

AMERICAN WOOD COUNCIL

Design of Wood Frame Structures for Permanence

6 Wood Construction Data

Design Considerations of Wood Frame Structures for Permanence - DES125

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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

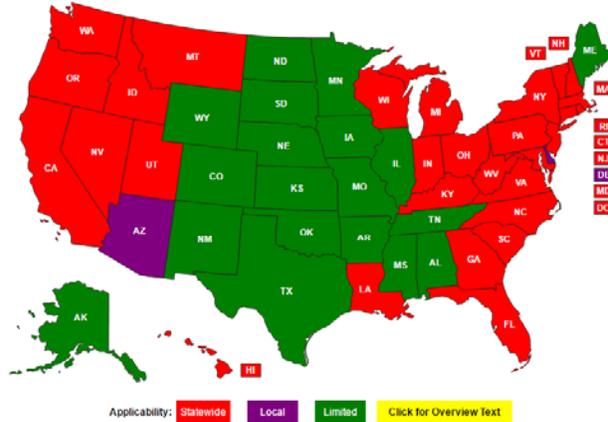
What is your profession?

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



Building Code Role

- State and local variations
- Code official is final authority



Conditions for Trees



Giant Sequoia
3000 years

- Moisture
- Air

First 3 years after planting:

- Check every other day in fast-draining soils, weekly in slow-draining soils

Water within the dripline

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.

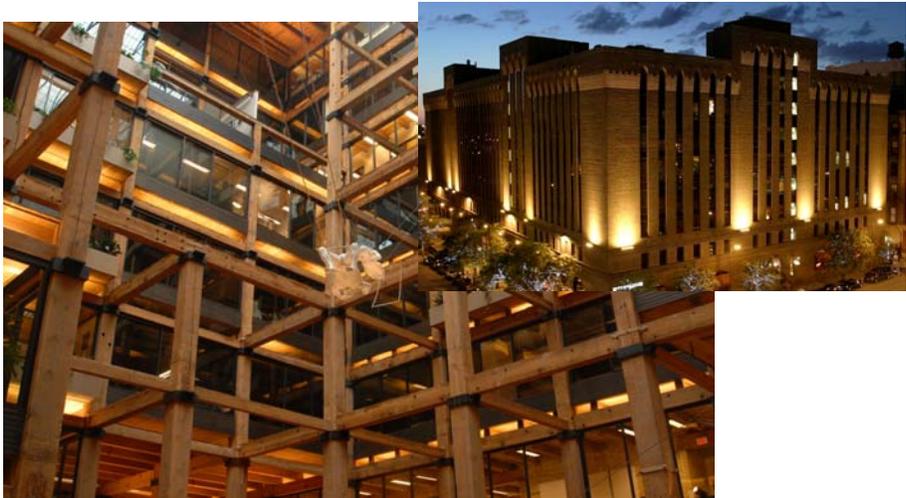


Glacier Hotel – Montana – 1915



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

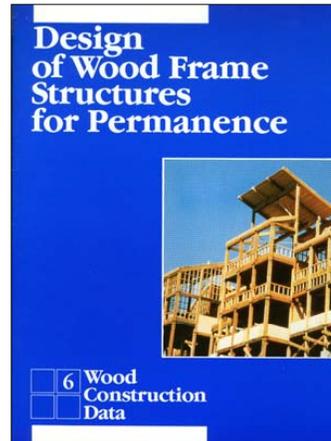
Butler Brothers Building – Minneapolis - 1906



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

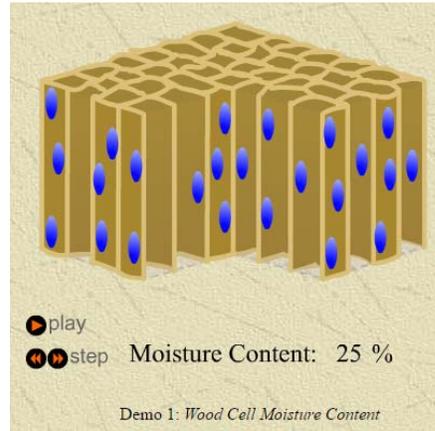
Best Practices - Construction

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



Moisture Content

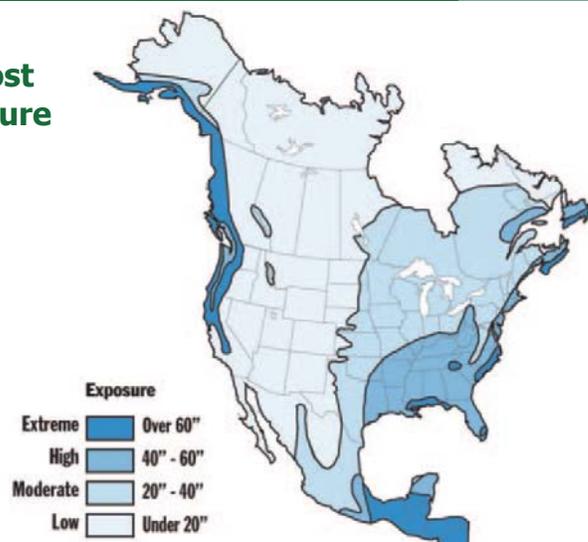
- **MC < 20%**
 - no decay
- **MC > 25%**
 - optimum condition for decay



Graphic Source: Washington State University – Civil Engineering

Rain Exposure Zones

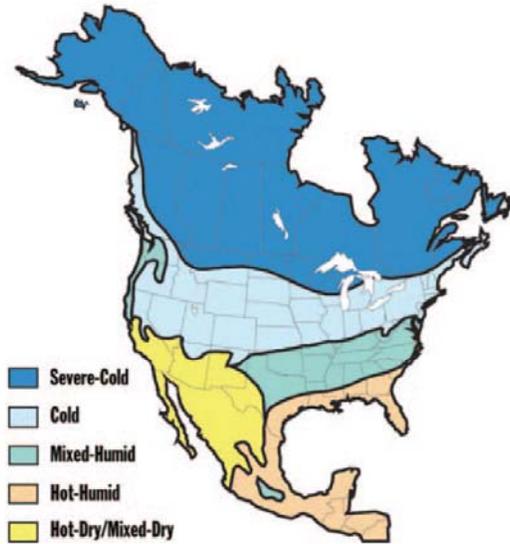
- **Liquid flow is most significant moisture load**
 - Rain
 - Groundwater



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

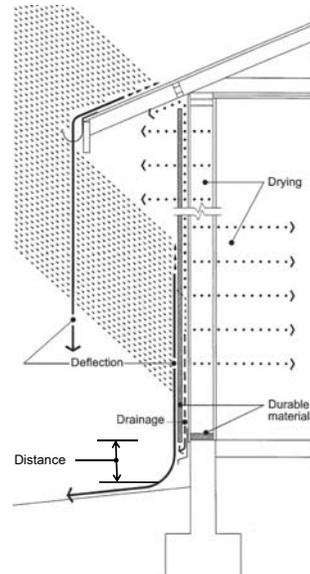
What is the optimum moisture content for wood decay?

- 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.

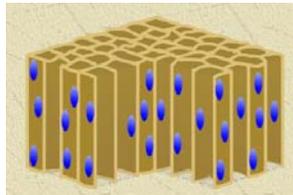
Weather Protection

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



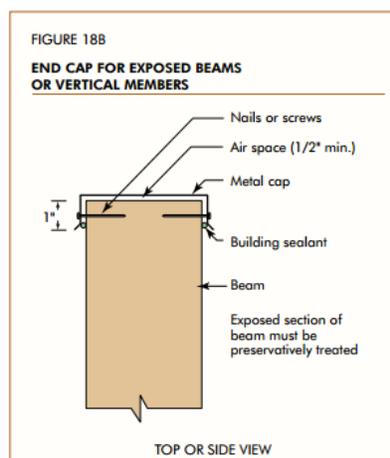
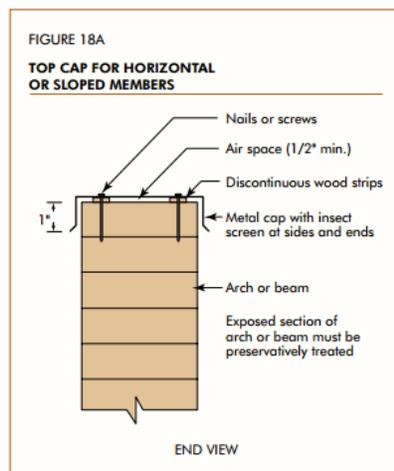
Detailing and Maintenance

- **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



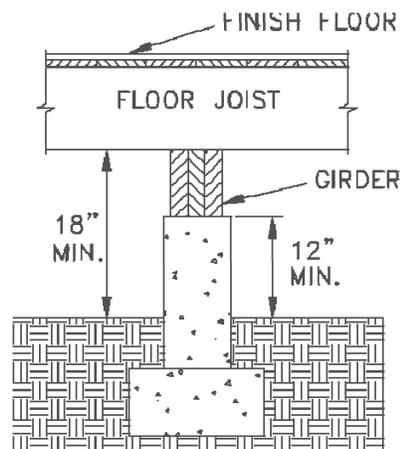
Detailing and Maintenance - Ventilation



Detailing – Code Requirements

- **Crawl space girder and floor joist**

- 2015 IRC R317.1 (1)
- 2015 IBC 2304.12.1.1

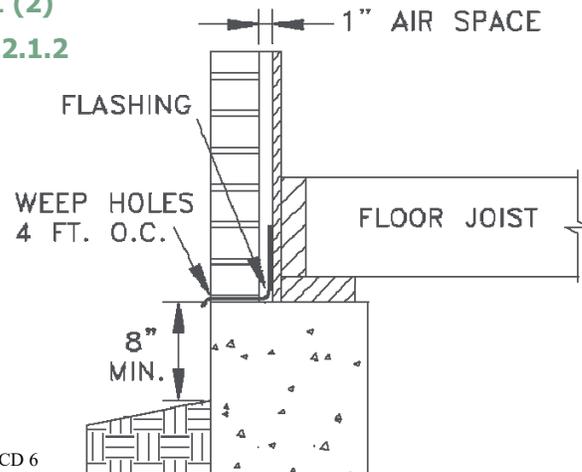


Graphic Source: WCD 6

Detailing – Code Requirements

- **Wood on concrete/masonry**

- 2015 IRC R317.1 (2)
- 2015 IBC 2304.12.1.2

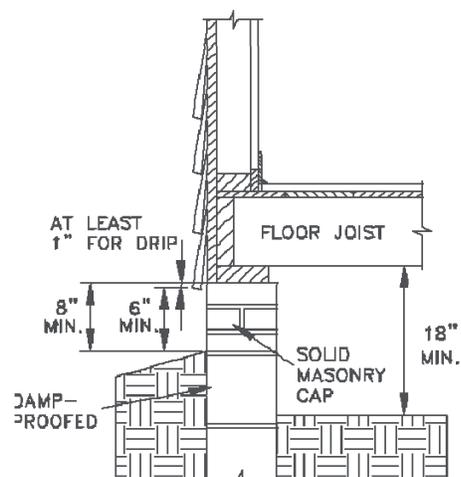


Graphic Source: WCD 6

Detailing – Code Requirements

- **Siding**

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

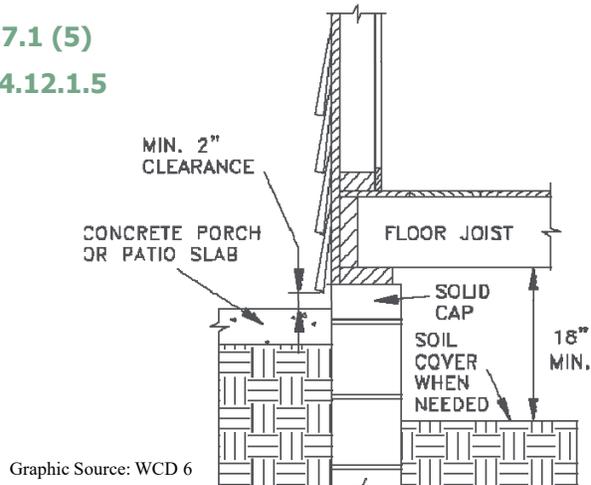


Graphic Source: WCD 6

Detailing – Code Requirements

• Siding

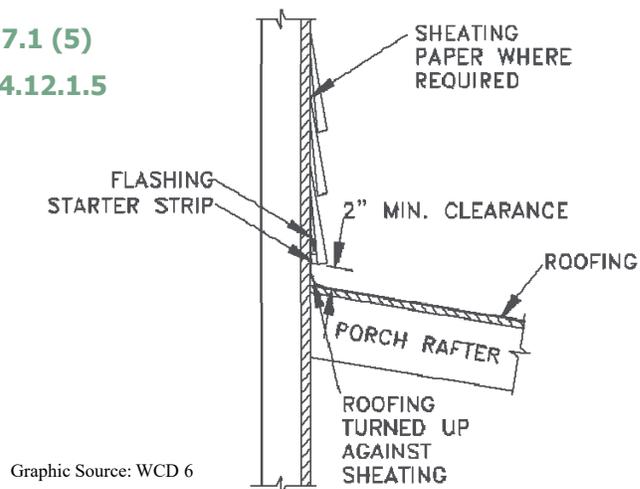
- 2015 IRC R317.1 (5)
- 2015 IBC 2304.12.1.5



Detailing – Code Requirements

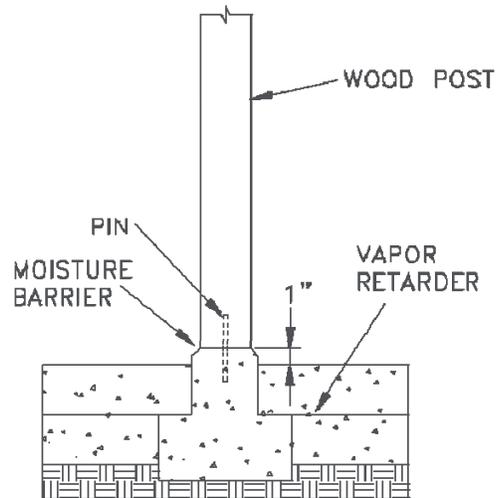
• Siding

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



Detailing – Code Requirements

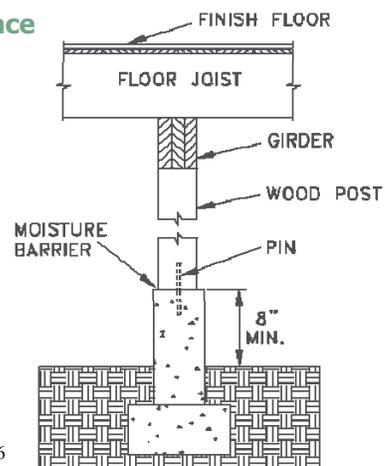
- **Wood columns**
 - 2015 IRC R317.1.4 (1)
 - 2015 IBC 2304.12.2.2



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

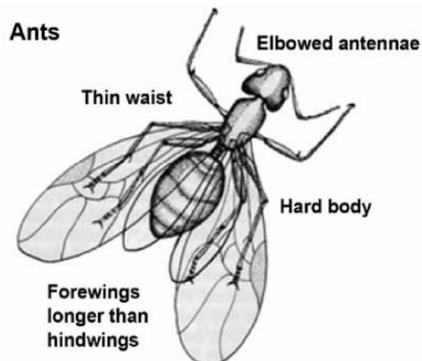
- **Preservative treated wood**
- **Shields**
- **Chemical treatment**
- **Concrete foundations**
- **Concrete caps**
- **Inspection**



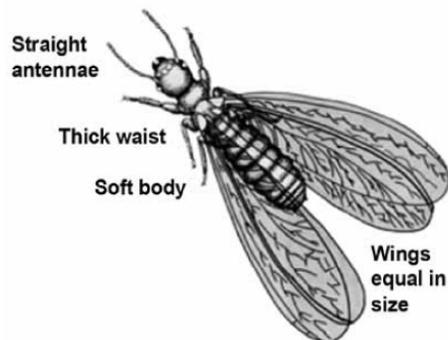
Graphic Source: www.awc.ca

Termite Control

- **Not all “flying ants” are termites**

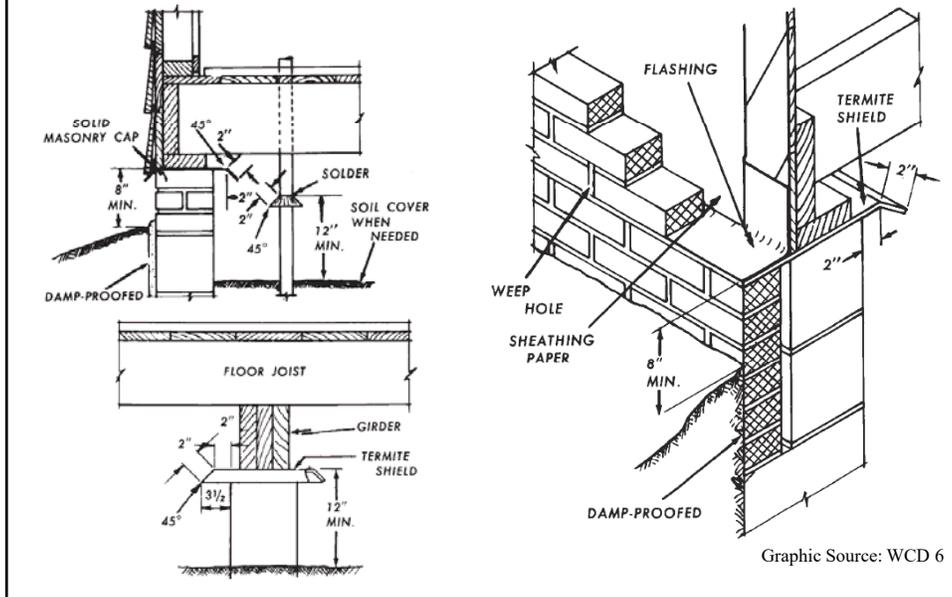


Termites



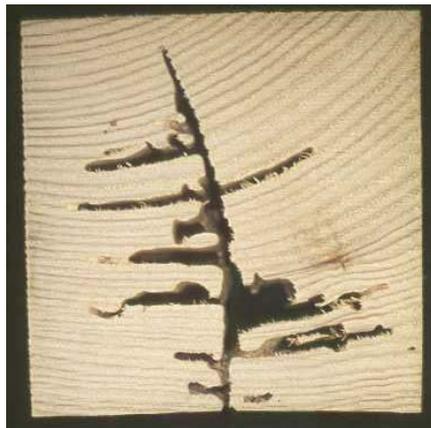
Graphic Source: USDA Forest Products Lab *Wood Handbook*

Termite Shields



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



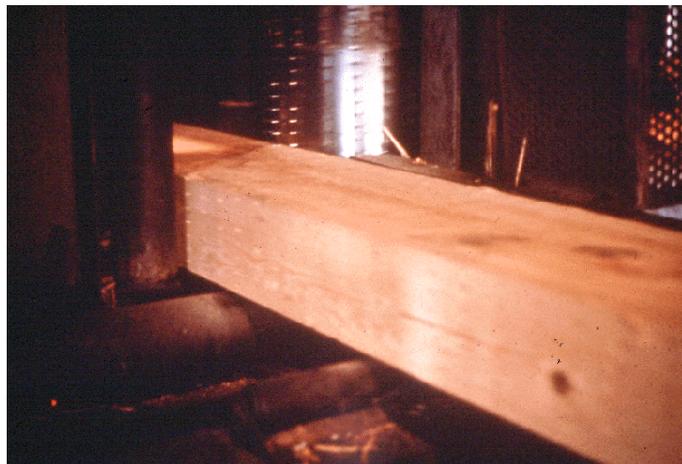
Graphic Source: USDA Forest Products Lab *Wood Handbook*

Refractory Species



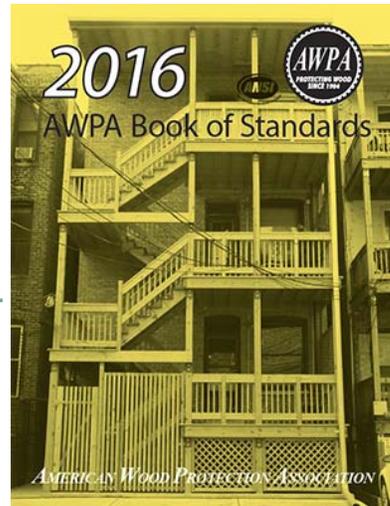
Incising

- **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



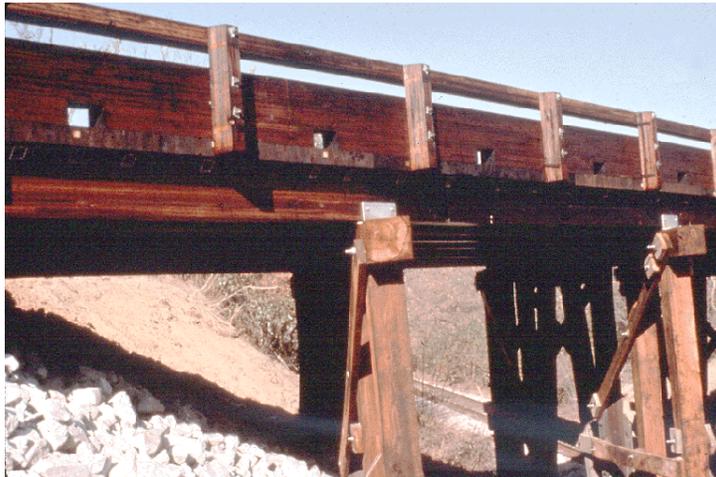
Penta – Utility Poles



Penta – Sound Barriers



Penta – Railroad Trestle



Waterborne - Permanent Wood Foundation



Source: Southern Forest Products Association

Waterborne - Decks



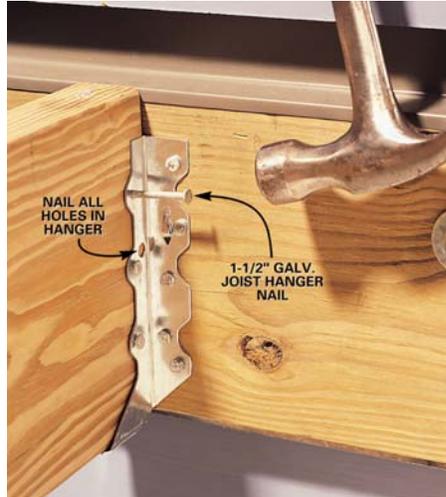
Waterborne - Fastener Corrosion

- **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

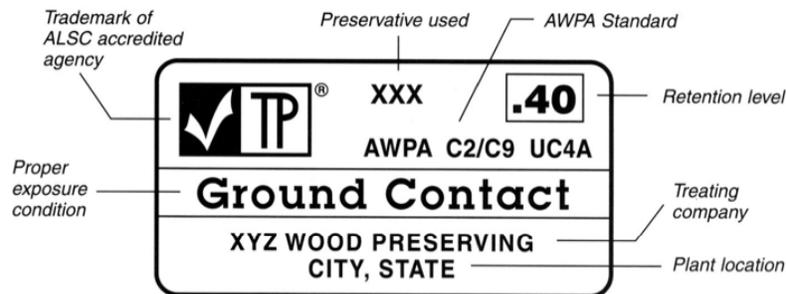
- **Saltwater exposure**

- **Stainless**



Grade Stamp

INTERPRETING A QUALITY MARK



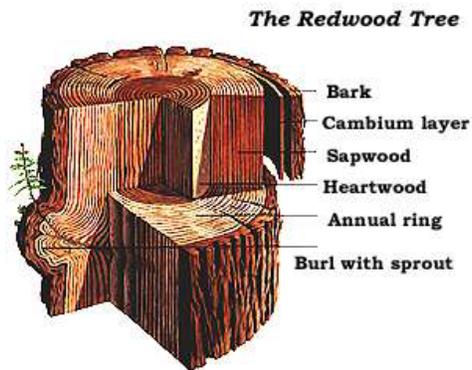
Naturally Durable Wood

- **Decay resistant**

- Redwood
- Cedars
- Black Locust

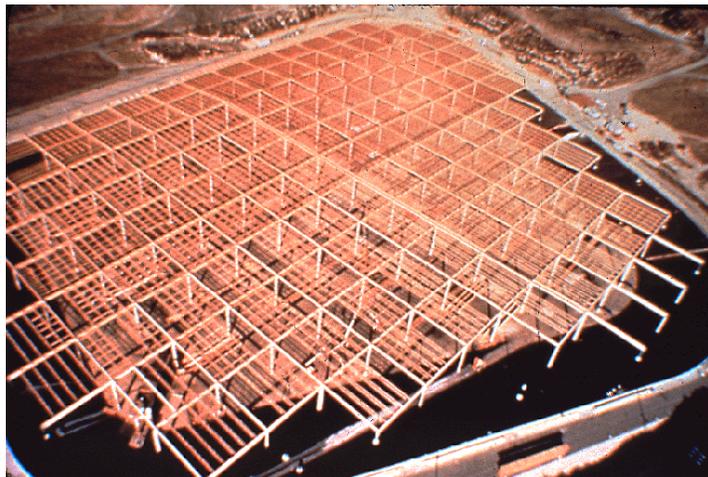
- **Termite resistant**

- 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

Finish	Application process	Appearance of wood	Maintenance	
			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 ^c

Table Source: USDA Forest Products Lab *Wood Handbook*

Safety Data Sheets

• Available from EPA and manufacturers

Safety Data Sheet

Material Name: COAL TAR CREOSOTE (PRESSURE APPLICATIONS)

Symbol(s)



Polling Question

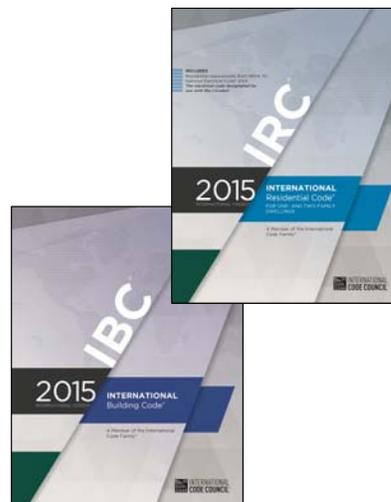
Which is important for effective preservative treatment?

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



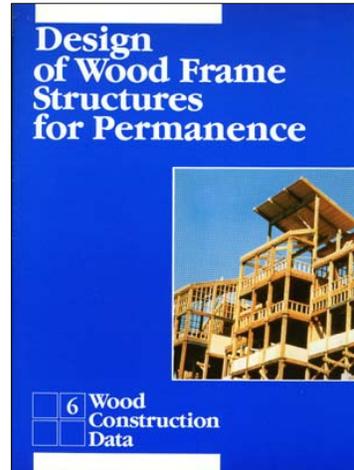
Quality Assurance

- **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

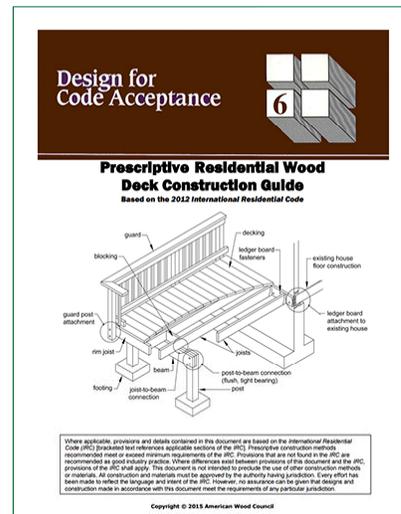
- **Decay / Termites**
- **Good Construction**
 - drainage
 - separation
 - condensation
 - barriers
- **Durability**
 - naturally
 - pressure treated
 - non-pressure treated



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

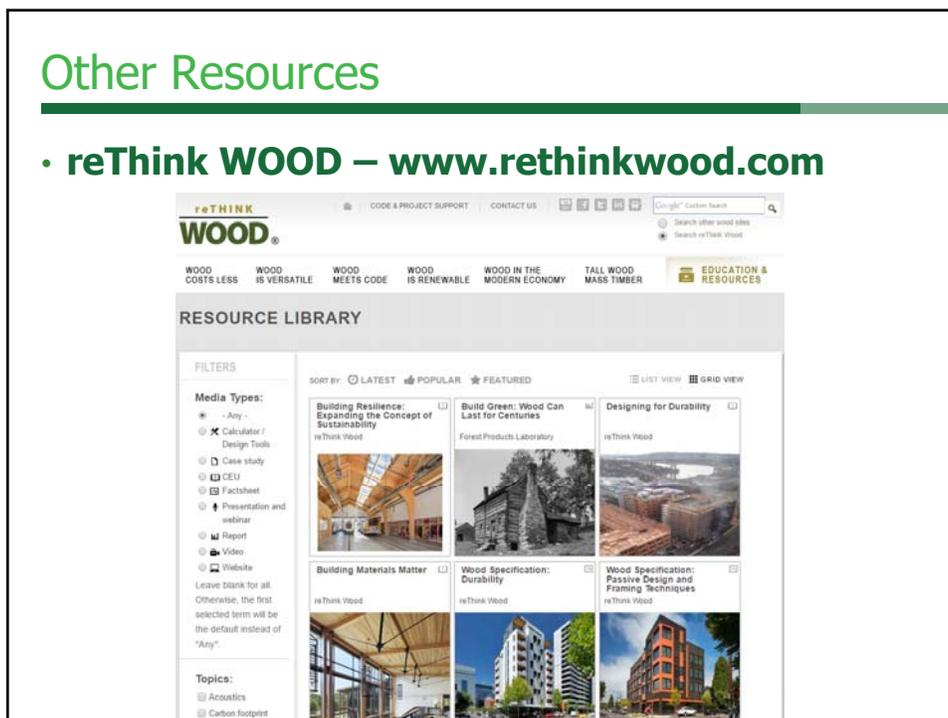
Other Resources

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



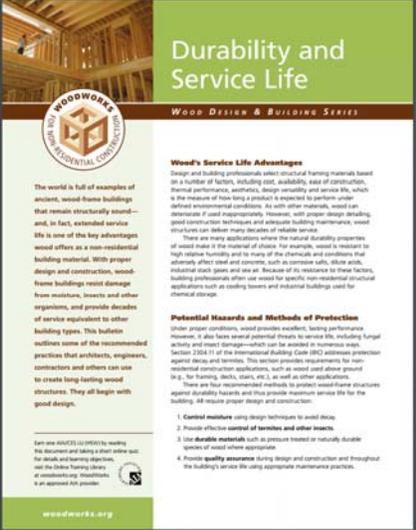
Other Resources

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



Other Resources

• Woodworks – www.woodworks.org



The world is full of examples of ancient, wood-frame buildings that remain structurally sound—and, in fact, extended service life is one of the key advantages wood offers as a non-residential building material. With proper design and construction, wood-frame buildings resist damage from moisture, insects and other organisms, and provide decades of service equivalent to other building types. This bulletin outlines some of the recommended practices that architects, engineers, contractors and others can use to create long-lasting wood structures. They all begin with good design.

Wood's Service Life Advantages
Design and building professionals select structural framing materials based on a number of factors, including cost, availability, ease of construction, thermal performance, aesthetics, design versatility and service life, which is the measure of how long a product is expected to perform under defined environmental conditions. As with other materials, wood can demonstrate if used inappropriately. However, with proper design detailing, good construction techniques and adequate building maintenance, wood structures can deliver many benefits of relative service life.

There are many applications where the natural durability properties of wood make it the material of choice. For example, wood is resistant to high relative humidity and to many of the chemicals and conditions that adversely affect steel and concrete, such as corrosion salts, alkali acids, industrial stack gases and sea air. Because of its resistance to these factors, building professionals often use wood for specific non-residential structural applications such as cooling towers and industrial buildings used for chemical storage.

Potential Hazards and Methods of Protection
Under proper conditions, wood provides excellent, lasting performance. However, it also faces several potential threats to service life, including fungal activity and insect damage—both can be avoided by numerous steps. Factor 2304.11 of the International Building Code (IBC) minimum protection against decay and termites. This section provides requirements for non-residential construction applications, such as wood used above ground (e.g., for framing, decks, stairs, etc.), as well as other applications. There are four recommended methods to protect wood-frame structures against durability hazards and the general minimum service life for the building. All require proper design and construction.

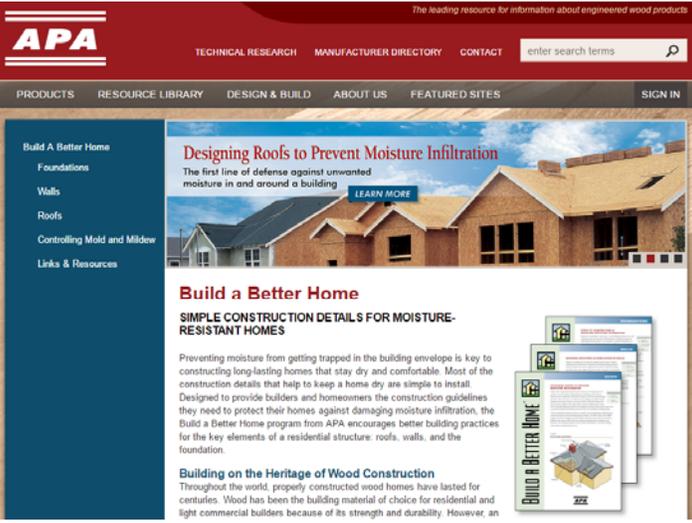
1. Control moisture using design techniques to avoid decay.
2. Provide effective control of termites and other insects.
3. Use durable materials such as pressure treated or naturally durable species of wood where appropriate.
4. Provide quality assurance during design and construction and throughout the building's service life using appropriate maintenance practices.

Learn more about the AWCC's 2016 Building Better Home program and taking a closer look at the details and building techniques, visit the online training library at www.woodworks.org. Woodworks is an approved AIA provider.

www.woodworks.org

Other Resources

• APA – www.apawood.org



The leading resource for information about engineered wood products

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Designing Roofs to Prevent Moisture Infiltration

The first line of defense against unwanted moisture in and around a building

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Build a Better Home

SIMPLE CONSTRUCTION DETAILS FOR MOISTURE-RESISTANT HOMES

Preventing moisture from getting trapped in the building envelope is key to constructing long-lasting homes that stay dry and comfortable. Most of the construction details that help to keep a home dry are simple to install. Designed to provide builders and homeowners the construction guidelines they need to protect their homes against damaging moisture infiltration, the Build a Better Home program from APA encourages better building practices for the key elements of a residential structure: roofs, walls, and the foundation.

Building on the Heritage of Wood Construction
Throughout the world, properly constructed wood homes have lasted for centuries. Wood has been the building material of choice for residential and light commercial builders because of its strength and durability. However, an

BUILD A BETTER HOME

Questions?

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

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80