

Converting 1979 Wood Preservation Problems Into Opportunities for 1999

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Abstract

The development of a body of knowledge we now call wood science and technology was already underway in the time of Christ. Recognized were the need for construction practices that keep wood dry, for allotting wood its proper place in structures, and for remedies against its infirmities. Then progress stood still. Not until the 17th and 18th centuries, when deteriorating piling in its dikes threatened the inundation of Holland, and dry rot in its men-of-war threatened the survival of England, were concerted efforts made to develop those remedies. From the wood preservation renaissance of the 19th century emerged the wood-treating industry of today.

Although great strides have been made in understanding wood, problems both old and new continue to plague its use. Exposure of untreated wood as seasoning checks deepen beyond the treated shell of timbers in service, inadequate preservative treatment of heartwood, inexcusable construction practices that trap water within untreated wood, archaic methods for inspecting timbers in service and estimating their residual strength, energy conservation practices that threaten the safety of thousands of homes, and general lack of knowledge about wood by those who design, construct, specify, or use wood present unlimited opportunities for improving its performance.

Research will continue to reveal new information about wood, but only education of users can dispel the pervasive general ignorance that discredits it and places an incalculable drain on our forests. The Forest Products Research Society and the Society of Wood Science and Technology should be part of a massive educational program for the wise use of this nation's only renewable resource. If by 1999 architects and engineers, home builders and homeowners, high school teachers and students, Campfire Girls, Boy Scouts, and Girl Scouts know a few basic facts about wood, we will have converted today's problems into opportunities for the new century.

TO PLACE IN PERSPECTIVE the wood-preserving problems of the present and opportunities for the future, we need some understanding of the long duration of the problems and of man's attempt to solve them. Several million years ago our ancestors first stood erect and freed their hands to use two versatile materials—wood and stone.

About 4,500 years ago in the Nile Valley, ancient artisans sheared off huge limestone blocks with swollen wood wedges. With uncanny precision and a few tools, they erected mammoth mortarless structures—tombs, temples, and observatories from which celestial measurements were made. Placed within the tombs, wood replicas assured eternal life for the departed, a 140-foot wood boat awaited reassembly for future trips, and delicately carved and ornamented wood furniture provided comfort as the travelers played wood games and enjoyed music from wood instruments during their eternal journey (2). Durable heartwoods were obviously favored for their color and serviceability.

Although the early Greek and Roman conquerors marveled at what these ancient artisans had wrought, no such good fortune befell the equally impressive and elaborate stone structures throughout Central and South America. The Spanish conquistadors, to demonstrate superiority over people they considered pagan savages, systematically attempted to wipe out all traces of accomplishment (and nearly succeeded) as they pillaged and destroyed. Only a few wood lintels remain in these ancient ruins as mute evidence of the role of durable heartwoods.

Wood Preservation Practices

In their temples the early Greek builders used durable heartwood pillars elevated on stones and placed stones on top of the pillars to shed water. This simple principle—keep wood dry—remains the most widely used means for preserving wood.

The Ten Books of Architecture written about 30 B.C. (12) tell "of preserving the trees after they are cut, what to plaster or anoint them with, of the remedies against their infirmities, and of allotting them their proper place in the building." Roman architects correctly observed that "after the timber is cut, it must be laid where the scorching heat of the sun or rude blasts of wind never come," and "you must not meddle with it under three months—the timber must

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have time to harden and to get a kind of maturity of strength before it is applied to use"; one anoints it "with lees of oil to preserve it against water," and "having thoroughly bedaubed a wooden tower in the Piraeus with allum, when Sulla besieged it, it would not take fire."

By 72 A.D., records of the early Roman naturalist, Pliny the Elder, as translated by Rackham (11), show that a basis for wood technology and preservation had been established. The Romans knew that sapwood is susceptible "to rotting easily and liable to wood worms"; that the heartwood of cypress, cedar, ebony, lotus, box yew, and juniper is durable and does not "experience decay and age"; and that trees under water in the Red Sea continued free from rot for 200 years whereas wood in marine waters was attacked by borerworms that have a very large head in proportion to their size. They also recognized that sound traveling through a beam of wood, however great its length, can be used to detect whether the timber is twisted and interrupted by knots; that teeth of saws are bent "each way in turn so as to get rid of the sawdust"; and that timber well smeared with cedar oil does not suffer from maggots or decay (8).

Ancient civilizations knew wood must be kept dry and must be treated to prevent fire.

Then progress in wood preservation stood still for over 1,000 years. The emerging European individual at the end of the Middle Ages faced breathtaking vistas of new continents just discovered, new trade routes just opened, and new knowledge unlocked by the introduction of paper and printing (9), but knowledge of wood and its preservation was slow to develop. Only when deteriorating piles in its dikes threatened the inundation of Holland, and deteriorating timbers in its men-of-war threatened the survival of England against its foes on the continent in the 1600s, were concerted efforts made to preserve wood from its infirmities. The 1700s witnessed a frantic search for ways to control marine borers that "made leaky sieves of dozens of the King's ships" and to control dry rot "which remained unmastered to the end" (1). The dry-rot problem in the British men-of-war "was prominent among the causes of delay which helped the cause of American independence" (1).

The minutes of the Proceedings of the Institution of Civil Engineers, London, chronicled early trials and failures and, then, in the 1800s, the renaissance in wood preservation:

- The destructive distillation of coal that yielded coke for steel and a myriad of chemicals, including creosote.
- The use of large pressure vessels for impregnating wood with hot creosote after a vacuum exhausted the wood of air—the Bethel full-cell process.

- Pasteur's introduction of the germ theory of infection and Boulton's recognition (3) that "invisible germs descending through cracks in treated wood that are deeper than that portion of wood charged with antiseptic will carry destruction into the center of the log."
- The breathtaking vistas seen through the microscope revealed that wood decay, though strikingly similar to slow combustion, was caused by plants called fungi.

The wood-preservation pioneers, though skeptical of water-soluble metal salts that leached from wood, recognized that creosote must be of good quality and must be injected into wood in sufficient quantity; that higher retentions of creosote were required for wood used in the sea than on land; and that penetration of preservatives could be improved by puncturing wood with numerous small holes. They knew that artificial methods for drying timbers would be adopted (but cautioned against the use of high temperatures that weaken wood); that a vacuum removes air but little moisture from wood; and that the SG of wood fiber was 1.5, a value they used to calculate the void space and maximum retentions of creosote in wood.

Railways sustained creosoting plants in Europe through the 1800s and were responsible for their rapid spread throughout the United States. In 1885, the American Society of Engineers' Committee on the Preservation of Timber (5) reported that zinc chloride was the "advisable process" for preserving railway ties because of its low cost. By 1920, 100 treating plants were producing ties treated with zinc chloride, but because of the need for longer service, creosote became and remains the preferred preservative.

Formation of the American Wood-Preservers' Association (AWPA) in 1904 and of the USDA Forest Service Forest Products Laboratory (FPL) in 1910, began a unique and enduring relationship. Results of research on wood preservation by the FPL were rapidly incorporated by the AWPA into standards for treating wood products. The trickle of publications from the FPL rapidly became a stream and by the 1950s, a sustained torrent as other private and state research organizations contributed to the deluge of information about wood and its protection from fire and wood-destroying organisms. Much of the information has also been published in the journals of the Forest Products Research Society since its inception in 1947.

Developments have been numerous. Fire-retardants, once used only for indoor wood, have been developed for outdoor wood. Pentachlorophenol, formerly used only in heavy oil, now is applied to wood in mineral spirits, liquefied petroleum gas, or methylene chloride. Leach-resistant formulations of arsenic and copper, which protect wood from decay fungi and insects, are now also used in much higher retentions alone or in dual treatments with creosote to protect wood against marine borers in warm waters. Copper-8-quinolinolate now protects wood in contact with foods. Gage retentions of preservatives based on the total volume of wood in a charge have been replaced by more realistic assay retentions based on the volume of a specified zone of treated wood. The fine structure of wood has been revealed in steadily increasing detail to help explain preservative movement through wood and the nature of wood degradation by decay fungi. Today, over 300 plants supply a wide range of preservative-treated wood products.

Problems-Challenges-Opportunities

Great strides have been made in understanding and preserving wood. Yet creosote is still a valued preservative; incising is required for many woods; the Bethel full-cell process remains the basis for today's pressure-treating industry; decay fungi continue to be the most important wood-destroying organisms; and keeping wood dry remains the most widely used method for preserving wood. Nonetheless, problems both old and new continue to plague its use. But problems also are challenges to be met and opportunities to improve the performance of wood.

Checking of Timbers in Service

Large round and sawed timbers, now predominantly of thin-sapwood nondurable heartwood species, continue to be used and "germs," descending through seasoning cracks, continue to carry destruction to the center. Yet national treating standards continue to ignore this checking problem and its solutions. Although large timbers cannot be seasoned to moisture contents they attain in service, their destruction can be greatly reduced or eliminated. Several narrow pressure-treated timbers can be used in place of a single wide timber. Transmission poles can be perforated in the critical groundline zone or incised to a depth of 2.5 inches before treatment to provide deep zones of protected wood, or they can be kerfed to the center from the butt to 5 feet above groundline to prevent checking in service.

Incising

Incising is required by national treating standards for thin-sapwood nondurable-heartwood species, unless it makes the material unfit for the intended use. Incising improves treatment of permeable heartwoods but does little to improve penetration of preservative into impermeable heartwoods. For heartwoods that can be treated longitudinally, penetration requirements of 3/8- to 1/2-inch all too frequently leave large cores unprotected when lumber and timbers are sawed or drilled during construction.

The modified oyster knife tooth that "separates" fibers, although less disfiguring than the chisel-knife incising tooth that cuts fibers, reduces the uniformity of treatment. The less end-grain cut, the poorer the penetration. Surely, good Yankee ingenuity can develop equipment that rapidly drills or punches uniform openings 3/16-inch in diameter to controlled depths up to 2-1/2 inches. When incised in this manner, material less than 3 inches thick incised on one face, or material 4 to 6 inches thick incised on two faces, would not require on-site treatment. These small openings would affect wood strength less than the slits made by our present incising equipment.

Impermeable Heartwoods

Nondurable heartwoods, which are difficult to treat with preservatives, pose a challenge for treaters and wood scientists alike. When thoroughly seasoned, treated, and used under moderate service conditions—on well drained ballast in dry climates, for example—crossties can provide long service even though the treatment is only "skin deep." The treaters have met the challenge.

But though scientists can explain why woods are impermeable, improved treatment has remained elusive. This is a Mt. Everest for novices—even with a well-organized assault carried out by highly skilled personnel, the prospects for success are poor.

Maintenance of Wood Structures

Maintenance of wood in structures, if thought of at all, has long been synonymous with replacement. Archaic inspection tools (eye, hammer, and drill), untrained personnel, and minimal budgets may or may not find "bad" timbers. Although more sophisticated sonic, radiation, electrical-resistance, and force-measuring devices are used with greater frequency, all detect only the changes in wood associated with advanced deterioration.

For Douglas-fir timbers, at least, preventive maintenance before significant loss of strength has become a reality. Cores can be removed rapidly with an increment borer and examined for advanced deterioration, the sound-appearing wood cultured for decay fungi, and the treated shell assayed or bioassayed for residual preservative. Poles can be wrapped with preservative bandages to rejuvenate the treated shell and can be treated internally with volatile chemicals to eliminate decay fungi and insects for 6 feet or more from the treating sites. Retreating cycles will exceed 10 years.

Estimates of residual strength, unfortunately, are still only optimistic guesses based on obvious rot. They will

In the 1800s breathtaking vistas through the microscope revealed that wood decay was caused by fungi.

remain guesses until we have better inspection methods and know more about fungal-related strength reductions in adjacent sound-appearing wood—we do know that wood toughness can be reduced as much as 60 percent by certain fungi.

Most of all, a maintenance program requires knowledgeable managers and well-trained inspectors who recognize the limitations of their tools. The success or failure of a program rests squarely on the inspectors' shoulders. A small investment in training managers and inspectors of wood-products systems that have replacement values varying from a few hundred thousand to more than a billion dollars offers unique opportunities for greatly reduced maintenance costs.

Poor Design and Construction Practices

"Inexcusable" is the only word to describe the damage from poor construction practices that we see all too frequently in wood structures:

- An attractive shopping center with 500 untreated timbers projecting beyond the overhang—nearly all decaying within 10 years.
- Banks, schools, motels, and churches with untreated laminated beams or arches exposed to the weather—decaying throughout the United States.
- Decks of nondurable woods supported by beams that extend through homes—decaying within 10 to 15

years, the beams providing ready access to the house for termites and carpenter ants.

- A bulkhead of creosoted Douglas-fir piling with sound-appearing tops sloped to shed water—and left unprotected—decaying within 4 years.
- Piers and docks in marine waters of creosoted timbers and piling with unprotected cutoffs both above and below marine water—timbers rotting above water and bracing and piling hollowed out by marine borers below water.
- Pressure-creosoted piling with small oval holes in the surface and hollow centers in the tidal zone, and on shore, new piling is being lifted into place with sharp, pointed tongs that expose unprotected wood.

Today "inexcusable" is the only word to describe damage from poor construction practices!

Obviously that 3,000-year-old refrain "keep wood dry," the message to use pressure-treated wood, and the instructions for its proper handling haven't been heard throughout the land.

Energy Conservation—a Rotten Deal for Homeowners?

The massive energy conservation program and the well-intended weatherization programs may be another missed challenge for wood technology and may become a massive economic headache for homeowners. Residential decay and insect damage are serious problems in states where they have been assessed: Alabama—52 percent (6), Louisiana—33 percent (4); North Carolina—22 percent (10); and Oregon—40 percent (7). To save energy, windows have been covered with plastic or glass, doors weather-stripped, and openings on the outside of homes caulked to save heat. The result—water vapor, which once escaped freely with the warm air, accumulates in the house and condensation may increase within walls and attics during cold weather. Adding fill insulation to exterior walls of existing homes, most of which have no vapor barrier on the warm side to slow water-vapor flow to the outside, adds to the problem. Insulation steepens the temperature gradient and further increases the probability of condensation and of rot in walls, especially in small homes of low-income residents who can ill afford more problems.

An example is the plight of an Oregon man in his seventies and his wife, who is in the hospital. Two years ago, their 15-year-old home, about 900-square-feet with a wide roof overhang, was weatherized and the walls were filled with water-containing urea-formaldehyde foam. Each morning since insulating, the man has had to open windows and doors and turn on a fan to rid the house of odor. The plywood siding on the north wall now has extensive rot and advanced decay; the other walls also have some advanced decay. Studs and fiberboard sheathing are still reasonably solid, indicating that water condensation behind and within the plywood provided the conditions for decay.

Unfortunately, thousands of weatherized and insulated homes may be similarly condemned. In these cases, the Department of Energy's national advertisement, "If it saves energy it will pay for itself" rings hollow indeed.

Wood's Future

Research will continue to reveal new information about wood, but only education can dispel the pervasive general ignorance that far too long has discredited wood and has placed an incalculable drain on our nation's forests and economy. Education for those who design, construct, specify, inspect, and use it offers unlimited opportunities for improving the utilization and performance of wood.

Industrial advertising features information about wood; universities have prepared slide-tapes, films, and television programs; the Society of Wood Science and Technology (SWST) has presented symposia on the use of wood; the annual meetings of the Forest Products Research Society (FPRS) have been invaluable forums for researchers and the wood products industry; and a "Theater of Wood Fundamentals" may be featured at future annual meetings of FPRS.

By and large, however, we in the wood industry and science educate each other and fail to reach those who put wood products into service. The FPRS and SWST should be part of a massive educational effort to dispel ignorance about wood. We must distill the knowledge of wood to those easily understood facts that can assure the continued performance of this useful material:

If by 1999, architects and engineers, home builders and homeowners, high school teachers and students, Campfire Girls, Girl Scouts, and Boy Scouts know a few basic facts about wood, we will have converted today's problems into opportunities for the new century.

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