

Durability and Service Life



WOOD DESIGN & BUILDING SERIES

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.

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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 deteriorate if used inappropriately. However, with proper design detailing, good construction techniques and adequate building maintenance, wood structures can deliver many decades of reliable service.

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 corrosive salts, dilute 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—which can be avoided in numerous ways. Section 2304.11 of the *International Building Code (IBC)* addresses 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 thus provide maximum 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.

Moisture Control

Wood is a hygroscopic material, which means it naturally absorbs and releases water to balance its internal moisture content with the surrounding environment. The moisture content of wood is measured by the weight of water as a percentage of the oven-dry weight of the wood fiber.

The key to controlling decay is to control moisture. Once decay fungi are established, the minimum moisture content for decay to propagate is 22 to 24 percent, so building experts recommend 19 percent as the maximum safe moisture content for untreated wood in service. Water by itself does not harm the wood, but rather, wood with consistently high moisture content enables fungal organisms to grow.

The secret to preventing decay is to keep the wood “dry by design.”

DRY BY DESIGN

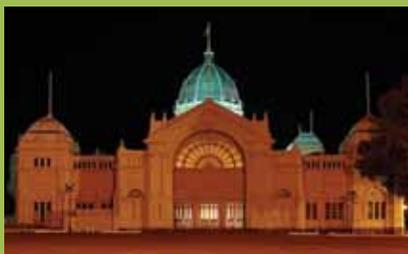
The primary objective when addressing moisture loads is to keep water from entering the building envelope in the first place, and to balance the moisture content within the building itself. Moisture control by means of accepted design and construction details is a simple and practical method of protecting a wood-frame building against decay.

To limit the amount of moisture intrusion, best-practice design uses the “4 Ds” for moisture control:

1. **Deflection** is the first line of defense. Most rainwater should never get past a good wall and roof skin into the building envelope. Use overhangs and flashing to deflect water away from the structure.



Worldwide, examples of old wood-frame buildings range from this stave church in Norway (1500-1600 a.d.) to Australia's Royal Exhibition Building, built for the 1880 Melbourne Exhibition.



2. A **drainage path** handles the small amount of water that may get past the cladding. This path allows any water in the cavity to flow along a water-resistant membrane to an exit point out from the wall.
3. If water gets inside the cavity and past the water-resistant membrane, then the wood sheathing and studs will get wet and must be allowed to **dry**. This water evaporates to vapor, which passes through the outer layers of the wall (if it is built properly to allow vapor permeability). *A wall can shed only a small amount of water through drying in a given period.* Therefore, deflection and drainage are the primary mechanisms for protecting walls from moisture.
4. Finally, for applications with a high risk of staying wet, designers should specify **durable** materials such as naturally decay-resistant species or wood that's been treated with preservatives. Cladding, shingles, sill plates and exposed timbers or glulam beams are examples of potential applications for treated wood.

Controlling Termites and Other Insects

Good construction practices and maintenance prevent conditions that could lead to termite attack. For buildings in termite zones, basic protection practices addressed in current building codes include (but are not limited to) the following:

- Grade the building site away from the foundation to provide proper drainage.
- Cover exposed ground in any crawl spaces with 6-mil polyethylene film and maintain at least 12 to 18 inches of clearance between the ground and the bottom of framing members above (12 inches to beams or girders, 18 inches to joists or plank flooring members).
- Support post columns by concrete piers so there's at least six inches of clear space between the wood and exposed earth.
- Install wood framing and sheathing in exterior walls at least eight inches above exposed earth; locate siding at least six inches from the finished grade.
- Where appropriate and desired, ventilate crawl spaces according to local building codes.
- Remove building material scraps from the job site before backfilling. If termites are found, eliminate their nests.
- If allowed by local regulation, treat the soil around the foundation with an approved termiticide to provide protection against subterranean termites.

Most of the above practices are put in place to prevent excessive moisture buildup in wood structures, which makes them more susceptible to insect attack. However, these practices also contribute to a healthier and more pleasant environment for the structure's occupants.

TERMITES

While a termite infestation may sound daunting, only when the insect is allowed to establish and maintain contact with moisture is the colony able to penetrate and consume wood in a structure.

Most termites fall into three categories:

- Dampwood termites live in damp areas; they attack damp, decaying wood and are rarely a primary source of damage to buildings in service.
- Drywood termites attack dry, sound wood. However, their impact on wood-frame buildings is very limited; they are typically found only in the extreme southern U.S. and Mexico.
- Subterranean termites are the primary cause of insect damage to wood structures in North America. They travel from moist soil to wood through shelter tubes to non-soil-contact components, so wood's proximity to the soil is a critical factor in reducing infestation.

Attacks from subterranean termites can be prevented by:

- Maintaining a dry environment for the wood structural frame
- Applying chemical termiticide to the soil, where allowed by local building regulations; some jurisdictions, such as Florida, now promote the field application of termiticides as their preferred method of protection
- Using baiting systems, which poison the termite colonies
- Using a physical barrier such as a thin wire mesh, a plastic screen treated with termiticide or a trench with small rock aggregate to separate the untreated wood from the adjacent earth

Termite barriers help drive the insects into the open, where activities can be more easily detected. Contractors can also install termite shields on top of foundation walls and piers and around all pipes leading from the ground. Under all circumstances, however, maintenance practices should include regular inspection.

Durable Materials

To avoid decay and termite infestation, it is important to separate untreated wood from the ground and other sources of moisture. These separations are required by current codes (see IBC Section 2304.11) for all buildings, and are considered necessary to maintain wood elements in permanent structures at a safe moisture content for decay protection. When it is not possible to separate wood from the sources of moisture, use naturally durable or treated wood. While many naturally durable wood species provide decay and termite resistance, designers often rely on preservative-treated wood.

PRESERVATIVE-TREATED WOOD

For non-residential projects, designers typically use wood that has been chemically treated with water-borne preservatives to make it undesirable to fungi and insects.

Section 2303.1.8 of the IBC lists requirements for preservative-treated wood, and all treated wood used in residential and non-residential construction is treated with preservatives approved by the Environmental Protection Agency (EPA). When wood is treated according to the standards of the American Wood Protection Association (AWPA) or *ICC Evaluation Service Acceptance Criteria* and used following the guidelines of the EPA, it is safe to use and poses no threat to people or animals.

Wood does not decay just because it gets wet, but because fungi and insects consume the wood fiber as food. Preservatives work by making the food source inedible—and this type of treatment can increase the service life of wood in adverse conditions by a factor of five to 10 times. In fact, treated utility poles with direct soil contact have proven service lives of more than 60 years.

There are two types of preservative treatment:

- **Non-pressure:** Methods include brushing, spraying or dipping the wood in a preservative solution. Building codes recognize this method for field treatment only during construction, when a pressure-treated piece of lumber must be cut and the cut end then retreated, for example.
- **Pressure:** With this method, treaters achieve deeper, more thorough chemical penetration by driving the preservative into the wood cells using various combinations of pressure and vacuum.
 - Pressure-treating preservatives consist of chemicals carried in a solvent, which can be either water or oil. Water-borne alternatives have become increasingly popular over the last 20 years due to the absence of odor, a cleaner wood surface and the ability to paint or stain the resulting wood product.

Depending on local codes, specifiers may choose from a number of types of wood preservatives, including copper naphthenate, alkaline copper quat (ACQ), copper azole (CA), chromated copper arsenate (CCA), pentachlorophenol (Penta) and borates. Building professionals should check with the AWPA for current guidelines. The Use Category System (UCS) of the AWPA designates preservative systems and retentions needed for effective protection of wood products under specified exposure conditions.



Quality Assurance and Maintenance

Quality assurance and proper maintenance are key to ensuring that wood structures will provide the service life desired.

For example, third-party quality inspection is required for all materials used in construction covered by the building codes. In addition, Chapter 17 of the IBC, *Structural Tests and Special Inspections*, defines specific portions of the construction sequence that are deemed critical to the structural capability of the building—such as tight diaphragm nailing in high seismic areas. In terms of treated products, it's important to use products that are treated according to AWPAs standards and identified with the quality mark of an accredited inspection agency of the American Lumber Standard Committee (ALSC).

In terms of maintenance, examples of practices that may contribute to extended service life include the following:

- Keep exposed wood properly painted, stained or otherwise protected.
- Periodically inspect both the inside and outside of raised foundation walls; watch for termite tubes, little piles of wood dust, or obvious insect activity.
- Know the useable life of applied termiticides and retreat as recommended.
- Keep heavy brush or shrubbery away from exterior walls.
- Point sprinkler systems away from wood walls.
- Keep roof gutters unclogged and running freely.

Wood's Proven Longevity

Historically, many building industry professionals believed that use of materials perceived as more 'durable,' such as steel and concrete, would result in buildings with longer service lives than wood buildings.

However, a survey of buildings demolished between 2000 and 2003 in the Minneapolis/St. Paul area demonstrated that there is no significant relationship between the structural system used and the actual life of the building. Reasons for demolition were instead related to changing land values, lack of suitability of the building for current needs, and lack of maintenance of various non-structural components. In fact, the survey found that developers demolish most buildings well before the end of the useful life of their structural framing.

Wood buildings in the study had the longest life spans. Sixty-three percent of the demolished wood buildings were older than 50 years at demolition and the majority were older than 75. By comparison, over half of the demolished concrete buildings fell into the 26-50 year category and only one third of the concrete buildings lasted more than 50 years. Similarly, 80 percent of the steel buildings demolished fell below the 50-year mark, and half of those were no older than 25 years.

This data shows that wood structural systems are fully capable of meeting a non-residential building's longevity expectations. Further, wood should be considered a preferred material because it enables easy building modification in response to changing needs, and because wood materials are easy to recover when a building is decommissioned.

SOURCES AND OTHER MATERIALS

American Wood Council/American Forest & Paper Association, www.awc.org

- *Design of Wood Frame Structures for Permanence*
- *Details for Conventional Wood Frame Construction*

APA – The Engineered Wood Association, www.apawood.org

- *Customer Service Tip: Decay of Engineered Wood Products*
- *Technical Topics 052: Service Life of Oriented Strand Board*
- *BuildaBetterHome.org*

Canadian Wood Council (CWC) / FPInnovations – Forintek Division, www.durable-wood.com

- *Borate-treated Wood for Construction* – FPInnovations – Forintek Division
- *Combating Termites* – Joint publication of FPInnovations – Forintek Division and the Canadian Mortgage and Housing Corporation
- *Integrated Control of Subterranean Termites: The 6S Approach* – FPInnovations – Forintek Division

- *Moisture and Wood-frame Buildings* – Joint publication of FPInnovations – Forintek Division and the Canadian Mortgage and Housing Corporation
- *Survey on Actual Service Lives for North American Buildings* – FPInnovations – Forintek Division
- *Termite Control and Wood-frame Buildings* – CWC
- *Understanding Biodeterioration of Wood in Structures* – FPInnovations – Forintek Division

Forest Products Lab, USDA Forest Service, <http://www.fpl.fs.fed.us>

- *Wood Handbook, Wood as an Engineering Material*

Southern Pine Council, www.southernpine.com

Western Wood Products Association, www.wwpa.org

Materials are also available via the WoodWorks Web site, in the section on *Key Issues/Durability*, www.woodworks.org

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