Preservation & Maintenance of Log Structures

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Building Systems Councils
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FORWARD

Log structures became part of the human shelter system early in the development of several civilizations where forests provided the primary indigenous source of building material. When these structures served as only temporary shelter for nomads, log preservation and maintenance were not an issue. However, as civilizations evolved, the need for permanent structures brought new considerations.

Even in ancient log construction, known to have been built before 700 BC in Eastern Europe, certain techniques were used to make log structures last as long as possible. Special corner notches that shed water, organic coatings that blocked water penetration and retarded fungal growth, and other innovations such as large roof overhangs and stone foundations were used to protect the logs from insects and fungal decay. These inventions were primarily based on the desired durability of the structure and the available materials found locally. Today we have many more options to choose from in making our log building decisions.

The purpose of this presentation is to include this historical perspective of log maintenance to a discussion relevant to today's log homes. When contemplating designing, building, and living in a log structure, what features and methods will ensure the permanent quality of the structure?

UNDERSTANDING THE BASICS

As an owner (or potential owner) of a log home, it is important to understand a few basic facts about wood in order to keep your home properly maintained and to avoid costly future repairs. Your preservation and maintenance decisions should be based primarily on your site and geographic location as well as an understanding of the abiotic and biological agents that are harmful to wood. Considerations of local building codes and regulations, successful local practices, and special situations must be factored when evaluating the information presented here.

The Forest Products Laboratory of the US Forest Service published the *Techline* publication on durability titled, *Effect of Climate on Durability of Wood* (see copy at end of this paper). This report includes a map that illustrates the degree of attention required in the different climate regions of the United States to ensure the permanence of log structures. The *International Residential Code for One- & Two-Family Dwellings* also includes valuable references in Ch. 3, Building Planning (Termite Infestation Probability Map; Decay Probability Map).

A comparison of the three maps shows strong similarities and interesting relationships. The decay probability map nearly matches the *Techline* durability map except that the entire Pacific coast is shown to have a low to moderate probability for decay. Both maps illustrate regions of similar relative humidity and precipitation. The termite map indicates the extent of documented colonies, but the probability of termite activity again shows high correlation with areas with greater decay probabilities and climate indexes over 35.

Let us begin our inquiry by focusing our attention on the stuff that dream homes are made of: Wood.

What is wood?

Wood is a cellular material that makes up the bulk of the tree. Water, tannins, waxes, gums, starches, alkaloids and oils occupy the cell cavities, contributing to the color, odor, taste, decay resistance, and flammability of the wood. It is like a honeycomb composed mainly of dead, hollow, tubular cells. This cellular structure is what gives wood it's amazing strength, insulating value and allows it to hold water, oxygen, and nutrients.

An organic material, wood is constantly changing moisture content with humidity and temperature changes in its environment, absorbing and releasing moisture. Wood in service is also a natural food source for several species of insects and organisms (fungi) and provides shelter and nests for other creatures. It is widely recognized that four elements must be present for a wood-digesting insect or fungus to survive – elimination of any one of these will protect against their damage. The four required elements are:

- Food Source: Polysacharides and other carbohydrates that make up the wood cell wall.
- Temperature: Organisms thrive in the range of 68-97^{o} F (23-36^{o}C); molds and sap stains grow in the 75-85^{o}F (24 -29^{o}C) range.
- Oxygen: Decay Organisms require 20% free oxygen in the wood. That's why wood kept totally submerged in water will not rot.
- Water: Decay Organisms typically require 28% - 30% moisture content (MC) in the wood, but some fungi can survive and discolor (stain) the wood with as little as 20% moisture content. Unprotected wood left in contact with water will absorb moisture to near fiber saturation (25% to 30% MC). In higher relative humidity, the wetted wood dries slowly, allowing the wood to decay for a longer period.

Insects

Trees and logs can be attacked and degraded by several biological agents, including insects, plants, fungi, bacterial and viruses. Bacteria and viruses are generally found as pathogens in living trees, and are generally pose no problems to utilization in solid wood building systems. Insects and fungi, however, do degrade both the living tree and in logs and timbers utilized for construction. Visual stress grading of houselogs, a requirement for all companies who are members of the Log Homes Council, requires an understanding of the signs of insect or fungal activity in the living tree, as well as in the log after it has been harvested. The principal affecters of wood strength and quality serve as a basis for forming judgments about the serviceability of any particular timber for use in a structural application.[1]

Compared to the total amount of wood destroyed by decay fungi, insect damage is small. This is not to underestimate the destructive capabilities of insects, and visual stress grading limits the effects of insects in a finished log or timber. If a problem with wood damaging insects is discovered, it should be taken seriously, but log homes have a HUGE advantage over conventionally framed homes - Termite tunnels and other insect activity can be readily seen and easily treated! In log buildings, the symptoms of insect activity do not remain hidden under wall and ceiling finishes.

Many different types of insects attack wood in the living and dead standing tree, as well as wood in service. Bark beetles, carpenter bees, wood boring beetles, termites and carpenter ants are all common residents of forest trees, and can also be found in standing log structures. Some insects utilize the wood as both food and shelter, as do wood boring beetles like long horned beetles, old furniture beetles, powder post beetles, or may only build nests and /or brood chambers in the wood as do carpenter ants and carpenter bees.

[1] Excerpted from The Log Homes Council Log Grading Program Training & Operations Manual, prepared by Edwin J. Burke, PhD, University of Montana Wood Science and Engineering Laboratory, for the Log Grading Committee of the Log Homes Council, Building Systems Councils, National Association of Home Builders, © 2003

A separation can be made between structurally damaging insects and those that attack, and often kill, live trees. The first group includes those varieties which tunnel and bore into the sapwood and heartwood of the tree, such as flathead and roundhead borers that attack dead and dying trees and logs. The latter group, primarily the bark beetles, does not usually penetrate deeply into the sapwood, but merely feeds on the nutritious inner bark and cambium, and consequently killing the tree in the process, leaving behind little more than engravings on the outer surface of the woody cylinder. It is assumed by the very nature of stress grading that the wood remains sound, and no consideration is given to the altered appearance of the log.

Any discussion of boring beetles will ultimately touch on the wide variety of species and sizes of beetles that eat and live in the xylem of trees and attack wood in service. While some boring beetles, especially the round-headed and flat-headed borers, can cause significant visual and customer relation problems with their relatively large tunnels and often untimely emergence in a finished home, others produce tunnels of such small size that their presence does not affect the structural integrity of the wood. Customers selecting logs made from standing dead timber should understand the life cycles and practical effects of these boring beetles. Most of the boring beetles spend less than two years in a log before emerging as short-lived adults looking for mates and a new standing or downed dead tree to lay eggs in. They will rarely, if ever, re-attack the log they emerged from, so the chances that logs and timbers in service being attacked or re-attacked by these forest dwellers is quite remote. If the logs are processed with the tunneling larvae still in them, their emergence can trigger inquiries and complaints if the human inhabitants are not expecting the nuptial flights of a log's former inhabitants.

Other species of insects, including carpenter bees, carpenter ants, and some beetles are wood-nesters, using the log or other exposed wooden member as a home site. Their colonization activity can be discouraged or eliminated by household bug sprays and regular maintenance of the exterior finish treatment. Spraying their entry holes and filling the holes with caulk will discourage future entry or exit. The re-infesting insects need to be treated with an EPA-registered pesticide labeled for use on wood.

Precautions against insect problems include visual stress grading of the logs and timbers, the application of good general practice in the design, specification, construction, and maintenance of the home, and periodic inspection techniques. These practices are outlined in the following sections and in other Log Homes Council literature. More specific information is available in *Log Tech Note 02-01 Controlling Carpenter Bees* and *Log Tech Note 03-02 Termite Prevention & Control*.

Ask your log home representative how they have addressed insect issues in the material they supply. Company philosophies on the subject vary due to primary market area, wood supply and/or species, etc. When selecting a log home company, weigh the protection against insects that they will provide against the probability of insect problems in the region you will be building.

Fungi

There are three groups of wood attacking fungi: Mold, Sapstain and Decay. Mold and sapstain fungi feed on the nutrients contained on the wood surface and within the few living cells of the un-dried sapwood. While not structurally harmful to wood, mold and sapstain cause unsightly discoloration of the wood ranging from black, gray, bluish green and white. When present in wood, they cause the wood to be more porous thereby increasing the rate at which the wood can be wetted to the moisture content conducive for decay.

Sapstain

A fungus that utilizes the cell contents in the living sapwood for nourishment causes sapstain. It does not decompose cell wall material, but merely consumes sugars stored in the sapwood of several softwood and hardwood species. Also referred to by some as mold, the filamentous bodies of these fungi pass from cell to cell via existing holes in the walls of the cells. The wood that has been infected will usually take on a blue or black (rarely purple or red) coloration that rapidly fades after exposure to sunlight. Sapstain has no marked effect on the strength of wood, and is, therefore, not limited by visual stress grading. Its major effect is on the appearance of the wood, and the increased permeability it gives to the wood, which increases the amount of finish that is absorbed into the stained areas. The coloration of logs taken from standing dead pines is at worst a visual defect, or at best, a highly sought-after feature enhancing the value of the log for cosmetic reasons.

Sapstain or mold can occur in the standing tree after attack by bark beetles that inoculate the wood with sapstain spores they carry with them from previously affected trees. Generally, this type of infection is well-developed by the time the tree is utilized, and will stop spreading when the moisture required by the fungus has left through drying. Sapstain can also occur on the ends and exposed sides of stacked logs waiting processing through the germination of airborne spores. Stain in these logs can be avoided by cutting and processing in the winter months when the temperatures are too low for fungal growth, by keeping the ends and sides of the logs continually wet (fungi cannot grow when liquid water is present on the log's surface), or by circulating air around surfaced material to dry their surfaces, greatly slowing further growth of existing fungi and preventing the further infection by airborne spores.

Decay Fungi

Decay fungi are the ones that can seriously damage any log or wood structure and the reasons an intelligent maintenance program is so important. Decay fungi feed off the wood cell wall's cellulose and lignin, breaking them down into simple sugars for easy consumption. The results vary from brown crumbly cubical size sections infesting the wood to spongy pockets that can spread across and inward from the log surface. The structural damage caused by decayed wood is significant before any outward sign is easily recognized. In fact, nearly 75% of the tension strength of the wood may be lost prior to any softening of the surface, and long before the wood is stringy or crumbly.

> Decay is defined in ASTM D-9 as:
>
> "The decomposition of wood substance caused by action of wood-destroying fungi, resulting in softening, loss of strength and weight, and often in change of texture and color."
>
> In addition to the inability of a visual inspection to accurately approximate damage due to decay, the loss of strength of wood fibers are the prime reasons that decay is limited. Advanced decay is not allowed in any structural grade of wood.[2]

Two categories of decay are:

1. Live-tree decay that thrives in the living tree and generally attacks the heartwood, ceasing growth activities when the tree is cut and subsequently dried, and
2. Service decay that thrives on and in the dead tree (and wood in service), generally attacking the sapwood, thriving due to the presence of moisture.

[2] Excerpted from The Log Homes Council Log Grading Program Training & Operations Manual, prepared by Edwin J. Burke, PhD, University of Montana Wood Science and Engineering Laboratory, for the Log Grading Committee of the Log Homes Council, Building Systems Councils, National Association of Home Builders, © 2003

Live-tree decay cannot survive the drying that occurs after the tree is harvested, and will not reactivate upon re-wetting when a timber is put in service. Pocket rot, or peck, appears as isolated areas of either white or brown decayed wood surrounded by normal, sound wood. The reduction in strength for the affected areas is predictable. For this reason, scattered patches of some of these live-tree decays, such as the brown peck and white speck (both referred to as pocket rots) are allowed in the lower grades of wall logs, so long as the pockets are well scattered and do not account for a significant volume of the log.

Service decay requires a different approach. These fungi will enter dormancy if either the temperature or moisture requirements are not sufficient and wait for more favorable conditions to begin growth and the decay process again.

For the purposes of log grading, fungal decay of wood can be seen in two distinct phases, incipient decay and advanced decay. Incipient decay is the manifestation on the wood surface of the beginning stages of decay and is recognized as a slight discoloration of unseasoned wood, without the marked softening of the wood structure. One stage of incipient decay, "firm red heart" merely discolors the wood and does not significantly affect the strength of the wood fibers. Inspection for incipient and advanced decay is directed at all surfaces of the timber, with more attention given to the heartwood, knots, checks, splits and any other such defect.

Advanced decay, or rot, is extensive in its damage and usually quite easily identified. The affected area is usually soft to the touch and is often discolored or bleached and may be evidenced by toadstools, thick mats of spore-bearing structures, conks or other fungal fruiting bodies. Only pieces free of advanced service decay or containing firm red heart or very limited amounts of live-tree decay can be allowed into the structural grades.

It is important to recognize that a dried, uninfected log or timber is not immune to further decay. Once dried, wood left exposed to precipitation or placed in contact with the ground may return to the fiber saturation point (approximately 30% moisture content), where the wood cell wall has reabsorbed a sufficient amount of water to saturate the cell wall. If the piece has sapwood exposed, or does not have decay-resistant heartwood, it is likely that decay will begin and will continue until steps are taken to re-dry the piece and remove it from water exposure or ground contact.

For more information on insects and fungi, refer to the *Wood Handbook: Wood as an Engineering Material* (FPL-GTR-113) and other Forest Service publications. Your state university agricultural extension is also an excellent source of information.

CONTROLLING THE NATURE OF THE WOOD

The only elements we can have some influence over are the presence of **water** and the availability of a food source: **the wood itself**.

Moisture Control

Moisture in log structures is from one of two sources: Original moisture from the tree that remains in the incompletely seasoned log and moisture that has entered dried wood from the environment.

The moisture present in the wood naturally is referred to as its initial moisture content, expressed as a percentage of its dry weight. The living tree typically has a moisture content that is greater than the fiber saturation point (FSP; generally accepted as 30% moisture content), and can be as high as 200% or greater in some domestic species. For wood products used in normal household environments (e.g., finish flooring), the wood is dried to 6% to 12% prior to milling to closely approximate the interior equilibrium moisture content it will attain in service, thereby minimizing the potential for movement or dimensional change due to moisture content change after installation. Most structural lumber products, such as 2x6 studs and 2x10 floor joists, are dried to between 19% to 15% moisture content for reasonable dimensional stability after they have been installed. Due to the large cross section of logs typically used in log structures, it is very difficult to guarantee specific moisture content throughout the piece. While the wood within 1" of the surface may measure less than 20% with a moisture meter, the piece can be expected to have greater moisture content within it.

A log's moisture content is significant for several reasons:

- Wood will continue to lose moisture through evaporation until it reaches equilibrium with the temperature and relative humidity of the surrounding environment. This moisture content, known as the Equilibrium Moisture Content, or EMC, varies with the small, day-to-day fluctuations in the temperature and humidity and with the large, seasonal differences in these two factors. At 95% humidity, the moisture content of the wood can be expected to be well above 20%; it drops to about 9% at 50% humidity. At any given humidity level, the higher the temperature, the lower the moisture content.
- Dimensional change is likely to occur due to this initial loss of moisture, called seasoning, generating significant dimensional change seen as shrinkage as the cell walls shrink and densify. The release of the stress created when the cells collectively shrink may be heard as a loud pop and appears as a crack (or check) running along the grain on the surface of the piece. Checks typically extend radially to the heart of the log. Upward facing checks will collect rain and must be protected from water entry and/or treated to eliminate the detrimental potential of water sitting in the log.
- Wood will also shrink and swell after reaching an initial EMC as the atmosphere around the wood changes in temperature and relative humidity. This shrinking and swelling seen in seasoned wood in service is known as movement; this movement plays a role in the complicated process of wood weathering as well as causing minor annoyances such as sticking doors and loosened furniture joints.
- Discoloration by sapstaining fungi when higher moisture content is combined with seasonal high temperatures. This is much less of a problem during the cooler seasons and in dry climates.
- Wood's physical properties benefit as moisture content is reduced. Less moisture means lower weight and easier handling; outer cells take stains and other treatments better; interior sanding quality improves and becomes easier.

Each log home supplier has made a series of decisions regarding the wood products they manufacture and offer to the consumer. To manage moisture content, several options may be employed, each providing different opportunities and results over any given period of time.

- Some log home suppliers have invested in kilns to dry their logs, thus "preshrinking" the wood, reducing the weight of the logs, making them easier to mill, crystallizing the pitch in resinous species, and killing any insects or organisms that may have invaded the live tree. Some companies further warrant specific moisture content, managing kiln time and cycles accordingly.
- Others use standing dead timbers that have low moisture content (typically at or below 20%) when they arrive for milling.
- Air-drying is another common method that involves particular storage of timbers over a period of time providing airflow to evaporate the moisture from the wood prior to incorporating the wood into a structure. Air-dried material can have moisture content ranging from 12% to 30% depending on drying time, method, and climate.
- Some companies use green or unseasoned wood, although it is often partially air dried before it is actually milled. The term "green" describes the wood as it arrives at the company's yard as a raw material without any processing to reduce moisture. These companies design their buildings to allow for moisture loss and shrinkage after the building has been constructed.
- Others shape laminated beams (with minimal moisture content) into wall-logs to reduce the log's tendency to shrink, twist, warp, and check.

Wood as a Food Source

Similar to management of moisture content, log home suppliers have made decisions regarding their product relative to the control of insects and decay that will attack the wood for food.

- Some control the moisture content of the wood.
- Some use chemical wood preservative treatment processes with their management of moisture.
- Some use particular wood species that deter insect and fungal attack due to the natural extractives and oils present in the wood. Moisture content in these species is less of an issue for durability of the wood in service.

Refer to the *Wood Handbook: Wood as an Engineering Material* (FPL-GTR-113) and other Forest Service publications for specific details about the durability of various wood species.

For wood species that are not naturally resistant to insect and fungal attack, EPA-registered wood preservatives are designed to make the wood unsuitable as a food source. Many log manufacturers use these preservative treatments to protect the wood, prevent decay, and/or kill insects that ingest the wood.

- Pressure treatment is a carefully monitored method of forcing preservatives deep into the structure of the wood cells. The wood materials are placed in a long, steel cylinder that is sealed and then filled with the treatment solution (the solution may include other treatments such as biocide). The solution is pressurized in the cylinder for a period of time that is determined to achieve maximum absorption and penetration of the preservatives.
- Dip treatment involves submersion of the wood products in a water-borne solution over a certain period of time. Often, dip treatments combine biocides for surface treatment of fungi and preservative salts in solution. Dip treating processes must balance the temperature of the solution, concentration of the salts (while maintaining them in solution), compatibility with biocides and other treatments, and submersion time. This balance effects how effectively the salts diffuse throughout the cross-section of the wood.
- Topical treatments include biocides, preservatives, brighteners, and other applications that are sprayed or brushed onto the surface of the wood. Most topical treatments are limited to protecting the outer layers of cells (up to ¼" deep). The homeowner or builder on the job site can apply most topical treatments if they have not been applied before delivery.

During and after construction, diligent attention to the following precautions can eliminate potential food sources and prove to be very inexpensive insurance against the possibilities of insect attack.

- Remove all woody debris from the construction site prior to backfilling the foundation.
- Carefully inspect firewood, furniture, and mulch before bringing them onto the building location.
- Store firewood away from log walls, as both wood ingesting and wood nesting insects can migrate to the walls from infested firewood.

As stated earlier, the attached *Techline* reprint of the durability map of the United States should be used to determine the maintenance requirements of the various regions of the country. Please note that guidelines for many building materials vary by climate and region. Concrete is a prime example. Mixtures and composition of concrete are different in cold and hot climates.

Differences exist by region for the use and maintenance of wood in construction! Regardless of the product you choose, follow a maintenance program suited to your location and building design.

Controlling Environmental Conditions

In addition to fungi and insects, the weathering process is a cause of wood and wood finish degradation. The combinations of exposures in the weathering process are: Ultraviolet rays (sunlight), moisture, temperature, and wind abrasion. Depending upon the wood species, the process of erosion can wear away up to a quarter of an inch or more of wood per century.

- **Ultraviolet (UV) Light** - UV causes a breakdown in the exposed lignin component of the wood cells, giving rise to color changes and the weakening of surface wood fibers. Lighter woods tend to darken and gray. Dark woods bleach out and gray. This color change is natural, normal, and does not pose any structural concerns. If the appearance of gray wood is aesthetically unappealing, pigmented stains should be applied regularly.
- **Moisture** - Wood swells and shrinks in response to the level of humidity or continual wetting by rainwater runoff. The repeated wetting by roof runoff splashing off a deck onto the log wall is a typical area of concern. This is just one reason that gutters are highly recommended in areas with higher levels of precipitation.
- **Temperature** - Increased temperatures accelerate the deterioration process caused by UV. For log homes, elevated surface temperatures increase the rate of moisture evaporation within the logs thereby causing more checking. Subsequent freezing and thawing of absorbed water contributes to checking and cracking as well.
- **Abrasion** - The mechanical action of wind, sand, and dirt can be a factor in the rate of surface degradation and removal of wood or exterior finish material. Windblown particles can have a sandblasting effect.

CONTROLLING DESIGN, SITE, AND CONSTRUCTION ELEMENTS

Eliminating the potential entry of moisture will help combat decay in walls and foundations, and around doors and windows. The factors below should be considered regardless of your selected source of log building materials.

Building Design and Location

There are important preventive steps that can be taken in order to greatly reduce the costs of exterior maintenance.

Site Drainage & Finish Grade

The first major consideration is the selection of the building site. Locate the log home on a site where rainwater and melting snow will drain away from the structure on all sides. If this is not possible, crown the area where the house is built, and alter natural drainage by using swales, retaining walls, ditches, or sub-surface drain tiles before you begin construction.

Do not allow the lower course of logs to come in contact with the ground. Earth/wood contact greatly enhances chances of colonization by termites and decay fungi. As a consequence, it is recommended that the foundation wall be constructed in such a manner that there be ample distance between the logs and earth. It should also be high enough to prevent rainwater from splashing on the logs.

Lastly, when landscaping the home, use common sense to prevent the introduction of insects through mulch and plantings.

Wall Surface Protection

Moisture from rain and even condensation can run down the face of the wall and move in and through any number of cracks in the wall. This is particularly acute around doors and windows, upward facing checks, and corners. A few tips:

- ❑ Never design into the structure any ledges that will hold standing water.
- ❑ Always apply flashing as drip cap over windows and doors. Water that gets behind the exterior trim can travel long distances undetected.
- ❑ Apply additional finish treatment to exposed surfaces at corners to protect the wood from possible standing moisture. Encourage drainage out and away from corners by incorporating joinery techniques. Ventilation can also be employed to encourage evaporation of moisture from corners.

Overhangs & Gutters

Two effective features to be built into a log home are a wide roof overhang and the installation of gutters because they move roof runoff away from the log wall surfaces. These options are particularly desirable in areas of high rainfall. Wider overhangs also provide the benefit of shading the wall from the sun and UV.

Minimum projections are recommended to be 18 inches or more (preferably 24 inches) for one story, 24 inches or greater for two stories. Structural roof members of logs or sawn lumber should not be allowed to project beyond the protective eaves. If they do, they will become easily wetted and susceptible to decay.

Ventilation of Spaces

As your home is being constructed, make certain that the attic and crawl space areas are adequately vented to prevent the accumulation of moisture within the living space. The soil in crawl spaces can be covered with polyethylene to reduce the relative humidity of the air in sub-floor spaces.

During Construction

During the construction phase, it's important to prevent the damaging effects of mold and mildew. As mentioned earlier, mold and sapstain make the wood more porous, increasing its tendency to absorb rainwater and high humidity, thus increasing the chances of decay. As noted earlier, some wood species and wood preservatives resist mold and mildew, but proper care for the logs is still warranted.

Attempt to keep the logs as mildew-free as possible while the home is being built. Some manufacturers pre-treat their logs with a wood preservative to minimize any major outbreaks of fungus during the construction phase. Even if they are pretreated, care should be taken at delivery to store the wood products properly. When the logs are delivered, prevent them from touching the ground or each other by placing stickers (spacers) between them. This procedure, by allowing air circulation between the logs, will help relieve any build-up of moisture and heat caused by the drying logs thereby reducing the chances of fungal attack. Be sure that the stacks of material are kept covered (lumber wrap or opaque polyethylene) and, if possible, located in a shaded area.

If mold and mildew are present they must be removed. There are products specifically designed for log home use. Follow the label instructions precisely **or**, treat with the following caustic solution. Wear goggles, rubber gloves and necessary clothing to prevent eye and skin contact. Also shield plants and shrubs from contact.

- ❑ 1 cup Trisodium Phosphate or non-ammoniated detergent
- ❑ 1 quart of household bleach
- ❑ 3 quarts of warm water.

Apply the solution onto the affected area with a hand-pump garden sprayer. Allow the solution to set for 5-10 minutes and pressure rinse thoroughly with clean fresh water. (Note: It is very important that the rinse is sufficient to remove all cleaning chemicals. Chlorine left in the wood can damage coatings applied over it.) This treatment will kill the fungal growth as well as clean the log surface. However, it will not prevent the future occurrence of these organisms if conditions are suitable.

Before cleaning the exterior of a building or a stained roof, confirm the nature and condition of the soil treatment. It is possible that the cleaning agent being used is not compatible with the soil treatment, and there could be a detrimental effect on termite soil treatment chemicals applied around the home. The soil pH is known to have a major impact on performance of termiticides because it affects how rapidly a compound degrades. The pH is used to describe whether soil is acidic (pH less than 7) or alkaline (pH above 7). Most soils have pH values between 4 and 8. In general, termiticides used today persist longer in acidic soil than in alkaline soil. In any case, take measures to shed cleaning agent runoff away from building (three to four feet), thereby protecting soil treatments.

THE FINISH TREATMENT

After construction, water absorption must continue to be controlled through regular maintenance with a water repellent treatment, stain, or coating. Select a product that is labeled for use on log homes. The weather factors (sunlight, water, temperature) can be mitigated with the proper finish treatment, provided that the home is properly designed for its location.

The finish treatment should possess, at minimum, the following characteristics:

- Exceptional water resistance/water repellency
- Mold and mildewcidal protection.
- Allow for moisture vapor transfer

Some products offer additional benefits of wood preservation, abrasion resistance, and control against ultraviolet light and fading.

Maintenance product manufacturers typically recommend the following steps for the care and maintenance of log homes:

- ❑ Always start with a clean surface, free of mill glaze. Mill glaze can inhibit or interfere with the finish treatment. Consult your dealer or log home representative if you are in doubt about mill glaze. They will also be a good source for availability of mill glaze removal products.
- ❑ Clean the logs with the bleach/TSP solution recommended above or select one of the cleaning products available specifically for logs. Always, make sure that all products used are compatible with each other.
- ❑ Apply a protective finish.

Consult your representative for recommendations for the proper finish treatment. Select products that are specifically labeled for use on log homes and follow the label directions and surface preparation instructions exactly. Select a product suitable for the geographical location in which you are building, keeping in mind the type of wood and the moisture content present at time of initial application. (Note: A wood moisture meter is the surest way to know the true moisture content of the wood.) Some products require that the wood "season" for a period of time before application. Others may not. Read the labels and all instructional materials before you begin.

FINAL NOTE

This paper has attempted to provide a greater understanding of wood, the product choices available from Log Homes Council members, the implications of your building site and building design, and their impact on your decisions as you develop your working knowledge of log home maintenance. It is not intended to encourage belief that log homes are somehow more of a problem or require more maintenance than other types of wood sided homes. That simply isn't true. However, the unique aspect of most log homes is that the logs themselves are what make up the structural soundness of the building. Because of this, clear understanding of how to care for them is vitally important. This understanding will help to insure years of enjoyable, trouble free, log home living.

For more information, refer to these publications and web sites:

PUBLICATIONS

- Wood Handbook: Wood as an Engineering Material (FPL–GTR–113)
- *Selection and Application of Exterior Stains for Wood*, Forest Products Laboratory, General Technical Report FPL–GTR–106
- *Selection and Use of Preservative-Treated Wood*, Publication No. 7299, Forest Products Society
- *Quality Drying of Softwood Lumber Guidebook–Checklist*, Forest Products Laboratory, General Technical Report FPL–IMP–GTR–1
- *Air Drying of Lumber*, Forest Products Laboratory, General Technical Report FPL–GTR–117
- *Dry Kiln Operators Manual*, Forest Products Laboratory, Agricultural Handbook #188

WEB SITES

American Forest and Paper Association	http://www.afandpa.org/
American Wood Council	http://www.awc.org/
American Plywood Association	http://www.apawood.org/
Forest Products Laboratory, USDA	http://www.fpl.fs.fed.us/
The Forest Products Society	http://www.forestprod.org/
Southern Pine Council	http://www.southernpine.com/
U.S. Department of Housing and Urban Development	http://www.hud.gov/

For more information on termites, see Log Tech Note 03-02 Termite Prevention & Control and these additional websites:

ARS Operation Full Stop web page	http://www.ars.usda.gov/is/fullstop/introduction.htm
Louisiana Pacific's Smart Guard web page	http://www.smartguard.lpcorp.com/about.invasion.asp
Louisiana State University	http://www.agctr.lsu.edu/termites
University of California	http://www.ipm.ucdavis.edu/PMG/PESTNOTES
University of Hawaii	http://www2.hawaii.edu/~entomol/index.htm
University of Nebraska Institute of Agricultural and Natural Resources	http://www.ianr.unl.edu/pubs/insects/
University of Toronto	http://www.utoronto.ca/forest/termite/dist_spc.htm

Recommendations contained within Forest Products Laboratory publications include:

Removal of Mildew

Commercially available wood cleaners work quite effectively to remove mildew and other stains on wood. Dissolving 1-part liquid household bleach can also make mildew cleaner and some powdered detergent in 2 to 4 parts water. Allow the wood to dry for 1 or 2 days before refinishing.

Suggested formula:
1/3-cup household detergent
1-quart (5%) sodium hypochlorite (liquid household bleach)
3 quarts warm water
(1 cup = 0.2 L; 1 quart = 0.9 L)

Caution: ***Do not use a detergent that contains ammonia; ammonia reacts with chlorine-containing bleach to form a poisonous gas. Many liquid detergents may contain other additives that react with bleach.***

Removal of Iron Stain

A common form of staining on wood surfaces results from contamination with iron. A portion of the extractives in wood includes a group of chemicals collectively called tannins. The amount of tannins depends on species; oak, redwood, and cedar are rich in tannins. Tannins react with iron to form a blue–black stain on wood. Note the darker color of the iron stain. Common causes of iron stain include use of ungalvanized or poorly galvanized fasteners, cleaning with steel wool or a wire brush, and contact of the wood.

Iron stain can be removed by scrubbing the stained area with a aqueous solution of oxalic acid in water. Oxalic acid is usually sold at drugstores and hardware stores. Dissolve 1 to 4 oz of oxalic acid in 1 qt of hot water. Scrub stained area using a stiff-bristle brush. Thoroughly rinse with water after treatment. [Note: 1 qt = 0.9 liter; 1 oz = 28 g]

Caution: ***Oxalic acid is toxic. Wear rubber gloves and avoid contact with skin. Work in a well-ventilated area. Avoid splashing the solution on plants because it can damage the foliage. Wash hands before eating or using tobacco products. Store in a locked space out of reach of children.***

Extractive Bleed

A common cause of discoloration is extractive bleed. All species contain extractives, but extractive bleed is most prevalent on highly colored woods. The discoloration often occurs around fasteners because the hole in the wood caused by the fastener cuts many wood cells. These cut cells increase water absorption. Water dissolves the extractives, and when the wood dries, the extractives accumulate at the surface and sunlight causes them to polymerize.

If extractive bleed is a problem, the extractives can be removed by scrubbing the wood with soap and water. Do not use a wire brush because the brush will contaminate the surface with iron, which will cause iron stain.

TECHLINE
Durability

Effect of Climate on Durability of Wood

Climate has an important bearing on the relative rate of wood decay and thus the expected service life of wood exposed to the weather. Researchers at the Forest Products Laboratory have devised a climate index map to predict relative decay hazard regions in the United States.

The map is based on mean monthly temperature and number of rainy days. The most severe location in the United States is the Southeast, where rainfall is high and weather is warm and humid. In the Northeast and Midwest, decay advances at a somewhat slower rate. In the Northwest, the decay hazard is moderate near the coast but it can be severe on the coast. Decay is less hazardous in most of the Southwest because this region is very dry.

In mountainous regions, localized areas with marked differences in temperature and rainfall occur. Index differences due to this factor are not reflected in the map. Where climate is relatively uniform over wide areas, the map can be used with confidence.

The climate index map primarily estimates the decay hazard of wood exposed above ground to weather. With certain restrictions, the map can also be used to determine the hazard for wood in contact with the ground. Any place where wood contacts the soil should be considered a high decay hazard, indicating pressure treatment of wood with a preservative.

Homeowners, architects, builders, and marina operators can use this map for help in selecting the wood species or preservative treatment that will ensure maximum service life of wooden structures.

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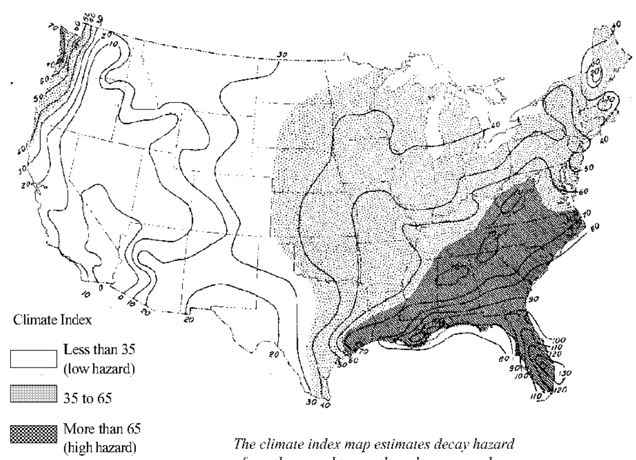

The climate index map estimates decay hazard of wood exposed to weather above ground.

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Maintenance Practices for Wood Bridges

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Abstract

Proper maintenance is necessary for the continued safe performance of bridges. In times of fiscal constraint, maintenance becomes increasingly important as funding for bridge replacement decreases and existing bridges must continue to safely support traffic loads. Many bridges in our transportation system are made of wood and require specific maintenance unique to wood structures. This paper summarizes several inexpensive maintenance practices for wood bridges, including moisture control, surface treatments, and fumigants.

Introduction

Pressure-treated wood is one of the most durable bridge materials, but over extended periods it may be subject to deterioration from decay, insect attack, or mechanical damage. Wood bridges must be periodically maintained in order to keep them in a condition that will give optimum performance and service life. Effective bridge maintenance programs improve public safety, extend the service life of the structure, and reduce the frequency and cost of repairs. When tied to a competent bridge inspection program, regular maintenance represents the most cost-effective approach for achieving long service life from existing structures. Unfortunately, maintenance is often neglected until critical problems develop which require costly repairs.

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In general terms, bridge maintenance includes those activities necessary to preserve the utility of a bridge and ensure the safety of road users. In practice, all maintenance is either preventative or remedial. Preventative maintenance involves keeping the structure in a good state of repair before decay or deterioration has started. Early remedial maintenance is performed when decay or other deterioration is present but does not affect the capacity or performance of the bridge in normal service. These types of maintenance are very important to prevent costly future repairs. Three inexpensive practices for preventative and early remedial maintenance involve moisture control, surface treatments, and fumigants.

Moisture Control

Moisture control is the simplest, most economical method of reducing the decay hazard in wood bridges. It can be used as an effective and practical maintenance technique to extend the service life of many existing bridges. When exposure to wetting is reduced, members can dry to moisture contents below that required to support most fungal and insect attack (approximately 25 percent). Moisture control was the only method used for protecting many covered wood bridges constructed of untreated wood, some of which have been in service for more than 100 years. Although modern wood bridges are protected with preservative treatments, decay can still occur in areas where the preservative layer is shallow or broken.

Moisture control involves a common sense approach of identifying areas with visible wetting or high moisture contents, locating the source of water, and taking corrective action to eliminate the source. For example, drainage patterns on approach roadways can be rerouted to channel water away from the bridge rather than onto the deck. Cleaning dirt and debris from the deck surface, curbs, drains, abutment caps, and other horizontal components also reduces moisture trapping and improves air circulation. Common roofing cement can be applied to wood end-grain and around openings at joints and fasteners to provide a watertight seal. Another option is to place protective covers over exposed end-grain IO restrict direct exposure to the elements.

One of the most effective approaches to moisture control is restricting or preventing water passage through the deck. Decks that are impervious to moisture penetration will protect critical structural members and substantially reduce the potential for decay. On many wood decks, the addition of an asphalt wearing surface with a watertight geotextile membrane provides a moisture barrier that protects not only supporting members but also the deck. If cracks develop in the asphalt surface, they should be thoroughly cleaned with a stiff brush and compressed air, then filled with an emulsion slurry or liquid asphalt mixed with sand. If pavement is broken or missing, surrounding pavement must be removed to the point where it is sound and tightly bonded to the deck, and a patch must be applied.

Surface Treatments

Surface treatments are applied to existing bridge members to protect newly exposed, untreated wood from decay or to supplement the initial treatment after installation. This type of treatment is most effective when applied before decay begins and is commonly used for treating areas with checks, splits, delaminations, mechanical damage, or areas that were field-fabricated during construction. The ease of application and effectiveness of surface treatments as toxic barriers make them useful in preventive maintenance; however, the shallow penetration limits their effectiveness against established internal decay.

Surface treating normally involves conventional liquid wood preservatives that are applied by brushing, squirting, or spray-flooding of the wood surface. The wood surface should be thoroughly saturated with preservative so that all cracks and crevices are treated; however, care must be exercised to prevent excessive amounts from spilling or running off the surface and contaminating water or soil. In addition to preservative liquids, some preservative compounds are available in semisolid greases or pastes. These preservatives are useful for treating vertical surfaces or openings because larger quantities of preservative can be locally applied in heavy coatings that adhere to the wood. Preservative adsorption over an extended period can produce deeper penetration than single surface applications of 1iquid treatments. Semisolid preservatives are commonly used at the ground line of posts, poles, and piling, where they are brushed on the surface; the wood is then wrapped with an impervious material to exclude moisture and prevent leaching of the treatment into the surrounding soil.

The effectiveness of surface treatments depends on the thoroughness of application, wood species, wood size, and moisture content at the time of treatment. Wet wood absorbs less preservative than does dry wood. This factor is significant in wood bridges because many areas requiring treatment are subject to wetting. Although field tests show that surface treatments in aboveground locations can prevent decay infections for more than 20 years (Scheffer & Eslyn 1982), it is recommended that treatments used for bridge applications be systematically reapplied at intervals of 3 to 5 years to ensure adequate protection from decay.

Fumigants

Fumigants are specialized preservative chemicals in liquid or solid form that are placed in prebored holes to arrest internal decay. In time, the fumigants volatilize into toxic gases that move through the wood, eliminating decay fungi and insects. Fumigants can diffuse in the direction of the wood grain for 3 m or more from point of application in vertical members, such as poles. In horizontal members, the distance of movement is approximately 0.5 to 1 m from the point of application. The most common fumigants are liquids, but solid fumigants are also available. Solid fumigants are normally easier to use, provide increased safety, and reduce risk of environmental contamination.

To be most effective, fumigants must be applied to sound wood. When applied in very porous wood or close to surfaces, some of the fumigant is lost by diffusion to the atmosphere. Before applying fumigants, the condition of the member should be carefully assessed to identify the optimal boring pattern that avoids fasteners, seasoning checks, badly decayed wood, and other openings to the atmosphere. In vertical members such as piles, holes should be bored at a steep downward angle toward the center of the member to avoid crossing seasoning checks. For horizontal members, holes are bored in pairs straight down to within 40 to 50 mm of the bottom side. If large seasoning checks are present in horizontal members, holes should be bored on each side of the check to more completely protect the wood. The amount of chemical and the size and number of treatment holes depend on member size and orientation. Information on fumigants and recommended dosages may be obtained from the chemical manufacturers.

Liquid fumigants are applied using commercial equipment, but they can also be applied from polyethylene squeeze bottles (Morrell and others 1984). Solid fumigants are inserted directly into the prebored holes. Both types of fumigants will eventually diffuse from wood. Fumigants can be reapplied at periodic intervals in the same holes used for the initial treatment. The retreatment interval depends on the condition of the wood and the presence of checks, splits, fasteners, and other features that allow the fumigant to escape. In the absence of specific site information, it is recommended that a 10-year treatment cycle be used with a regular inspection program at 5-year intervals.

As with other preservatives and pesticides, fumigants for in-place treating are toxic to humans and must be used in accordance with State and Federal laws. When properly applied, the treatments pose no environmental or health hazard; however, the potential for environmental damage can be higher in some field locations because of variable conditions and the proximity to streams and other water sources. In-place treatments must be applied only by trained and licensed personnel who fully understand their use and the required safeguards.

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