Engineered Wood A to Z

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Midwest Regional Manager
American Wood Council

MAT210 - Traditional and Engineered Wood Products

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AMERICAN WOOD COUNCIL

Tall Wood Structures: Current Trends and Related Code and Standards Changes-DES600

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Description

This course is an introduction to the ever-growing family of traditional and engineered wood products (EWP). Products covered are lumber, glued-laminated timber (glulam), cross-laminated timber, nail-laminated timber, structural composite lumber, wood I-joists, and wood structural panels. The standards that form the basis for the manufacture and development of design stresses for each product are discussed as well as design provisions included in AWC's *National Design Specification (NDS) for Wood Construction*. Unique characteristics for each product are highlighted and extensive examples of the use of these products in a wide range of building applications are presented. The course also provides both an introduction to historic wood structures and modern innovative wood structures.

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Learning Objectives

- **Be familiar with the ever-growing family of engineered wood products (EWP's) and their unique characteristics, including: lumber, glued-laminated timber (glulam), cross laminated timber (CLT), nail laminated timber (NLT), structural composite lumber, wood I-joists, plywood, oriented strand board.**
- **Be familiar with the standards that form the basis for the manufacture, development of design stresses, and design procedures for each product.**
- **Be knowledgeable about the use of these products through examples of a wide range of building applications.**
- **Be familiar with the resources that are available to obtain more information.**

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Palette of Wood Framing Members Available

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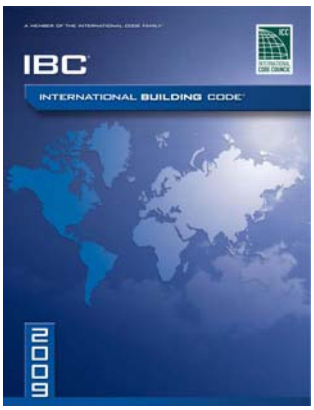
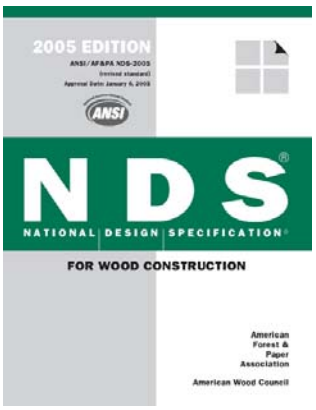
Wood Framing Members – Codes/Standards

Structural Panels	Repetitive Framing	Beams/ Girders	Wall Studs	Mass Timber





2011 Ohio Building Code

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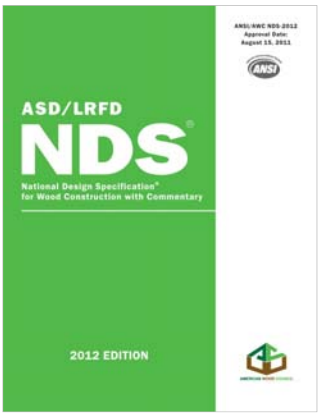
Wood Framing Members – Codes/Standards

Structural Panels	Repetitive Framing	Beams/ Girders	Wall Studs	Mass Timber



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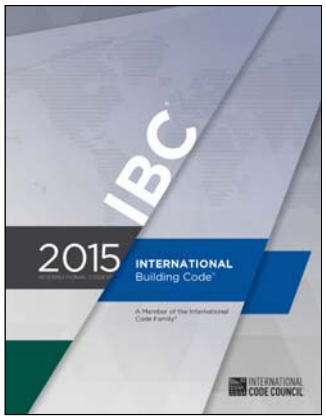
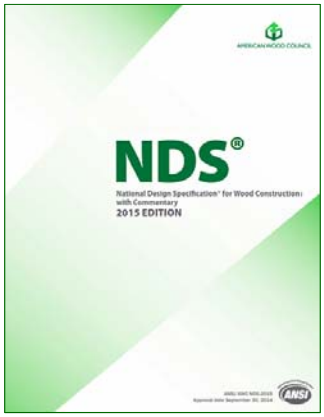
Wood Framing Members – Codes/Standards

Structural Panels	Repetitive Framing	Beams/ Girders	Wall Studs	Mass Timber





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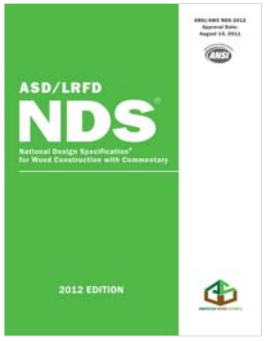
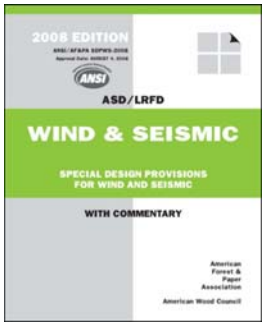
NDS 2012 Chapters



1. General Requirements for Building Design
2. Design Values for Structural Members
3. Design Provisions and Equations
4. Sawn Lumber
5. Structural Glued Laminated Timber
6. Round Timber Poles and Piles
7. Prefabricated Wood I-Joists
8. Structural Composite Lumber
9. Wood Structural Panels
10. Mechanical Connections
11. Dowel-Type Fasteners
12. Split Ring and Shear Plate Connectors
13. Timber Rivets
14. Shear Walls and Diaphragms
15. Special Loading Conditions
16. Fire Design of Wood Members

SDPWS 2008 Chapters



- General Design Requirements
- Members and Connections
- Lateral Force-Resisting Systems
  - Diaphragms
  - Shear Walls

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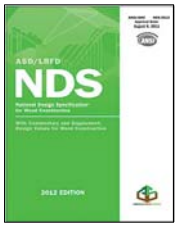
2015 NDS Chapter Reorganization

2012 NDS

- 1-3 General
- 4-9 Products
- 10-13 Connections
- 14 Shear Walls & Diaphragms
- 15 Special Loading
- 16 Fire



2015 NDS

- 1-3 General
- 4-10 Products +CLT
- 11-14 Connections
- Shear Walls & Diaphragms
- 15 Special Loading
- 16 Fire

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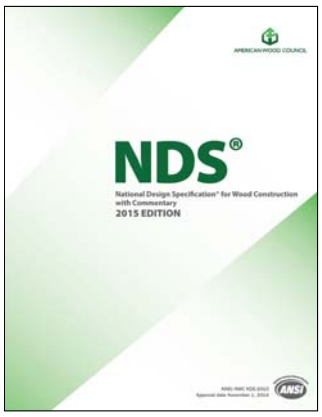
CLT Design: 2015 NDS

2015

1. General Requirements for Building Design
2. Design Values for Structural Members
3. Design Provisions and Equations
4. Sawn Lumber
5. Structural Glued Laminated Timber
6. Round Timber Poles and Piles
7. Prefabricated Wood I-Joists
8. Structural Composite Lumber
9. Wood Structural Panels
10. **Cross-laminated Timber**
11. Mechanical Connections
12. Dowel-Type Fasteners
13. Split Ring and Shear Plate Connectors
14. Timber Rivets
15. Special Loading Conditions
16. Fire Design of Wood Members



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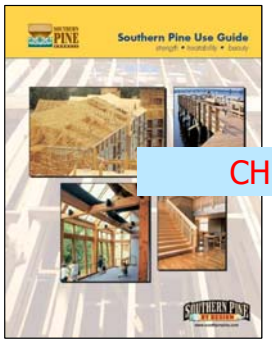
Wood Framing Member Resources

Structural Panels	Repetitive Framing	Beams/ Girders	Wall Studs	Mass Timber



CHECK LOCAL AVAILABILITY

www.sfpa.org
#200

www.wwpa.org
Model #A

www.apawood.org
APA Form E30U

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Wood Framing Members

Structural Panels	Repetitive Framing	Beams/ Girders	Wall Studs	Mass Timber

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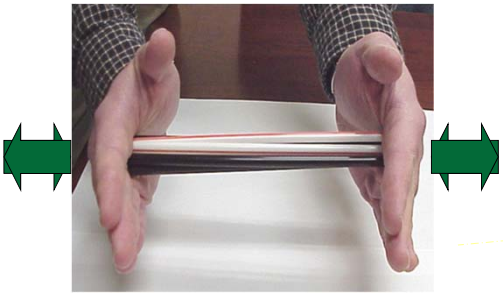
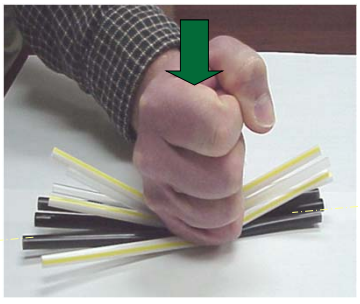
Wood Parallel to Grain

Parallel



Stronger

Perpendicular



Less strong

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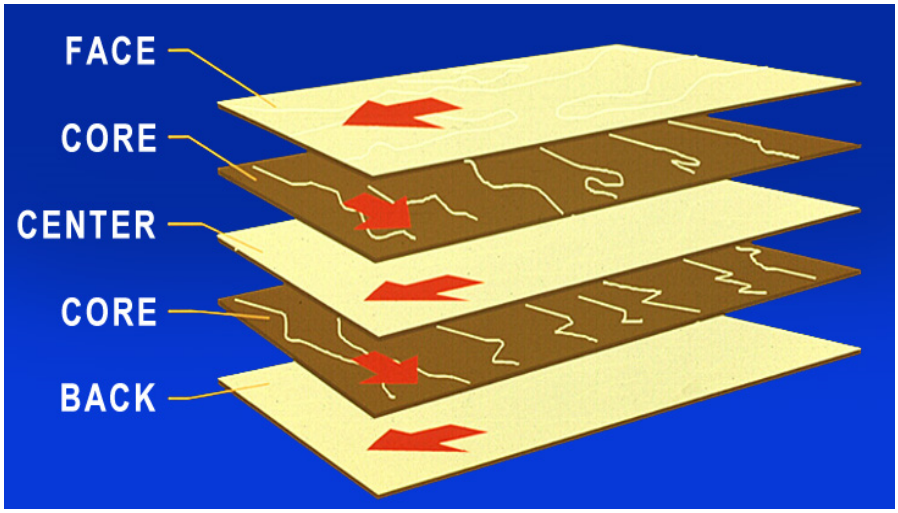
Plywood Layup



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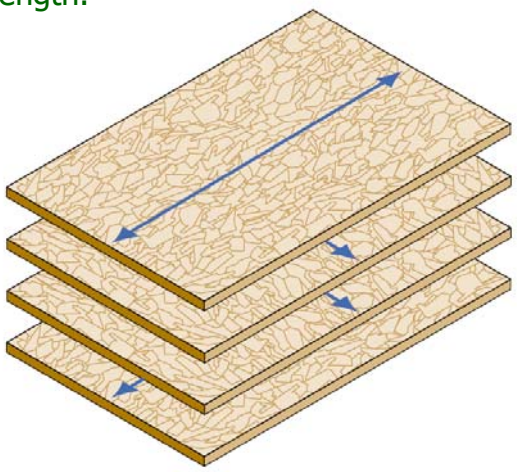
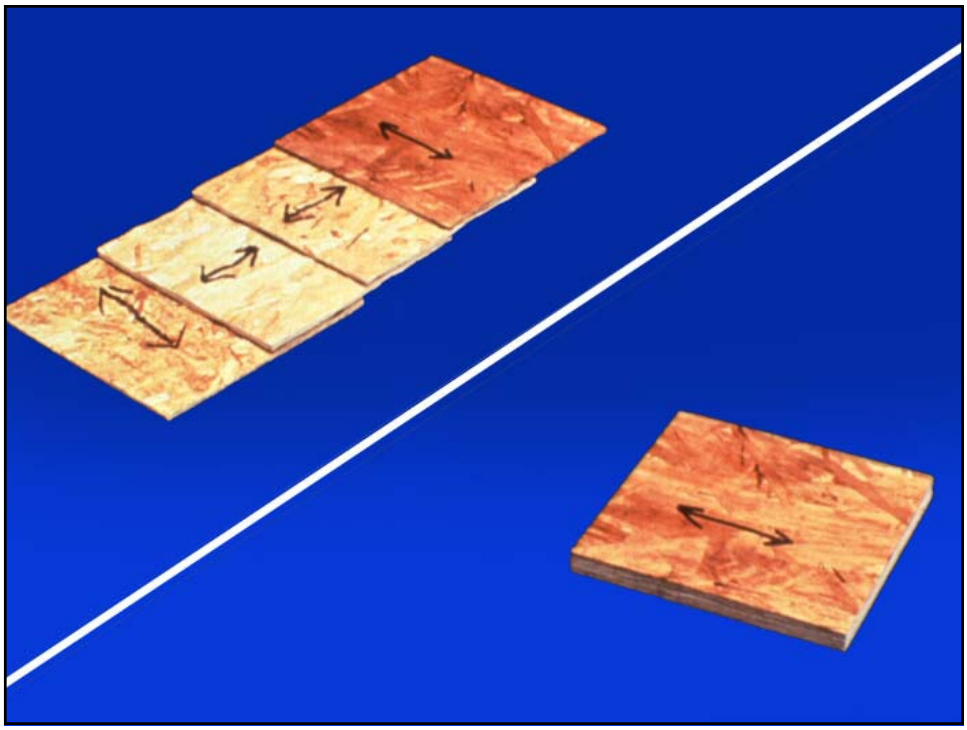
Structural Panels Manufacturing
Oriented Strand Board (OSB)

OSB layers are
engineered for strength.





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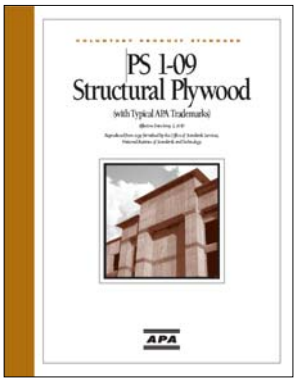
Manufacturing Standards



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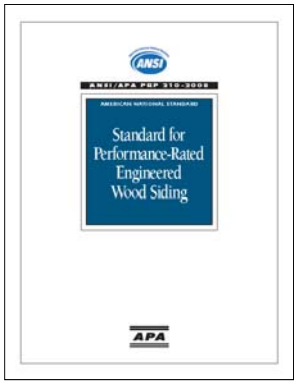

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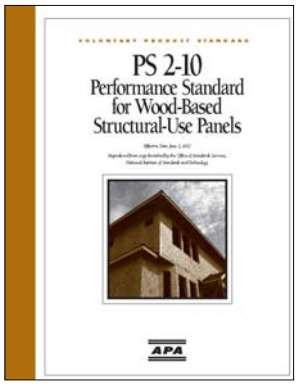

S350

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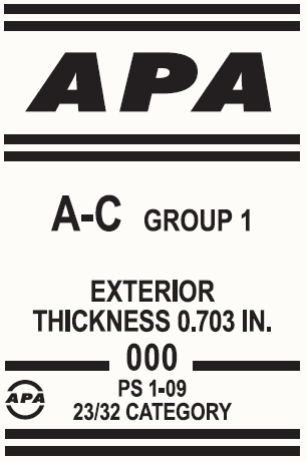
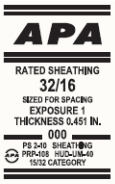
Grade Stamping



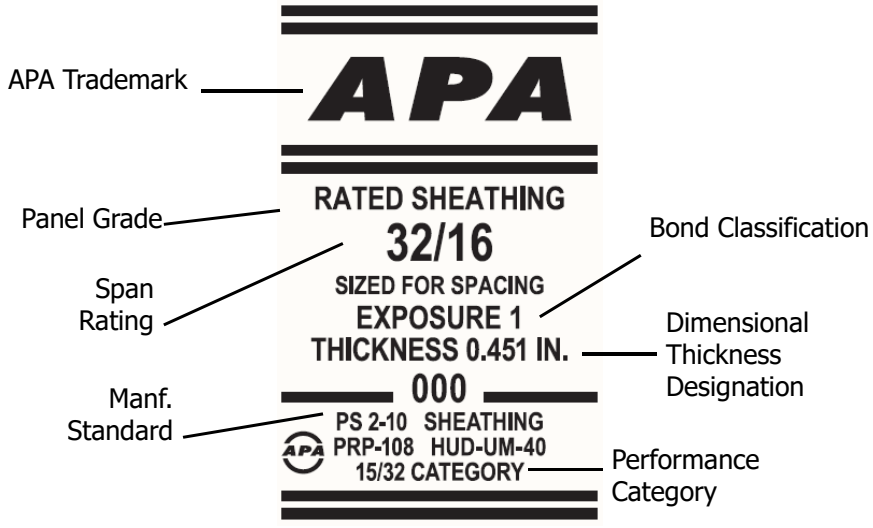
APA RATED SHEATHING
Typical Trademark



APA STRUCTURAL I
RATED SHEATHING[c]
Typical Trademark

APA RATED
STURD-I-FLOOR
Typical Trademark

Grade Stamping



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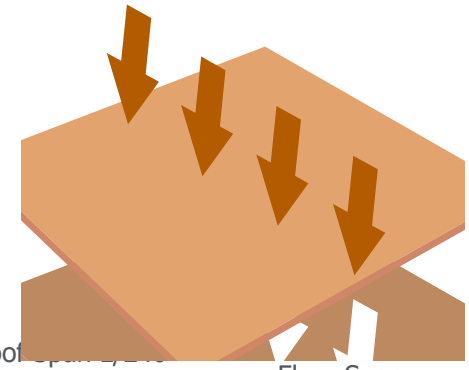
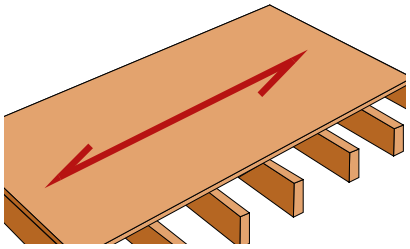
Span Rating Design Criteria



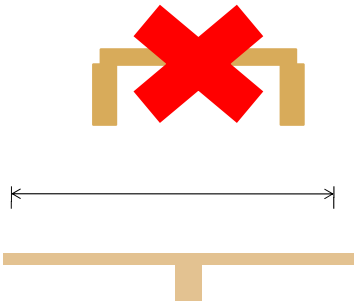
Roof Span L/240
30 PSF live
10 PSF dead

Floor Span
L/360
100 PSF live
10 PSF dead

Span Rating Conditions



Strength axis perpendicular to supports



Continuous across 2 or more spans

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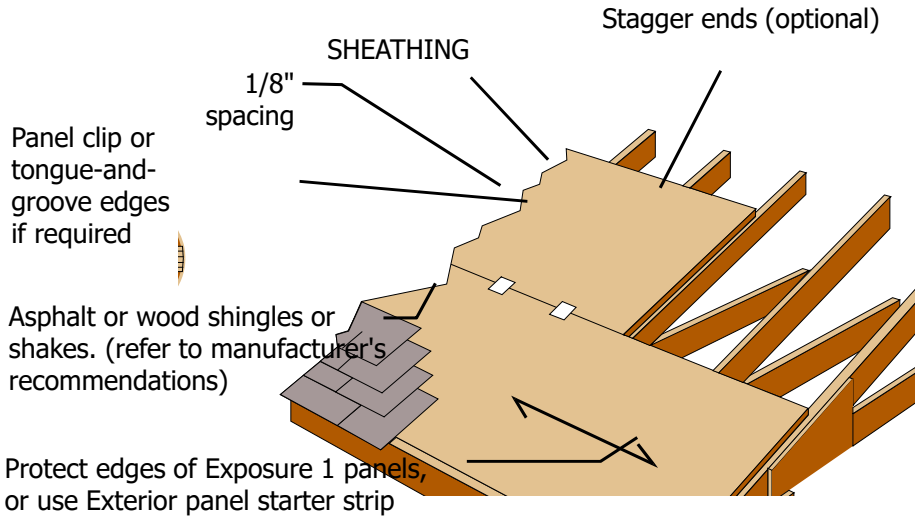
Correct Panel Spacing



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Veneer Grade of Sheathing

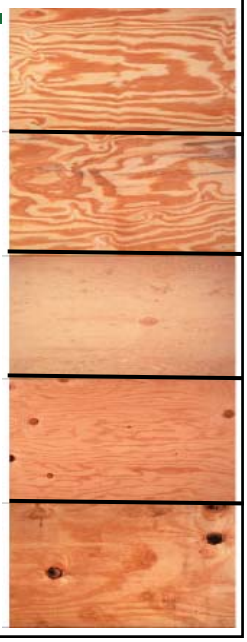
A Smooth, paintable. Not more than 18 neatly made repairs.

B Solid surface. Repairs, and tight knots to 1 inch.

C-Plugged
Improved C veneer. Knotholes or other open defects limited to 1/4 x 1/2 inch.

C Tight knots to 1-1/2 inch. Knotholes to 1 inch across grain. Occasional 1-1/2-inch knothole.

D Knots and knotholes to 2-1/2 inch. Occasional 3-inch knothole.



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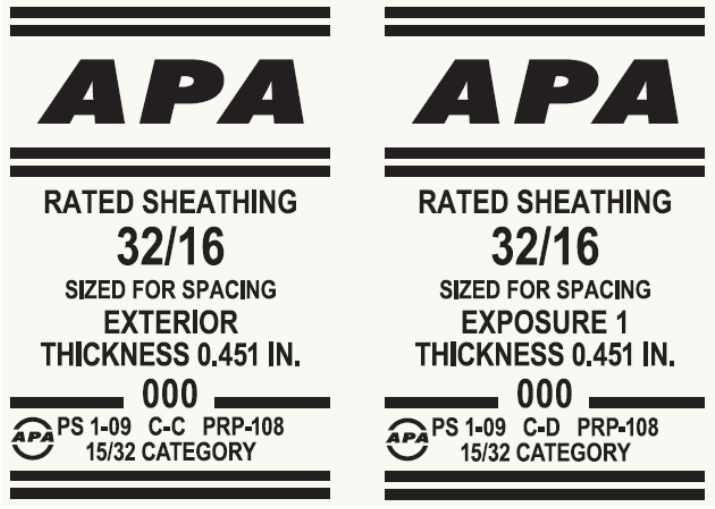
Bond Classifications



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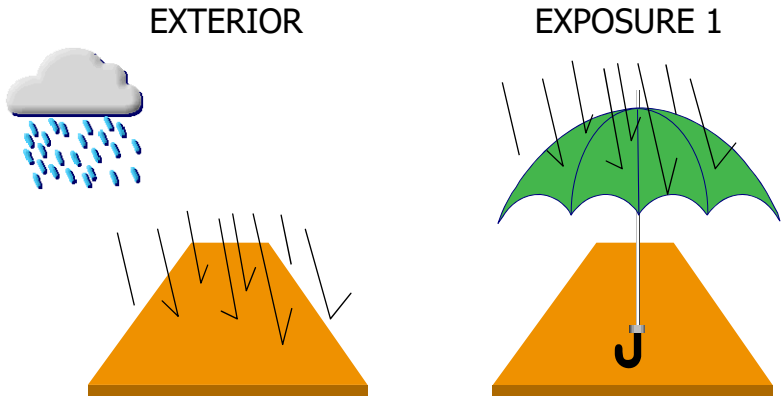
Bond Classifications



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Exposure Durability Levels

Exposure 1

- **Waterproof glue**
- **Permits use of D-grade veneer (plywood)**

Exterior

- **Waterproof glue**
- **Minimum C-grade veneer (plywood)**

CDX does NOT mean Exterior grade . . . Just exterior glue!!!

Moisture Exposure Recommendations

In-Service Moisture Content	End-Use Moisture Conditions	Recommended Bond Classification	Design Moisture Conditions[a]
Less than 16%	Dry uses	Exposure 1 or Exterior	Dry
16% to 19%	Humid interior or protected uses	Exposure 1 or Exterior	Wet
Greater than 19%	Long-term exposure to weather	Exterior	Wet
	Other very humid or wet uses	Exterior[b]	Wet
	Ground contact	Exterior[b]	Wet

(a) Contact APA for specific design provisions.
(b) Recommend pressure treatment.

APA E30

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Roof Sheathing Application – HUGE Warehouses

- **40% of US Imports flow through California ports**
- **Ports are Bottlenecks**
- **Consolidated warehousing gaining favor**
- **1 Million square foot warehouses are becoming common place**

Slide provided by John Lawson, S.E., Kramer and Lawson

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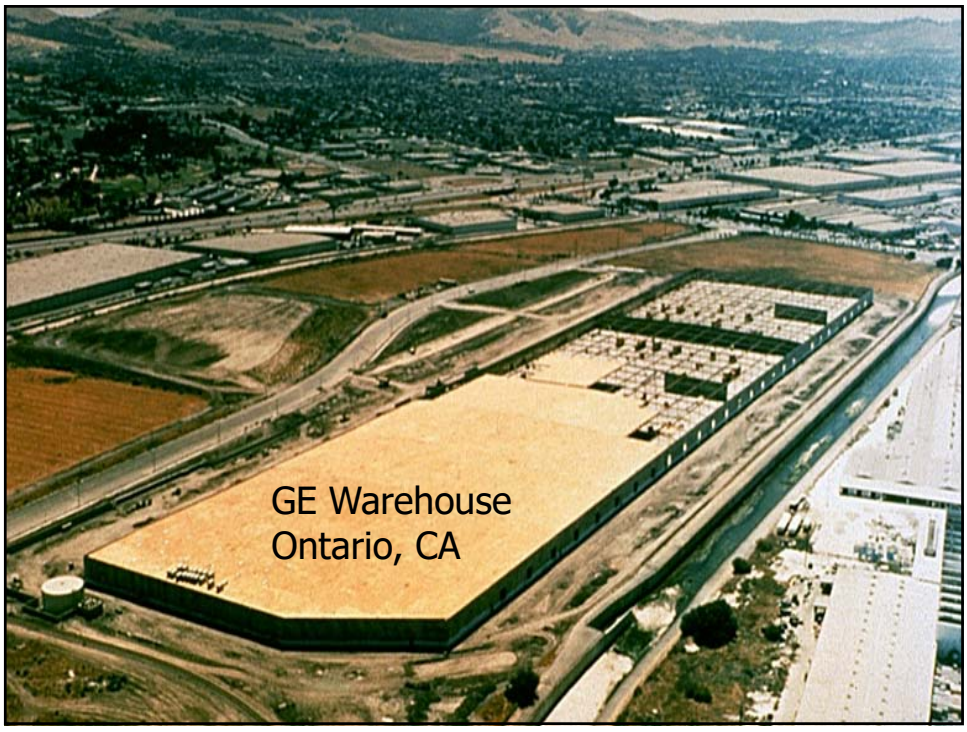

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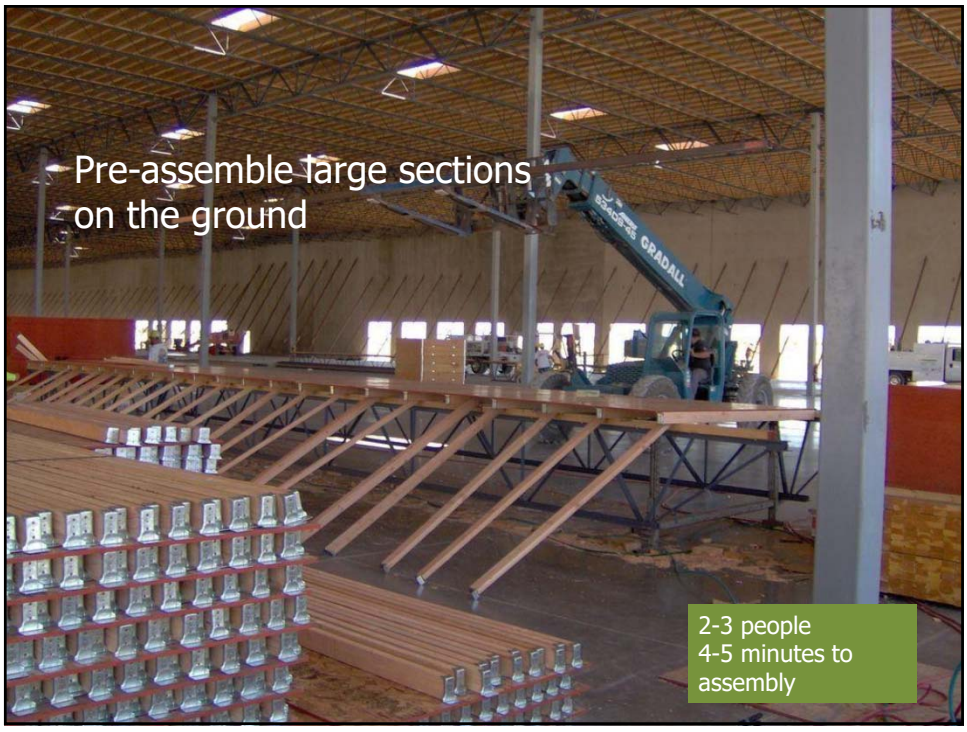

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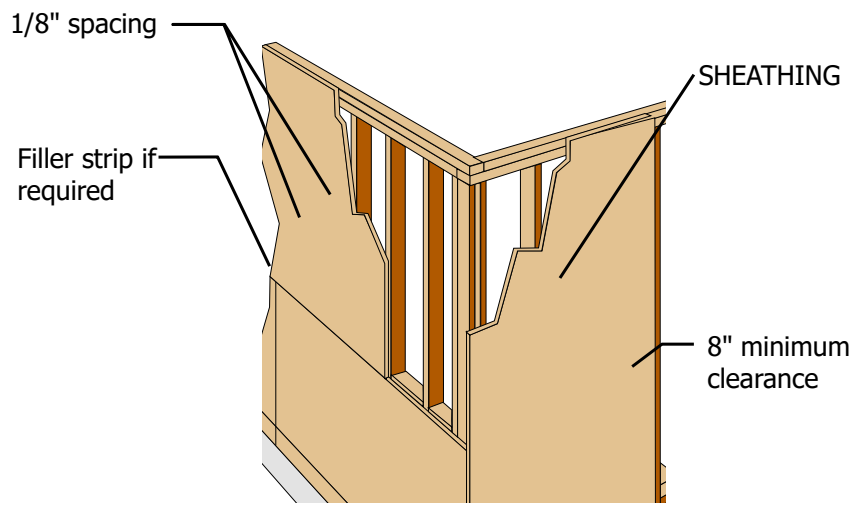
Wall Sheathing



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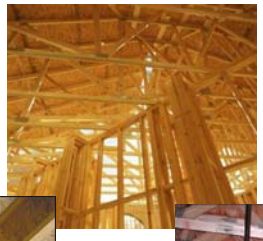
Typical Panel Sizes

- Wall and roof sheathing - 3/8, 7/16, 15/32, 1/2, 19/32, 5/8, 23/32, and 3/4 inch thick.
- Floor sheathing - 19/32, 5/8, 23/32, 3/4, 1, and 1-1/8 inch thick.
- Plywood –
  - 4 x 8 foot panels
  - 4 x 10, 5 x 10, 4 x 12 and 5 x 12 feet western mills
  - 10 and 12 foot panels have very limited availability
  - Larger panels can be produced by joining two panels together with structural scarf or finger joints.
- OSB –
  - 4 x 8 foot panels
  - Most manufacturers make oversized panels up to 8 x 24 feet, which are typically used for panelized roof systems or modular floor systems.

Wood Framing Members

Structural Panels | Repetitive Framing | Beams/ Girders | Wall Studs | Mass Timber



Rafters, Joists, I-Joists, Trusses

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Solid Sawn Lumber - Rafters

Solid Sawn Lumber – Floor Joist

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Solid Sawn Lumber

Rafters and Joists
- Readily available
- 2x4 to 2x12 (sometimes 2x14
- 8′ to 20′ lengths (in 2′ increments)
- ≤ 16′ spans are the most cost effective solution

NOTE: check local availability

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Products Association

- **Rules writing/Quality Services**
- **Economic Services**
- **Lumber Grading**
- **Technical Support**
- **Information Services**
- **Product Support Services**

Southern Pine Inspection Bureau

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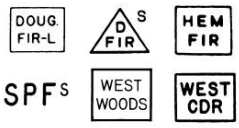
Visual Stress-Graded Lumber

- **Dimension Lumber evaluated by certified lumber graders**
  - **Visually examine each piece**
  - **Assigned grade based on visual characteristics**
  - **Each grade denotes design strength and stiffness value**
  - **Based on ASTM D1990**
- **+90% of lumber is visually graded.**

Grade Stamps

BASIC INFORMATION FROM STAMP:
1. Who made it
2. How strong is it

GRADE MARKS:
a) Certification mark
b) Mill Identification
c) Grade designation
d) Species identification



e) Condition of seasoning
MC-15 – 15% max. MC
KD-15
S-DRY - 19% max. MC
KD
S-GRN - over 19% MC
(unseasoned)

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Machine Graded Lumber

Machine Stress-Rated Lumber (MSR)

- **Machine Non-destructively evaluates stiffness**

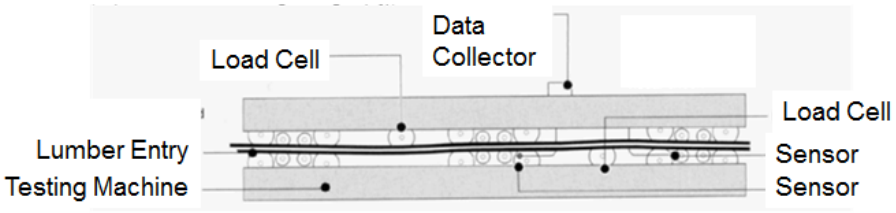
Machine Evaluated Lumber (MEL)

- **Machine Non-destructively evaluates density**

- **Both MSR & MEL**
  - **Strength - Bending Stiffness**
  - **Stiffness - Sorts by Modulus of Elasticity**

Machine Grade Lumber - MSR and MEL

- **Machine Stress Lumber**
- **Grading machinery induces slight stresses to measure stiffness.**



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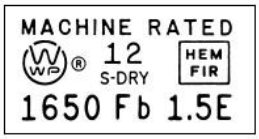
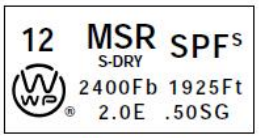
Machine Stress-Rated Lumber (MSR)

GRADE STAMP

- Product Designation – MSR, MACHINED RATED
- Registered Trademark of Grading Agency
- Mill Number or Name
- Moisture Content
- Species F_b and E rating
- When additional control process are implemented F_t, SG, F_{cperp} and F_v



Typical MSR Stamp



MSR Stamp with Additional Quality Control

Machine Evaluated Lumber (MEL)

GRADE STAMP

- Product Designation – MEL, MACHINE RATED
- Registered Trademark of Grading Agency
- Mill Number or Name
- Moisture Content
- Species F_b and E rating
- When additional control process are implemented F_t, SG, F_{cperp} and F_v

Sample MEL Grade-mark

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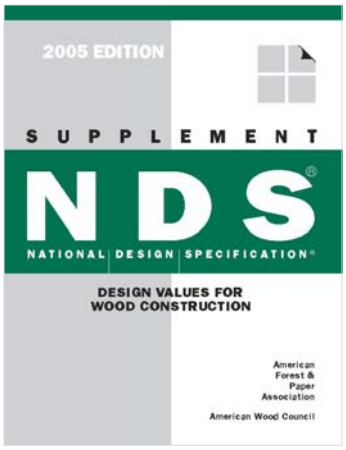
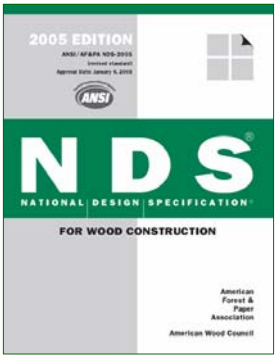
Governing Standards for Engineered Wood Design

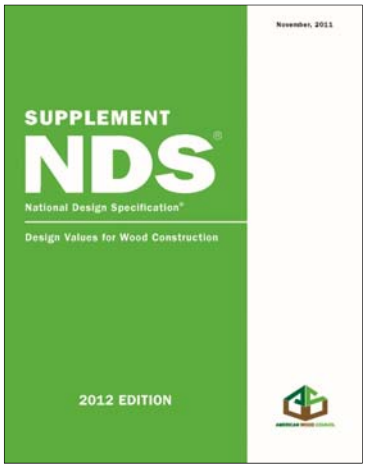


2005 National Design Specification for Wood Construction

And Supplement

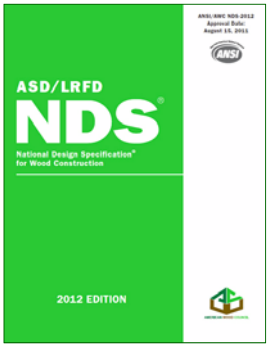


Governing Standards for Engineered Wood Design



2012 National Design Specification for Wood Construction

And Supplement



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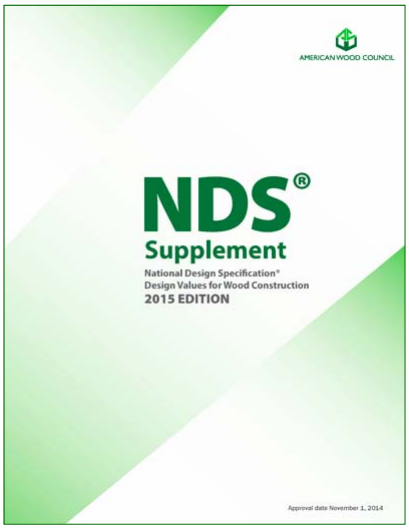
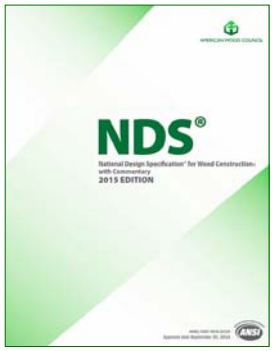
Governing Standards for Engineered Wood Design



2015 National Design Specification for Wood Construction

And Supplement



57

Solid Sawn - Availability

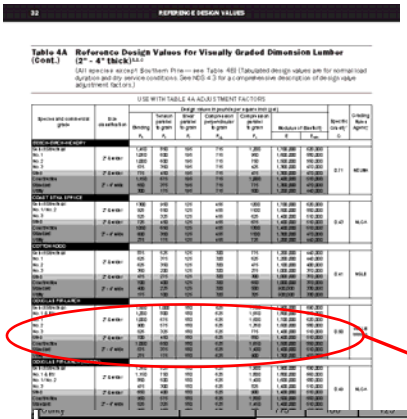


Table 4A (Cont.) Reference Design Values for Visually Graded Dimension Lumber (2" - 4" thick)

Species and commercial grade	Size classification	Bending F_b	Tension parallel to grain F_t	Shear parallel to grain F_v	Compression perpendicular to grain $F_{c\perp}$	Compression parallel to grain F_c	Modulus of Elasticity E	E_{min}	Specific Gravity G	Grading Rules Agency
DOUGLAS FIR-LARCH										
Select Structural	2" & wider	1,500	1,000	180	625	1,700	1,900,000	690,000	0.50	WCLIB WWPA
No. 1 & Btr		1,200	800	180	625	1,550	1,800,000	660,000		
No. 1		1,000	675	180	625	1,500	1,700,000	620,000		
No. 2		900	575	180	625	1,350	1,600,000	580,000		
No. 3		525	325	180	625	775	1,400,000	510,000		
Stud	2" & wider	700	450	180	625	850	1,400,000	510,000		
Construction	2" - 4" wide	1,000	650	180	625	1,650	1,500,000	560,000		
Standard		575	375	180	625	1,400	1,400,000	510,000		
Utility		275	175	180	625	900	1,300,000	470,000		

- **US and Canadian Wood Species**
  - **National Design Specification lists 27 commercial grades.**
  - **In the Western U.S. Douglas Fir Larch, Hem Fir, and Spruce Pine-Fir are commonly available.**
  - **In the Eastern U.S. Southern Pine is more common**

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Excerpt from American Wood Council's NDS Supplement

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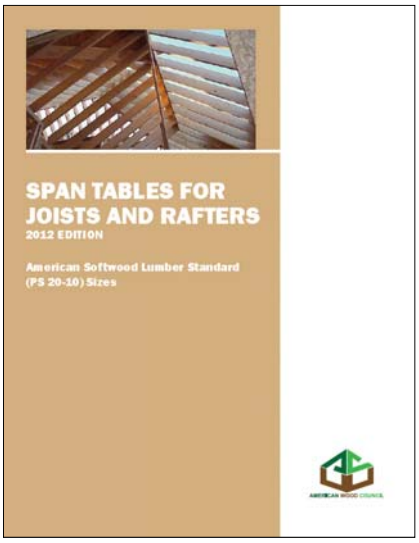
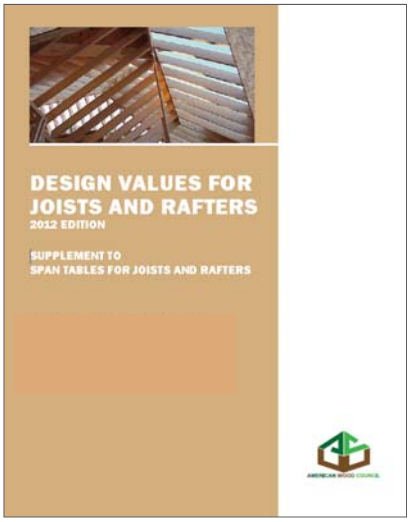
Span Tables for Joists and Rafters



Span Tables

http://www.awc.org/pdf/STJR_2012.pdf

Span Tables for Joists and Rafters



Design Values

http://www.awc.org/pdf/AWC-2012DVJR-wSPaddendum.pdf

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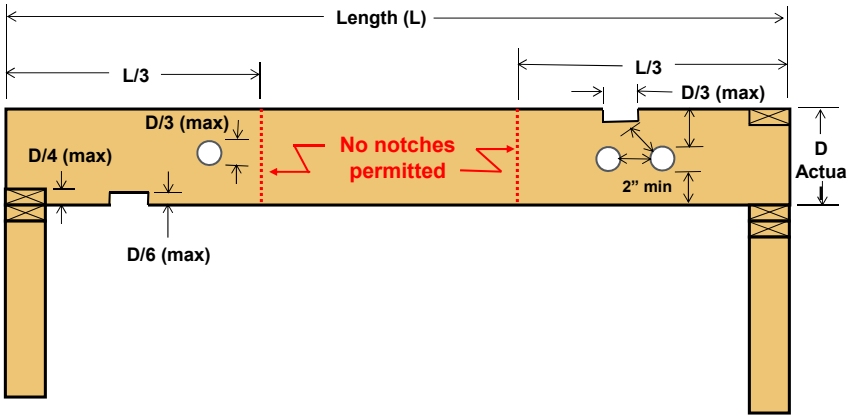
Cutting, Notching & Drilling



Cutting, Notching & Drilling of Joists

Background - Effects of Notching

- **Background**
- **D/6 only reduces stiffness by +/- 2%**
- **Permitted notches parallel fact that NDS® bending design values (Fb) already reduced for edge knots**
- **Affect of notches**
  - **Increases stresses at notch corners**
  - **Increases stresses parallel to grain & tension perpendicular to grain**

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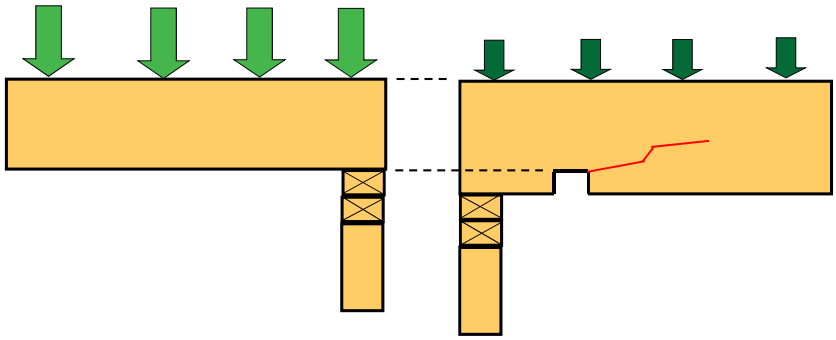
Floor Framing

- **Background (cont'd)**
- **Affect of notches (cont'd)**
  - **They cause failure to begin at lower loads than expected from un-notched member of a depth equal to net depth of notched member**



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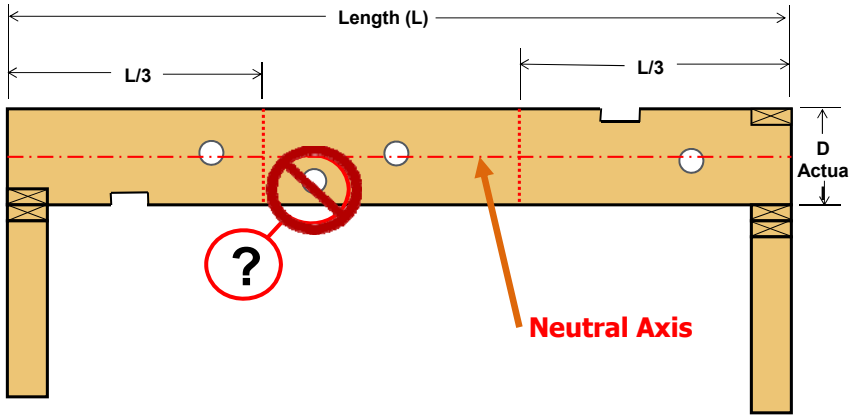
Drilling



Drilling of Joists

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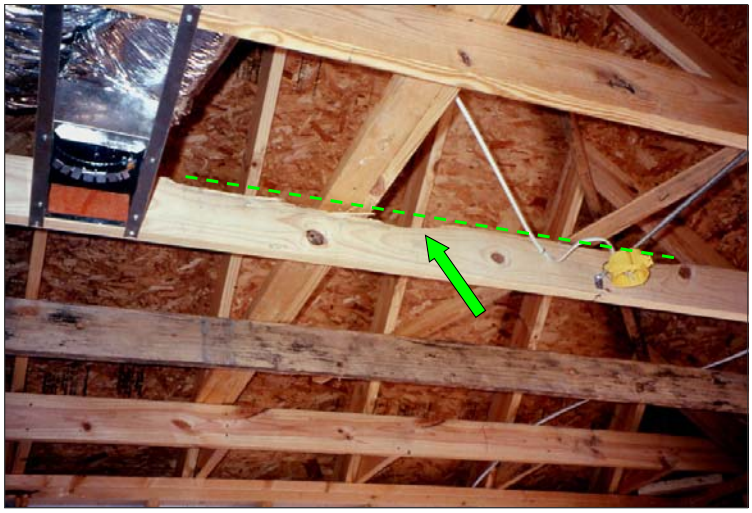
Floor Framing-what is the field repair?

Ceiling Framing-what about this one?



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Floor Framing

- **Engineered wood products.**
- **More in a couple of slides!!**

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Alteration of EWP in IRC

- **R502.8.2 (floors) & R802.7.2 (roofs) prohibit alterations of EWPs unless permitted by manufacturer or by engineering analysis.**

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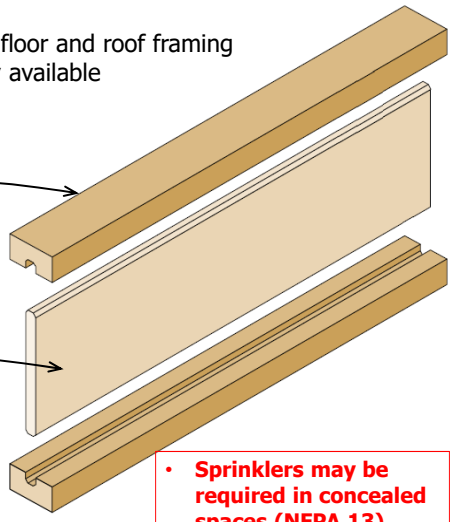
I-Joist

I-Joist

I-Joist:
- Commonly used for floor and roof framing
- Long lengths readily available



Flange:
- Lumber
- LVL

Web:
- OSB
- Plywood

Flange Widths:
- 1-1/2" to 3-1/2"

Common Depths:
- 9-1/2"
- 11-7/8"
- 14"
- 16"
- 18"
- 20" - 32"

- **Sprinklers may be required in concealed spaces (NFPA 13) >160 ft^3**

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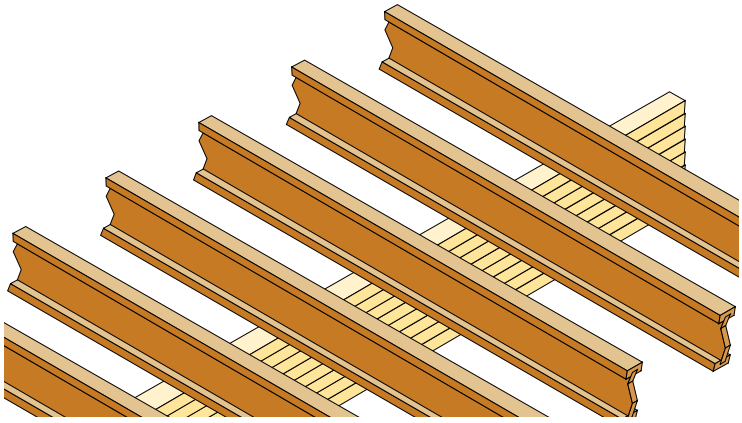
I-Joist

- Long floor spans approx. 60’
- Design flexibility



I-Joist

Adaptability to skewed, curved & radiuses in the plans

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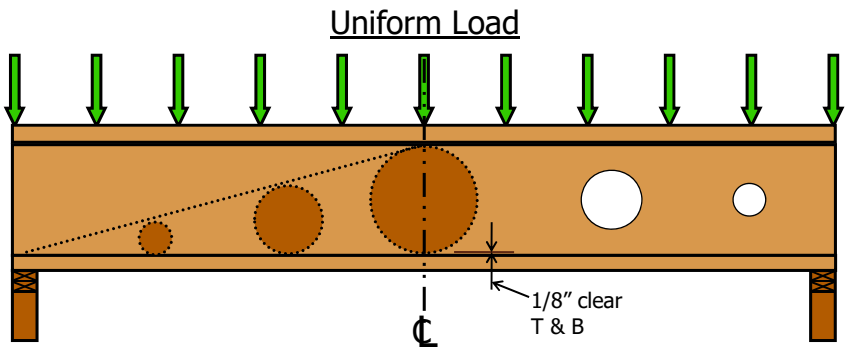
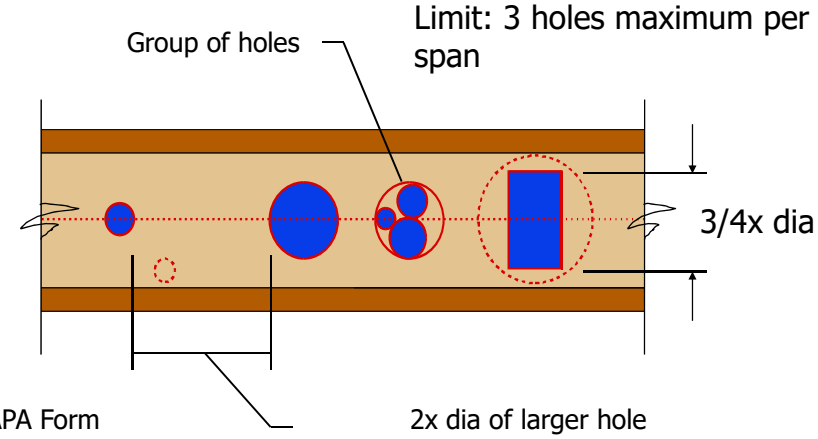
Holes in Web



Hole Size in Proportion to Shear Force

APA Form
No. EWS
D710

I-Joist Holes



APA Form
No. EWS
D710

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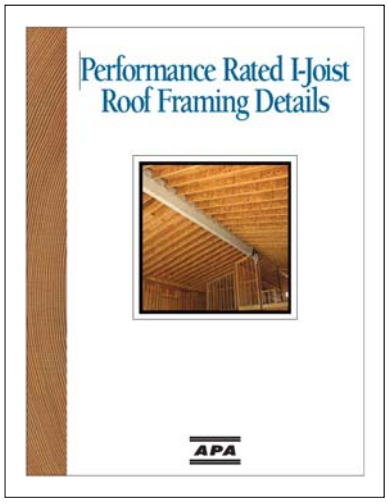
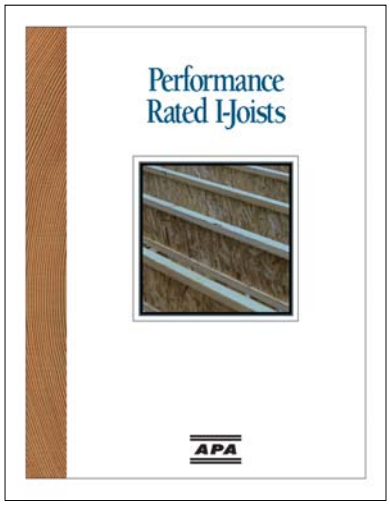
I-Joist

APA Form D710



APA Form Z725



b, a, d, g

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Trusses

METAL PLATE CONNECTED TRUSSES

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Framing w/ Trusses IRC

- GENERAL TRUSS REQUIREMENTS
- Truss drawings submitted to AHJ before installation (R802.10.1)
  - Detailed slope/depth, span, spacing
  - Location of joints
  - Design loads
  - Joint connector type & description
  - Lumbers size, species, grade
  - Deflection
  - Permanent bracing
- Bracing required in compliance with drawings
- Professional design where required by AHJ

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Basic Truss Requirements IBC

- GENERAL TRUSS REQUIREMENTS - 2303.4 Trusses. Wood trusses to comply with Sections 2303.4.1 through 2303.4.7
- 2303.4.1 - Design
- 2303.4.2 - Truss placement diagram
- 2303.4.3 - Truss submittal package.
- 2303.4.4 - Anchorage.
- 2303.4.5 - Alterations to trusses
- 2303.4.6 - TPI 1 specifications.
- 2303.4.7 - Truss quality assurance.

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Truss Design Requirements IBC

- 2303.4.1 – Design
- Wood trusses to be designed in accordance with the provisions of this code and accepted engineering practice. A lot of detailed provisions included in 2303.4.1.1 through 2303.4.1.4
- 2303.4.1.1 - Truss design drawings
- 2303.4.1.2 - Permanent individual truss member restraint.
- 2303.4.1.3 - Trusses spanning 60 feet or greater.
- 2303.4.1.4 - Truss designer (Ohio Mod)

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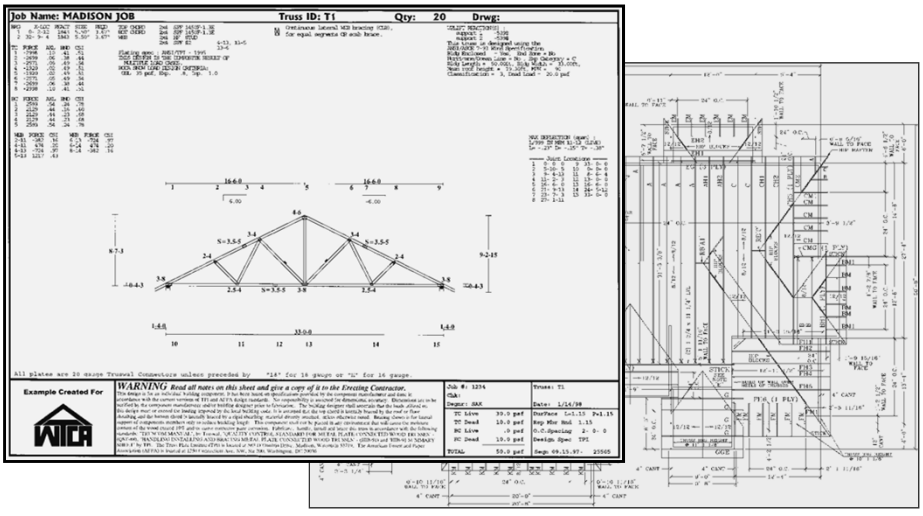
IBC Truss Plan Details – 2303.4.1.1

1. Slope or depth, span and spacing
2. Location of all joints and support locations
3. Number of plies if greater than one
4. Required bearing widths
5. All applicable design loads
6. Other lateral loads like drag strut loads
7. Adjustments to wood member and metal connector plate design value for conditions of use
8. Applicable max. reaction force and direction of reaction forces
9. Metal-connector-plate details
10. Size, species and grade for each wood member
11. Truss-to-truss connections and truss field assembly requirements
12. Calculated span-to-deflection ratio and maximum vertical and horizontal deflection for live and total load as applicable
13. Maximum axial tension and compression forces in the truss members
14. Required permanent individual truss member restraint

Truss Manufacturer Drawings



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Truss Design Requirements IBC

- 2303.4.1.2 - Permanent individual truss member restraint.

Where permanent restraint of truss members is required on the truss design drawings, it shall be accomplished by one of the following methods:

1. Permanent individual truss member restraint/bracing shall be installed using standard industry lateral restraint/bracing details in accordance with generally accepted engineering practice. Locations for lateral restraint shall be identified on the truss design drawing.

2. The trusses shall be designed so that the buckling of any individual truss member is resisted internally by the individual truss through suitable means (i.e., buckling reinforcement by T-reinforcement or L-reinforcement, proprietary reinforcement, etc.). The buckling reinforcement of individual members of the trusses shall be installed as shown on the truss design drawing or on supplemental truss member buckling reinforcement details provided by the truss designer.

3. A project-specific permanent individual truss member restraint/bracing design shall be permitted to be specified by any registered design professional.

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Truss Design Requirements IBC

- 2303.4.1.3 - Trusses spanning 60 feet or greater.

The owner or the owner's *representative* shall contract with any qualified registered design professional for the design of the temporary installation restraint/bracing and the permanent individual truss member restraint/bracing for all trusses with clear spans 60 feet (18 288 mm) or greater.

This requirement is also followed-up on in IBC s. 1705.5.2 which calls upon the special inspector to verify this bracing has been installed.

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Truss Design Requirements IBC

- 2303.4.1.4 - Truss designer
- The individual or organization responsible for the design of trusses.
- **2303.4.1.4.1 Truss design drawings.** *Each* individual truss design drawing shall bear the seal and signature of the truss designer (a registered design professional).
- A couple of exceptions . . .
- No Exceptions OHIO

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Truss Requirements IBC

- 2303.4.2 - Truss placement diagram
- The truss manufacturer shall provide a truss placement diagram that identifies the proposed location for each individually designated truss and references the corresponding truss design drawing. The truss placement diagram shall be provided as part of the truss submittal package, and with the shipment of trusses delivered to the job site.

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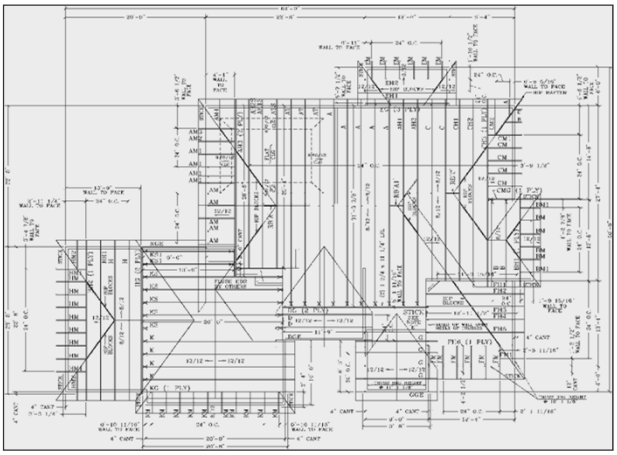
Truss Requirements IBC

- 2303.4.2 - Truss placement diagram example



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Truss Requirements IBC

- 2303.4.3 - Truss submittal package.
- The truss submittal package provided by the truss manufacturer shall consist of each individual truss design drawing, the truss placement diagram, the permanent individual truss member restraint/bracing method and details and any other structural details germane to the trusses; and, as applicable, the cover/truss index sheet.

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Truss Requirements IBC

- 2303.4.4 - Anchorage.
- The design for the transfer of loads and anchorage of each truss to the supporting structure is the responsibility of the registered design professional.

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Truss Requirements IBC

- 2303.4.5 - Alterations to trusses
- Truss members and components shall not be cut, notched, drilled, spliced or otherwise altered in any way without written concurrence and approval of a registered design professional. Alterations resulting in the addition of loads to any member (e.g., HVAC equipment, piping, additional roofing or insulation, etc.) shall not be permitted without verification that the truss is capable of supporting such additional loading.

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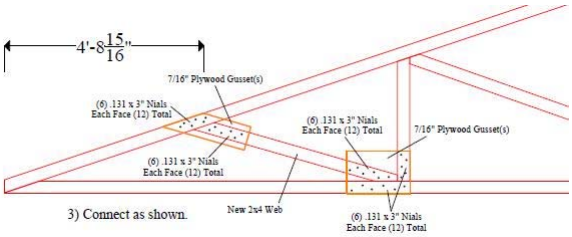
Truss Repairs

- 2303.4.5 - Alterations to trusses
- All is not lost if truss members or components are improperly cut, notched, drilled, spliced or otherwise altered in any way . . .



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Truss Repair

www.awc.org

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Truss Requirements IBC

- 2303.4.6 - TPI 1 specifications.
- In addition to Sections 2303.4.1 through 2303.4.5, the design, manufacture and quality assurance of metal-plate connected wood trusses shall be in accordance with TPI 1. Job-site inspections shall be in compliance with Section 110.4, as applicable.

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Truss Requirements IBC

- 2303.4.7 - Truss quality assurance.
- Trusses not part of a manufacturing process in accordance with either Section 2303.4.6 or a referenced standard, which provides requirements for quality control done under the supervision of a third-party quality control agency, shall be manufactured in compliance with Sections 1704.2.5 and 1705.5, as applicable.

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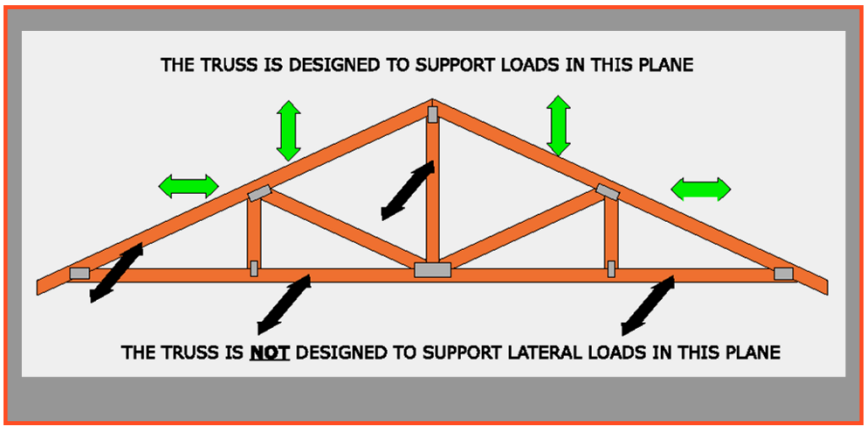
Trusses



Truss Loads

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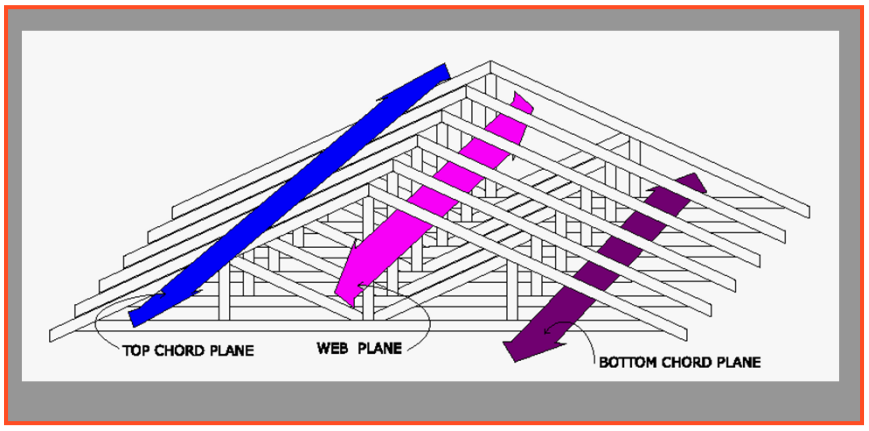
Truss Bracing Requirements



Three Planes for Permanent Bracing

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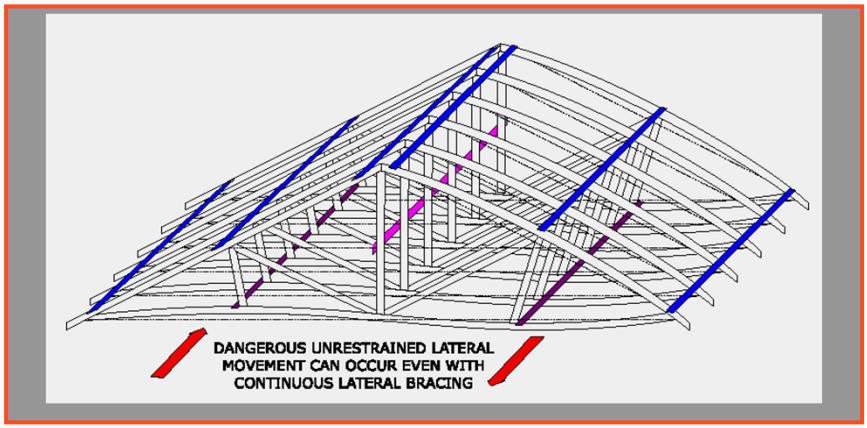
Trusses and Lateral Loads



Racking of Trusses

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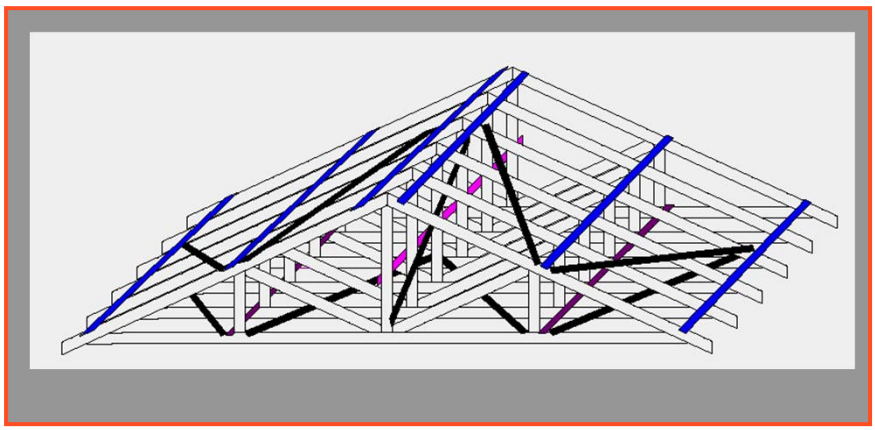
Truss Bracing



Diagonal Bracing

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Truss erection not lasting more than 4 hours!

FRAMING BY: "THE CLOSE ENUFF' CONST. CO."

99

Truss inspection…what's missing here?

ANOTHER QUALITY JOB BY: "CLOSE ENUFF' TRUSS PLANT INSPECTION"

100

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Wood Framing Members

Structural Panels	Repetitive Framing	Beams/ Girders	Wall Studs	Mass Timber

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Solid Sawn Timber– Beams

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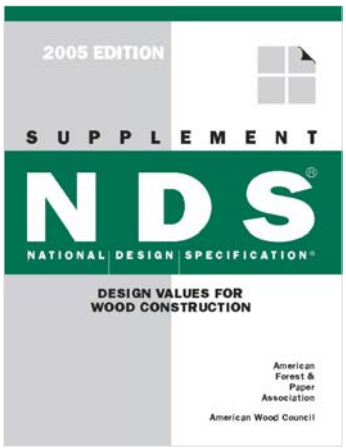
Solid Sawn Lumber

Beams and Timbers

- Readily available
- Western species 4x, 6x and 8x (possibly 20x)
- Southern Pine 2x (generally built-up)
- 8′ to 20′ lengths (2′ increments)

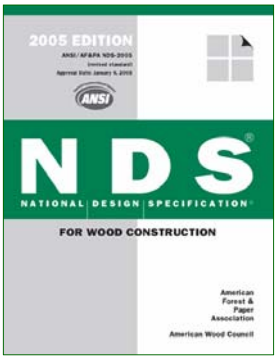
NOTE: check local availability

Governing Standards for Engineered Wood Design



2005 National Design Specification for Wood Construction

And Supplement



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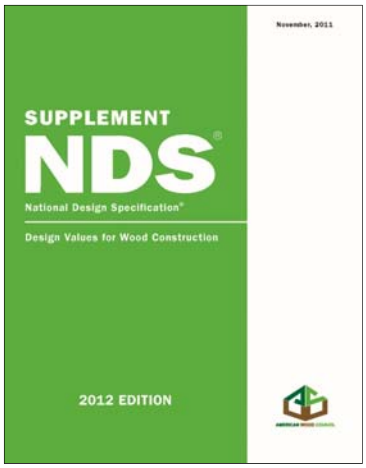
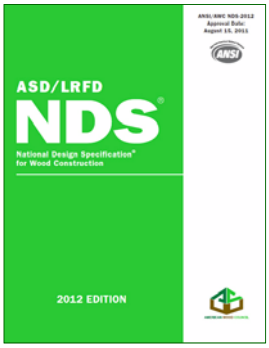
Governing Standards for Engineered Wood Design



2012 National Design Specification for Wood Construction

And Supplement



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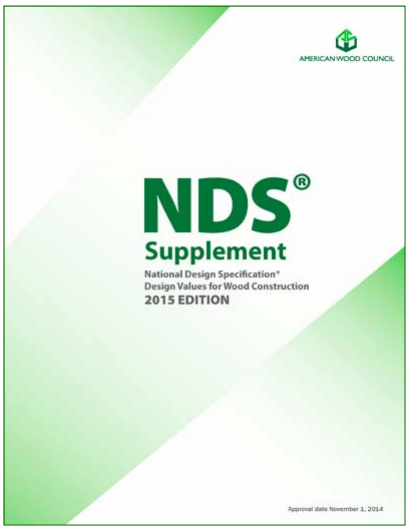
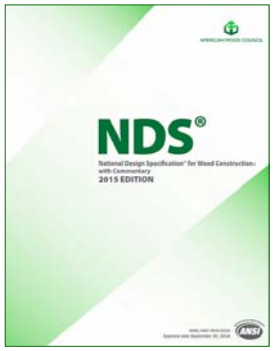
Governing Standards for Engineered Wood Design



2015 National Design Specification for Wood Construction

And Supplement



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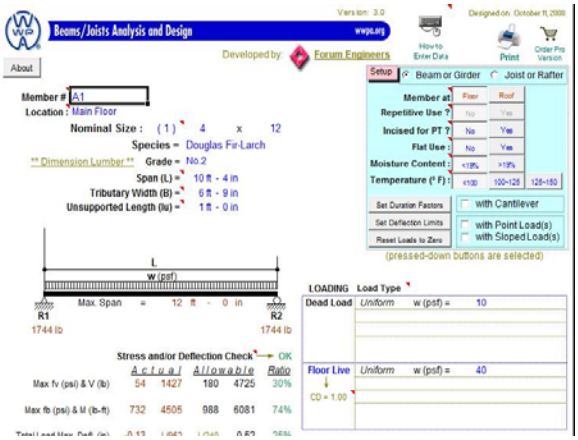
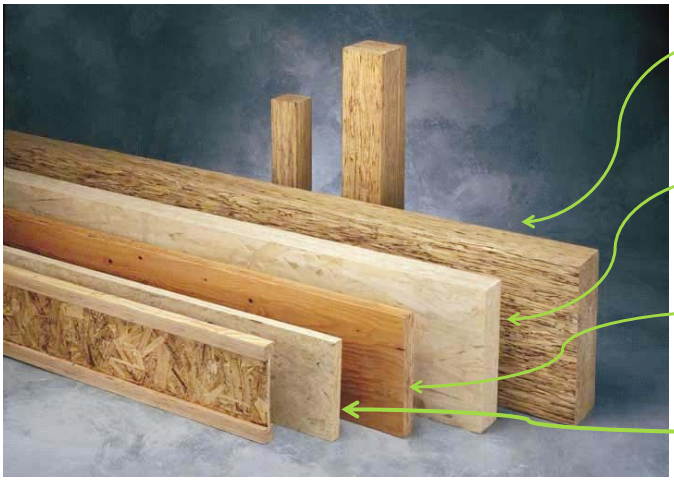
Solid Sawn Lumber Beams

- **Lumber Design Suite available for sawn lumber.**
- **Free Download www.wwpa.org**



Structural Composite Lumber (SCL)



- PSL
- LSL
- LVL
- OSL

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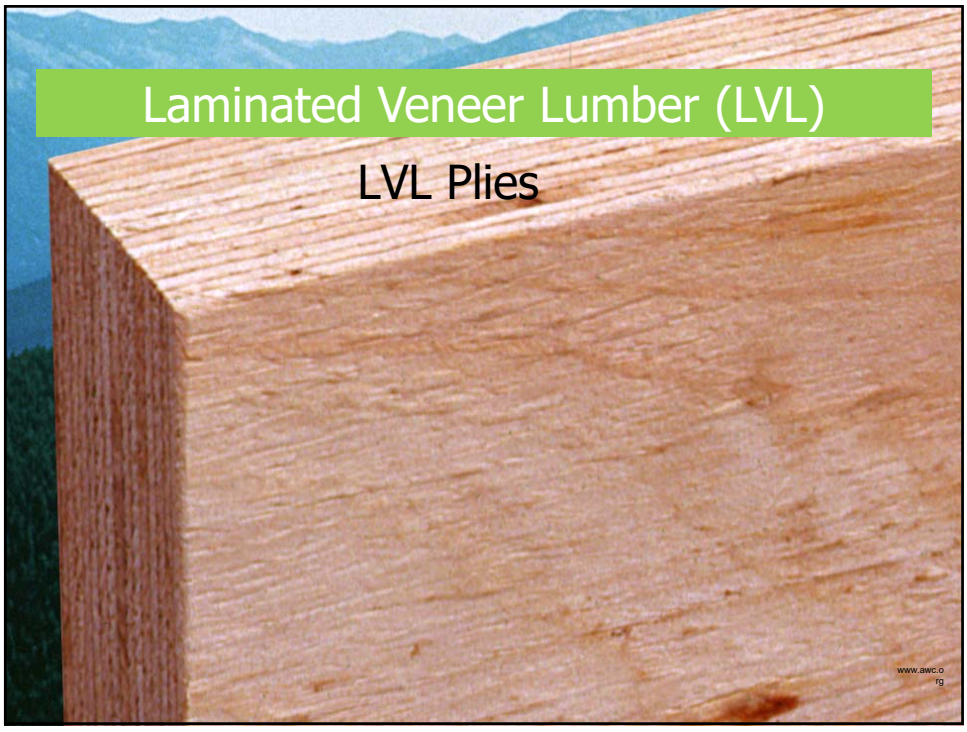
SCL – Features & Applications

Structural Composite Lumber (SCL):

- The wood grain of veneers or strands is primarily oriented in the same direction.
- Strong when either face- or edge-loaded.
- Milled (sawn) to consistent sizes.

Strength Properties

- APA publishes strength properties for its members on a proprietary basis.
- See manufacturer for details



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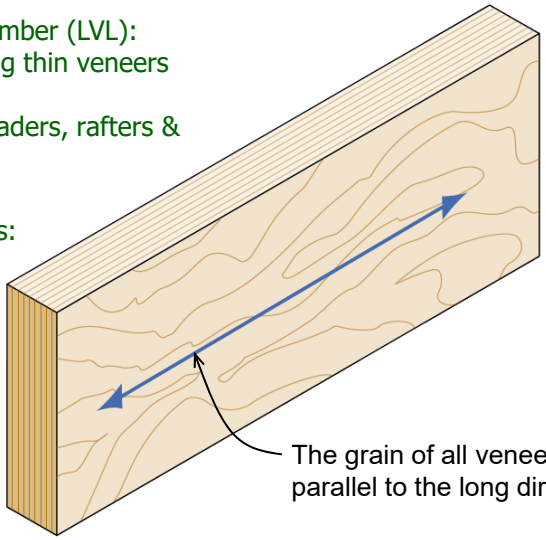
SCL – Features & Applications

Laminated Veneer Lumber (LVL):
- Produced by bonding thin veneers together
- Used for beams, headers, rafters & scaffold planking

Common Thicknesses:
- 1-3/4" to 7"

Depths:
- 5-1/2" – 24"
- Up to 60' lengths



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SCL Product Basics

Parallel Strand Lumber (PSL):

- Manufactured from veneers clipped into long strands in a parallel formation and bonded together
- Strand length-to-thickness ratio is around 300
- Used for headers and beam as well as columns.

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SCL Product Basics

Stock Widths
3-1/2″
5-1/4″
7″

Standard Widths
3-1/2″
5-1/4″
7″

Stock Depths:
9-1/2″
11-7/8″
14″
16″
18″

Standard Depths (in 2″ increments)
3-1/2″ width: 20″ through 24″

- Lengths up to 60′ (for up to 66′ check w/local manufacturer.)

SCL Product Basics

Laminated Strand Lumber (LSL):

- Similar to PSL.
- Flaked strand length-to-thickness ratio is around 150
- Used for a variety of applications from studs to millwork components and Rim Boards

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SCL Product Basics

Oriented Strand Lumber (OSL):

- Similar to LSL.
- Flaked strand length-to-thickness ratio is around 75
- Used for a variety of applications from studs to millwork components

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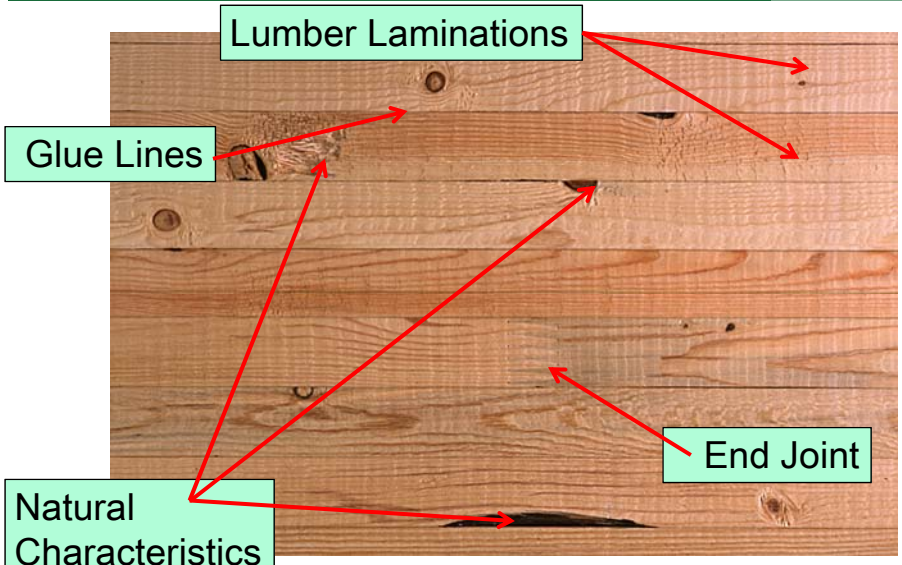
Glulam = One of the Original Engineered Wood Composites



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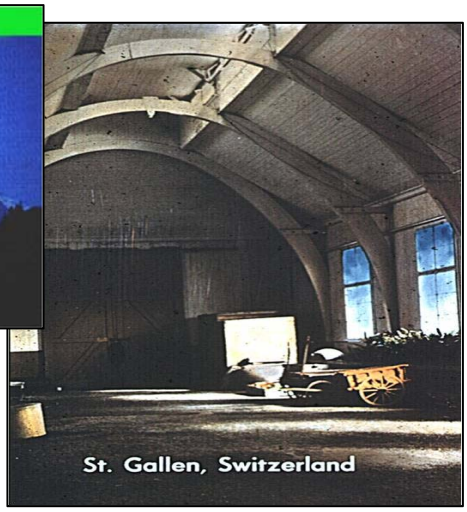
Glulam- One of the Original Glued Engineered Wood Composites



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Original U.S. Glulam Structure
USDA Forest Products Laboratory

1934

2008

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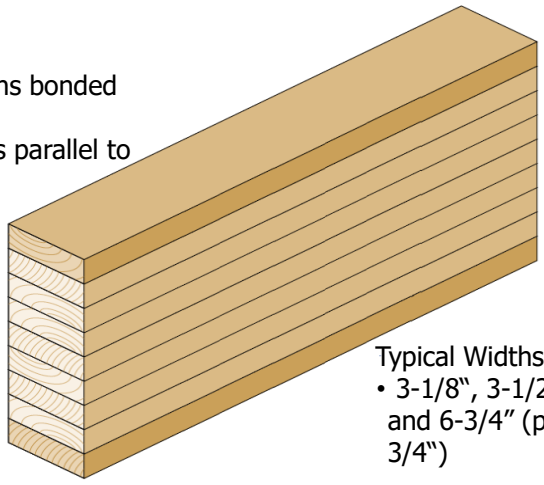
Glulam – Features & Applications

Glulam:
- Wood laminations bonded together
- Wood grain runs parallel to the length



Typical Widths:
- 3-1/8", 3-1/2, 5-1/8" and 6-3/4" (possibly 10-3/4")

Laminations:
1-3/8" for Southern Pine
1-1/2" for Douglas Fir

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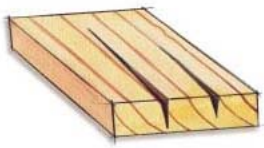
Checks, Shakes and Splits



Check

Shake

Split

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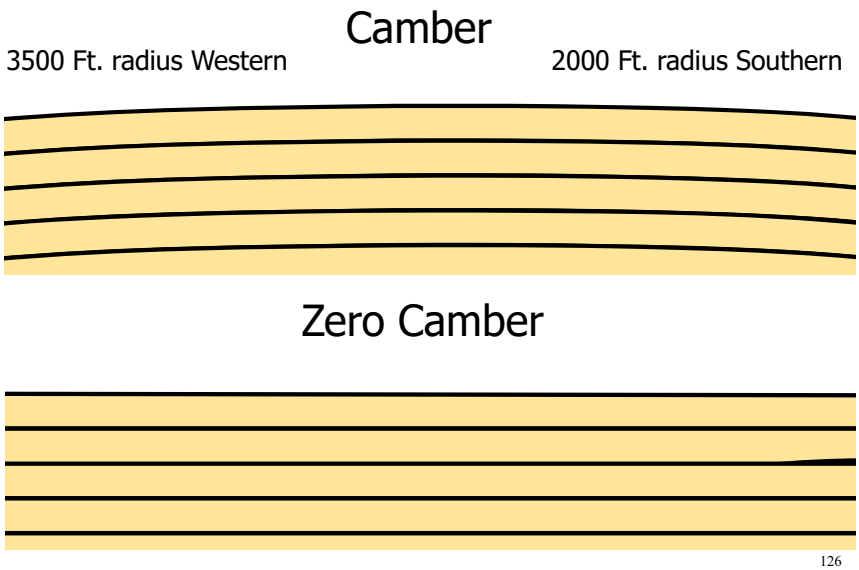
Glulam Manufacturing- Appearance Classifications

- **Appearance Classifications:**
- **Framing (-L) (3-1/2", 5-1/2")**
- **Industrial (-L)**
- **Architectural**
- **Premium (verify local availability)**

Note: Appearance classifications do not affect design values.

Glulam Manufacturing – Camber



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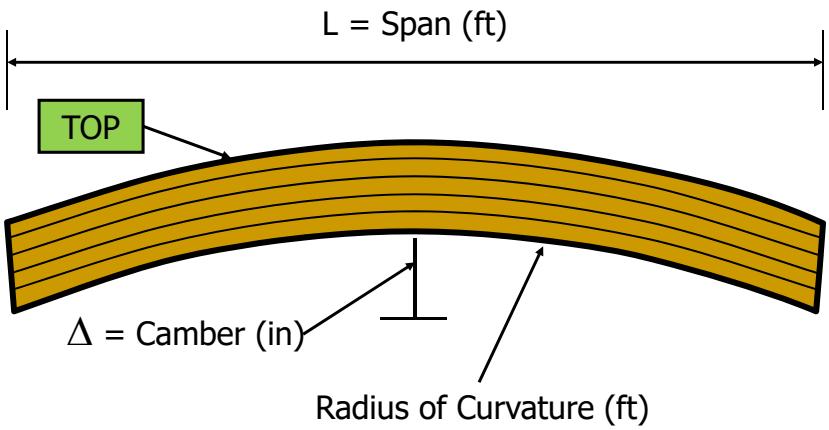
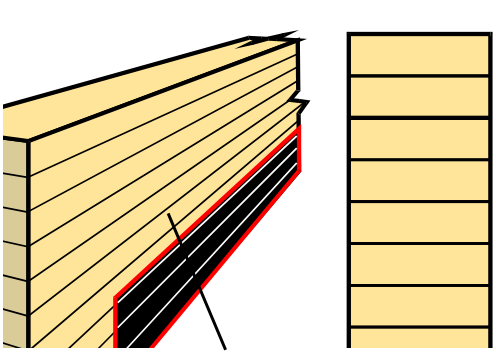
Glulam Manufacturing – Camber



3500 Ft. Radius = Western 2000 Ft. Radius = Southern

Glulam Manufacturing- Engineered Layups



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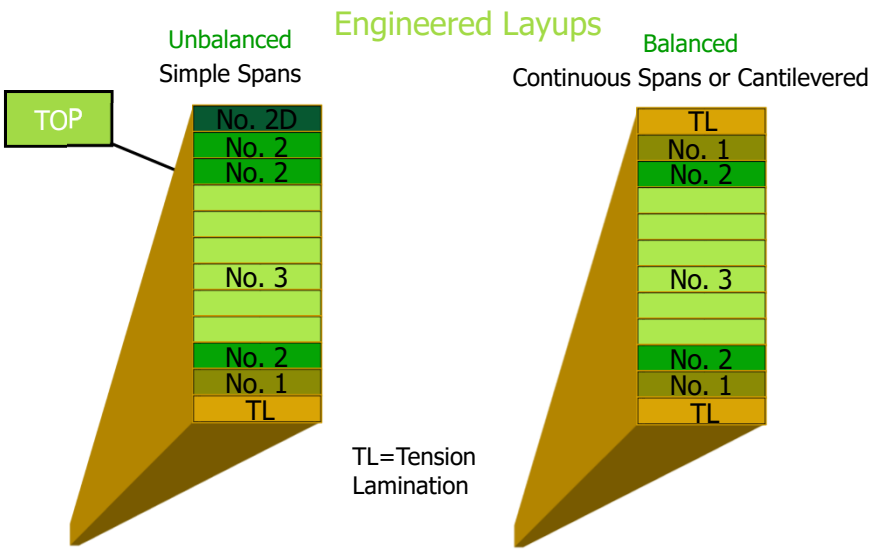
Glulam Manufacturing- Engineered Layups



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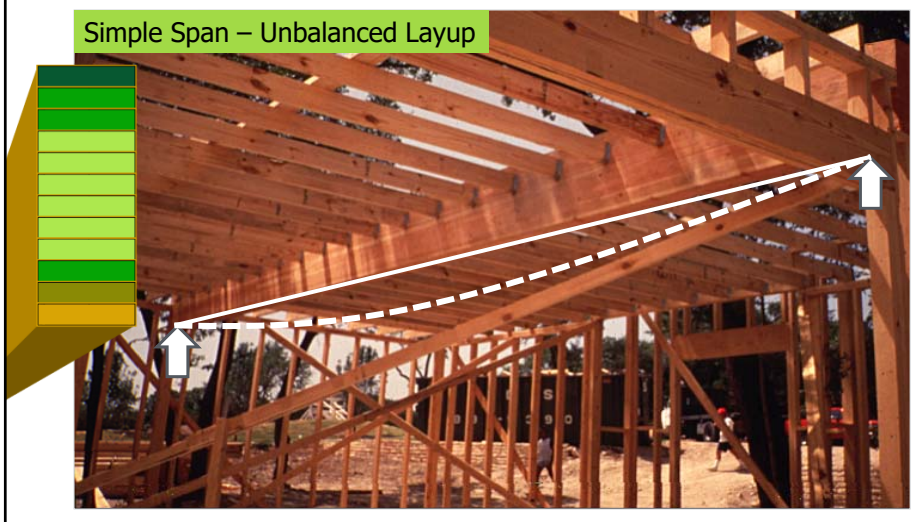
Glulam Manufacturing – Engineered Layups



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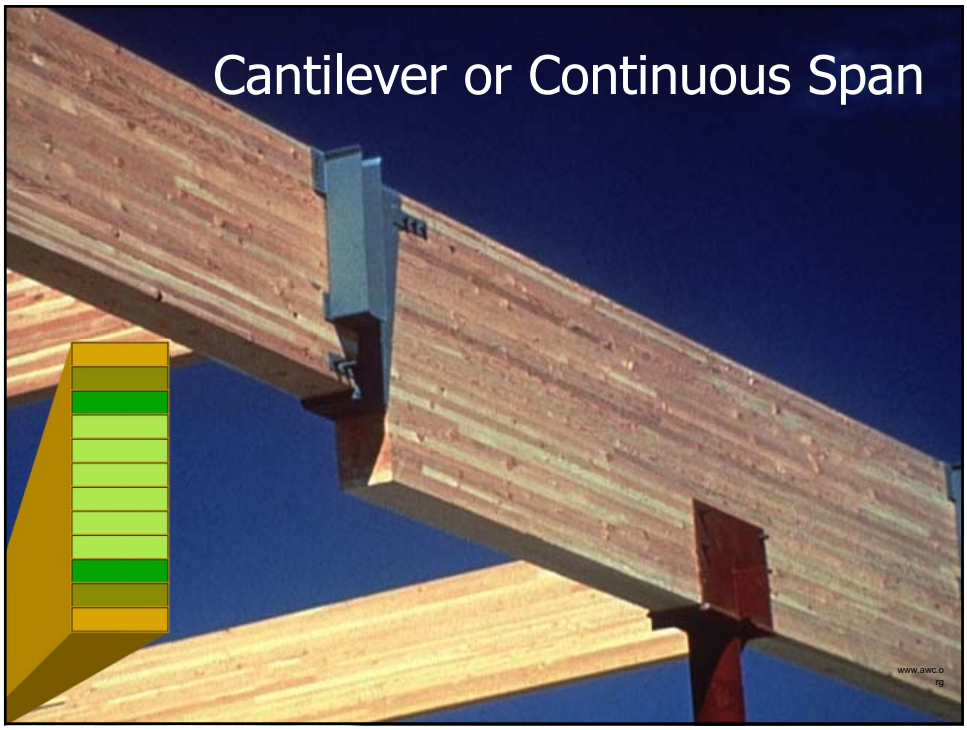

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TOP Stamp

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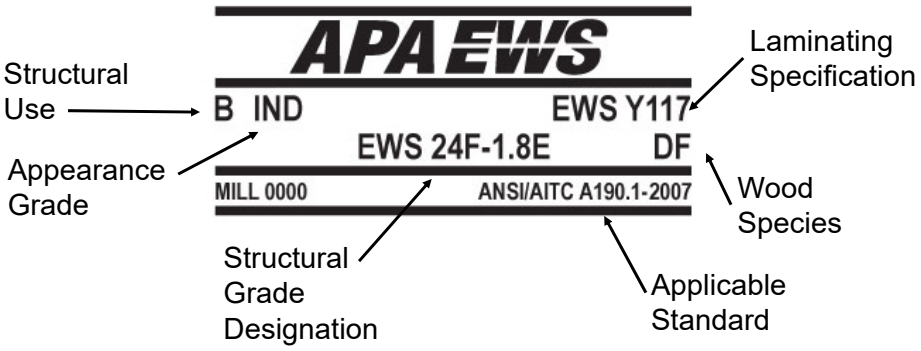
Unbalanced Layups

"Upside Down" Bending Stresses For Glulam

Based on full-size beam tests conducted at APA, the "upside down" bending stress is <u>75%</u> of the normal bending capacity

Source: Thomas Williamson

Trademarks



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Glulam Manufacturing – Decay Resistance

Alternative to Preservative Treatment:

- Alaska Yellow Cedar
- Western Red Cedar
- Port Orford Cedar

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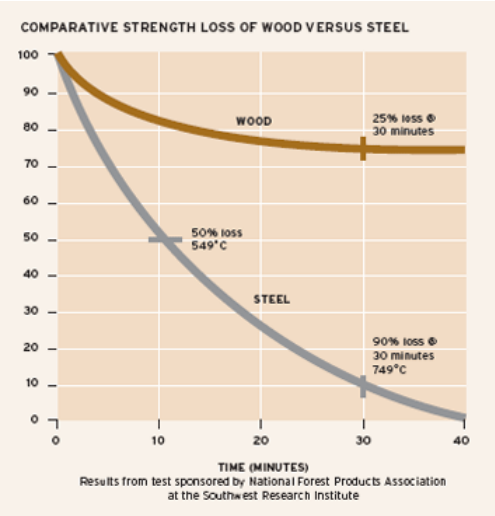
Performance of Wood vs. Steel



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Chapter 16 – Fire (ASD)

- **Fire resistance up to *two hours***
  - Columns
  - Beams
  - Tension Members
  - ASD only
- **Products**
  - Lumber
  - Glulam
  - SCL
  - Decking

SECTION 722
CALCULATED FIRE RESISTANCE

722.1 General. The provisions of this section contain procedures by which the *fire resistance* of specific materials or combinations of materials is established by calculations. These procedures apply only to the information contained in this section and shall not be otherwise used. The calculated *fire resistance* of concrete, concrete masonry and clay masonry assemblies shall be permitted in accordance with ACI 216.1/TMS 0216. The calculated *fire resistance* of steel assemblies shall be permitted in accordance with Chapter 5 of ASCE 29. The calculated *fire resistance* of exposed wood members and wood decking shall be permitted in accordance with Chapter 16 of ANSI/AF&PA *National Design Specification for Wood Construction (NDS)*.

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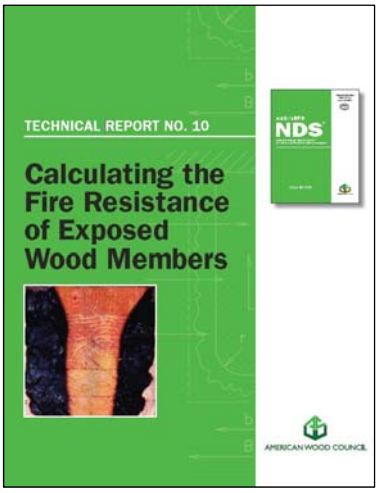
Chapter 16 – Fire (ASD)

Technical Report No. 10



Chapter 16 – Fire (ASD)

722.6.3 Design of fire-resistant exposed wood members. The *fire-resistance rating*, in minutes, of timber beams and columns with a minimum nominal dimension of 6 inches (152 mm) is equal to:

IBC 2012 uses 4 empirical design Equations (Equation 7-18 through 7-21

DCA 2
Design of Fire-Resistive Exposed Wood Members

- Simplified approach
- Beams/Columns

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Chapter 16 – Fire (ASD)


CODE UPDATES

code developments and announcements

Design of Fire-Resistive Exposed Wood Members

Fire Design of Exposed Wood Members

Basis for NDS Chapter 16 Approach

Code Updates - Design of Fire-Resistive Exposed Wood Members

http://www.awc.org/publications/download.php

Glulam Specification

- **Specification Challenges**
- **50+ Glulam Bending Stress combinations tabulated in the 2012 NDS**
- **51+ Glulam Axial Load combinations in the 2012 NDS**
- **Specification Solution**
- **Simplified Table of 7 stress class combinations in the 2012 NDS Supplement**

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NDS Stress Classes (Table 5A Supplement)

Stress Class	Fb	MOE	Fv
16F-1.3E	1600	1,300,000	195
20F-1.5E	2000	1,500,000	210
24F-1.7E	2400	1,700,000	210
24F-1.8E	2400	1,800,000	265
26F-1.9E	2600	1,900,000	265
28F-2.1E	2800	2,100,000	300
30F-2.1E	3000	2,100,000	300

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NDS Stress Classes by Species

Stress Class	Western Species		Southern Pine	
	Unbalanced	Balanced	Unbalanced	Balanced
16F-1.3E	16F-V1 (DF/SW) 16F-V2 (HF/HF) 16F-V3 (DF/DF) 16F-V4 (DF/SW) 16F-E1 (SW/SW) 16F-E2 (HF/HF) 16F-E3 (DF/DF)	16F-V6 (DF/DF) 16F-V7 (HF/HF)	16F-V2 (SP/SP) 16F-V3 (SP/SP) 16F-E1 (SP/SP)	16F-V5 (SP/SP) 16F-E3 (SP/SP)
20F-1.5E	20F-V3 (DF/DF) 20F-V4 (DF/DF) 20F-V10 (DF/HF) 20F-V12 (AC/AC) 20F-E2 (HF/HF) 20F-E3 (DF/DF) 20F-E8 (ES/ES) 22F-V3 (DF/DF) 22F-V10 (DF/DFS)	20F-V7 (DF/DF) 20F-V8 (DF/DF) 20F-V9 (HF/HF) 20F-V13 (AC/AC) 20F-E6 (DF/DF) 20F-E7 (HF/HF) 22F-V8 (DF/DF)	20F-V2 (SP/SP) 20F-E1 (SP/SP) 22F-V1 (SP/SP) 22F-V2 (SP/SP) 22F-V3 (SP/SP) 22F-V4 (SP/SP) 22F-E1 (SP/SP)	20F-V5 (SP/SP) 20F-E3 (SP/SP) 22F-V5 (SP/SP) 22F-E3 (SP/SP)

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Wood Framing Members

Structural Panels | Repetitive Framing | Beams/ Girders | Wall Studs | Mass Timber

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Stud Walls

- For walls over 10’ prescriptive tables not applicable. Engineering is required.
- 2x4, 3x4, 2x6 & 2x8
- When wall framing exceeds 20’ in height special orders may be required.
- NDS has slenderness requirement for studs (l/d<50).
- For a load bearing stud
- 2x4 L < 14’-7” ALWAYS

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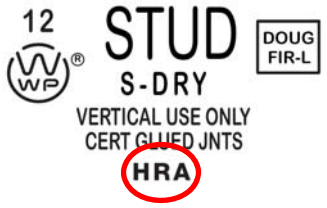
Finger Jointed Sawn Lumber

- **Also known as end-jointed & edge-glued**
- **2303.1.1 Sawn lumber - Approved end-jointed lumber is permitted to be used interchangeably with solid-sawn members of the same species and grade.**
- **Note HRA for fire-resistance rating**



Finger Jointed Sawn Lumber


WESTERN WOOD PRODUCTS ASSOCIATION FAST FACTS

Heat-Resistant Adhesives (HRA) and Finger-Jointed Lumber

Finger-jointed lumber gradestamps

Background

Use of HRA and Non-HRA lumber


AMERICAN WOOD COUNCIL

Frequently Asked Questions

- **WWPA** - **http://www2.wwpa.org/Portals/9/docs/PDF/FF-HRA.pdf**
- **AWC – FAQ** http://www.awc.org/helpoutreach/faq/FAQfiles/Finger-joinedLumber.html

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Fire Retardant Lumber

2304.9.5 Fasteners and connectors in contact with preservative-treated and fire-retardant-treated wood.

2304.9.5.3 Fasteners for fire-retardant-treated wood used in exterior applications or wet or damp locations.

2304.9.5.4 Fasteners for fire-retardant-treated wood used in interior applications.

Fire Retardant Lumber

- **Reduced design values for lumber**

PROPERTY	SERVICE TEMPERATURE[4] TO 100°F/38°C			PYRO-GUARD® ROOF FRAMING, CLIMATE ZONE[1,2,4]					
	SP	DF	Other	1A		1B		2	
				SP	DF	SP	DF	SP	DF
Extreme fiber in bending	0.91	0.97	0.88	0.90	0.90	0.85	0.93	0.89	0.96
Tension parallel to grain	0.88	0.95	0.83	0.80	0.80	0.84	0.87	0.88	0.93
Compression parallel to grain	0.94	1.00	0.94	0.94	0.94	0.94	0.98	0.94	1.00
Horizontal shear	0.95	0.95	0.93	0.92	0.95	0.93	0.95	0.94	0.96
Modulus of elasticity	0.95	0.95	0.94	0.95	0.96	0.95	0.96	0.95	0.96
Compression perp. to grain	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Fasteners/connectors	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90

Example – Contact Mfr.

[1]Climate Zone definition:
1 - Minimum design roof live load or maximum ground snow load up to 20 psf:
A - Southwest Arizona, Southeast Nevada (Las Vegas-Yuma-Phoenix-Tucson triangle)
B - All other qualifying areas of the Continental United States

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Fire Retardant Plywood/Lumber

- **Design values and span ratings are often adjusted for FRT treatment**
- **Information available from manufacturer's or www.icc-es.org**

PLYWOOD[9] THICKNESS (inches)	UNTREATED ROOF/SUBFLOOR SPAN RATING	PYRO-GUARD[@1,2,3,4,5,8,11,12] ROOF SHEATHING MAX. LIVE LOAD (psf)				PYRO-GUARD[@2,10] SUBFLOOR
		Span (inches)	Climate Zone[6,7]			Span (inches)
			1A	1B	2	
$^{15}/_{32}$, $^{1}/_{2}$	32/16	24	19	30	43	16
$^{19}/_{32}$, $^{5}/_{8}$	40/20	24 32	42 20	64 32	87 45	20 20
$^{23}/_{32}$, $^{3}/_{4}$	48/24	32 48	34 10	51 18	71 27	24 24
$^{7}/_{8}$	—	48	12	20	30	—
$1^{1}/_{8}$	—	48	21	33	47	48

Example – Contact Mfr.

Wood Framing Members

Structural Panels | Repetitive Framing | Beams/ Girders | Wall Studs | Mass Timber

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Mass Timber – Laminated Timber

- **Cross-laminated Timber**
- **Glued-laminated Timber**
- **Nail-laminated Timber**

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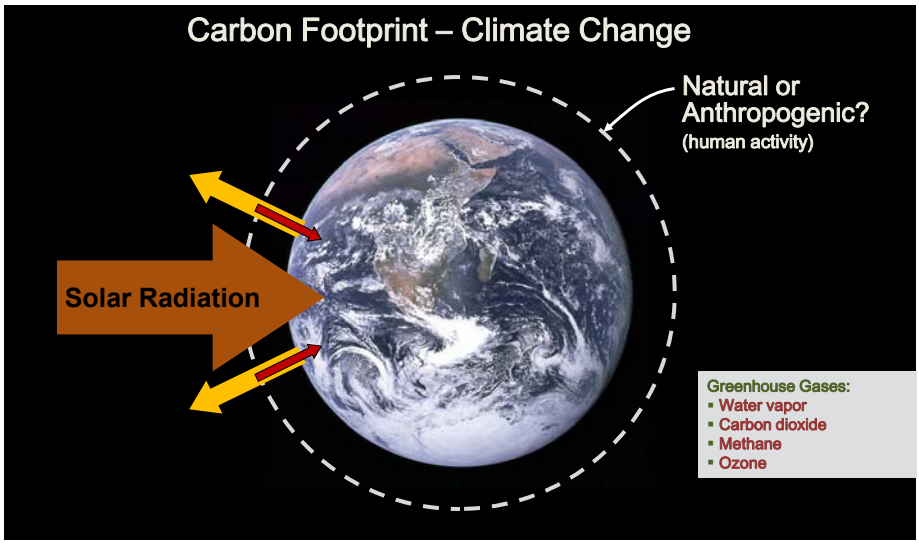
Climate Change



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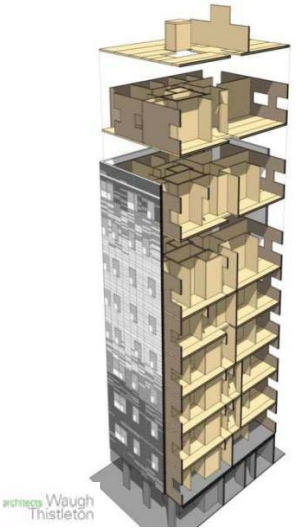
Climate Change



Stradthaus – 24 Murray Grove
London infill project
29 flats
4x less weight than concrete
~1/2 construction time of precast concrete (saved 22 weeks 30%)
Saves 300 metric tons of CO2
21 years of building energy usage

Heavy Timber Type IV

TABLE 602.4 WOOD MEMBER SIZE EQUIVALENCIES

MINIMUM NOMINAL SOLID SAWN SIZE		MINIMUM GLUED-LAMINATED NET SIZE		MINIMUM STRUCTURAL COMPOSITE LUMBER NET SIZE	
Width, inch	Depth, inch	Width, inch	Depth, inch	Width, inch	Depth, inch
8	8	$6^{3}/_{4}$	$8^{1}/_{4}$	7	$7^{1}/_{2}$
6	10	5	$10^{1}/_{2}$	$5^{1}/_{4}$	$9^{1}/_{2}$
6	8	5	$8^{1}/_{4}$	$5^{1}/_{4}$	$7^{1}/_{2}$
6	6	5	6	$5^{1}/_{4}$	$5^{1}/_{2}$
4	6	3	$6^{7}/_{8}$	$3^{1}/_{2}$	$5^{1}/_{2}$

For SI: 1 inch = 25.4 mm.

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Heavy Timber Type IV

602.4.3 Columns.
Wood columns shall be s
dimension where support
8 inches (203 mm) nomin
or superimposed and con
required.

602.4.4 Floor framing.
Wood beams and girders
mm) nominal in width anc
timber arches, which spri
nominal in any dimension
inches (203 mm) nominal

602.4.5 Roof framing.
Wood-frame or glued-lam
do not support floor loads
less than 8 inches (203 m
mm) nominal in depth for
the top of walls or wall ab
loads, shall have membe
mm) nominal in depth. Sp

602.4.6 Floors.
Floors shall be without concealed spaces. Wood flo
or 602.4.6.2.

602.4.6.1 Sawn or glued-laminated plank floors.
Sawn or glued-laminated plank floors shall be one c

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Heavy Timber Type IV

[BS] CROSS-LAMINATED TIMBER. A prefabricat
layers of solid-sawn lumber or *structural composite*
bonded with structural adhesive to form a solid woo

[BS] STRUCTURAL COMPOSITE LUMBER. Structur
together with exterior adhesives. Examples of structura

Laminated strand lumber (LSL). A composite of woo
along the length of the member, where the least dimen
or less and their average lengths not less than 150 tim

Laminated veneer lumber (LVL). A composite of woo
oriented along the length of the member, where the ve
less.

Oriented strand lumber (OSL). A composite of wood
the length of the member, where the least dimension o
less and their average lengths not less than 75 times a
elements.

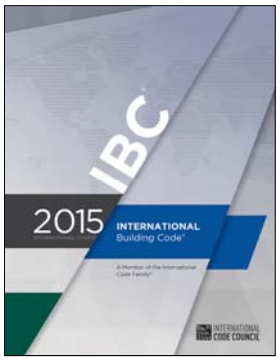
Parallel strand lumber (PSL). A composite of wood s
the length of the member where the least dimension ot
and their average lengths not less than 300 times the l

[BS] STRUCTURAL GLUED-LAMINATED TIMBER. A
plant, comprised of assemblies of specially selected ar
laminations is approximately parallel longitudinally and

2304.9.3 Mechanically laminated decking.
Mechanically laminated decking shall comply

2304.9.3.1 General.
Mechanically laminated decking consists of s
to the adjacent pieces and to the supports.

2304.9.3.2 Nailing.
The length of nails connecting laminations sh



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Structural Composite Lumber (SCL)

Photo provided by Truss Joist

Photo provided by Weyerhaeuser

- **PSL**
  - parallel strand lumber
- **LSL**
  - laminated strand lumber

Photo provided by Structurecraft

Photo provided by Wood Solutions

- **LVL**
  - laminated veneer lumber
- **OSL**
  - oriented strand lumber

Nail Laminated Timber (NLT)

Photo courtesy of Structurecraft

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Nail-Laminated Timber

- **2304.8.3 Mechanically laminated decking.** Mechanically laminated decking shall comply with Sections 2304.8.3.1 through 2304.8.3.3.
- **2304.8.3.1 General.** Mechanically laminated decking consists of square-edged dimension lumber laminations set on edge and nailed to the adjacent pieces and to the supports.
- **2304.8.3.2 Nailing.** The length of nails connecting laminations shall not be less than two and one-half times the net thickness of each lamination. Where decking supports are 48 inches (1219 mm) on center (o.c.) or less, side nails shall be installed not more than 30 inches (762 mm) o.c. alternating between top and bottom edges, and staggered one-third of the spacing in adjacent laminations. Where supports are spaced more than 48 inches (1219 mm) o.c., side nails shall be installed not more than 18 inches (457 mm) o.c. alternating between top and bottom edges and staggered one-third of the spacing in adjacent laminations. Two side nails shall be installed at each end of butt-jointed pieces.

  Laminations shall be toenailed to supports with 20d or larger common nails. Where the supports are 48 inches (1219 mm) o.c. or less, alternate laminations shall be toenailed to alternate supports; where supports are spaced more than 48 inches (1219 mm) o.c., alternate laminations shall be toenailed to every support.
- **2304.8.3.3 Controlled random pattern.** There shall be a minimum distance of 24 inches (610 mm) between end joints in adjacent courses. The pieces in the first and second courses shall bear on at least two supports with end joints in these two courses occurring on alternate supports. A maximum of seven intervening courses shall be permitted before this pattern is repeated.

Nail-Laminated Timber




Resource: StructureCraft

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Glued-laminated Timber (GLT)

Cross-laminated Timber (CLT)

Photo provided by FPInnovations

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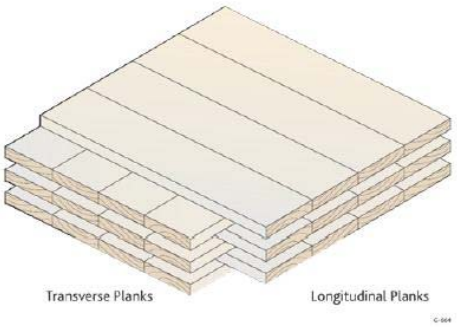
Mass Timber Concept - History of CLT

- 1985 1st CLT patent - France
- 1993 1st CLT projects - Switzerland and Germany
- 1995-1996 Improved press technology
- 1998 1st multi-story Res. building - Austria
- Early 2000's
  - CLT use (Europe) increased significantly
  - Green building movement driven
  - Better efficiencies, product approvals, improvec marketing and distribution channels
  - Over 500 CLT buildings in England
- Recent - US and Canadian use of CLT

Some Advantages of CLT Panels

- Cross lamination minimizes swelling and shrinkage in the board plane
- Good load-bearing capacity
  -In-plane & out-of-plane
- ≈Two way action capability as concrete slab



Source: FPInnovations

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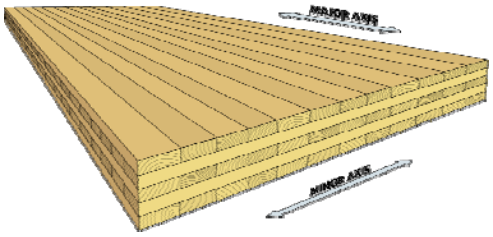
CLT vs. GLT

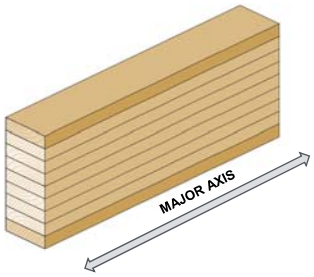
Cross Laminated Timber



Thick Orthotropic Plate

Graphics provided by WoodWorks

Glued Laminated Timber



Beam-like member

Graphics provided by APA

169

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CLT Press and Glue Operations

Photos provided by Structurlam

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CNC Technology

Photos provided by Structurlam

Ready to Ship

Slide provided by Structurlam

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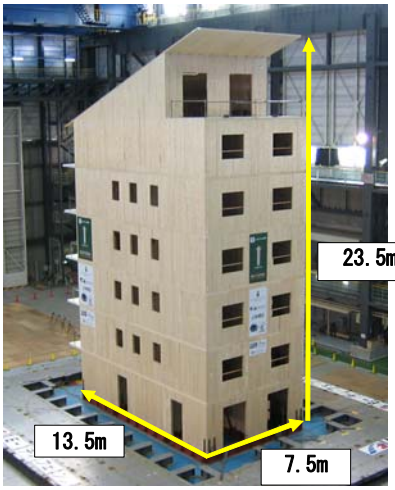
Shake Table Tests on 7-Story Building

175

Shake Table Tests on 7-Story Building

- **Conducted at E-Defense**
- **Building weight 270t**
  - **Self weight 120t**
  - **Added weight 150t**
- **Panel thickness**
  - **140 mm (5.5″) floors 1 and 2**
  - **125 mm (4.9″) floors 3 and 4**
  - **85 mm (3.3″) top 3 floors**
- **Wall panels length 2.3 m (7.5′)**



77.1′

44.3′ 24.6′

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Shake Table Tests on 7-Story Building

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Other Innovations

- **Dowel Laminated Timber**
- **Wood-Concrete Composites**

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Dowel Laminated Timber

Photos courtesy of StructureCraft

Wood-Concrete Composites

Photos courtesy of StructureCraft

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Wood-Concrete Composites

Photos courtesy of StructureCraft

Wood-Concrete Composites

Wood (LSL) - Concrete composite panels
(4” conc., 1” insulation, over 3-1/2” LSL)

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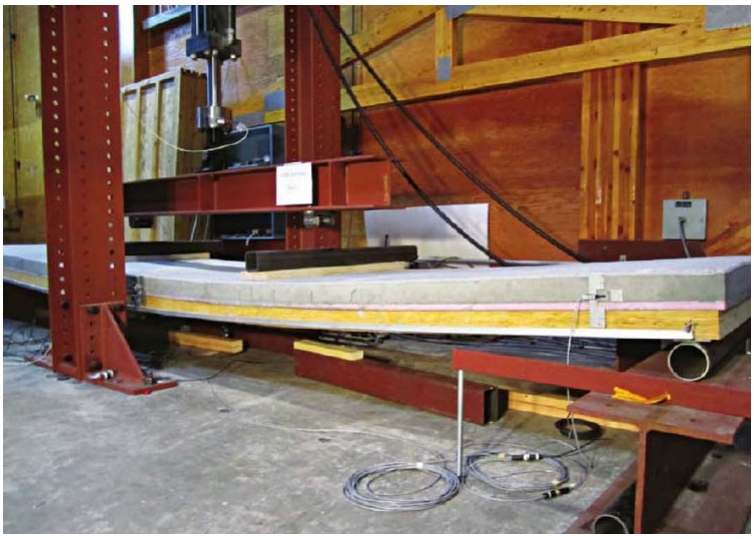
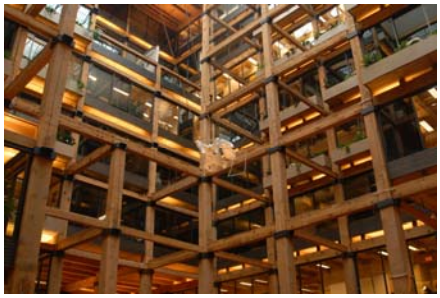
Wood-Concrete Composites



Historical Tall Wood



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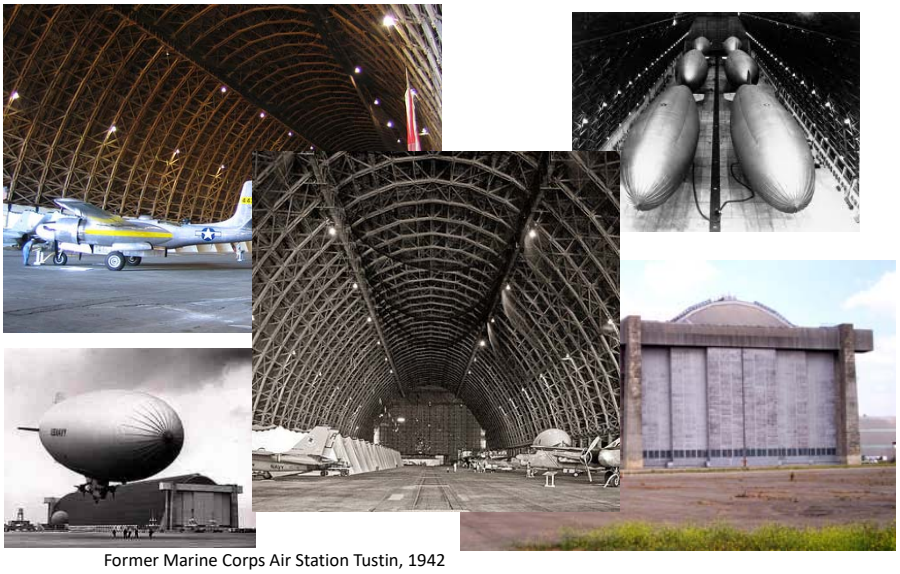
Historical Tall Wood



Former Marine Corps Air Station Tustin, 1942
U.S. Naval Air Station Hangar B, now Tillamook Air Museum, Tillamook, Oregon, 1942

Historical Tall Wood

Kelly, Douglas and Co. Warehouse;
Vancouver , BC (c. 1905)

The Purse Building, Dallas, TX, (c. 1905)

Leckie Building, Vancouver, BC
(c. 1908)

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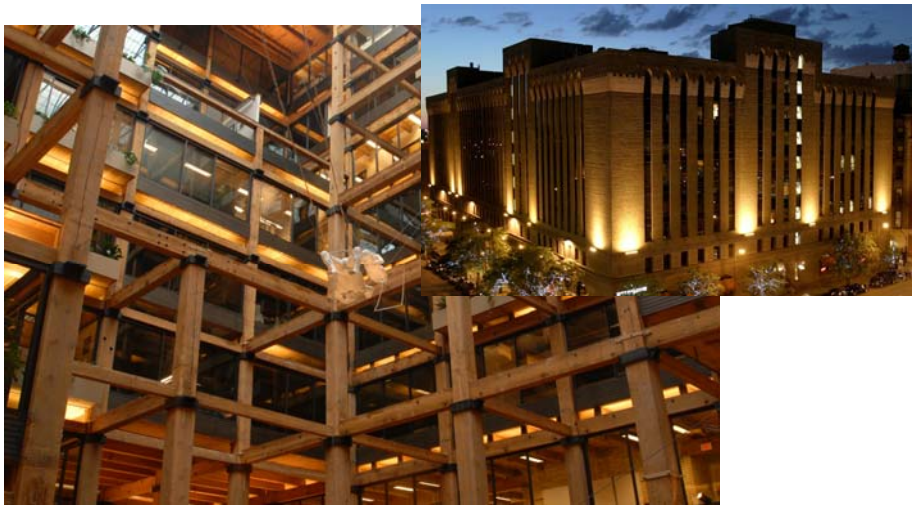
Butler Brothers Building – Minneapolis - 1906



From *Designing for Durability* – reThinkWood.com
Building interior: Preservation Alliance of Minnesota; Building exterior: Butler Square

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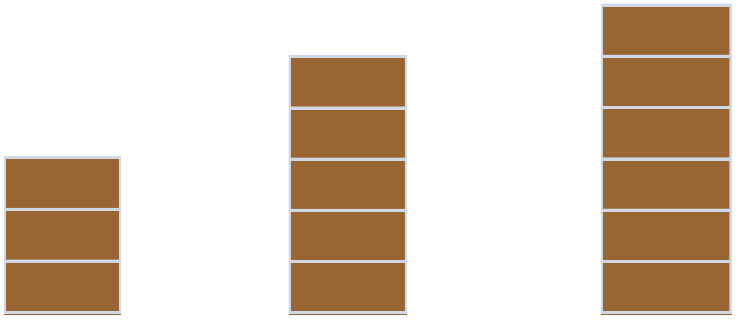
Historic Wood Heights and Areas



1920 - 1999	1999 - 2015	2015 – 2018
• 3-stories • 40 ft height • 6,000 ft^2	• 5-stories • 70 ft height • 13,200 ft^2	• 6-stories • 85 ft height • 20,500 ft^2

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2000 IBC vs 1999 BOCA NBC

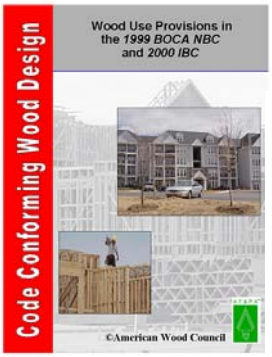
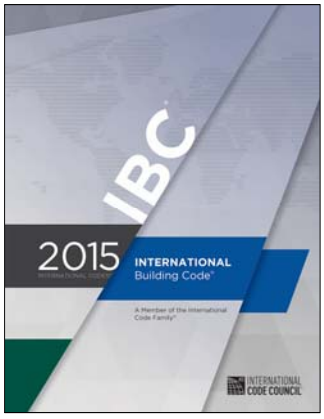


Table II
Code Comparison - Area Increases

Feature	IBC	BNBC
Minimum open space for increase credit	20 feet	30 feet
Basis of open space increase credit	Ratio of total perimeter to open perimeter	same
Maximum possible area increase with total open perimeter of at least 20 feet in width	50 percent	no increase permitted (30 feet minimum width required for open perimeter)
Maximum possible area increase with total open perimeter of at least 30 feet in width	75 percent	150 percent
Automatic sprinkler system increase credit (NFPA 13 system)	300% increase for one-story buildings, 200% increase for multi-story buildings	200% increase for one and two-story buildings 100% increase for buildings three or more stories
Additional area limits for multistory buildings	Aggregate floor area limited to not more than three times the single-story allowable area, basements excluded	Percent reduction applied to single story area, based on construction type and number of stories, per Table 506.4

Mass Timber per the Current IBC



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Mass Timber – US

Fire House

Multnomah County, Oregon

Owner: Multnomah County Rural Fire Protection District 10. Oregon
Architect: Hennebery Eddy Architects, Inc
Photo by Josh Partee

Mass Timber – US

Elementary School

Franklin, West Virginia

Photos by LignaTerra

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Mass Timber – US

Private Army Hotel
Redstone Arsenal Huntsville, AL

Photos by LignaTerra

Four stories 58,000 sq ft
Architect: Lend Lease

Mass Timber – US

Mixed retail/office space

Minneapolis, Minnesota

- T3 Project
- 7 Stories
  - https://vimeo.com/162580838

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Nail Laminated Timber – Minneapolis, MN

- Glue & Nail Laminated Timber – Vertical 2x lumber mechanically connected w/nails
- Engineered with NDS principles of mechanics

•7 Stories total
•6 Stories of Type IV Construction
•1 Story Type 1-A Podium
• See IBC Section 510
•(509 Ohio Building Code)

Architect: DLR Group
Completed: Under Construction (Fall 2016)

Mass Timber per Alternate Means

Tall Wood

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US Projects

- Framework
  - Portland, Oregon
    - 12 Story
    - Street-level retail, office, workforce housing and community space
    - U.S. Tall Wood Building Prize Competition winner *
      - http://www.nextportland.com/2016/07/21/framework-dz1/

Photo provided by Next Portland

* Sponsored by the U.S. Department of Agriculture, the Softwood Lumber Board and the Binational Softwood Lumber Council

US Projects

Carbon 12

- Portland, Oregon
  - 8 Stories
  - Residential tower
    - http://www.nextportland.com/2015/05/14/carbon12/

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Canadian Projects

The Origine

- Point-Aux-Liévres, Québec
  - 12 Stories on a concrete podium
  - Residential Condominium

Canadian Projects

The Arbora

- Québec, Canada
  - 8 Stories
  - 434 Residential condo, townhouse and rental units

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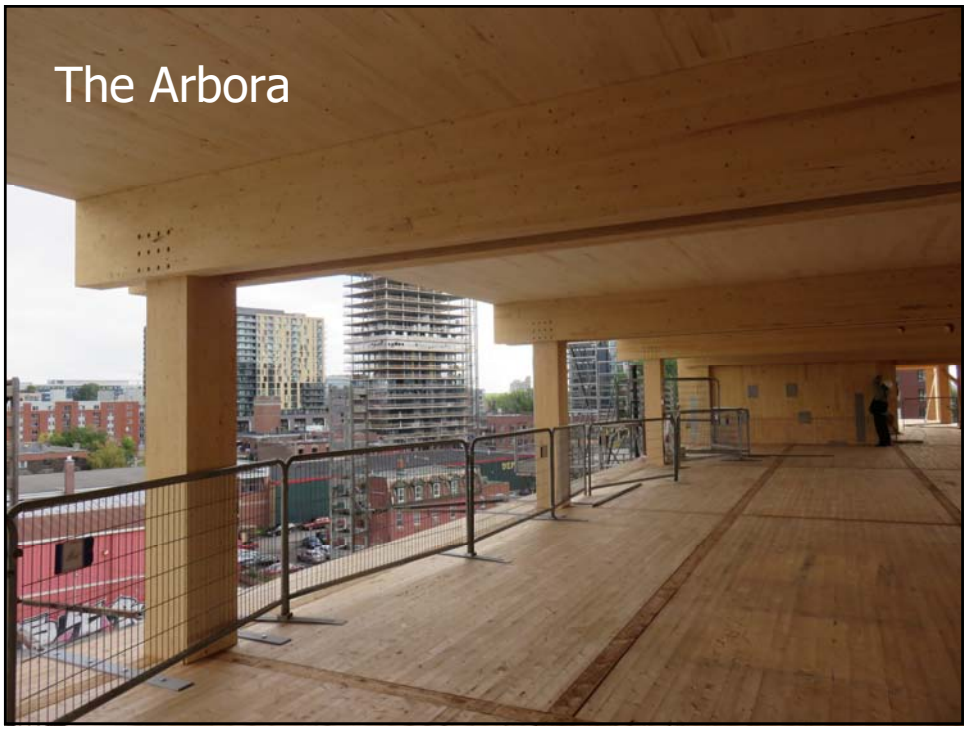
The Arbora

The Arbora



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The Arbora

Canadian Projects

The Wood Innovation and Design Centre

- Prince George, British Columbia, Canada
  - 8 Stories
  - Office and education space

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Canadian Projects

Brock Commons

- Vancouver, British Columbia, Canada
  - 18 Stories
  - Mixed use student housing

UBC - Brock Commons

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UBC - Brock Commons

- Brock Commons Videos
  - https://www.youtube.com/watch?v=zB5H1ZVZk-c&t=2s
  - https://www.youtube.com/watch?v=GHtdnY_gnmE
  - https://www.youtube.com/watch?v=rYwI6wHcRVc

Tall Wood Worldwide

http://www.rethinkwood.com/tall-wood-mass-timber/tall-wood-gallery

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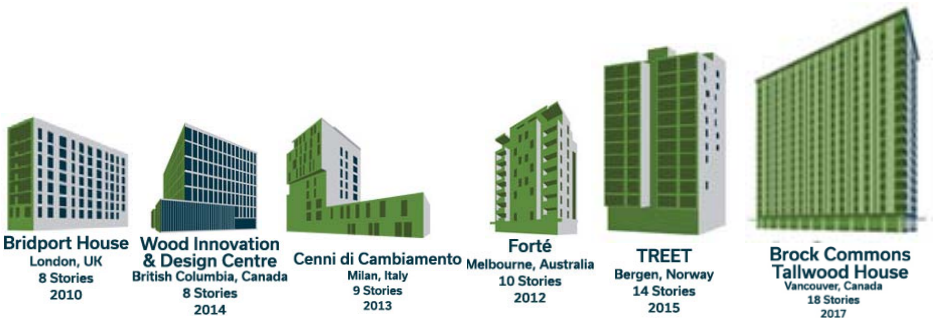
Tall Wood Worldwide



Source: reTHINK WOOD

http://www.rethinkwood.com/tall-wood-mass-timber/tall-wood-gallery

International Projects

Bridport House

- Hackney, London, England
  - 7 Stories
  - Residential

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International Projects

LCT One

- Dornbirn, Austria
  - 8 Stories
  - Business office

Cenni di Camiamento

- Milan, Italy
  - 9 Stories
  - Commercial and residential

International Projects

Holz 8

- Bad Aiblng, Germany
  - 8 Stories
  - Commercial and residential

The Stadthous

- Hoxton, London
  - 9 Stories
  - Residential

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International Projects

- Forte´
  - Melbourne, Austrailia
    - 10 Stories
    - Residential apartments

International Projects

Treet

- Bergen, Norway
  - 14 Stories
  - Luxury apartments

https://www.youtube.com/watch?v=3jl0U36x3D4

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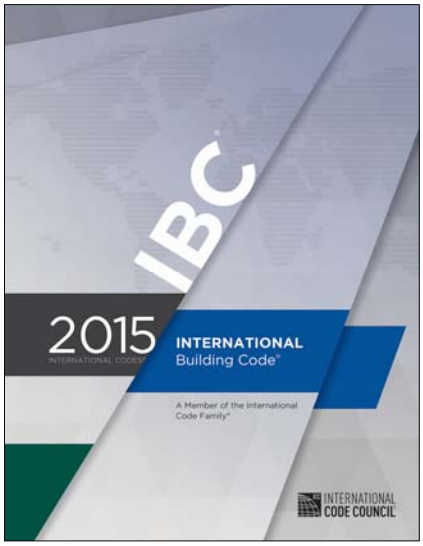
International Projects

- Baobab
  - Paris, France
    - 35 Stories
    - Mixed Use
    - Réinventer Paris competition entry

Building Codes



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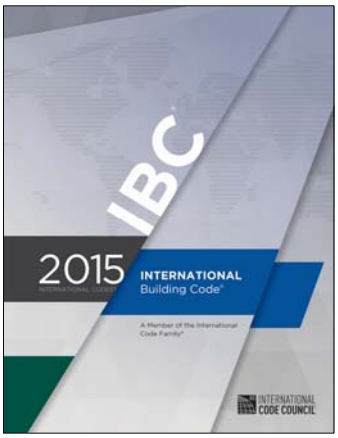
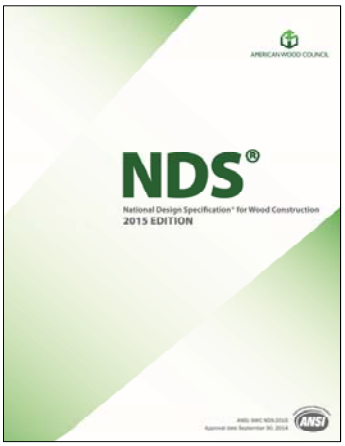
Governing Codes for Wood Design

2015 IBC references in 2015 NDS





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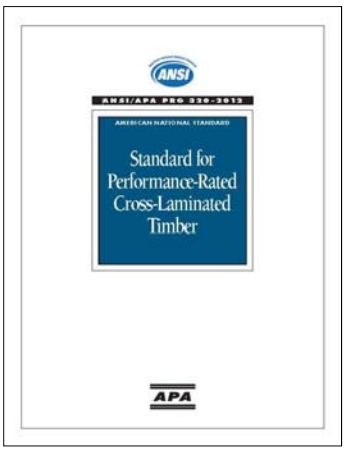
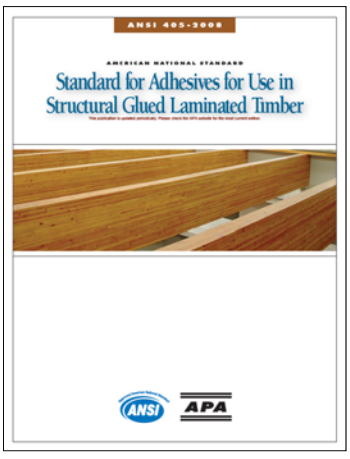
GLT and CLT Adhesives





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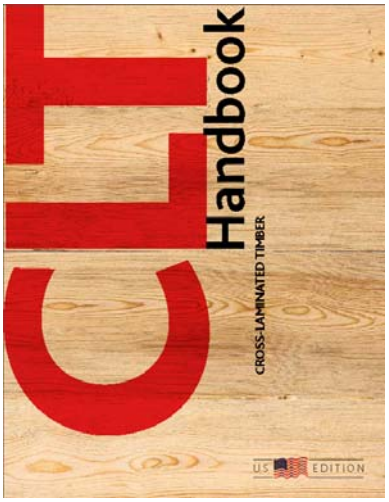
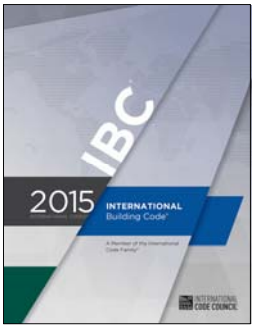
CLT Handbook

- **Additional information on issues not yet covered in NDS or IBC**
  - Energy
  - Sound
  - Vibration
  - Enclosures
  - Handling



Determining Fire Resistance (IBC 703)

- **Seven methods to determine fire resistance**
  - Tested fire assembly (ASTM E 119 or UL 263)
  - Fire resistance designs documented in approved sources
  - Prescriptive assemblies (IBC 721)
  - Calculation of fire resistance (IBC 722)
  - Engineering comparison of tested building elements, components, or assembly designs
  - Alternative protection methods (IBC 104.11)
  - Fire-resistance designs certified by an approved agency



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Heavy Timber Fire Resistance Rating

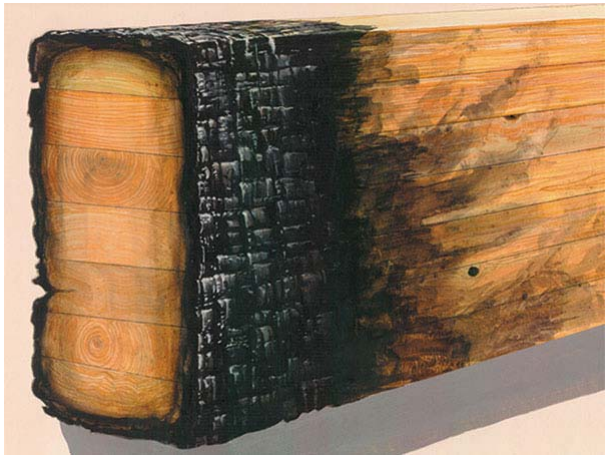
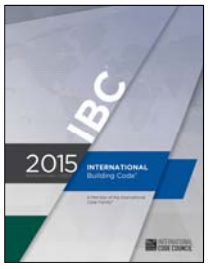


Photo by Structure Magazine

NDS Chapter 16 – Fire (ASD)

- Fire resistance up to *two hours*
  - Columns
  - Beams
  - Tension Members
  - ASD only
- Products
  - Lumber
  - Glulam
  - SCL
  - Decking
  - CLT - NEW



SECTION 722
CALCULATED FIRE RESISTANCE

722.1 General. The provisions of this section contain procedures by which the *fire resistance* of specific materials or combinations of materials is established by calculations. These procedures apply only to the information contained in this section and shall not be otherwise used. The calculated *fire resistance* of concrete, concrete masonry and clay masonry assemblies shall be permitted in accordance with ACI 216.1/TMS 0216. The calculated *fire resistance* of steel assemblies shall be permitted in accordance with Chapter 5 of ASCE 29. The calculated *fire resistance* of exposed wood members and wood decking shall be permitted in accordance with Chapter 16 of ANSI/AF&PA *National Design Specification for Wood Construction (NDS)*.

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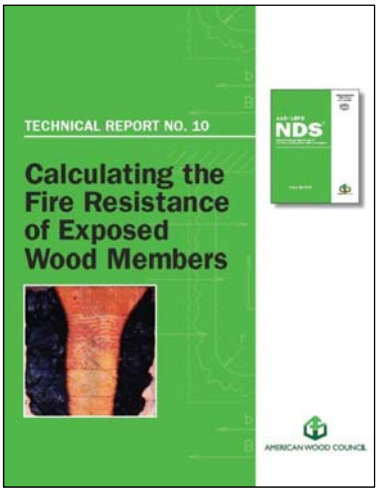
NDS Chapter 16 – Fire (ASD)

Technical Report No. 10

- Background on NDS provisions
- Design examples
- Updated with CLT

Free download www.awc.org



TR-10 Test Data

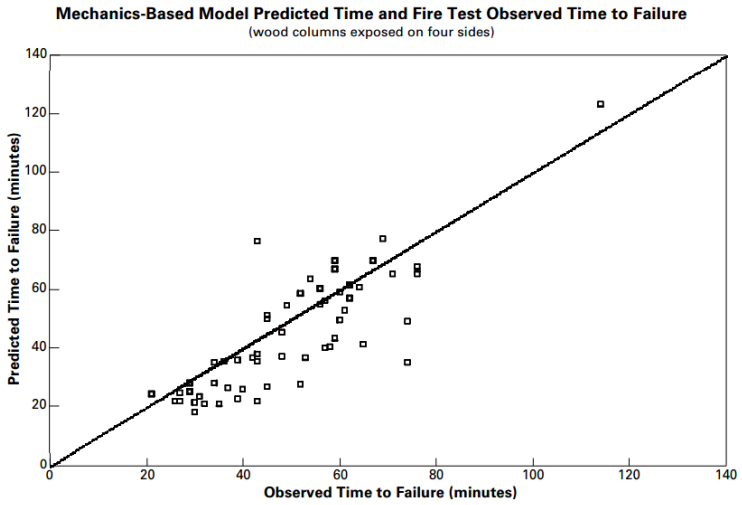


Figure 2-2 Comparison of predicted to observed time to failure (wood columns exposed on four sides)

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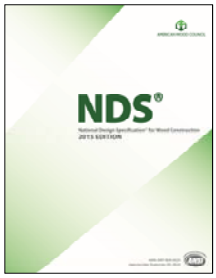
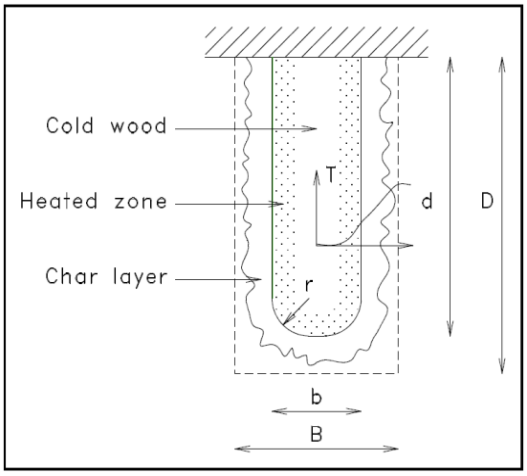
NDS Chapter 16 – Calculated Resistance

- **Fire resistance of exposed wood members may be calculated using the provisions of NDS Chapter 16**





Predictable

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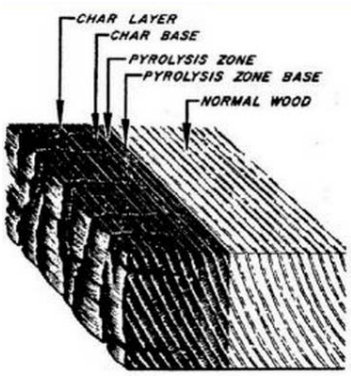
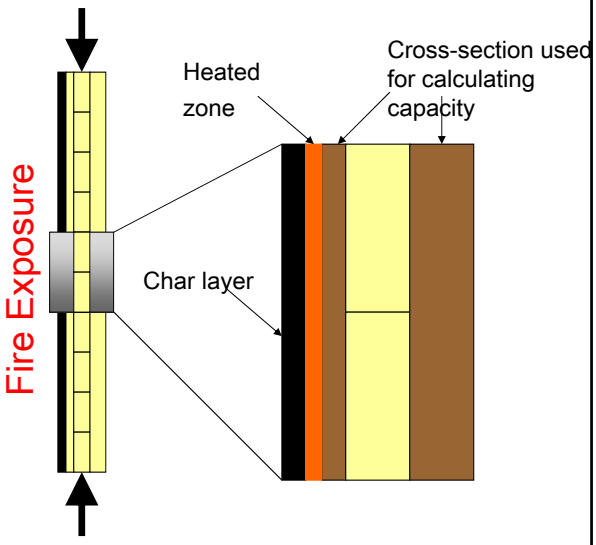
Fire Performance





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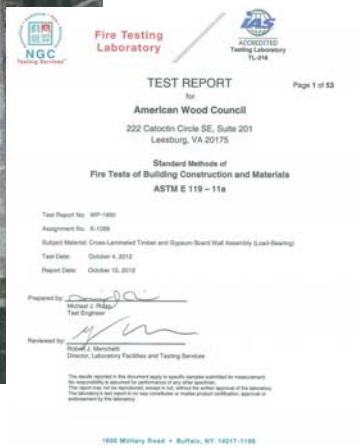
CLT Fire Test Report WP-1950



Fire Testing Laboratory

TEST REPORT

for

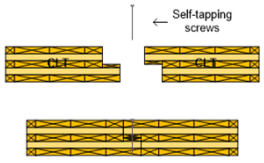
American Wood Council

222 Catoctin Circle SE, Suite 201
Leesburg, VA 20175

Standard Methods of
Fire Tests of Building Construction and Materials
ASTM E 119 – 11a

CLT Fire Test Report WP-1950

American Wood Council
ASTM E119 Fire Endurance Test
- 5-Ply CLT (approx. 7" thick)
- 5/8" Type X GWB each side
- Sought 2 hour rating
- RESULTS: 3 hours 6 minutes



Half-lapped in middle of panel

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CLT Fire Test Report WP-1950

American Wood Council
ASTM E119 Fire Endurance Test
- 5-Ply CLT (approx. 7" thick)
- 5/8" Type X GWB each side
- RESULTS: 3 hours 6 minutes
- For a copy:

http://www.awc.org/Code-Officials/2012-IBC-Challenges/#

Fire Testing Laboratory

TEST REPORT

Page 1 of 53

for

American Wood Council

222 Catoctin Circle SE, Suite 201
Leesburg, VA 20175

Standard Methods of
Fire Tests of Building Construction and Materials
ASTM E 119 – 11a

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CLT Test Report WP-1950

Exposed Side – Post Test

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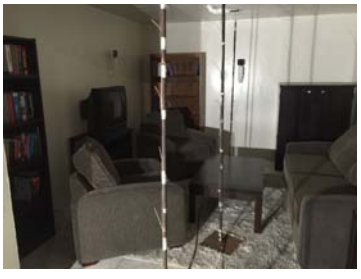
Residential Fire Load Demonstration

CLT and NLT : September 3, 2015

Residential Fire Load Demonstration



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Residential Fire Load Demonstration

Residential Fire Load Demonstration

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2021 and Beyond – ICC Tall Wood Adhoc

- October 2015
  - ICC Board of Directors (IBOD) agrees to request for public comment to form the Tall Wood Ad-hoc (TWAH)
- December 2015
  - IBOD Approves formation of the TWAH
- January 2015
  - ICC Advertises call for committee
  - Over 60 applications received
- April 2015
  - IBOD appoints committee

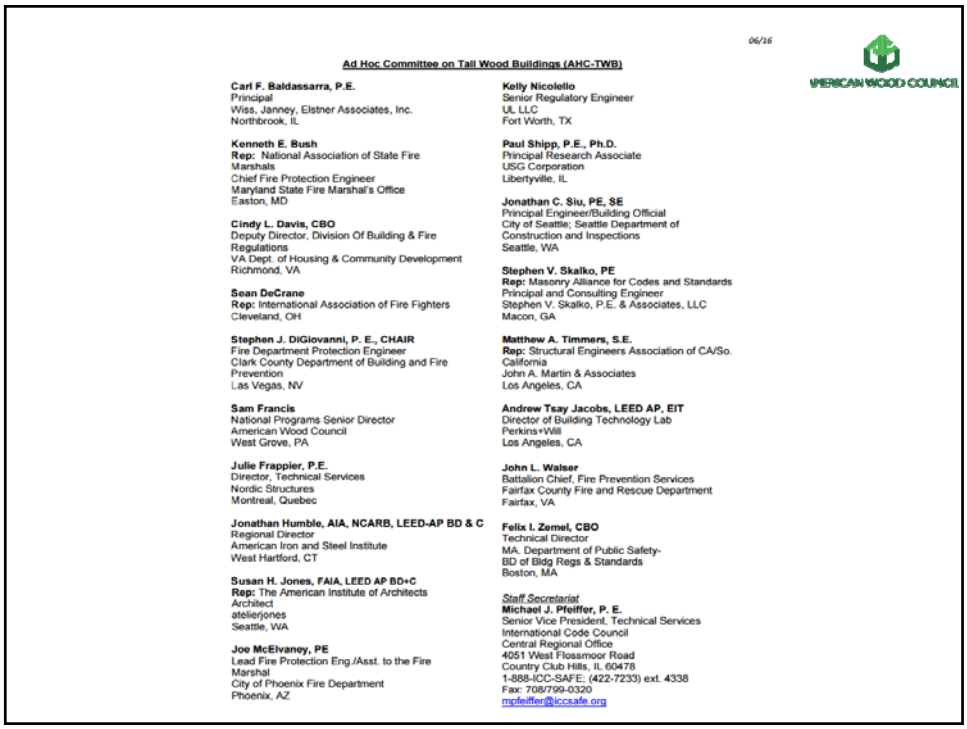
ICC NEWS RELEASE

For Immediate Release
Janurary 7, 2016
www.iccsafe.org

Contact: Trey Hughes
1-888-ICC-SAFE (422-7233), ext. 5237
thughes@iccsafe.org

ICC Accepting Applications for Ad Hoc Committee on Tall Wood Buildings

The International Code Council (ICC) Board of Directors has established an ad hoc committee to explore the building science of tall wood buildings. Tall wood is a term used in the industry to identify wood construction which utilizes Cross Laminated Timber (CLT) in buildings of heights greater than six stories. CLT buildings with heights varying from seven to 12 stories are in the planning stages in Minneapolis, Portland, and New York City.



06/16

Ad Hoc Committee on Tall Wood Buildings (AHC-TWB)

Carl F. Baldassarra, P.E.
Principal
Wiss, Janney, Elstner Associates, Inc.
Northbrook, IL

Kenneth E. Bush
Rep: National Association of State Fire Marshals
Chief Fire Protection Engineer
Maryland State Fire Marshal's Office
Easton, MD

Cindy L. Davis, CBO
Deputy Director, Division Of Building & Fire Regulations
VA Dept. of Housing & Community Development
Richmond, VA

Sean DeCrane
Rep: International Association of Fire Fighters
Cleveland, OH

Stephen J. DiGiovanni, P. E., CHAIR
Fire Department Protection Engineer
Clark County Department of Building and Fire Prevention
Las Vegas, NV

Sam Francis
National Programs Senior Director
American Wood Council
West Grove, PA

Julie Frappier, P.E.
Director, Technical Services
Nordic Structures
Montreal, Quebec

Jonathan Humble, AIA, NCARB, LEED-AP BD & C
Regional Director
American Iron and Steel Institute
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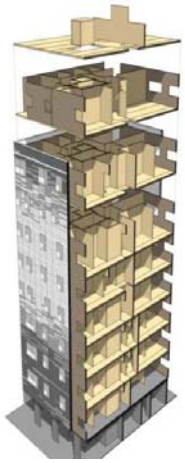
ICC Tall Wood Ad Hoc

- First meeting July 2016 in Chicago
  - 83 Issues identified (many overlapping)
  - Subcommittees established
    - Allowable height and area
    - Fire
    - Structural
    - Definitions
- Second meeting November 2016 in Seattle
  - UBC – Brock Commons presentations
  - Committee Reports

AWC Proposals

- Existing Type IV construction to remain
- New categories for CLT/Mass Timber
  - Examples based on Use Groups R1 and R2
  - Type IV C - 9 Stories meeting existing code requirements for HT except with 2-hour fire performance
  - Type IV B - 12 Stories meeting existing code requirements (except for non-combustibility) of Type IB construction
  - Type IV A - 20 Stories meeting existing code requirements (except for non-combustibility) of Type IA construction
  - Additional enhancements above current code requirements can be considered for each category



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ICC TWAH Next Steps

- TWAH to remain in place through the 2021 Code Development process
  - Code provisions for all items except structural to be submitted November 2017
  - Remaining provisions by November 2018
- **For TWAH Details: http://www.iccsafe.org/codes-tech-support/cs/icc-ad-hoc-committee-on-tall-wood-buildings/**
- ICC Code Development process information:
  - http://www.iccsafe.org/codes-tech-support/code-development-process/

COC Benefits

- No cost to qualifying participants:
  - Code Officials Inspectors Plans Examiners
- Free electronic AWC technical publication
- Discounted publications
- One free *WoodWorks* access per department
- *WoodPost* bi-weekly e-newsletter
- Free Online Tools and updates
- Free continuing education
  - ICC Preferred Provider
  - National Council of Structural Engineers Association
  - American Institute of Architects

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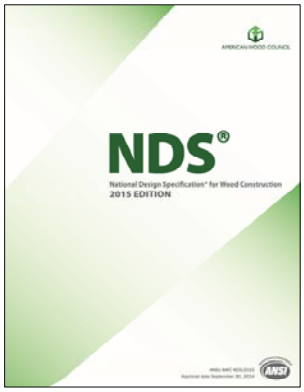

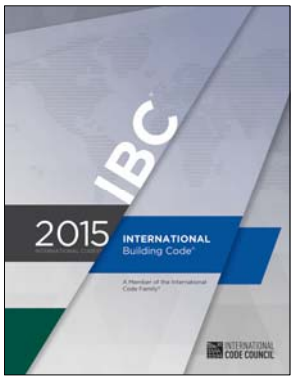

AWC is committed to ensuring a resilient, safe, and sustainable built environment.

Resources

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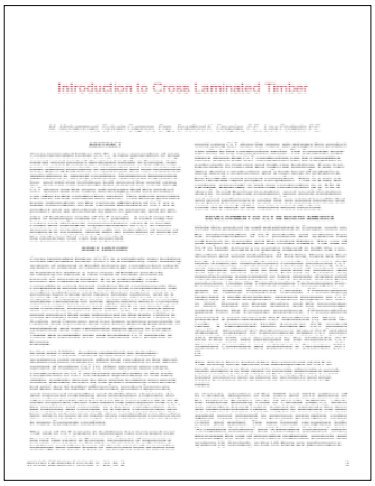
CLT Resources


Introduction to Cross Laminated Timber

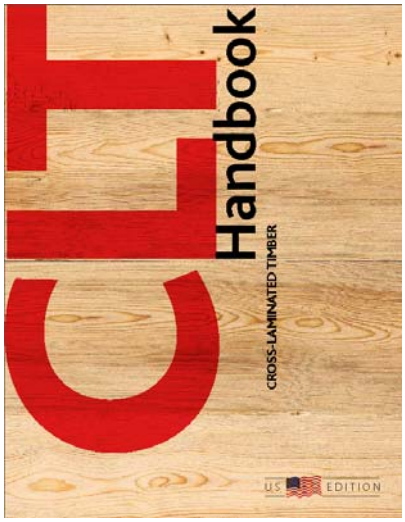

INSIGHTS

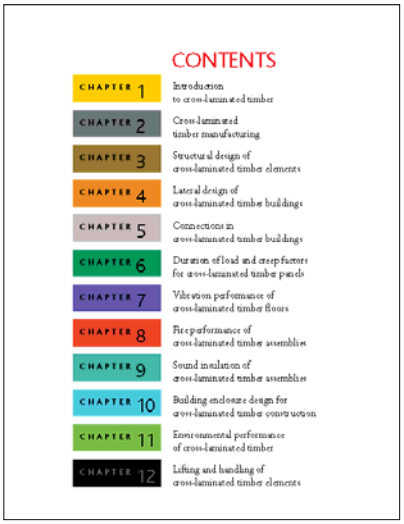
New Wood Materials

Cross Laminated Timber (CLT)

http://www.awc.org/publications/download.php

U.S. CLT Handbook




CONTENTS

CHAPTER 1 Introduction to cross-laminated timber

CHAPTER 2 Cross-laminated timber manufacturing

CHAPTER 3 Structural design of cross-laminated timber elements

CHAPTER 4 Lateral design of cross-laminated timber buildings

CHAPTER 5 Connections in cross-laminated timber buildings

CHAPTER 6 Duration of load and creep factors for cross-laminated timber panels

CHAPTER 7 Vibration performance of cross-laminated timber floors

CHAPTER 8 Fire performance of cross-laminated timber assemblies

CHAPTER 9 Sound insulation of cross-laminated timber assemblies

CHAPTER 10 Building enclosure design for cross-laminated timber construction

CHAPTER 11 Environmental performance of cross-laminated timber

CHAPTER 12 Lifting and handling of cross-laminated timber elements

http://www.awc.org/standards/manuals.html

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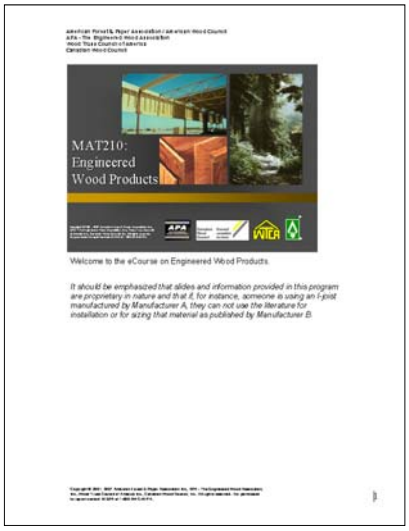
Free Downloadable Resources

http://www.awc.org/helpoutreach/ecourses/index.html



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Free Downloadable Resources

- **American Wood Council**
  - **www.awc.org**
- **APA – The Engineered Wood**
  - **www.apawood.org**
- **Western Wood Products Association**
  - **ww2.wwpa.org**
- **Wood Truss Council of America**
  - **www. sbcindustry.com**

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Free Downloadable Resources

http://www.structuremag.org
October 2014 Issue
Traditional and Engineered Wood Products and EPD

Free Downloadable Resources

Framing Member	Design Reference	Product Standard
Sawn lumber	NDS	USDOC PS20
Structural Glued Laminated Timber	NDS	ANSI A190.1 & ASTM D3737
Prefabricated Wood I-Joists	NDS and ER	ASTM D5055
Structural Composite Lumber	NDS and ER	ASTM D5456
Wood Structural Panels	NDS and ER	USDOC PS1 & PS2
Cross Laminated Timber	ER	ANSI/APA PRG 320

ER= Proprietary product see manufacturer' s Evaluation Report for design values.

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Resources

- 2012 IBC Changes for Wood Design

Resources

Summary of Changes to 2012 IBC.

IBC Section	Standard or topic	Modification
1609.1.1 Determination of wind loads	AWC 2012, *Wood Frame Construction Manual* (WFCM) *for One- and Two-Family Dwellings*	Updated standard
	ICC 600 *Standard for Residential Construction in High-Wind Regions*	Updated standard
1905.1.9 ACI 318, Section D.3.3	ACI 318-11 Appendix D	Permits NDS anchor bolt design
2301.2 General design requirements	AWC WFCM 2012	Updated standard
	ICC-400-12 *Log Structure Standard*	Updated standard
2301.1.1.2 End-jointed lumber	End-jointed lumber	New heat resistant adhesive designation
2303.1.4 Wood structural panels 2304.6.2 Interior paneling	*DOC PS 1-09 and PS 2-10 for Plywood and Wood-based Structural-use Panels*	Updated standards
2305 Lateral Force Resisting System	AWC 2008 *Special Design Provisions for Wind and Seismic* (SDPWS)	Removed code criteria duplicated in 2008 SDPWS
2306 Allowable stress design	AWC 2008 SDPWS	Removed code criteria duplicated in 2008 SDPWS
2306.1 Allowable stress design reference standards	AWC NDS-2012	Updated standard
	AITC 113-10 Standard glulam dimensions	Updated standard
	AITC 117-10 Softwood glulam	Updated standard
	APA PRP-210 plywood siding	New standard
2306.1.1 Joists and Rafters	AWC *Span Tables for Joists and Rafters 2012*	Updated standard
2307 Load and resistance factor design	AWC 2008 SDPWS	Removed code criteria duplicated in 2008 SDPWS
2307.1 Load and resistance factor design reference standards	AWC NDS-2012	Updated standard
2308.2.1 Nominal design wind speed greater than 100 mph (3-second gust)	AWC WFCM 2012	Updated standard
2308.12.4 Braced wall line sheathing	Braced wall line requirements for seismic design categories D and E	Table 2308.12.4 revised and new section 2308.12.4.1 added

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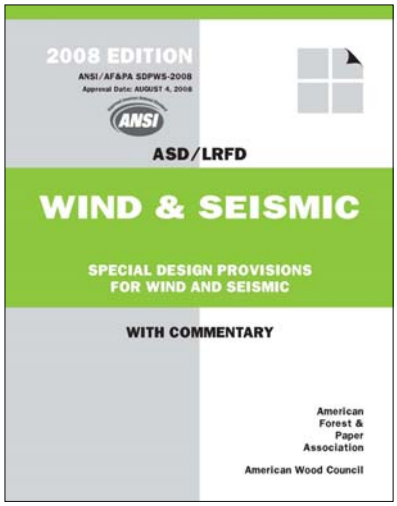
Resources

- 2012 NDS Changes

Resources

http://www.awc.org/helpoutreach/ecourses/index.html

2008 SDPWS - Diaphragm Deflection Design - Webinar



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Resources

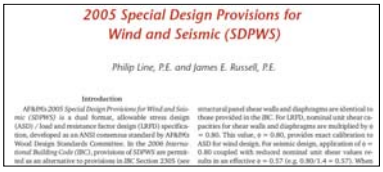
- 2015 NDS Changes are covered by one of our many PowerPoint presentations
- http://www.awc.org/education/std
- STD510 – Significant Changes to AWC's 2015 NDS and the 2015 SDPWS

Resources

- Wind & Seismic Standards
- More details on changes
- *Wood Design Focus* papers
  - 2005 Special Design Provisions for Wind and Seismic (SDPWS)
  - 2008 Special Design Provisions for Wind and Seismic
  - Use of Wood Structural Panels to Resist Combined Shear and Uplift from Wind

Download free at

www.awc.org


2005 Special Design Provisions for Wind and Seismic (SDPWS)

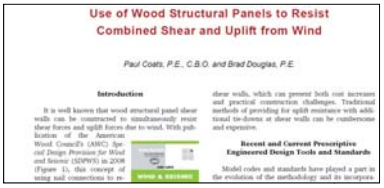
Philip Line, P.E. and James E. Russell, P.E.

Introduction


2008 Special Design Provisions for Wind and Seismic

Philip Line, P.E., Bradford K. Douglas, P.E., and Peter Mazikins, P.Eng.

Introduction


Use of Wood Structural Panels to Resist Combined Shear and Uplift from Wind

Paul Coats, P.E., C.B.O. and Brad Douglas, P.E.

Introduction

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Resources

- ALLOWABLE USE OF WOOD IBC 2009, 2012 & 2015

http://www.awc.org/codes-standards/buildingcodes/ccwd

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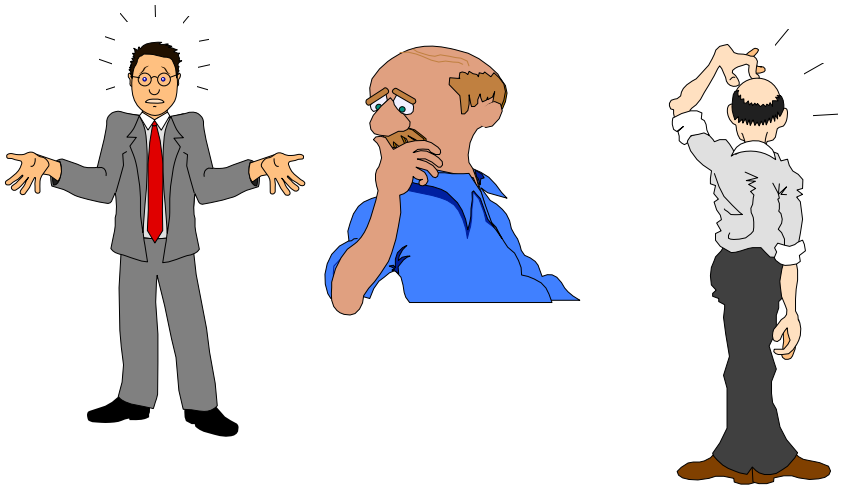
Questions ???



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Questions

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