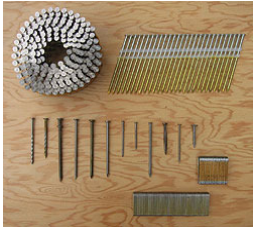




**Other types:**


- Rivets
- Split rings
- Shear plates
- Wood dowels

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**Mechanical Connectors**



**WOOD SCREW**



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**Small Diameter Fasteners**

**Nails and nomenclature**

- Short
- Box nail
- Ring nail
- Common nail
- Sinker
- Power-driven
- Roofing
- Etc.

**10d Nails**

3 x 0.250 Boat Nail	2 7/8 x 0.120 Sinker Nail
3 x 0.128 Box Nail	2 7/8 x 0.135 Corker Nail
2 7/8 x 0.113 Box Nail	3 x 0.148 Common Nail
3 x 0.128 Casing Nail	3 x 0.113 Finish Nail
2 7/8 x 0.120 Cooler Nail	3 x 0.135 Flooring Nail, Deformed

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**Nail Nomenclature**

- There is *no control* over nail nomenclature!
- Manufacturers can and will call fasteners anything that they want.
- 10d is not a clear specification!

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**Specifying Nails**

Avoid problems by specifying pennyweight, type, diameter and length

- Ex: 10d common (0.148" shank dia. X 3" shank length)

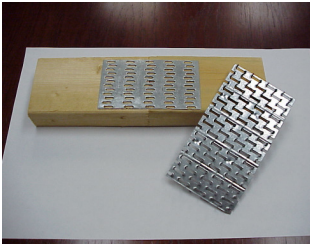


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**Connection Techniques**

**Truss plates**

- Design metal plate connections using the latest edition of ANSI/TPI 1



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**Large Fasteners**

- Lag Screws or Lag Bolts**
  - 1/4" – 1" diameter
  - Typically used where bolts can't
  - Turned into pre-drilled holes



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**Large Fasteners**


- Lag Screw Connections  
[www.awc.org/pdf/D\\_A1-LagScrew.pdf](http://www.awc.org/pdf/D_A1-LagScrew.pdf)



www.woodworks.org

**Large Fasteners**


- **Bolts**
  - ¼ to 1" dia. X 1"-16" long (NDS commentary 1" dia. Max.)
  - Pre-drilled holes 1/32 to 1/16" larger
  - Common mistake is not allowing room for installation



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**Bolts**


- Bolts in wood bearing must be 1 inch or less in diameter
- Diameters of 1" and larger can initiate high tension-perp stresses on the bolt hole that induce splitting of the wood



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**All-Wood Fasteners System\*\***

- Long History > 100 years
- Uses automated CNC milling technology
  - machine joints
  - pre-drill holes
- Timber Framers' Guild - [www.tfguild.org](http://www.tfguild.org)



www.woodworks.org

**Timber Rivets**

- **NDS - Rivets**
  - Hot-Dipped Galvanized
  - Fixed-shank cross-section
  - Fixed head dimension
  - Vary only in length
- **American Wood Council**  
[www.awc.org](http://www.awc.org)

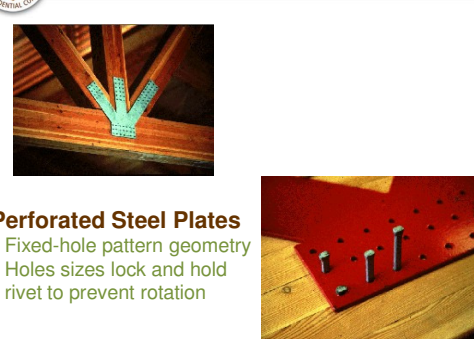
- Canada several decades
- **2005 NDS**
  - Glued Laminated Timber
    - DFL
    - SP



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**Timber Rivets\*\***

- **Perforated Steel Plates**
  - Fixed-hole pattern geometry
  - Holes sizes lock and hold rivet to prevent rotation



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**Specialized Connectors**


- **Split Ring**
  - Wood-to-wood
  - Require special tooling of wood prior to job site
- **Shear Plates**
  - Wood-to-dissimilar materials (concrete or steel)
- **Both have successful long history**
  - Large Glulam or PSL
- **NDS & AWC**



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**Pre-engineered Connectors**

- **Joist and beam hangers**
  - Top and face mount
  - Product specific
  - Use correct nail
  - Fill all holes
  - Ensure proper fastener penetration




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**Pre-engineered Connectors**


**Column Cap & Base hardware**



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**Pre-engineered Connectors**


**Hanger hardware**



www.woodworks.org

**Pre-engineered Connectors**

**Hold-down hardware**



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## Codes, Provisions, and Guidance

- **Prescriptive**
  - Follows a recipe
  - IBC, ER, NER reports
  - No design values
- **Engineered**
  - NDS & NER-272
  - Design values
  - Accounts for performance of different materials
  - Nominal value
    - End use application

[www.woodworks.org](http://www.woodworks.org)

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## Codes, Provisions, and Guidance

### ICC Reports – International Staple, Nail and Tool Association (ISANTA)

- NER-272
- ESR-1539

ICC Evaluation Service, Inc.  
www.icc-es.org

Division: 06—WOOD AND PLASTICS  
Section: 0609—Nails

Report Holder:  
INTERNATIONAL STAPLE, NAIL AND TOOL ASSOCIATION

NER-272  
Revised January 7, 2004  
Revised in August 7, 2004

ESR-1539  
Revised September 1, 2005  
This report is subject to re-examination in two years.

ICC Evaluation Service, Inc.  
www.icc-es.org

Division: 06—WOOD AND PLASTICS  
Section: 0609—Nails

Report Holder:  
INTERNATIONAL STAPLE, NAIL AND TOOL ASSOCIATION

NER-272  
Revised January 7, 2004  
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## Codes, Provisions, and Guidance

### IBC & ICC-ES

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### IBC & ICC-ES

2006

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### IBC & ICC-ES

2006

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### IBC & ICC-ES

2006

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## Codes, Provisions, and Guidance

### National Design Specification for Wood Construction, 2005 Edition (NDS)

WOODWORKS INTERNATIONAL PRESIDENTIAL COUNCIL

### National Design Specification for Wood Construction, 2005 Edition (NDS)

2005 EDITION

NDS  
NATIONAL DESIGN SPECIFICATION  
FOR WOOD CONSTRUCTION

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### National Design Specification for Wood Construction, 2005 Edition (NDS)

2005 EDITION

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### National Design Specification for Wood Construction, 2005 Edition (NDS)

2005 EDITION

NDS  
NATIONAL DESIGN SPECIFICATION  
FOR WOOD CONSTRUCTION

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## NDS\*\*

AMERICAN FOREST & PAPER ASSOCIATION  
American Wood Council  
Engineered and Traditional Wood Products

1944 1962 1968 1971 1973 1977 1982 1986 1991 1997 2001 2005

and so it was for a long time

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## Basic Theory: Engineered Design

- Nominal Design Values defined by a table in code or NDS.
- Nominal Design Values based on equations in the NDS
- Nominal Design Values based on assumed end-use conditions
  - Normal Load Duration (10 year)
  - Dry Condition of Use
  - No Sustained exposure to elevated temperatures
  - And others.

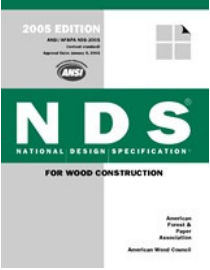
www.woodworks.org



**Basic Theory: Engineered Design\*\***

The NDS has design provisions

- Nominal x adjustment factors = Allowable (or LRFD)
- Adjustment factors account for a wide range of different end use applications
- Strength = total fasteners (group action)



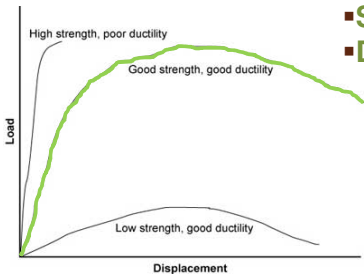
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**Basic Theory: Engineered Design**

- For nails, spikes, bolts, lag screws and wood screws
  - Lateral load design values are calculated by yield-limit equations – Yield Model
  - Withdrawal design capacity calculated from empirical (test-based) equations.
- Split rings, shear plates, dowels, drift pins, and timber rivets etc.
  - Lateral and withdrawal design values from empirically based tables.

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**Connection Behavior**



- Strength
- Ductility

www.woodworks.org

**Mechanical Connections**

**Basic Type of Connections**

- Dowel-type fasteners
  - Bolts, Lag Screws, Wood Screws, Nails/Spikes, Drift bolts, and Drift Pins
- Split Ring and Shear Plate Connectors
- Timber Rivets
- Lateral and Withdrawal Loads.

www.woodworks.org

**RESOURCES**

Where to get more information

www.woodworks.org

**WEBSITES**

- American Wood Council - [www.awc.org](http://www.awc.org)
- APA – The Engineered Wood - [www.apawood.org](http://www.apawood.org)
- Canadian Wood Council - [www.cwc.ca](http://www.cwc.ca)
- Forest Products Laboratory - [www.fpl.fs.fed.us](http://www.fpl.fs.fed.us)
- Southern Pine Council - [www.southernpine.com](http://www.southernpine.com)
- Wood Truss Council of America – [www.woodtruss.com](http://www.woodtruss.com)
- WoodWorks - [www.woodworks.org](http://www.woodworks.org)

www.woodworks.org

**Where to Find Specifics**

**IBC & ICC-ES**

**ES LEGACY REPORT** NER-272  
Revised January 1, 2004  
 ICC Evaluation Service, Inc.  
 www.iccs-es.org

**INTERNATIONAL BUILDING CODE**  
**2006**

**ES REPORT™** ESR-1539  
Released September 1, 2005  
 ICC Evaluation Service, Inc.  
 www.iccs-es.org

**DIVISION 05—WOOD AND PLASTICS**  
SECTION 05050—DOORS  
 REPORT HOLDER:  
 INTERNATIONAL STAPLE NAIL AND TOOL ASSOCIATION  
 115 WEST BURLINGTON AVENUE, SUITE 203  
 LAWRENCE, ILLINOIS 62524-2345  
 T708.682.6100  
 WWW.ISTANAIL.COM

**POWER-DRIVEN STAPLES AND NAILS**

**WOODWORKS PRESIDENTIAL COUNCIL**

**Where to Find Specifics**

**NDS**

**2005 EDITION**  
 ANSI/AWC 2005  
 NATIONAL DESIGN SPECIFICATION  
**NDS**  
 NATIONAL DESIGN SPECIFICATION  
 FOR WOOD CONSTRUCTION

**2005 EDITION**  
 ANSI/AWC 2005  
 ASD/LRFD  
**EXAMPLES**  
 STRUCTURAL WOOD DESIGN  
 SOLVED EXAMPLE PROBLEMS

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[www.woodworks.org](http://www.woodworks.org)

**Where to Find Specifics**

- The NDS has design provisions
- Allowable = nominal x adjustment factors
- Adjustment factors account for a wide range of different end use applications

**2005 EDITION**  
 ANSI/AWC 2005  
**NDS**  
 NATIONAL DESIGN SPECIFICATION  
 FOR WOOD CONSTRUCTION

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[www.woodworks.org](http://www.woodworks.org)

**Where to Find Design Examples**

**APPLICATION OF TECHNICAL REPORT 12 FOR LAG SCREW CONNECTIONS**  
 DESIGN AID No. 1

**GENERAL DOWEL EQUATIONS FOR CALCULATING LATERAL CONNECTION VALUES**  
 TECHNICAL REPORT 12

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[NDS Free Download http://www.awc.org](http://www.awc.org)

[www.woodworks.org](http://www.woodworks.org)

**Where to Find Design Examples**

**TODENAIL CONNECTIONS**  
 DESIGN AID No. 2

**POST FRAME RING SHANK NAILS**  
 DESIGN AID No. 4

**WOODWORKS PRESIDENTIAL COUNCIL**

[NDS Free Download http://www.awc.org](http://www.awc.org)

[www.woodworks.org](http://www.woodworks.org)

**Where to Find Design Examples**

**TFEC 1-07**  
 Standard for Design of Timber Frame Structures and Commentary

**Free Download - Timber Framers Guild**  
<http://www.tfguild.org/publications/tfec1-07.pdf>

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[www.woodworks.org](http://www.woodworks.org)

**Where to Find Design Examples**

**Timber Rivet Connections**

**Timber Rivet Connections – The Design Process Revealed**  
 Robert F. Taylor, Ph.D., F.Eng., Assoc. ASCE\*\*  
 David M. Nicks, Ph.D., F.Eng., Ph.D., LEED AP\*\*

**INTRODUCTION**  
 Timber rivet connections have been used extensively in timber structures over the past 50 years. They are part of the US and Canadian minimum wood design code, but unfortunately, there are few published design examples to aid designers.<sup>1,2,3,4</sup> This paper is required by the construction manager and provides a clear summary of the 2005 NDS<sup>5</sup> design process for timber rivet connections along with comments to design teams of contractors.

**Features and installation**  
 In general, timber rivet connections can be characterized as large, solid mass joints. The hole diameter and the dimensions of the rivet head are important factors required to design "solid rivets." Connections with small heads may not develop this characteristic. The tensile strength of the rivet depends on the size, type, support and construction of the rivet prior to insertion to this (not necessarily the connection designer). Dimensional details of the rivet rivets being used, along with details related to a pretensioned steel plate are described in the 2005 NDS<sup>5</sup>, Appendix M.

**Timber rivets have a unique installation procedure that is noted in CSA 1016 and further explained in the Commentary.<sup>6</sup> Timber rivets of the group shall be driven flat. Successive timber rivets should be driven in a spiral pattern from the outside to the center of the group.<sup>7</sup> In Dr. Robert F. Taylor's definition of Timber Connections, he describes the original line of reasoning behind this procedure: "The wood cross section of the rivet with its long dimension placed parallel with the grain drives when the head is perpendicular to the grain does not cut the fibres, but pushes the fibres to each side as the rivet drives into place, the fibres between two adjacent rivets are compressed axially to about 20%."<sup>8</sup> See**




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**AWC & WWP**

**FREE DOWNLOAD**

- Notching & Boring Guide
  - <http://www2.wwpa.org/TECHGUIDEPAGES/Literature/tabid/883/Default.aspx>
- Timber Rivet Connections
  - [www.awc.org/pdf/TimberRivetConnections.pdf](http://www.awc.org/pdf/TimberRivetConnections.pdf)
- Lag Screw Connections
  - [www.awc.org/pdf/DA1-LagScrew.pdf](http://www.awc.org/pdf/DA1-LagScrew.pdf)
- Dowel Equations for Lateral Loads 2001 NDS
  - [www.awc.org/pdf/tr12.pdf](http://www.awc.org/pdf/tr12.pdf)
- Toenail Connections
  - [www.awc.org/pdf/DA2-Toenails.pdf](http://www.awc.org/pdf/DA2-Toenails.pdf)
- Post Frame Ring Shank Nails Connections
  - [www.awc.org/pdf/DA4-RingShank.pdf](http://www.awc.org/pdf/DA4-RingShank.pdf)

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**For More Information: APA Forms**

- Go to [www.apawood.org](http://www.apawood.org) and enter the Publications store
- The following publications expand on the information given in this presentation and can be downloaded for free using subject, title, or form number

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**APA Forms (www.apawood.org)**

- G535 – Field Notching and Drilling of Laminated Veneer Lumber
- S560 – Field Notching and Drilling of Glued Laminated Timber Beams
- T300 – Glulam connection details
- E830 – Screw and plywood connections
- E825 - Bolt and plywood connections
- D485 – Corrosion resistant fasteners
- TT-035 – Corrosion resistant fasteners
- TT-036 – Glued floors
- TT-039 – Nail withdrawal
- TT-070 – Nail pull through

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**Fastener Corrosion\*\***

- AWC - Fact Sheet –Fastener Corrosion**  
<http://www.awc.org/Publications/FactSheets/CorrosionFactSheet.pdf>
- APA – Technical Note D485 Corrosion-Resistant Fasteners for Construction**  
<http://www.apawood.org>

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**Next...**

**Design software**

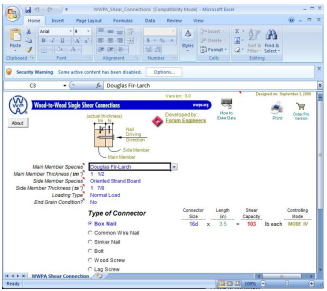
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**WWPA Free Downloadable**

**WWPA Lumber Design Suite**

- Beams and Joists
- Post and Studs
- Wood to Wood Shear Connections (nails, bolts, wood screws and lag screws)

<http://www2.wwpa.org/TECHGUIDEPAGES/DesignSoftware/tabid/859/Default.aspx>



The screenshot shows the WWPA Lumber Design Suite software interface. It features a menu bar, a toolbar, and a main workspace. A table titled 'Type of Connector' is visible, listing different connector types and their properties. The table has columns for Connector, Length, Shear Capacity, and Controlling Stress.

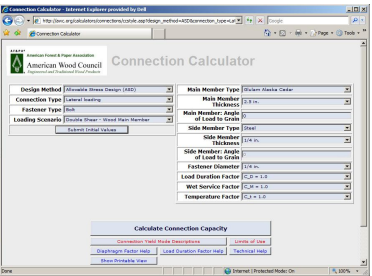
Connector	Length	Shear Capacity	Controlling Stress
1/2" x 3 1/2"	3 1/2"	955	to each 16000 lb

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**AWC Free Online Calculator**

- Single and Double Shear
- Withdrawal
  - Bolts, nails, lag screws and wood screws.
- Wood-to-Wood
- Wood-to-Concrete
- Wood-to-Steel

<http://awc.org/calculators/connections/ccstyle.asp>



The screenshot shows the AWC Free Online Calculator interface. It includes a title bar, a menu bar, and a main content area with various input fields for design parameters. A 'Calculate Connection Capacity' button is prominently displayed at the bottom.

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**www.APACAD.org**

**CAD Construction Details**


HOME PUBLICATIONS SPECIFICATIONS CAD DETAIL INDEX

Panel Floor Construction  
Panel Roof Construction  
Panel Wall Construction  
Build a Better Home  
Gullam Beams  
Joists Floor Framing  
Lateral Load Connection for Low-Slope Roof Diaphragms  
Special Construction Systems

Welcome to APACAD.org, a resource for building designers and construction professionals in search of CAD details for wood-frame construction.

To search for a detail, select CAD Detail Index from the column on the left. You'll be able to preview thumbnail images of more than 100 CAD details, sorted by product and construction topics. After selecting the detail that you need, simply follow the on-screen instructions to download the detail in .DWG, .DXF, or .DWG format. If you don't have a CAD program on your computer, you can preview images in CAD format by downloading the Autodesk DWG Viewer software.

[www.woodworks.org](http://www.woodworks.org)



The screenshot shows the www.APACAD.org website. It features a navigation menu on the left with categories like 'HOME PUBLICATIONS SPECIFICATIONS CAD DETAIL INDEX'. The main content area includes a welcome message and instructions on how to search for and download CAD details.

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**www.WoodUniversity.org**

WELCOME TO WOOD UNIVERSITY

The Online Resource for Learning About Engineered Wood.

Knowledge is Power! Whether you're an architect, engineer, builder or student, Wood University provides engineered wood product training at your fingertips. Funded by APA—The Engineered Wood Association's extensive resources, Wood University's goal is to expand your understanding of engineered wood products and applications through an easy-to-navigate web format.

Earn Continuing Education Credits! Wood University also gives you the opportunity to register for course credit (earning units) via the American Institute of Architects and the American Institute of Building Design. At this time, continuing education credits are only available for Course 101, Engineered Wood Basics.

Getting Started

- To Register for a course, click the blue 'Register' button to your left.

[www.woodworks.org](http://www.woodworks.org)



The screenshot shows the www.WoodUniversity.org website. It features a 'WELCOME TO WOOD UNIVERSITY' banner, a navigation menu, and a registration form. The main content area includes a welcome message and information about course credit.

www.woodworks.org

**AWC Free Online Course**

**DES110: The Wood Connection Session**

<http://www.awc.org/HelpOutreach/eCourses/index.html>



The screenshot shows the AWC Free Online Course page for DES110: The Wood Connection Session. It features a large image of a wood connection and a title box with the course name. Logos for APA, AWC, and WCA are visible at the bottom.

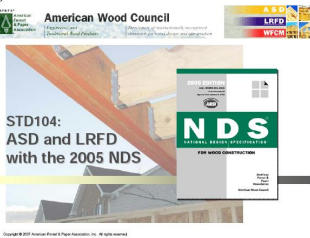
www.woodworks.org

**AWC Free Online Course**

AMERICAN FOREST & PAPER ASSOCIATION  
American Wood Council  
Engineered and Traditional Wood Products

**STD104: ASD and LRFD with the 2005 NDS**

<http://www.awc.org/HelpOutreach/eCourses/STD104/STD104eCourseV11-2007.pdf>



The screenshot shows the AWC Free Online Course page for STD104: ASD and LRFD with the 2005 NDS. It features a large image of a wood connection and a title box with the course name. Logos for AWC and NDS are visible at the bottom.

www.woodworks.org



## Take home messages...

It's easy to create strong durable wood connections

- Avoid the use of details which induce tension perpendicular to grain stresses in the wood
- Allow for dimensional changes in the wood due to potential in-service moisture cycling
- Minimize exposure of end grain
- Avoid moisture entrapment in connections
- Use smaller multiple fastener connections

[www.woodworks.org](http://www.woodworks.org)



## Questions???

**WoodWorks!**

Michelle Kam-Biron, S.E.

Technical Director

**Scott Lockyear, P.E.**

Cell: (615) 439-0624

[scott@woodworks.org](mailto:scott@woodworks.org)

[www.woodworks.org](http://www.woodworks.org)

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