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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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

- Moisture
- Air

Giant Sequoia

First 3 years after planting:

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

Water within the dripline

Giant Sequoia

3000 years
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

Butler Brothers Building – Minneapolis - 1906

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

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

Rain Exposure Zones

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

Graphic Source: Washington State University – Civil Engineering

Graphic Source: WCD 6
Hygro-Thermal Zones

- Air movement and diffusion are less significant moisture contributors

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Wood Equilibrium Moisture Content

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

<table>
<thead>
<tr>
<th>Temperature (°C, °F)</th>
<th>5%</th>
<th>10%</th>
<th>15%</th>
<th>20%</th>
<th>25%</th>
<th>30%</th>
<th>35%</th>
<th>40%</th>
<th>45%</th>
<th>50%</th>
<th>55%</th>
<th>60%</th>
<th>65%</th>
<th>70%</th>
<th>75%</th>
<th>80%</th>
<th>85%</th>
<th>90%</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>-11 (-30)</td>
<td>1.4</td>
<td>2.6</td>
<td>3.7</td>
<td>4.6</td>
<td>5.5</td>
<td>6.3</td>
<td>7.1</td>
<td>7.9</td>
<td>8.7</td>
<td>9.5</td>
<td>10.4</td>
<td>11.3</td>
<td>12.4</td>
<td>13.5</td>
<td>14.9</td>
<td>16.5</td>
<td>18.5</td>
<td>21.0</td>
<td>24.3</td>
</tr>
<tr>
<td>44 (40)</td>
<td>1.4</td>
<td>2.6</td>
<td>3.7</td>
<td>4.8</td>
<td>5.5</td>
<td>6.3</td>
<td>7.1</td>
<td>7.9</td>
<td>8.7</td>
<td>9.5</td>
<td>10.4</td>
<td>11.3</td>
<td>12.4</td>
<td>13.5</td>
<td>14.9</td>
<td>16.5</td>
<td>18.5</td>
<td>21.0</td>
<td>24.3</td>
</tr>
<tr>
<td>10.0 (50)</td>
<td>1.4</td>
<td>2.6</td>
<td>3.6</td>
<td>4.6</td>
<td>5.5</td>
<td>6.3</td>
<td>7.1</td>
<td>7.9</td>
<td>8.7</td>
<td>9.5</td>
<td>10.3</td>
<td>11.2</td>
<td>12.3</td>
<td>13.5</td>
<td>14.8</td>
<td>16.4</td>
<td>18.4</td>
<td>20.7</td>
<td>24.3</td>
</tr>
<tr>
<td>15.6 (60)</td>
<td>1.3</td>
<td>2.5</td>
<td>3.6</td>
<td>4.6</td>
<td>5.4</td>
<td>6.2</td>
<td>7.0</td>
<td>7.8</td>
<td>8.6</td>
<td>9.4</td>
<td>10.2</td>
<td>11.1</td>
<td>12.3</td>
<td>13.5</td>
<td>14.8</td>
<td>16.4</td>
<td>18.4</td>
<td>20.7</td>
<td>24.3</td>
</tr>
<tr>
<td>21.1 (70)</td>
<td>1.3</td>
<td>2.5</td>
<td>3.5</td>
<td>4.5</td>
<td>5.4</td>
<td>6.2</td>
<td>7.0</td>
<td>7.8</td>
<td>8.6</td>
<td>9.4</td>
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<td>16.4</td>
<td>18.4</td>
<td>20.7</td>
<td>24.3</td>
</tr>
<tr>
<td>32.2 (80)</td>
<td>1.3</td>
<td>2.4</td>
<td>3.5</td>
<td>4.4</td>
<td>5.3</td>
<td>6.1</td>
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<td>7.6</td>
<td>8.3</td>
<td>9.1</td>
<td>9.9</td>
<td>10.8</td>
<td>11.7</td>
<td>12.9</td>
<td>14.2</td>
<td>15.7</td>
<td>17.7</td>
<td>20.2</td>
<td>23.6</td>
</tr>
<tr>
<td>37.8 (100)</td>
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<td>2.3</td>
<td>3.3</td>
<td>4.2</td>
<td>5.0</td>
<td>5.8</td>
<td>6.5</td>
<td>7.2</td>
<td>7.9</td>
<td>8.7</td>
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<td>11.2</td>
<td>12.3</td>
<td>13.5</td>
<td>14.8</td>
<td>16.3</td>
<td>18.6</td>
<td>22.0</td>
</tr>
<tr>
<td>43.3 (110)</td>
<td>1.1</td>
<td>2.2</td>
<td>3.2</td>
<td>4.0</td>
<td>4.9</td>
<td>5.6</td>
<td>6.3</td>
<td>7.0</td>
<td>7.7</td>
<td>8.4</td>
<td>9.2</td>
<td>10.0</td>
<td>11.0</td>
<td>12.0</td>
<td>13.2</td>
<td>14.7</td>
<td>16.6</td>
<td>19.1</td>
<td>22.4</td>
</tr>
<tr>
<td>48.9 (120)</td>
<td>1.1</td>
<td>2.1</td>
<td>3.0</td>
<td>3.9</td>
<td>4.7</td>
<td>5.4</td>
<td>6.1</td>
<td>6.8</td>
<td>7.5</td>
<td>8.2</td>
<td>8.9</td>
<td>9.7</td>
<td>10.6</td>
<td>11.7</td>
<td>12.9</td>
<td>14.4</td>
<td>16.2</td>
<td>18.6</td>
<td>22.0</td>
</tr>
</tbody>
</table>

**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

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

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

Photo courtesy of Togawa Smith Martin, Inc.

Weather Protection

• Allow drying before installing insulation and gypsum
  • Durability
  • Shrinkage

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

![Diagram of structural details](source: www.apawood.org)

Detailing and Maintenance

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

![Diagram of top/end cap details](source: www.apawood.org)
Detailing and Maintenance

- Structural Glulam – exposed
- Tapered under roof
- Untreated

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

![Wood column diagram](image1.png)

Graphics Source: WCD 6

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Detailing – Code Requirements

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

![Wood column diagram](image2.png)

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

- 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

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**TREATING STANDARDS**

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>RETENTION LBS./CU. FT.</th>
<th>AWPA USE CATEGORY STANDARDS FOR STRUCTURAL APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Ground</td>
<td>0.25 0.06 N/A</td>
<td>UC1, UC2, UC3A, UC3B</td>
</tr>
<tr>
<td>Ground Contact, Fresh Water Immersion</td>
<td>0.40 0.15 N/A</td>
<td>UC4A, UC4B</td>
</tr>
<tr>
<td>In Ground (Structural)</td>
<td>0.60 0.31 N/A</td>
<td>UC4B</td>
</tr>
<tr>
<td>Above Ground, Continuously Protected from Liquid Water (Sililplate)</td>
<td>0.25 0.06 0.25</td>
<td>UC1, UC2</td>
</tr>
</tbody>
</table>

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

Trademark of ALSC accredited agency

Preservative used
AWPA Standard

Retention level

Proper exposure condition

Treated company

Plant location

XYZ Wood Preserving City, State
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>
<thead>
<tr>
<th>Finish</th>
<th>Application process</th>
<th>Appearance of wood</th>
<th>Maintenance</th>
<th>Service life³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-repellent preservative (WRP)</td>
<td>Brush-apply 1 coat or dip. Apply a second coat only if it will absorb.</td>
<td>Grain visible; wood tan to brown, fades to gray with age</td>
<td>Brush to remove surface dirt; wash to remove mildew</td>
<td>1–3 years</td>
</tr>
<tr>
<td>Tinted clear finish (slightly pigmented deck finish)</td>
<td>Brush-apply 1 coat or dip. Apply a second coat only if it will absorb.</td>
<td>Grain and natural color slightly changed</td>
<td>Same as with WRP</td>
<td>2–3 years</td>
</tr>
<tr>
<td>Semitransparent stain</td>
<td>Brush-apply 1 coat or dip. Apply a second coat only if it will absorb.</td>
<td>Grain visible; color as desired</td>
<td>Same as with WRP</td>
<td>4–8 years (on saw-textured or weathered wood) 10–20 years for paint, 6–15 years for solid-color stain³</td>
</tr>
<tr>
<td>Paint and solid-color stain</td>
<td>Brush-, roller-, or spray-apply primer and 2 top-coats</td>
<td>Grain and natural color obscured</td>
<td>Clean and apply topcoat if old finish is sound, if not sound, remove peeled finish, prime, and apply topcoats³</td>
<td></td>
</tr>
</tbody>
</table>

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):**

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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
  Drying and Control of Moisture Content and Dimensional Changes
  Richard Bergman, Research Forest Products Technologist

Biodeterioration of Wood
  Carol A. Clausen, Supervisory Research Microbiologist

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-repellent 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

American Wood Council
info@awc.org
www.awc.org