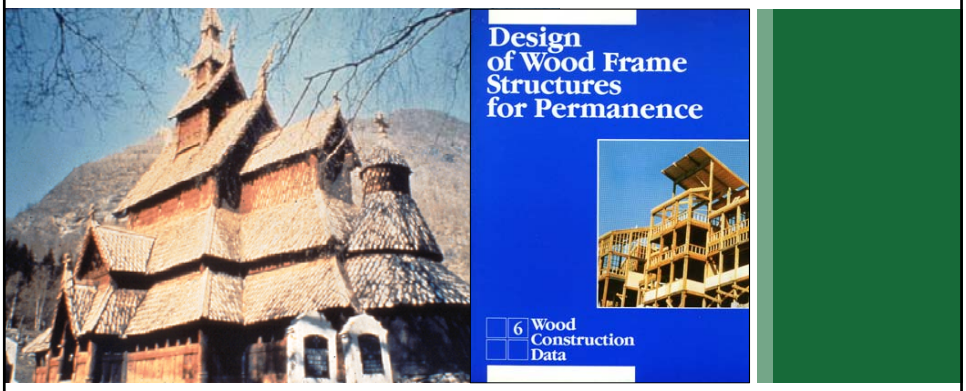

Design Considerations of Wood Frame Structures for Permanence - DES125

John "Buddy" Showalter, P.E.
Vice President, Technology Transfer
American Wood Council

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- **Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.**

Description

When properly designed, wood frame structures will resist damage by moisture and living organisms. Recommendations for control of moisture and protection against decay and insect infestations are contained in AWC's *Design of Wood Frame Structures for Permanence, WCD No. 6*. Protection of wood frame structures to provide maximum service-life involves four methods of control, which can be handled by proper design and construction: (1) control moisture content of wood, (2) provide effective termite controls, (3) use of durable materials such as naturally durable or preservative treated wood, and (4) quality assurance.

Learning Objectives

Upon completion, participants will

1. **Understand conditions necessary for wood-destroying organisms to thrive**
2. **Understand construction techniques that prevent moisture intrusion into wood-framed structure including code-required clearances, site drainage, and correct placement of moisture barriers**
3. **Understand remedies for improper design and construction**
4. **Be knowledgeable about preservative treated wood and naturally durable species, grading issues, and tips on preventing moisture-related insect and fungal attack**

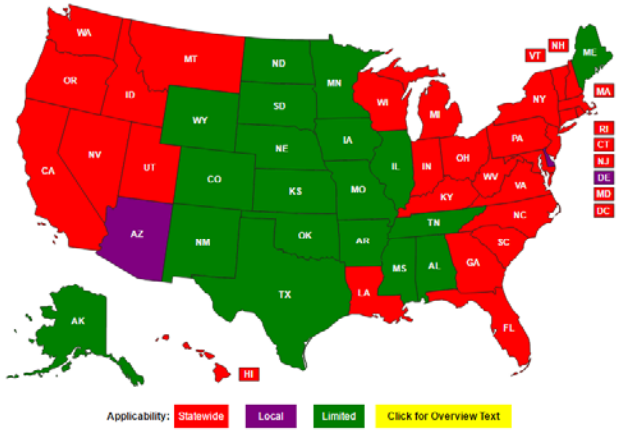
Polling Question

What is your profession?

a) Architect
b) Engineer
c) Code Official
d) Builder
e) Other

Building Code Role

- **State and local variations**
- **Code official is final authority**

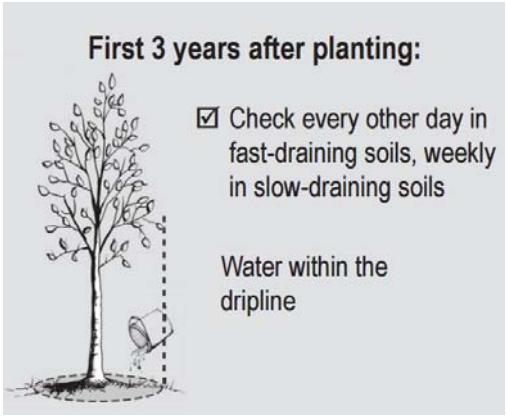


Graphic Source: www.awc.org

Conditions for Trees

Giant Sequoia
3000 years

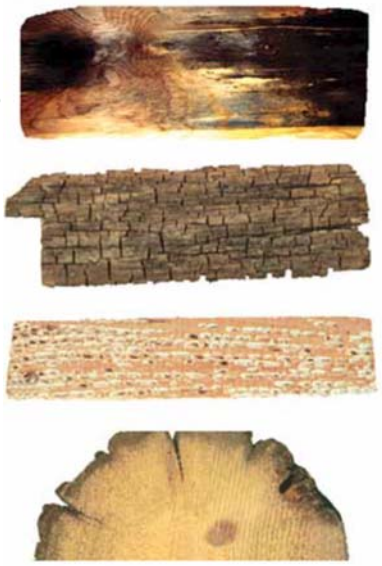
- **Moisture**
- **Air**



Conditions for Organisms

Conditions necessary for wood-destroying organisms

- **Moisture**
- **Oxygen**
- **Warm Temperature**
- **Food Source**



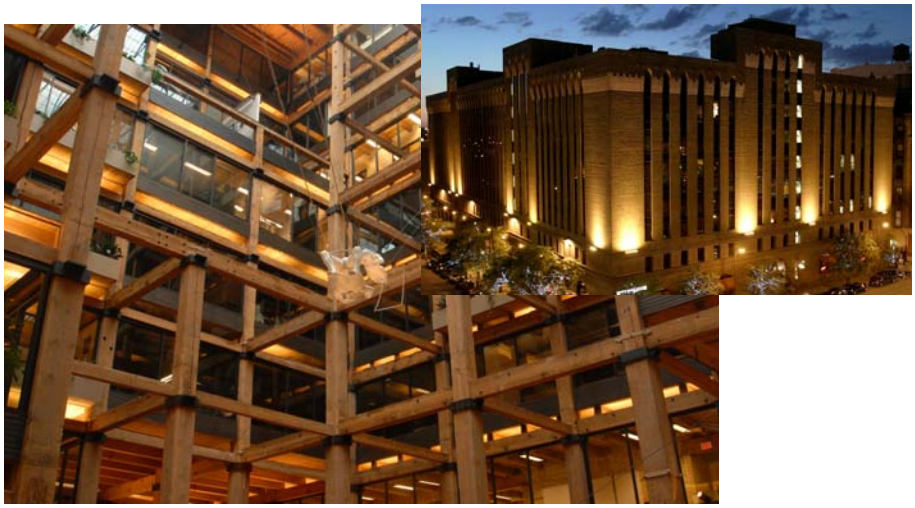
Graphic Source: USDA FPL *Wood Handbook*

Stave Church – Norway – 1100 A.D.

Glacier Hotel – Montana – 1915

From *Designing for Durability* – reThinkWood.com
Photo courtesy of David Restivo, National Park Service; inset photo by T.J. Hileman, courtesy of Montana State University Library

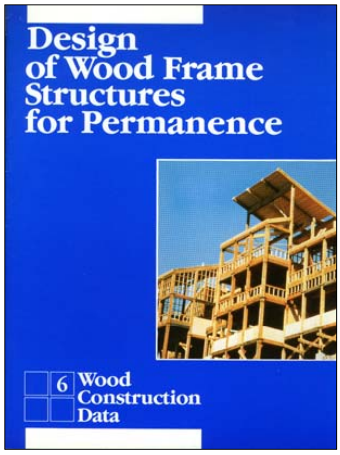
Butler Brothers Building – Minneapolis - 1906



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

Proper Design for Maximum Service Life

- **Control moisture content**
- **Termite barriers/details**
- **Naturally durable and preservative treated wood**
- **Quality assurance**



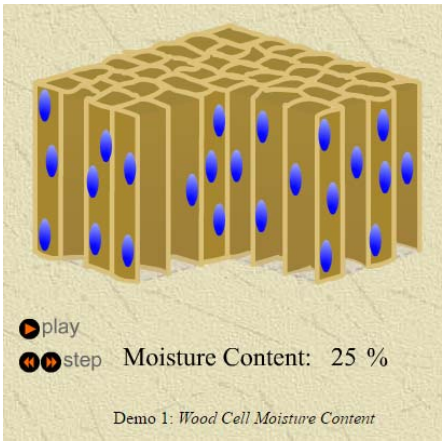
Available free: www.awc.org

Best Practices - Construction

- **Positive drainage**
- **Adequate separation**
- **Ventilation and condensation control**
- **Naturally durable and preservative treated wood**

Moisture Content

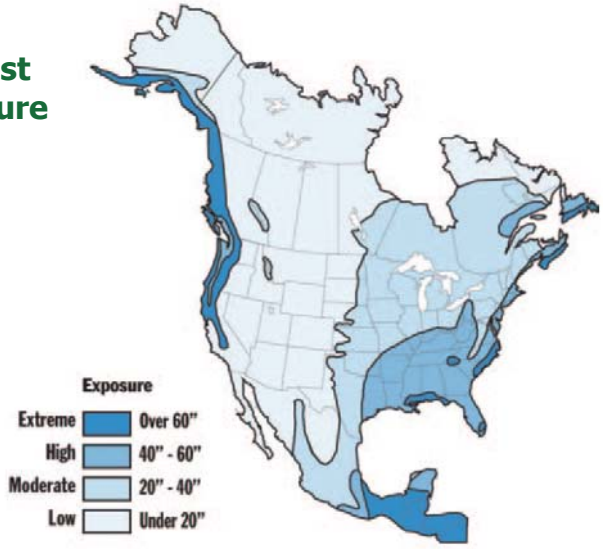
- **MC < 20%**
  - **no decay**
- **MC > 25%**
  - **optimum condition for decay**



Graphic Source: Washington State University – Civil Engineering

Rain Exposure Zones

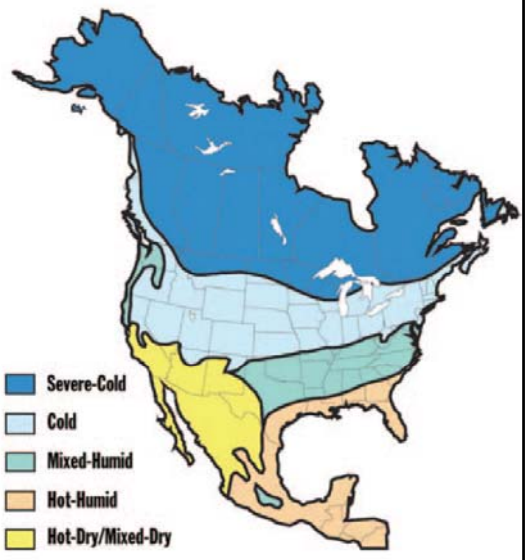
- **Liquid flow is most significant moisture load**
  - **Rain**
  - **Groundwater**



Graphic Source: WCD 6

Hygro-Thermal Zones

- **Air movement and diffusion are less significant moisture contributors**



Graphic Source: WCD 6

Wood Equilibrium Moisture Content

Table 4–2. Moisture content of wood in equilibrium with stated temperature and relative humidity

Temperature		Moisture content (%) at various relative humidity values																		
(°C	(°F))	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
–1.1	(30)	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.4	13.5	14.9	16.5	18.5	21.0	24.3
4.4	(40)	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.3	13.5	14.9	16.5	18.5	21.0	24.3
10.0	(50)	1.4	2.6	3.6	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.2	12.3	13.4	14.8	16.4	18.4	20.9	24.3
15.6	(60)	1.3	2.5	3.6	4.6	5.4	6.2	7.0	7.8	8.6	9.4	10.2	11.1	12.1	13.3	14.6	16.2	18.2	20.7	24.1
21.1	(70)	1.3	2.5	3.5	4.5	5.4	6.2	6.9	7.7	8.5	9.2	10.1	11.0	12.0	13.1	14.4	16.0	17.9	20.5	23.9
26.7	(80)	1.3	2.4	3.5	4.4	5.3	6.1	6.8	7.6	8.3	9.1	9.9	10.8	11.7	12.9	14.2	15.7	17.7	20.2	23.6
32.2	(90)	1.2	2.3	3.4	4.3	5.1	5.9	6.7	7.4	8.1	8.9	9.7	10.5	11.5	12.6	13.9	15.4	17.3	19.8	23.3
37.8	(100)	1.2	2.3	3.3	4.2	5.0	5.8	6.5	7.2	7.9	8.7	9.5	10.3	11.2	12.3	13.6	15.1	17.0	19.5	22.9
43.3	(110)	1.1	2.2	3.2	4.0	4.9	5.6	6.3	7.0	7.7	8.4	9.2	10.0	11.0	12.0	13.2	14.7	16.6	19.1	22.4
48.9	(120)	1.1	2.1	3.0	3.9	4.7	5.4	6.1	6.8	7.5	8.2	8.9	9.7	10.6	11.7	12.9	14.4	16.2	18.6	22.0

Desorption ←

Resorption (adsorption) →
- More difficult
- Prolonged exposure at high RH
- Covered structures considered dry (<19%)

Table Source: USDA Forest Products Lab *Wood Handbook*

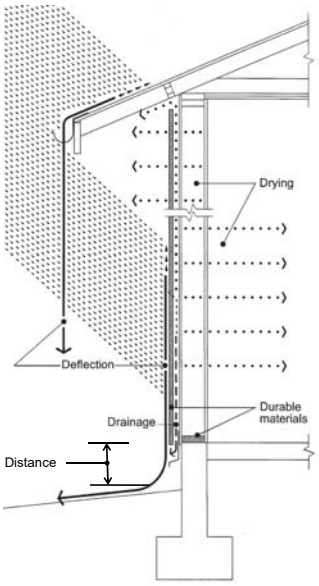
Polling Question

What is the optimum moisture content for wood decay?

a) 10%
b) 15%
c) 20%
d) 25%

Water Management Principles

- **Deflection**
- **Distance (separation)**
- **Drainage**
- **Drying**
- **Durable Materials**



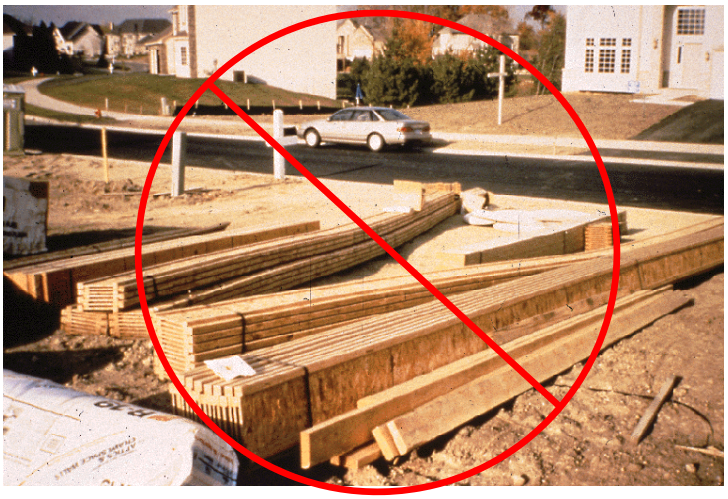
Graphic Source: Canadian Wood Council

Moisture Control

- **Site drainage**
- **Building drainage**
- **Separation of wood elements**
- **Condensation control**

Material Handling and Storage

- **EWP MC typically < 15%**



Material Handling and Storage

Material Handling and Storage

From *Designing for Durability* – reThinkWood.com
Photo courtesy of KK Law

Weather Protection

- **Close-in as quickly as possible**
  - **Roof coverings**
  - **Building envelope**

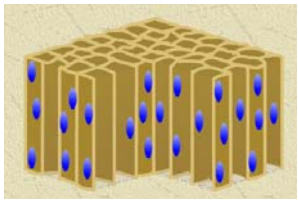
From *Designing for Durability* – reThinkWood.com
Photo courtesy of Togawa Smith Martin, Inc.

Weather Protection

- **Allow drying before installing insulation and gypsum**
  - **Durability**
  - **Shrinkage**

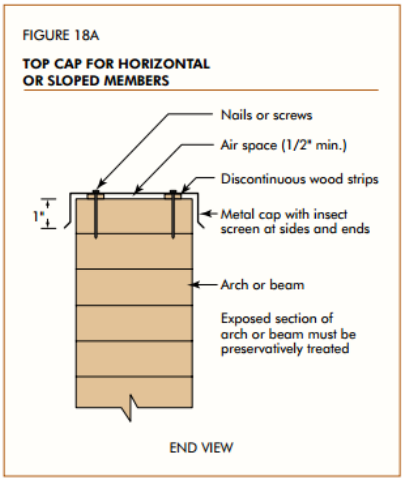
Detailing and Maintenance

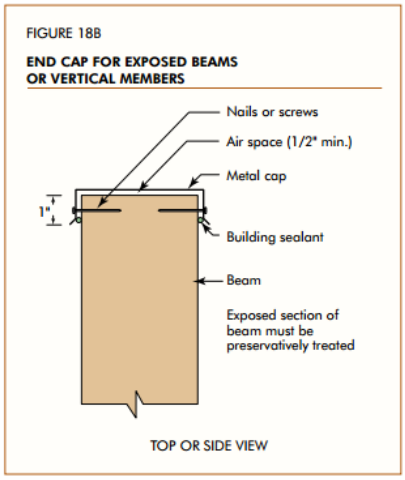
- **Structural Glulam – exposed (2015 IBC 2304.12.2.4)**
- **Solutions**
  - **Preservative treated**
  - **Naturally durable**
  - **Under roof/eave**
    - Similar covering
  - **Top and end caps**
    - Industry practice



Detailing and Maintenance

- **Structural Glulam – exposed – top/end cap details**





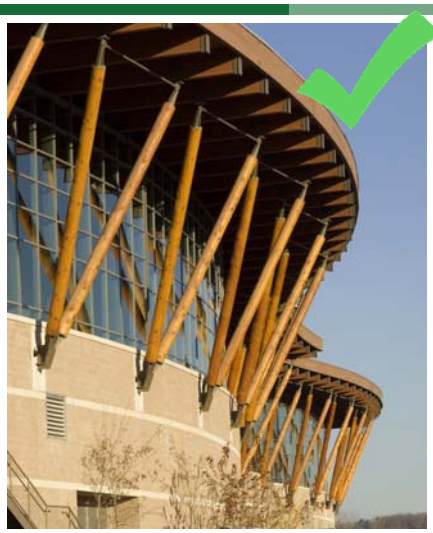
Source: www.apawood.org

Detailing and Maintenance

- **Structural Glulam – exposed**
- **Tapered under roof**
- **Untreated**

Detailing and Maintenance

- **Exposed poles & glulam**
- **Under roof overhang**
- **End caps**

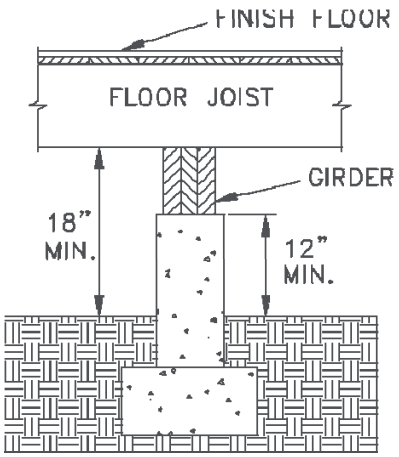


From *Designing for Durability* – reThinkWood.com
Photo courtesy of Brian Gassel, tvsdesign

Detailing and Maintenance - Ventilation

Detailing – Code Requirements

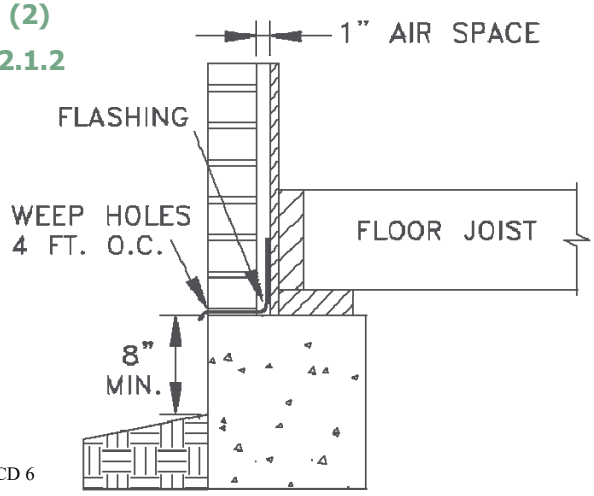
- **Crawl space girder and floor joist**
  - **2015 IRC R317.1 (1)**
  - **2015 IBC 2304.12.1.1**



Graphic Source: WCD 6

Detailing – Code Requirements

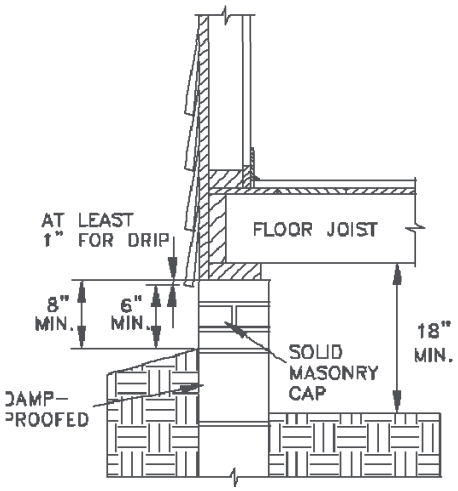
- **Wood on concrete/masonry**
  - **2015 IRC R317.1 (2)**
  - **2015 IBC 2304.12.1.2**



Graphic Source: WCD 6

Detailing – Code Requirements

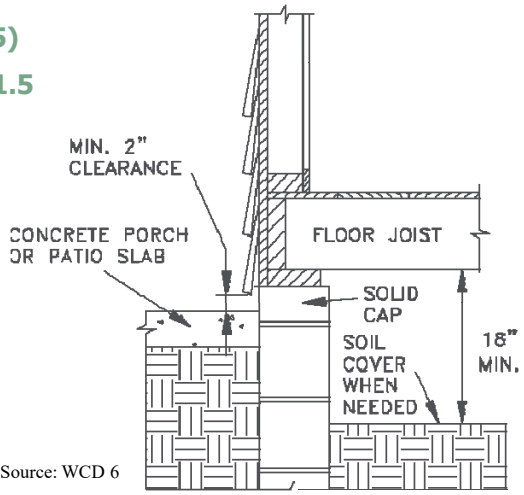
- **Siding**
  - **2015 IRC R317.1 (5)**
  - **2015 IBC 2304.12.1.5**



Graphic Source: WCD 6

Detailing – Code Requirements

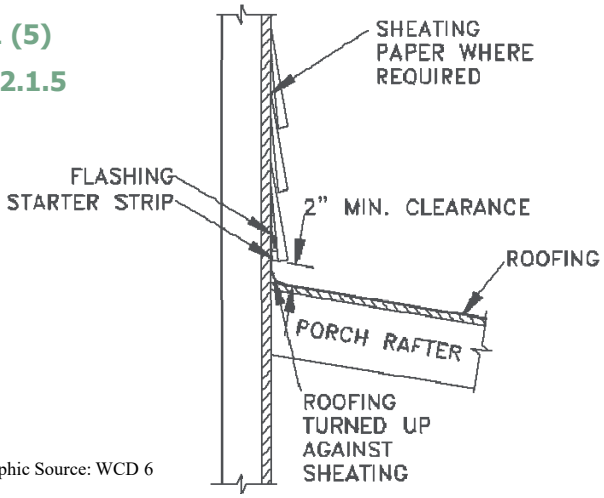
- **Siding**
  - **2015 IRC R317.1 (5)**
  - **2015 IBC 2304.12.1.5**



Graphic Source: WCD 6

Detailing – Code Requirements

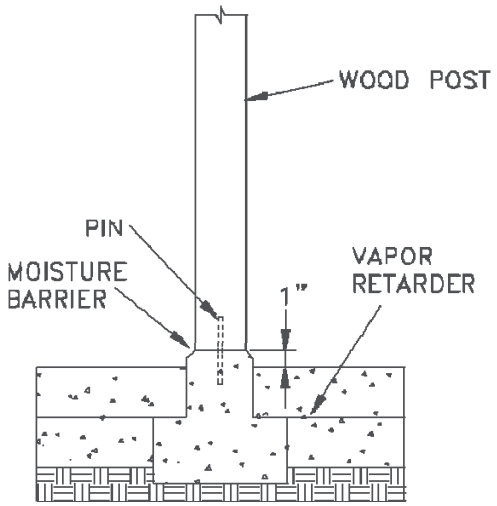
- **Siding**
  - **2015 IRC R317.1 (5)**
  - **2015 IBC 2304.12.1.5**



Graphic Source: WCD 6

Detailing – Code Requirements

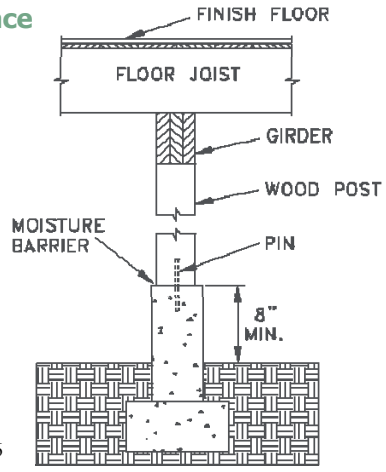
- **Wood columns**
  - **2015 IRC R317.1.4 (1)**
  - **2015 IBC 2304.12.2.2**



Graphics Source: WCD 6

Detailing – Code Requirements

- **Wood columns**
  - **2015 IRC R317.1.4 (2) – crawl space**
  - **2015 IBC 2304.12.2.2**



Graphic Source: WCD 6

Polling Question

Which is NOT a solution for protecting exposed structural glulam?

a) Preservative treated or naturally durable wood
b) Taper under roof/eave
c) Incising
d) Top and end caps

Termite Damage

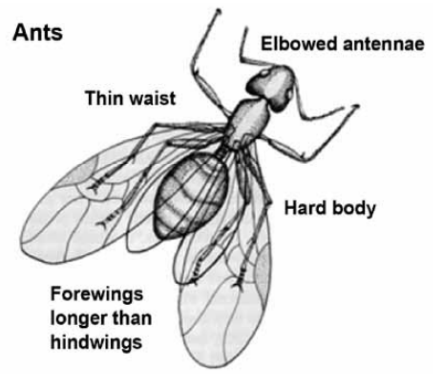
Termite Control

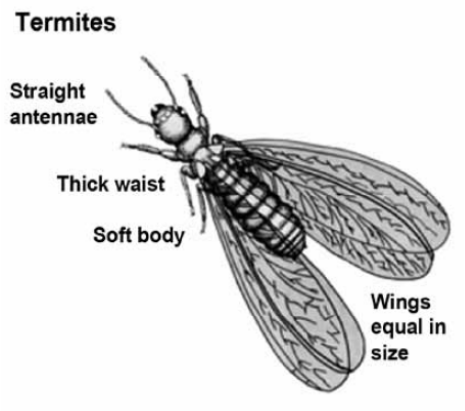
- **Preservative treated wood**
- **Shields**
- **Chemical treatment**
- **Concrete foundations**
- **Concrete caps**
- **Inspection**

Graphic Source: www.cwc.ca

Termite Control

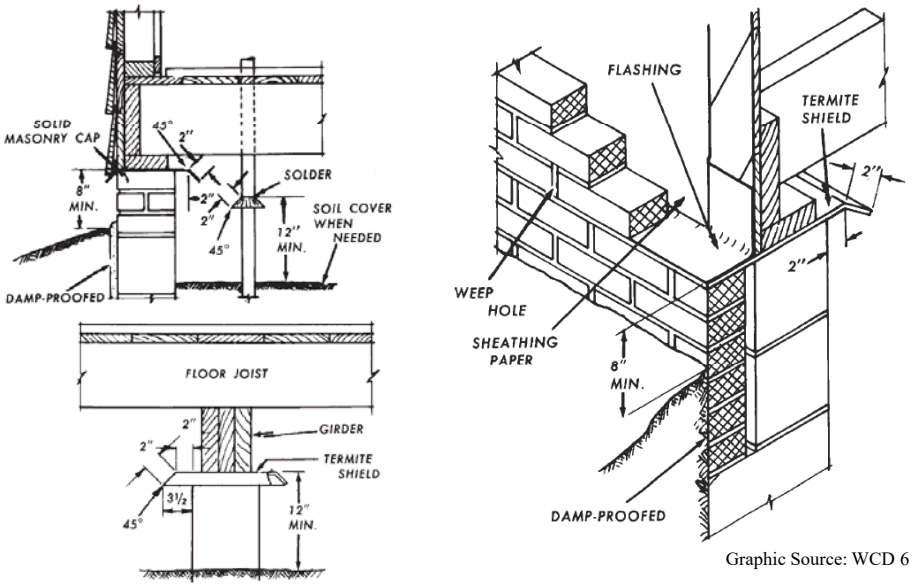
- **Not all "flying ants" are termites**





Graphic Source: USDA Forest Products Lab *Wood Handbook*

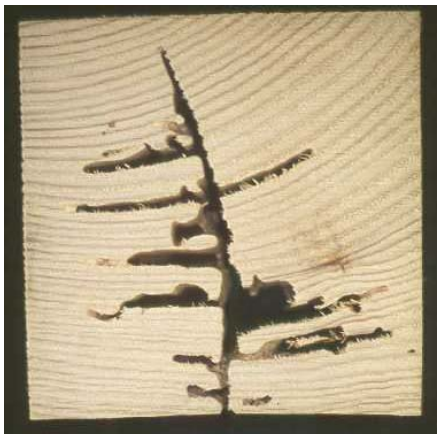
Termite Shields

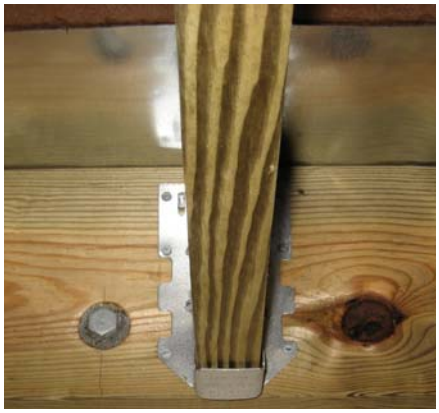


Graphic Source: WCD 6

Preservative Treatment

- **Protects against insect attack and decay**





Preservative Treatment

- **Effectiveness**
  - **Chemical type**
  - **Penetration**
  - **Retention**
  - **Uniform distribution**

From *Designing for Durability* – reThinkWood.com
Photo courtesy of BS&S Treated Lumber

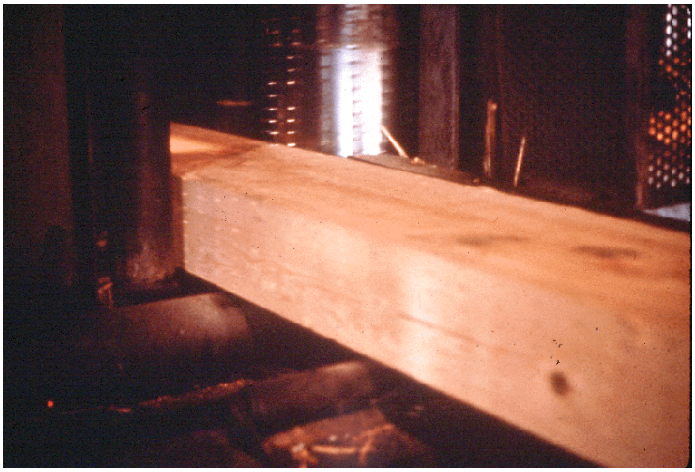
Treatment Penetration

Graphic Source: USDA Forest Products Lab *Wood Handbook*

Refractory Species

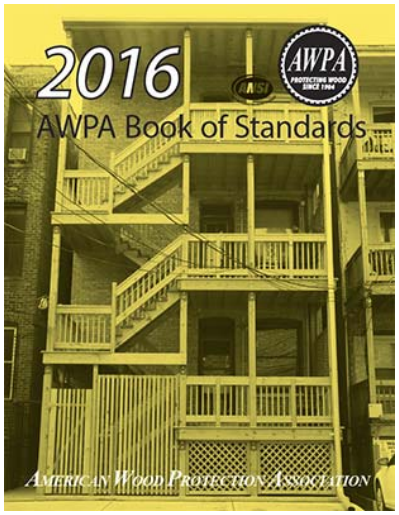
Incising

- **Design value adjustment per NDS for incising**
- **No adjustment for preservatives alone**



AWPA Standards

- **UC3B - Above Ground, Exposed**
  - **Usually deck boards, rails, siding, joists, etc.**
- **UC4A - Ground Contact, General**
  - **Soil, concrete, or fresh water contact items such as deck posts**
  - **Some special heavy duty above ground applications like beams or girders**
- **UC4B - Ground Contact, Heavy**
  - **For structural members difficult or expensive to replace**



Source: www.awpa.com

AWPA Standards

TREATING STANDARDS

APPLICATION	RETENTION LBS./CU. FT.			AWPA USE CATEGORY STANDARDS FOR STRUCTURAL APPLICATIONS
	ACQ/ACZA	CA-C	DOT	
Above Ground	0.25	0.06	N/A	UC1, UC2, UC3A, UC3B
Ground Contact, Fresh Water Immersion	0.40	0.15	N/A	UC4A, UC4B
In Ground (Structural)	0.60	0.31	N/A	UC4B
Above Ground, Continuously Protected from Liquid Water (Sillplate)	0.25	0.06	0.25	UC1, UC2

Source: Western Wood Preservers Institute

Types of Preservatives

- **Oil-borne or Oil-type**
  - Creosotes, pentachlorophenol
- **Waterborne preservatives**
  - CCA, CA-B, ACQ, ACZA
- **Non-pressure preservatives**
  - Water-repellents

Creosote - Marine

Creosote - Timber Bridge

Penta – Horse Stable

Penta – Timber Bridge

Penta – Utility Poles

Penta – Sound Barriers

Penta – Railroad Trestle

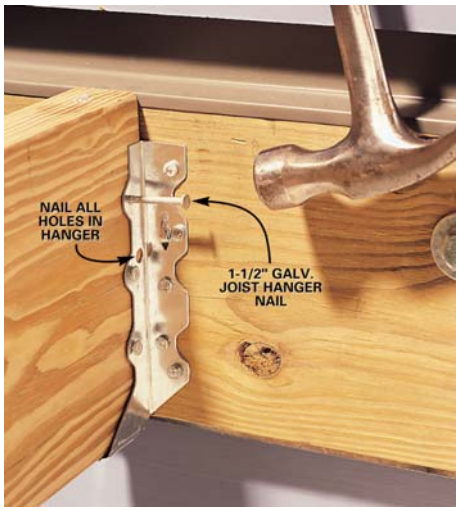
Waterborne - Permanent Wood Foundation

Source: Southern Forest Products Association

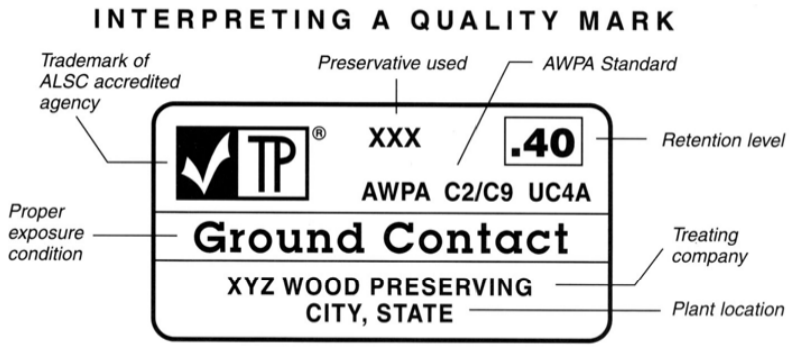
Waterborne - Decks

Waterborne - Fastener Corrosion

- **Corrosion Resistance**
  - **2015 IRC R317.3**
  - **2015 IBC 2304.10.5**
    - Screws, bolts, nails
      - Hot-dipped galvanized
      - Stainless
      - Silicon bronze
      - Copper
    - Hangers and anchors
      - Galvanized
      - Stainless
- **Saltwater exposure**
  - **Stainless**

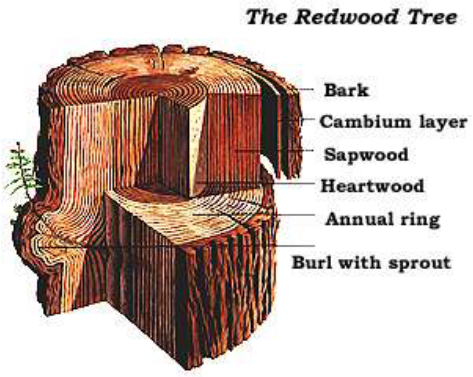


Grade Stamp



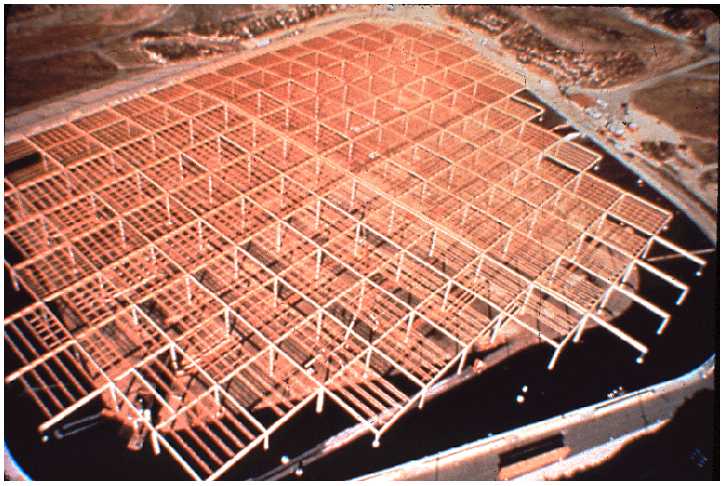
Naturally Durable Wood

- **Decay resistant**
  - Redwood
  - Cedars
  - Black Locust
- **Termite resistant**
  - Redwood
  - Eastern Cedar



Los Angeles Reservoir Cover

- **Alaskan Yellow Cedar glulam and trusses**



Redwood Deck

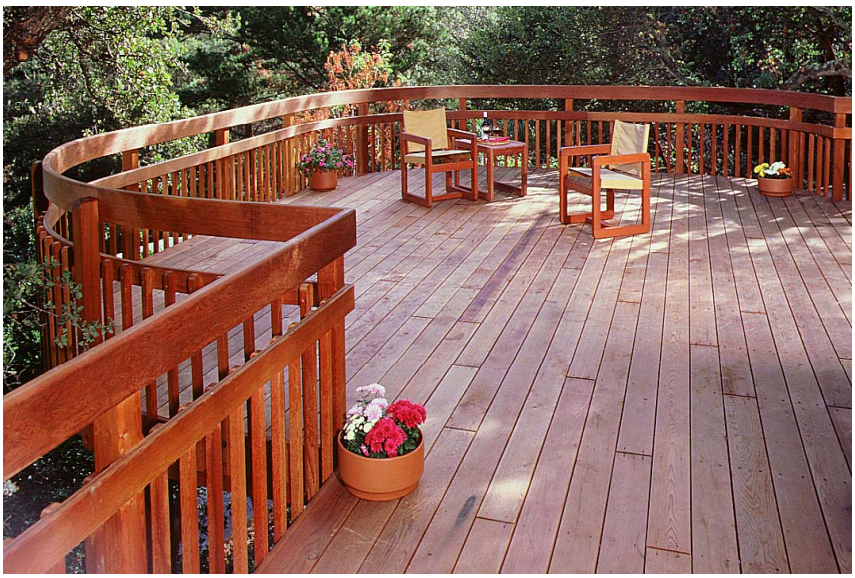


Photo courtesy of California Redwood Association

Non-pressure Preservatives

- **Water repellent preservatives**
  - **Can be painted**
- **Oil-borne preservatives**
  - **Not recommended for painting**
  - **Dipping or vacuum process**
- **Moderate exposures**
  - **Windows, siding, exterior trim, porch framing**

Non-pressure Preservatives

- **Water repellent preservatives**

Table 16–5. Initial application and maintenance of exterior wood finishes[a]

			Maintenance	
Finish	Application process	Appearance of wood	Process	Service life[b]
Water-repellent preservative (WRP)	Brush-apply 1 coat or dip. Apply a second coat only if it will absorb.	Grain visible; wood tan to brown, fades to gray with age	Brush to remove surface dirt; wash to remove mildew	1–3 years
Tinted clear finish (slightly pigmented deck finish)	Brush-apply 1 coat or dip. Apply a second coat only if it will absorb.	Grain and natural color slightly changed	Same as with WRP	2–3 years
Semitransparent stain	Brush-apply 1 coat or dip. Apply a second coat only if it will absorb.	Grain visible; color as desired	Same as with WRP	4–8 years (on saw-textured or weathered wood)
Paint and solid-color stain	Brush-, roller-, or spray-apply primer and 2 top-coats	Grain and natural color obscured	Clean and apply topcoat if old finish is sound; if not sound, remove peeled finish, prime, and apply topcoats[d]	10–20 years for paint[c]; 6–15 years for solid-color stain[e]

Table Source: USDA Forest Products Lab *Wood Handbook*

Safety Data Sheets

- **Available from EPA and manufacturers**

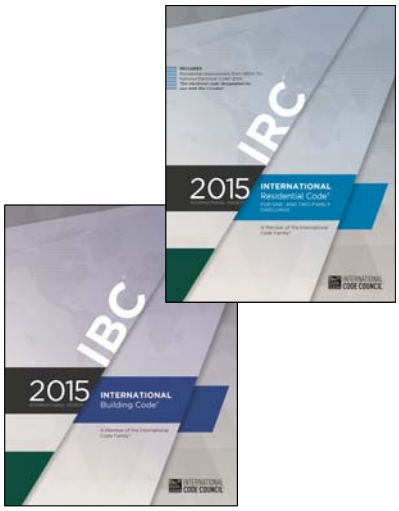
Polling Question

Which is important for effective preservative treatment?

a) Chemical type
b) Penetration
c) Retention
d) Uniform distribution
e) All of the above

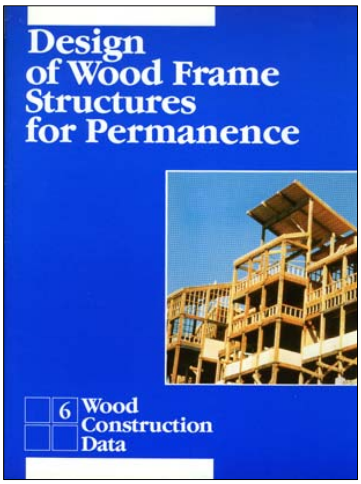
Quality Assurance

- **Conformance to building codes**
  - **Inspection by code officials**
  - **Special inspection**
    - High wind and seismic detailing
- **Conformance to standards**
  - **Treated wood – quality mark**
    - AWPA standards
    - Evaluation service reports



WCD 6 - Design for Permanence

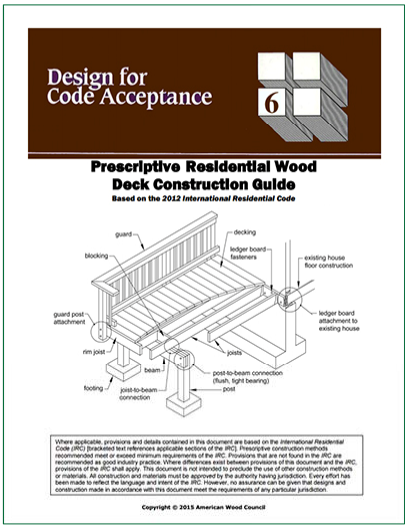
- **Decay / Termites**
- **Good Construction**
  - drainage
  - separation
  - condensation
  - barriers
- **Durability**
  - naturally
  - pressure treated
  - non-pressure treated



Available free: www.awc.org

DCA 6 – Wood Deck Construction

- **Good Practice**
- **Exposed to Elements**
- **Durability Issues**
  - Lumber
  - Fasteners



Available free: www.awc.org

Other Resources

- **USDA FPL Wood Handbook**

CHAPTER 13

Drying and Control of Moisture Content and Dimensional Changes

Richard Bergman, Research Forest Products Technologist

CHAPTER 14

Biodeterioration of Wood

Carol A. Clausen, Supervisory Research Microbiologist

CHAPTER 15

Wood Preservation

Stan T. Lebow, Research Forest Products Technologist

Available free: www.fpl.fs.fed

Other Resources

- **USDA FPL Moisture Management Series**

Video 1: Series Overview - The building enclosure includes the foundation, exterior walls, and the roof. It provides environmental separation between the inside of the house and the outdoors. The building enclosure must keep out rain water, isolate the building from ground water, and manage heat flow, air flow, and vapor flow. view

Video 2: Foundation Overview - A well-designed foundation supports the house and directs water away from the structure. There are several types of foundations, including basements, crawl spaces, and slabs on grade. The foundation should be suitable for the conditions at the building site. view

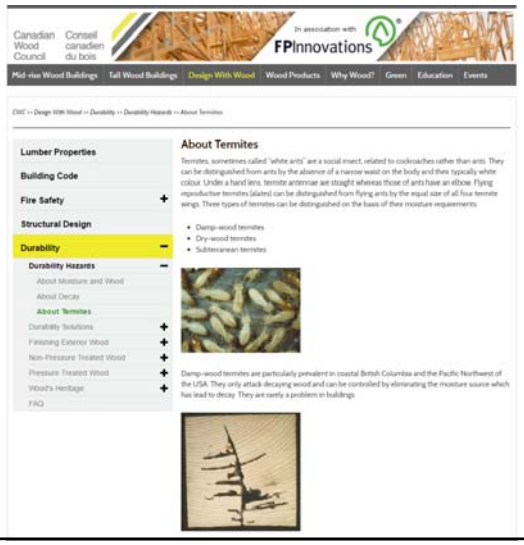
Video 3: Exterior Wall Overview - Exterior walls include various moisture management features. This video provides an overview of drainage principles and details such as water-resistive barriers and flashings. It also discusses thermal insulation, air barriers, and vapor retarders. view

Video 4: Roof Overview - The roof has several moisture management features. Roof overhangs, flashings, gutters, and downspouts are discussed in this video. view

Available free: www.fpl.fs.fed

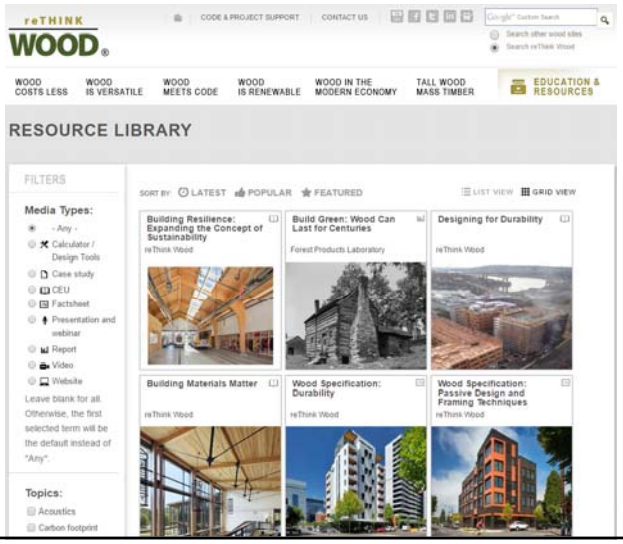
Other Resources

- **Canadian Wood Council – www.cwc.ca**



Other Resources

- **reThink WOOD – www.rethinkwood.com**

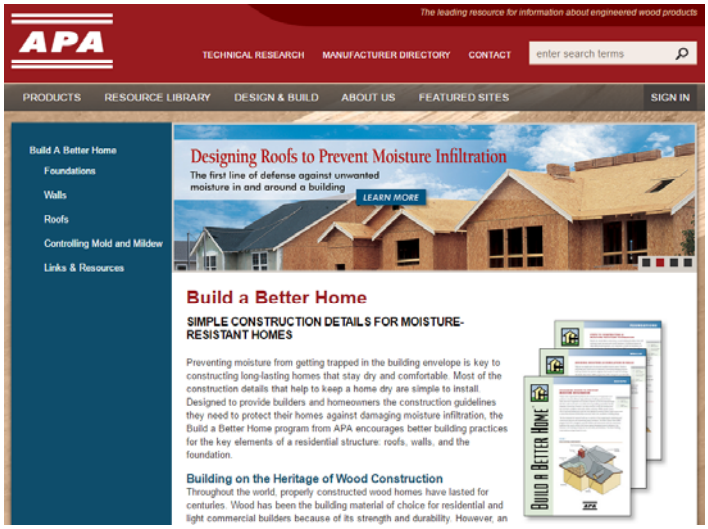


Other Resources

- **Woodworks – www.woodworks.org**

Other Resources

- **APA – www.apawood.org**



Questions?

- **This concludes The American Institute of Architects Continuing Education Systems Course**

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AMERICAN WOOD COUNCIL

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