Timber Preservation Treatments for Highway Applications

tech transfer summary

Wood preservatives are evaluated for their performance effectiveness in building new timber bridges in Iowa.

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RESEARCH PROJECT TITLE
Field Evaluation of Timber Preservation Treatments for Highway Applications

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The Bridge Engineering Center (BEC) is part of the Center for Transportation Research and Education (CTRE) at Iowa State University. The mission of the BEC is to conduct research on bridge technologies to help bridge designers/owners design, build, and maintain long-lasting bridges.

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Objective

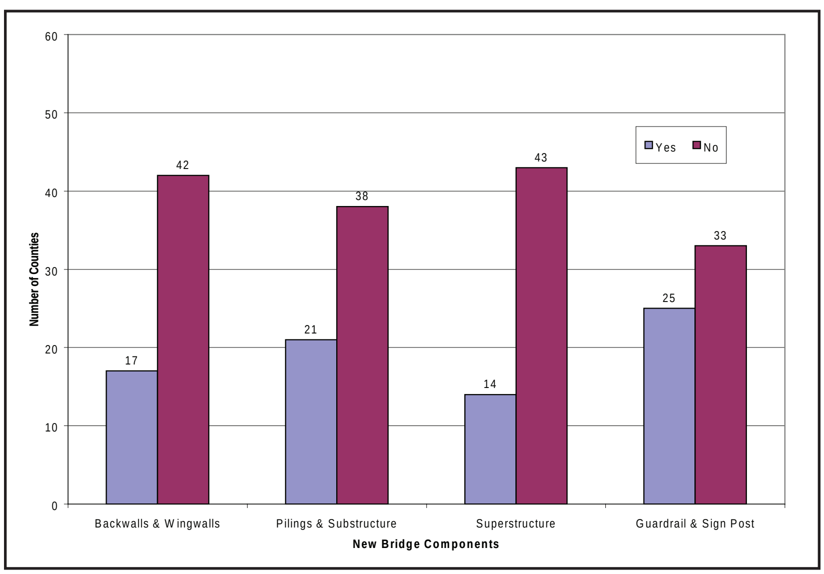
The primary objective of this research was to evaluate the performance of different wood preservatives in the field and to review current specifications and testing procedures to determine whether they provide the level of timber treatment required for acceptable performance.

Problem Statement

Timber can be a cost-effective building material for new bridge construction. The single most limiting factor for increased use of timber bridges continues to be concerns with durability. The durability of timber bridges is largely a product of the initial preservative treatment used to protect the wood, although construction practices and maintenance also play an important role.

Proper preservative treatment creates an excellent barrier against fungi and insects, which can destroy the wood; however, the preservative barrier can be compromised during on-site installation or as a result of checks and cracks from normal weathering and moisture changes. Any break in the treatment barrier may expose untreated wood to fungal or insect attack.

The Iowa State University Bridge Engineering Center (BEC), in conjunction with the United States Department of Agriculture Forest Products Laboratory (FPL), evaluated the various types of wood preservatives used in Iowa and outlined recommendations for their use in new bridge construction.



Use of timber for construction of new bridges by Iowa counties (results from 63 respondents)

Research Description

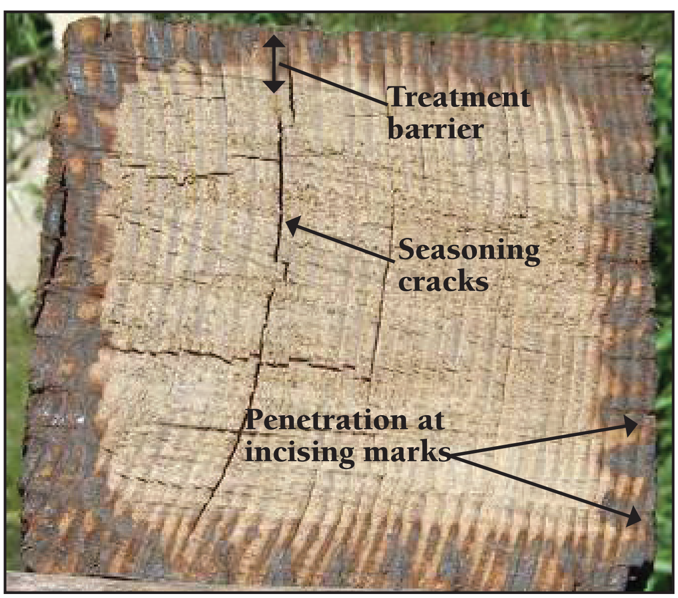
The research team conducted on-site visual inspections of 47 bridges in eight Iowa counties using different preservative types. The goal of the inspections was to evaluate the performance of current preservatives used in Iowa. The following preservative types were evaluated:

- creosote
- pentachlorophenol
- copper naphthenate
- ammoniacal copper zinc arsenate (ACZA)
- chromated copper arsenate (CCA)
- alkaline copper quaternary (ACQ)

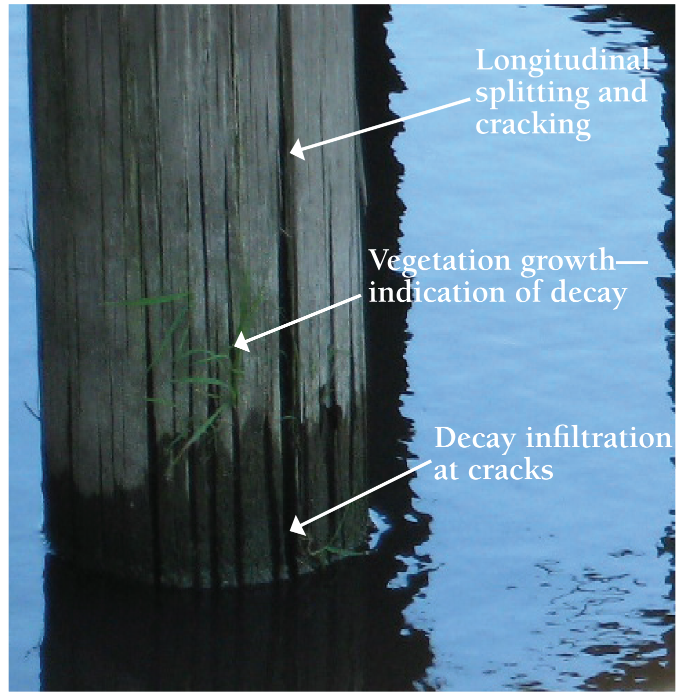
When conducting the inspections, all available piles, cap beams, backwalls, stringers, decking, and guard railing were inspected for decay, physical defects, and damage—signs that the preservative treatment is not performing effectively or may have been compromised for future protection.

Preservative Evaluation

Highway applications of timber material in Iowa vary greatly and include bridge pilings, abutment backwalls, guardrail posts, bridge deck planking and many others. Currently, various in-plant preservative treatments are being used in Iowa to extend the service life of structures. Creosote has been the in-plant preservative of choice for many years; however, due to environmental concerns and handling issues, a movement is being made away from creosote to other preservative alternatives. Remedial, or in-place, preservative treatments have seen minimal usage in the state of Iowa. As Iowa's timber bridges become older, the implementation of in-place treatments will be necessary to reduce future costly repair and replacement.



Pentachlorophenol treated railing post with field-cut end grain and no in-place treatment which increased the amount of physical defects



Common visual signs of interior decay on bridge piles located in stream channels

Plant-Applied Preservative Treatments

Plant-applied wood preservatives can be broadly classified as either oilborne or waterborne, based on the chemical composition of the preservative and the solvent/carrier used during the treating process. Generally, oilborne preservatives are used with petroleum based solvents ranging from heavy oils to liquefied gases. Waterborne preservatives are applied using water-based solutions, such as water and ammonia. There are advantages and disadvantages associated with using each type that depend upon the application.

Estimated service life of treated round fence post in southern Mississippi

Preservative	Average retention (lb/ft³)	Estimated service life (yrs)	90% confidence limits for service life (yrs)	
			Lower	Upper
Copper naphthenate	0.03	65	55	78
Creosote	5.6	54	47	62
Pentachlorophenol	0.32	74	60	91
ACA	0.34	60	51	69
Untreated	0	2.4	2.1	2.7

Properties and uses of plant-applied preservatives for timber bridges

Standardized Uses	Preservative	Solvent Characteristics	Surface Characteristics	Color	Odor	Fastener Corrosion
All uses	Creosote	Oil-type	Oily, not for frequent human contact	Dark brown	Strong, lasting	No worse than untreated wood
All uses	Ammoniacal copper zinc arsenate	Water	Dry, but contains arsenic	Brown, possible blue areas	Mild, short term	Worse than untreated wood
All uses	Chromated copper arsenate	Water	Dry, but use is restricted by EPA	Greenish brown, weathers to gray	None	Similar to untreated wood
All uses (except in seawater)	Pentachlorophenol Type A (heavy oil)	No. 2 fuel oil	Oily, not for frequent human contact	Dark brown	Strong, lasting	No worse than untreated wood
All uses (except in seawater)	Copper naphthenate	No. 2 fuel oil	Oily, not for frequent human contact	Green, weathers to brownish gray	Strong, lasting	No worse than untreated wood
All uses (except in seawater)	Alkaline copper quat	Water	Dry, okay for human contact	Greenish brown, weathers to gray	Mild, short term	Worse than untreated wood
All uses (except in seawater)	Copper azole	Water	Dry, okay for human contact	Greenish brown, weathers to gray	Mild, short term	Worse than untreated wood
Above ground, fully exposed	Pentachlrophenol Type C (light oil)	Mineral spirits	Dry, okay for human contact if coated	Light brown, weathers to gray	Mild, short term	No worse than untreated wood
Above ground, fully exposed	Oxine copper	Mineral spirits	Dry, okay for human contact	Greenish brown, weathers to gray	Mild, short term	No worse than untreated wood
Above ground, fully exposed	Copper HDO	Water	Dry, okay for human contact	Greenish brown, weathers to gray	Mild, short term	Worse than untreated wood

The most common oilborne preservatives are creosote, pentachlorophenol, and copper naphthenate. Conventional oilborne preservatives, such as creosote and pentachlorophenol, have been confined largely to uses that do not involve frequent human contact. The exception is copper naphthenate, a preservative that has become available more recently but has been used less widely.

Oilborne preservatives may be visually oily, oily to the touch, and sometimes have a noticeable odor. However, the oil or solvent that is used as a carrier makes the wood less susceptible to cracks and checking and provides a barrier against moisture, making them the preferred preservative for bridge structural elements.

Waterborne preservatives are formulations of inorganic arsenical compounds that react with or precipitate in treated wood. The reaction takes place when members are treated, "fixing" the precipitants (e.g., copper, chromium, and/or arsenic) within the cells of the wood to help prevent leaching and migration.

Waterborne preservatives, however, are used due to their preferred handling properties, clean surfaces, and low leaching levels. Waterborne preservative treatments have been found to reduce the mechanical properties of wood under some conditions. Energy-related properties are often reduced slightly; however, strength and elasticity properties are generally not affected when correct treatment levels are used.

In-Place Preservative Treatments

For best performance, as much fabrication should be completed prior to pressure treatment to allow all exposed surfaces to be protected. On-site fabrication of timber bridge components typically results in breaks in the protective barrier. Pile tops, which are typically cut to length after installation, need reapplication of the preservative to the cut ends. Likewise, the exposed end-grain in joints and the immediate area around all fasteners, including drill holes, require supplemental on-site treatment.

Periodic inspections should seek to identify cracks, splits, and checks that result from normal seasoning as well as areas of high moisture or exposed end grain in joint areas. These areas require periodic reapplication of supplemental preservative. Supplemental in-place treatments are available in several forms: surface-applied chemicals, pastes, diffusible chemicals, and fumigants.

Specifications and Guidelines

State of Iowa specifications pertaining to the handling and preservative treatment of timber used for bridges can be found in the Iowa Department of Transportation Standard Specifications, which can be found online at http://www.erl.dot.state.ia.us/. The American Wood-Preservers' Association (AWPA) is the primary standard-setting body for preservative treatment in the United States. Their timber standards can be purchased online at http://www.awpa.com/standards/ucs.asp.

Properties and uses of in-place preservatives for timber bridges

In-place preservative type	Active ingredient	Solvent type	Internal vs. external	Leeching or diffusing	Bridge location	Handling and other
Surface treatment liquid	Copper naphthe-nate	Oil	External sprayed or brushed	Insoluble in water	Bolt holes, exposed end grain, checks and splits	Non-RUP
Surface treatment liquid or powder	Borate solutions	Water	External sprayed or brushed	Leech away by pre-cipitation	Bolt holes, exposed end grain, checks and splits	Non-RUP
Surface treatment paste	CuNap, sodium fluoride, borates Cu-Hydrooxide	Water	External and covered with wrap	Boron & fluoride move into wood, Copper stays at surface	Ground line area of terrestrial piles & under pile caps	Non-RUP
Diffusible chemical liquid	Boron, fluoride, copper	Water	Internal through drilled holes	Needs moisture to diffuse into wood	Pile & deep timbers with drill accessibility	Non-RUP, low toxicity & ease of handling
Fumigant liquid	Chloropicrin	NA	Internal through drilled holes	Volatizes into gas & moves into wood	Pile & deep timbers with drill accessibility	RUP
Fumigant solid	Solid-melt MITC	NA	Internal through drilled holes	Volatizes into gas & moves into wood	Pile & deep timbers with drill accessibility	RUP
Fumigant liquid	Methan Sodium (Vapam)	NA	Internal through drilled holes	Volatizes into gas & moves into wood	Pile & deep timbers with drill accessibility	RUP
Fumigant solid	Granular dazomet	NA	Internal through drilled holes	Volatizes into gas & moves into wood	Pile & deep timbers with drill accessibility	RUP

Findings and Recommendations

The results of this study led to the following conclusions and recommendations:

1. Copper naphthenate is recommended as the plant-applied preservative treatment for timber bridge elements. Copper naphthenate has been tested extensively by the FPL in past years and has been shown to have comparable, if not better, performance to other commonly used preservatives, such as creosote. Additional reasons for recommending copper naphthenate include good handling characteristics, clean surfaces, comparable availability to other preservatives, and the potential for lower environmental impact.
2. During the construction of timber bridges, the Best Management Practices should be followed to minimize environmental impacts to the surrounding ecosystem and ensure quality treatment of both plant-applied and in-place preservatives. In addition to the best management practices, bridge owners need to insure that pile tops and cap beams are protected from moisture by use of metal covers and that all field cuts are treated with in-place treatments.
3. The AWPA standards are the basis for the Iowa DOT specifications, which are the regulating standards for bridges constructed with state or federal funding in the state of Iowa. If the bridges are being constructed without state or federal funding, the Iowa DOT specifications and plant certifications are still recommended.
4. Treated Southern Pine piles are recommended to have penetration of 3.0 in., or 90% of sapwood penetration. The penetration is in accordance with AWPA standards and is currently stricter than Iowa DOT specifications.
5. Timber bridge maintenance programs need to be developed and implemented. A maintenance program that utilizes combinations of inspection tools and various in-place treatments can easily extend a bridge's service life. Future work could entail development of a timber bridge maintenance program for bridge owners. An effective maintenance program contains many components that need to be developed, including 1) personnel training and education, 2) inspection procedures, 3) evaluation of structure and restoration, 4) in-place treatment procedures, and 5)records and data management.
6. Future workshops and/or short courses presenting biodeterioration and preservative concepts to timber bridge owners, designers, and inspectors are recommended in order to implement the information and procedures presented in this study.