PIER AND WHARF CONSTRUCTION PART III: **LOAD REQUIREMENTS**

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TIMBER PILES

COST EFFECTIVE BRIDGE REPAIRS AND TREATMENT OF PILES

PLUS

REPAIR AND REBUILD AUGERS
With Jeffrey Machine

MAGNACORE SELF-DRILLING ANCHORS
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CAISSON DRILLING
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Timber Piles

When it comes to load-bearing piles, concrete, steel, and composite are all viable options, but — for this issue — we're going to focus on timber piles, particularly with their use in bridges around the United States.

Two species of timber account for 90% of the usage — Southern Pine and Douglas Fir, Southern Pine found mainly in the southern United States and Douglas Fir a product of the Northwest Coast.

For marine piling applications, specialty timber is sometimes imported from tropics, specifically Greenheart Piling, which comes from South America and features high strength and superior resistance to decay.

Although timber piles tend to be more vulnerable to both driving damage, as well as deterioration, here are the top reasons to use timber pilings on your next job:

- Low cost, per ton of capacity.
- Dependable, renewable supply – available in a range of lengths and sizes.
- Long history of successful application to low and medium unit loads.
- Easily handled and driven with conventional equipment.
- Tapered shape and full displacement characteristics advantageous for developing soil capacity in shorter lengths.
- Strength in tension and bending applications. ■

Photo credit: Linde-Griffith Construction Co.

A. Smoot

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This issue of *Pile Buck* is dedicated to Joe Gruber who passed away August 11, 2019. As many in the industry know, Joe was an incredibly good guy and talented equipment manager at Goettle.

Repair of warn and damaged timber piles are made using the patented pile repair system, PileMedic® by QuakeWrap. Repair work using this system are made with minimal service interruption. Photo courtesy of QuakeWrap Inc.

TIMBER PILE BRIDGES

A GUIDE FOR TIMBER PILING SPECIFICATIONS, CONDITION ASSESSMENTS, EFFECTIVE MAINTENANCE & REPAIRS OPTIONS

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Pile Buck would like to thank the Minnesota Department of Transportation for allowing us to use data from the manual: 'Cost-Effective Timber Bridge Repairs: Manual for Repairs of Timber Bridges in Minnesota.'

INTRODUCTION & BACKGROUND

Timber piles have been utilized around the world for thousands of years. History reveals that the Neolithic tribes in Switzerland used natural (untreated) logs as pilings to support homes built on the region's shoreline for almost 6,000 years. Archeologists have found a similar use of timber piling for bridges spanning the Tiber River dating back to 620 B.C. Standards exist today to ensure replicable strength values and durability that provide a consistent level of quality and service for the market place. These standards provide consistency in design applications with various types of timber piles. They also provide direction to engineers and bridge owners on cost-effective ways to maintain and repair piles. This article provides an overview of assessing the condition of timber pile, common maintenance practices and cost effective repair techniques.

Timber piles are a unique product in that they are made from a natural material and are subject to variations in species, size, straightness, and strength. In North America, there are two predominant species used for timber piles, Southern Pine and Douglas fir, which are protected by preservatives to ensure long service life. There are other types of wood species utilized such as Bald Cypress and other such species that provide better natural durability.

SPECIFICATION AND TREATMENT OF TIMBER PILES

Often forests are managed specifically for use in manufacturing piles. These forests are maintained for 35+ years to create timber piles. Sustainability is built in by growing more trees than are harvested, and the enhanced durability of preservative-treated timber pilings allows forests more time to produce mature trees.

While growing timber for piling, it is important that the material characteristics be reproducible. The American Society for Testing and Materials (ASTM) first developed standards for timber piles in 1915, titled ASTM D25, Standard Specification for Round Timber Piles.

TIMBER PILES ARE A UNIQUE PRODUCT IN THAT THEY ARE MADE FROM A NATURAL MATERIAL AND ARE SUBJECT TO VARIATIONS IN SPECIES, SIZE, STRAIGHTNESS, AND STRENGTH. IN NORTH AMERICA, THERE ARE TWO PREDOMINANT SPECIES USED FOR TIMBER PILES, SOUTHERN PINE AND DOUGLAS FIR, WHICH ARE PROTECTED BY PRESERVATIVES TO ENSURE LONG SERVICE LIFE.

Worn timber piles under a commercial pier before repair using the patented PileMedic® by QuakeWrap system. Photo courtesy of QuakeWrap Inc.

These rules established minimum criteria to ensure that each tree produced for piling creates a replicable timber pile and performs as intended. Standard D25 is updated periodically and focuses primarily on the quality, straightness, and size of piling.

ASTM D25 specifies that piles shall be of any species of wood for which strength values are provided for in ASTM D2555, Standard Practice for Establishing Clear Wood Strength Values. ASTM D25 ensures quality by requiring that each pile be of sound wood, establishing a minimum number of growth rings per inch and a minimum percentage of summerwood in the outer 50 percent of a pile tip. The standard also provides requirements for the straightness of each pile, taper, spiral grain, and the size and number of knots allowed to ensure consistency while accommodating minor variations in this naturally grown product.

The standard also addresses the size of timber piles by providing minimum tip and butt dimensions for each of the designated lengths. These minimum dimensions ensure a predictable taper for each pile so designers can calculate the diameter at any location along its length. Tables are provided for both Southern Pine and Douglas Fir that allow a designer to specify a tip or butt circumference.

For an end-bearing pile, a tip circumference is specified. The table provides a corresponding minimum pile butt circumference, measured three feet from the large end (butt) of the pile, based on the designated length. Conversely, for piles that rely primarily on skin friction, a butt circumference is specified. The table provides a corresponding minimum tip circumference, based on a designated length of the pile. There is also a table that specifies minimum tip size.

Timber piles in the United States and Canada classify this butt measurement by a Class. Sizes of Class A (14-inch butt) and Class B (12-inch butt) piles are for designers that prefer those designations. The American Wood Council publishes design values for timber piles conforming to ASTM D25 titled, "National Design Specification for Wood Construction." These strength values are used in determining the bearing capacity, lateral capacity, and allowable driving stress of a pile.

To ensure a long service life in harsh environments, wood requires preservative treatment. Standards are written by the American Wood Protection Association (AWPA), a group of consumers, scientists, and wood preserving companies, to ensure consistency of treatment for all variations of preservatives, wood species, and treatment processes. American Wood Protection Association has published these standards for over 110 years. A Use Category System for all wood products is provided in the front of their Book of Standards.

The guide describes minimum treatment levels for various exposure conditions to ensure long service life for all treated wood products. The Use Category System Standard U1 is used by specifiers to determine the appropriate treatment for a particular service condition. There are five major Use Categories depending on service conditions where the wood will be used. Timber piles are found in two of the Use Categories. Foundation piles and piles used on land or in freshwater are listed in UC4C, Commodity Specification E: Round Timber Piling. Piling used in saltwater environments are listed in UC5, Commodity Specification G: Marine Applications. Timber piles used in marine applications are further divided into subcategories UC5A, UC5B, and UC5C. These subcategories are based on geographical regions and specify the amount of preservative needed to provide optimum protection. The Use Category subdivisions for timber piles in marine applications list the prescribed treatments that are approved by the EPA and the retention levels for the common preservatives used. These preservatives are Creosote and Creosote solutions, Chromated Copper Arsenate (CCA), and Ammoniacal Copper Zinc Arsenate (ACZA).

When using specifications for round timber piles, a sample specification

A USE CATEGORY SYSTEM FOR ALL WOOD PRODUCTS IS PROVIDED IN THE FRONT OF THEIR BOOK OF STANDARDS. THE GUIDE DESCRIBES MINIMUM TREATMENT LEVELS FOR VARIOUS EXPOSURE CONDITIONS TO ENSURE LONG SERVICE LIFE FOR ALL TREATED WOOD PRODUCTS. THE USE CATEGORY SYSTEM STANDARD U1 IS USED BY SPECIFIERS TO DETERMINE THE APPROPRIATE TREATMENT FOR A PARTICULAR SERVICE CONDITION.

The patented PileMedic® system from QuakeWrap can be adapted quickly to most field conditions when repairing timber marine piles. Here PileMedic® laminates are prepared to wrap a timber pile in close quarters under a bridge in Montana. Photo courtesy of QuakeWrap Inc.


PILE PROBLEMS?

may be written, such as Southern Pine/Douglas Fir piles shall conform to ASTM D25, unused, clean peeled, uniformly tapered, one piece from butt to tip. Specify butt or tip diameters from tables listed in the ASTM D25 standard, including the pile length. The preservative portion could be addressed as follows. Pressure treatment shall be in accordance with the following AWPA Use Category Standard: UC4C, UC5A, UC5B, or UC5C. Handling, storage, and field fabrication, including the treatment of cut ends or penetrations, shall be in accordance with AWPA M4.

To properly treat timber piles with preservative, moisture must first be removed from the cellular structure (lumens) of the wood so that it may receive the preservative. Once a timber pile is sufficiently dry, it is placed into a pressurized cylinder. The cylinder undergoes a period of vacuum and then is flooded with liquid preservative, which is then pressurized, forcing preservative into the wood cells. Once sufficient preservative has been absorbed, a final vacuum is used to ensure that excess preservative is not retained in the wood cell, and the piles are removed from the cylinder. Analytical testing is conducted to ensure the preservative has penetrated the wood and that the proper retention levels have been met according to the AWPA standards. It is important to note that in some piling, the preservative treatment does not penetrate the entire pile, but creates a protective envelope around the pile's circumference. It is important to avoid puncturing or damaging this protective envelope prior to or during installation. Should the outer area of the pile become damaged, or if the pile is cut or drilled after treatment, the protective envelope will need to be repaired. AWPA M4 standard provides procedures for the proper handling, storage, and field treatment of timber piles to address any repairs that may be needed.

PENTACHLOROPHENOL TREATMENT

One of the best treatments for timber piles is Pentachlorophenol (Penta), a synthetic preservative treatment that is used only for heavy construction timbers such as railway ties, utility poles and bridge timbers. Pentachlorophenol, being an oil-based preservative treatment, has low solubility and is water repellent therefore has a very low leach out rate.

Over 60 years ago, Pentachlorophenol was formulated to contain high levels of toxicity to act as a mass defoliant. Produced as polychlorinated dioxins 2,3,7,8-T or 2,4,5-T, Pentachlorophenol was highly toxic and ultimately dangerous to humans. These formulations are now banned or heavily restricted and the Pentachlorophenol formulation used to preservative-treat timber has a completely different dioxin with a much lower toxicity but still must be handled with care — same as for any treated timber. Therefore by minimizing direct contact with immediate water environment, TRS significantly reduces impact on the environment. All components are pre-fabricated in the factory where it is cut to length and all holes drilled before treatment. Where possible; avoid any cutting, drilling of treated timber whether in the factory or on site however, when it is required, appropriate PPE must be worn.

Heavy duty wood preservatives, such as Penta, are applied to wood in specialized high pressure treatment cylinders at wood treatment facilities. With oil-borne preservatives such as Penta, bleeding after application can occur. To reduce this, timbers are vacuum-treated, extracting excess treatment solution that has not been fixed in the wood. Performing a double vacuum treatment is a standard practice for penta-treated wood intended for use in sensitive environments, such as open water locations. These vacuuming procedures reduce the chance that the Penta and carrier solution will migrate into the environment through water runoff.

Over the last 30 years, there have been multiple examinations by US, Canadian and private agencies of treated timber's environmental effects on organisms and surrounds. Penta readily degrades in the environment by chemical, microbiological, photolysis and photochemical processes. Photolysis appears to be a significant process for degradation since a measured photolysis half-life has been reported to be 52 minutes in running water under sunlight.

COMMON FACTORS CAUSING TIMBER PILE DETERIORATION

Wood deteriorates for numerous reasons, and as deterioration implies this adversely affects woods properties. The two primary causes of deterioration in wood are: biotic (living) agents and physical (nonliving) agents. In many cases the agents that first alter the wood, provide the conditions for other agents to attack (e.g. insects bring woodpeckers). The effectiveness of an inspection of deteriorated wood depends upon the inspector's knowledge of the agents of deterioration. A well-trained inspector is essential for accurately assessing wood deterioration.

PILE DETERIORATION DUE TO BIOTIC AGENTS

Biotic, or living, organisms that attack wood include bacteria, fungi, insects, and marine borers. As living organisms, they require certain conditions for survival such as moisture, oxygen, temperature, and food, which is usually the wood. When the basic necessary living conditions are available biotic agents of wood deterioration are free to proliferate, but if any one of them is removed the wood is safe from further biotic attack. Geographical regions tend to have higher moisture content due to average temperature and relative humidity.

COVER STORY

The patented PileMedic® system from QuakeWrap can be adapted quickly to most field conditions when repairing timber marine piles. Here PileMedic® laminates are prepared to wrap a timber pile in close quarters under a bridge in Montana. Photo courtesy QuakeWrap Inc.

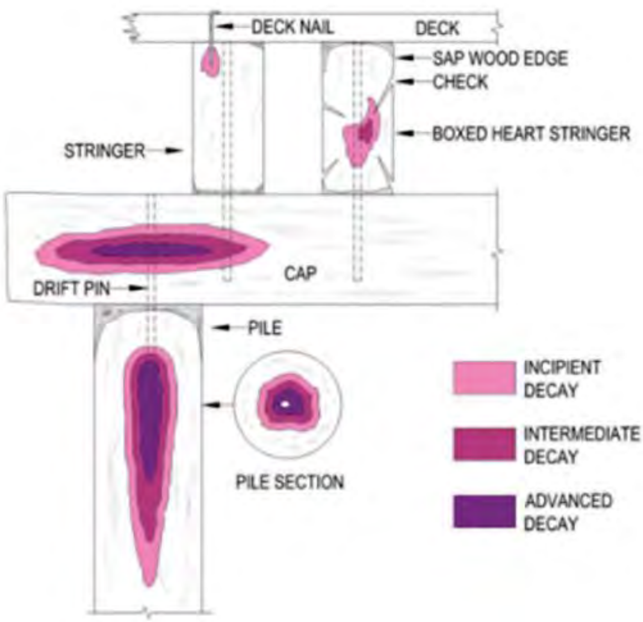
BACTERIA

In very wet environments bacteria can colonize untreated wood. Bacterial damage can include softening of the wood surface, increased permeability, and even degradation of chemical preservatives so that the wood becomes more susceptible to less chemically tolerant organisms. Usually the process bacterial attack is very slow, but under extensive exposure for long periods, damage can become significant.

FUNGI

When exposed to favorable conditions, most types of wood become an attractive food source for a variety of decay-producing fungi. The fungi require moderate temperature, oxygen, and a moisture content of approximately 22% or greater (oven dry basis) to become active. Decay progresses most rapidly at temperatures between 50°F and 95°F, outside this range decay growth slows considerably, and ceases when the temperature drops as low as 35°F or rises as high as 120°F. Over 82% of all timber bridge/pile degradation is due to decay causing fungi. It is known that with as little as a 10% loss in Specific Gravity (SG) up to an 80% loss in compression perpendicular to grain strength and a 75% loss in bending strength can occur in wood. Wood can be too wet for decay also. If the wood is water-soaked, the supply of oxygen may be inadequate to support development of typical decay fungi. Thus, wood will not decay, and decay already present from prior infestation will not progress if appropriate conditions are not met.

Decay fungi may be generally classified into two categories by the appearance on the wood surface.



Shows the level of decay that occurs in timber due to the use of vertical fasteners. Vertical fasteners increase the rate of decay in timber as they allow moisture to travel down the fastener into the heartwood of the cap, stringers, corbels and piles, therefore increasing the moisture content in the middle of these elements.

1. **Brown Rot** | Appears darker and can crack across the grain. Brown rot fungi attack the cellulose in the wood fibers. The brown color is due to the remaining lignin (the binder which holds the cellulose structure together), which is not consumed by the fungi. The decayed wood tends to form into small cubic shaped sections, which is a sign of advanced decay.
2. **White Rot** | Appears lighter in color and does not crack across the grain until severely degraded. In contrast to brown rot, white rot consumes both the lignin and cellulose and leaves the surface appearing generally intact, but with little or no significant mechanical strength. The surface of the decayed wood tends to have a "white" appearance.

WHEN EXPOSED TO FAVORABLE CONDITIONS, MOST TYPES OF WOOD BECOME AN ATTRACTIVE FOOD SOURCE FOR A VARIETY OF DECAY-PRODUCING FUNGI. THE FUNGI REQUIRE MODERATE TEMPERATURE, OXYGEN, AND A MOISTURE CONTENT OF APPROXIMATELY 22% OR GREATER (OVEN DRY BASIS) TO BECOME ACTIVE.

WOOD DETERIORATION DUE TO VERTICAL FASTENERS

The figure above shows the level of decay typically found due to vertical fasteners. The use of vertical drifts pins to attach caps to pile tops allow excess moisture into bright wood behind treatment. Side plates and horizontal through bolts should be used instead. A similar occurrence happens to the base of the column when they are sitting directly on concrete. The timber soaks up the water from the concrete, which accelerates decay. Further, wrapping cavitated piles with concrete above oxygen level leads to accelerated decay as the concrete holds the moisture content in the wood above the threshold for decay which is generally considered to be 22%

CONDITION ASSESSMENT INSPECTIONS

There are many ways to assess damage to a pile bridge. However, the amount of experience an inspector has greatly impacts the cost and accuracy of the assessment. Multiple types of tests will help pinpoint specific issues and increase the reliability of inspections. It is recommended that a standard set of assessment tools be employed to standardize condition assessment inspections.

VISUAL ASSESSMENT

An experienced and well trained eye can spot many maintenance problems with a timber pile bridge. Color changes in the wood can indicate structural failure. There are several types of corrosion that are visible to the naked eye; such as split, cracked, or crumbling wood. The following visual signs should be noted in the assessment report.

IDENTIFYING DEFECTS

Following are physical properties and defects that can may indicate areas of concern and should be noted and scheduled for future maintenance inspections.

Checks: Separations in the wood that run parallel to the growth rings at the end grain of a bridge member. Checks are considered none structure defects accounted for in the current standards. Only when checks are severe in depth and length should down rating be considered.

Decay at Fasteners: Deterioration found at the holes and cuts used to connect the wood bridge members.

End Grain Decay: Deterioration at the ends of the timber members that extend into the member that is parallel to the wood grain.

Splitting: Damage that extends perpendicular through the board to an adjacent face.

Surface Decay: The exterior of a timber member can deteriorate from various sources including insects, mold, sapwood stains, and microorganisms that feed on wood.

Ultraviolet Degradation: The surface of the wood turns gray from weathering and is not generally considered a significant contributor to timber degradation from a structural point of view.

COMMON TESTING METHODS

There are various methods available to test the wood to identify the specific type of deterioration, if any. Some of these tests are subjective. Other tests use tools that specifically measure the potential source of the deterioration, such as an electronic moisture meter. The best inspection methods are nondestructive testing (NDT) methods that don't cause damage to the structural integrity of the timber member.

PROBING AND PICK TESTS

PROBING

Use a sharp, pointed tool (like an awl) to poke at problem areas identified in the visual inspection. The affected areas are 'soft' spots that indicate decay from fungi or insect damage.

Use an inspection probe to find pockets of decay near the wood's surface. Splinter patterns can also be tested for. You will not be able to easily probe

Repair of warn and damaged timber piles are made in Montana using the patented pile repair system, PileMedic® by QuakeWrap. Repairs are made with minimal service interruption. Photo courtesy of QuakeWrap Inc.

wood that is not decayed. Probing may break the wood. Fibrous breaks are long and they separate from the wood's surface at a distance from the probing tool. Splintering breaks result in splinters that fall right on top of the tool.

PICK

A pick test is a subjective test that requires the inspector to make a judgement on the presence and type of deterioration based on sound. If picking at the wood with a sharp tool (such as flathead screwdriver or pocketknife) results in few (or no) splinters, the sound will be subdued.

MOISTURE MEASUREMENT

Use an electronic hand-held moisture meter to determine the moisture content of a wood member. Two metal pins are driven into the wood. The meter measures the electrical resistance between the pins. Moisture content above 22% provides an environment where decay will begin.

SOUNDING OR BORE SOUNDING

Sounding requires that you strike the surface of the wood with a hammer. If you hear a hollow sound, this indicates a pocket of decay. Solid wood will not sound hollow. Experienced inspectors learn to hear the difference. It is recommended that sounding be used with other testing methods as this has a low accuracy level. Bore sounding involves drilling holes (typically 5/16″) into the timber element and inserting a probe into the hole to measure the

THERE ARE VARIOUS METHODS AVAILABLE TO TEST THE WOOD TO IDENTIFY THE SPECIFIC TYPE OF DETERIORATION, IF ANY. SOME OF THESE TESTS ARE SUBJECTIVE. OTHER TESTS USE TOOLS THAT SPECIFICALLY MEASURE THE POTENTIAL SOURCE OF THE DETERIORATION, SUCH AS AN ELECTRONIC MOISTURE METER. THE BEST INSPECTION METHODS ARE NON-DESTRUCTIVE TESTING (NDT) METHODS THAT DON'T CAUSE DAMAGE TO THE STRUCTURAL INTEGRITY OF THE TIMBER MEMBER.

annulus thickness or size of cavity if one is found. However, this method does not speak to the quality of the wood if no cavities are found. It is typically an out dated method. Long before cavities appear the wood has degraded so significantly that it can't carry any load.

STRESS WAVE TESTING DEVICES

A stress wave device measures how long it takes for stress waves (compression wave) to travel through a wood member. Lousy wood or cavities caused by decay can be found by measuring the velocity of a stress wave traveling through the timber. The stress wave is introduced by striking the member with a hammer which contains one half of a transducer pair, which also starts a timer. When the wave reaches a receiver containing the other half of a transducer pair held on the opposite side of the member, the timer is stopped. The velocity of this wave is related to the Modulus of Elasticity and the density of the timber and can be used to identify where the timber has been degraded by decay. Because this test is non-destructive, it can be used in more locations throughout the bridge. This method also has the advantage that it can detect decay before a cavity has formed.

DRILL RESISTANCE DEVICES

In this test, the resistance needed to drill through a wood member is recorded. Less resistance indicates lower density and likely deterioration. This method is less invasive since the drill bits are small. As well, the cross-section of the drilling location can be accurately defined. It, too, should be used with other testing methods.

CORE SAMPLING

Incremental samples are taken perpendicular from the face of the wood member. Immediately insert a wood plug into test holes. The plug should be treated with a preservative that works as well as the preservative that was originally applied to the sample. Visually inspect the cores for deterioration. They can be sent to a lab for biological and chemical analysis.

GENERAL TIMBER MAINTENANCE

Routine and periodic maintenance goes a long way in reducing the need for timber bridge repair works.

MOISTURE CONTROL

The single most effective way to keep timber healthy is through moisture control. It is best that the timber abutments be placed far from stream banks, where possible. Existing piles that are regularly going through wet and dry cycles should be inspected more often.

Designing connections that do not use vertical fasteners the penetrate the top surface of the elements reduces the moisture content around the fasteners and thus eliminates the decay found.

END GRAIN TREATMENT

Protect the cut ends of the timber members by brushing on a timber treatment firstly Copper Naphthenate in an oil based solvent followed by paraffin wax in a water solution. Other end treatments such as trimming a 'shelf cut' at the ends of caps and cross bracing to allow for a natural drip edge that occurs in the heartwood in solid sawn elements.

IN-PLACE TREATMENTS

There are several types of in-place treatments to prevent deterioration. A few examples include paste, surface treatments, diffusers and fumigants. Pile tops cut to length, end-grain joints, and the area around fasteners should be retreated with a preservative right after installation.

FASTENER MAINTENANCE

Ensure structural fasteners are tight and test them for corrosion. Retighten fasteners as needed. Replace highly corroded fasteners.

MAINTENANCE FOR SUPERSTRUCTURE ELEMENTS

OUTSIDE TIMBER STRINGERS

A timber bridge's outside stringer is more likely to deteriorate as it is highly exposed to rain, sun, and debris flow. In addition to removing dirt and loose decayed material, it is recommended that flashing be installed along the timber stringer. Proper flashing is spaced so air flow around the elements will allow moisture dry out.

MAINTAIN DECK DRAINAGE

Road debris, gravel, and sand can block the bridges' drainage system. Keep the bridge and, where installed, scuppers clear of debris. This allows the water to flow freely off the bridge and ensure it doesn't drip down onto the members (piles) underneath.

MAINTENANCE FOR SUBSTRUCTURE ELEMENTS

REMOVAL OF DEBRIS FROM PILE CAPS

Gaps between the deck boards will allow some debris to fall on top of pile caps. This can trap water against the pile cap and cause it to deteriorate faster. If the debris is not regularly removed, the pile cap can deteriorate enough to compromise the support of the superstructure. Regular maintenance can avoid (or delay) the need to install a new pile cap.

REPAIR SMALL TO MEDIUM CRACKS

Decay fungi can enter untreated shrinkage checks and splits in the wood at the timber pile's core. It is important not to fill shrinkage checks with epoxy. Checks will open and close with moisture cycling through the year. Epoxy will act as a wedge in the check that will split the wood deeper when the moisture cycles down and the wood shrinks. Exposed checks should just be treated with wood preservative preferably that is oil based.

STRENGTHENING AND REHABILITATION OF BRIDGE SUPERSTRUCTURE ELEMENTS

The following are general concepts. The consultant engineer will determine the final design, material specifications, and products to be used for a specific timber bridge. The repairs covered are not an exhaustive list, but those typically used for timber bridge rehabilitation. Deterioration of the superstructure to the superstructure may compromise a bridge's pile strength.

STRENGTHENING OF INDIVIDUAL TIMBER STRINGERS

For minor to moderate deterioration that has weakened the strength of members at the ends of the span, attach using an epoxy high strength fiber panels that increase the shear strength of the member. Alternatively, steel plates can be used but the transfer of forces is lost due to the limitations is connecting the steel to the timber as over time the timber element shrinks and expands resulting in loose bolts. Plane sections don't remain plane.

For additional tensile strength, use timber fish plates, steel plates, or high strength fiber polymers. The high strength fibers can be epoxied onto the existing member resulting in a high load transfer rending the best results. Any added elements should extend out at least two feet from either side of the deteriorated area.

STRENGTHENING AND REHABILITATION OF BRIDGE SUBSTRUCTURE ELEMENTS

There are several repair methods to strengthen timber piles which are described below.

HIGH STRENGTH FIBER WRAPS

Glass fiber wraps can be installed to increase the compressive and bending capacity of a decayed section of pile. The remaining sound wood under the wraps need to be diffused to prevent decay from high moisture under the wraps. Any cavities located should be injected with a high strength epoxy filler.

POSTING NEW SECTION OF PILE

Cut piles below decayed area and install a new section of timber. An adequate pile posting detail includes a vertical shear pin, timber splines and

ROAD DEBRIS, GRAVEL, AND SAND CAN BLOCK THE BRIDGES' DRAINAGE SYSTEM. KEEP THE BRIDGE AND, WHERE INSTALLED, SCUPPERS CLEAR OF DEBRIS. THIS ALLOWS THE WATER TO FLOW FREELY OFF THE BRIDGE AND ENSURE IT DOESN'T DRIP DOWN ONTO THE MEMBERS (PILES) UNDERNEATH.

steel plates at the joint. A hole is drilled in the solid stub for the steel shear pin. The pin is off-center to avoid the through bolts. Once the pin is set, the posting is lowered or slid over existing pile stub. For segment posting this step would be skipped and the pin installed during the following step. Otherwise, the pin would be in the way of sliding in the post. Tapered, vertical slots are cut into the pile for the insertion of wood rotation splines. The splines are glued into the slots using 100% solids, two-part epoxy. Depending on the application and strength capacity required, the pile may be wrapped with high-strength fiber reinforcement at this point. The large steel fish plates are connected to both sections of the pile by using through bolts. This pile posting detail greatly improves the life span of the member, the stability of the joint, and can be designed to increase the original capacity of the substructure.

ADVANCED TIMBER POSTING – HOURGLASS SHAPED PILE

A variation to the pile posting outlined above for piles reduced to an hourglass shape would be the Dutchman's patch. This repair allows the piles to be upgraded and eliminates the need for framing a bent. The Dutchman's patch is an effective solution when a pile is highly degraded on the exterior, but a solid core remains. This is often the case in piles where deterioration is accelerated by erosion or debris impact, when piles have been attacked by marine borers, or the result of debris or vehicle impact. Installing a Dutchman's patch consists of removing the decayed exterior to leave a square core and then installing a prefabricated timber sleeve which fits around the core. One advantage of this solution is the solid core remains intact throughout the process, eliminating the need for temporary shoring and allowing traffic to continue while the repairs take place.

ADDING STEEL CHANNELS TO PILES

This method is appropriate for minor damage up to 18 inches. Attach steel channels to timber pile with bolts or lag bolts. This procedure is often called trussing a pile. The forces required to reinforce a deteriorated pile cannot be developed in the fasteners that attach steel channels to timber piles so alternatively methods such as the ones mentioned above should be utilized.

ADD STEEL SISTERS FOR PILE REINFORCEMENT

Determine the required capacity to bring the pile up to code. Size steel channels to place on each side of the pile. The channel should extend two feet beyond the deteriorated section on each side. Attach the channel with enough bolts of the proper size to the pile. Weld 1x1x1/8-inch angles to the web of the channel equally spaced between the rows of bolts. Notch the pile to accept the angle. Be sure to apply a preservative treatment at trimmed and notched areas. This method is very costly and has large limitations due to the accessibility of the site location.

ADD REINFORCED CONCRETE JACKETS TO PILES

Encasing timber in concrete will elevate the moisture content and thus increase the rate of decay. It is not an effective long term timber pile repair method.

ENCAPSULATION OF PILE GROUPS

With this method the timber piles are trimmed to sound wood and the stubs are encased in a concrete footing (toe beam). It is critical that this keying of the timber pile stubs is done below ground or where the oxygen level will be below the point where decay fungi growth is activated. New timber posts are installed on top of the concrete footing with an air gap to allow the new timber member to naturally breathe and not 'soak' up any moisture from the concrete.

SUMMARY

Regular inspection of timber pile bridges is key in reducing the overall cost of maintenance and repair. As well, proper and careful repairs will ensure that pile bridges remain safe throughout your state. Refer to the images below for typical long term and economical repairs of structural elements in timber bridges.

REGULAR INSPECTION OF TIMBER PILE BRIDGES IS KEY IN REDUCING THE OVERALL COST OF MAINTENANCE AND REPAIR. AS WELL, PROPER AND CAREFUL REPAIRS WILL ENSURE THAT PILE BRIDGES REMAIN SAFE THROUGHOUT YOUR STATE.

Fiber reinforcement on the bottom of stringers.

High strength fiber wrap.