APPENDIX T

Appendix/Attachment Title

Timber Bridge Inspection Guidance (TBIG)

Appendix/Attachment Revision and Year:

Version 1.0, 2024

Appendix/Attachment Introduction and Discussion

The purpose of this guidance is to help promote understanding of materials, inspection techniques, tools, and best practices for inspecting timber bridges. The guidance will help provide understanding of when to use these tools and how to interpret the results.

Appendix/Attachment Description

This guidance is separated into sections as listed below:

- 1.0 Timber Bridge Overview
- 2.0 Timber Inspection Equipment
- 3.0 Typical Timber Defects
- 4.0 Routine Timber Inspection Requirements
- 5.0 In-Depth Timber Inspection (IDTI) Requirements
- 6.0 In-Depth Timber Underwater Inspection (IDTUWI) Requirements
- 7.0 Resistance Drilling and Results
- 8.0 Condition Assessment

Previous timber bridge inspection procedures used in South Carolina are mostly limited to visual inspection of the wood components and sounding with a hammer to confirm suspected damage areas. These techniques have generally been adequate for advanced decay detection but are not adequate when the damage is in the early stage or is located internally in members like piles or bent caps.

Routine inspections have the potential to miss decay or deterioration that is not readily apparent using traditional inspection techniques, which can adversely affect the load capacity and service life of the bridge.

Recently, the industry has seen an increase in the use of advanced inspection techniques for timber bridges. These techniques make use of equipment like resistance drilling. When used by experienced inspectors, this equipment offers the potential to locate and quantify the extent of decay that is present in bridge elements, often before it reaches an advanced stage.

1.0 OVERVIEW

Approximately one-third of the bridge inventory in South Carolina is reported to have wood or timber as a primary superstructure type or a primary substructure type. Additionally, there are numerous structures that may employ timber as a secondary member.

Wood is a natural engineering material that is prone to deterioration caused by decay, fungi, insect attack, and through mechanical damage. Mechanical damage might include broken or damaged wood members or mechanical fasteners. This results in localized deterioration, such as areas of high moisture content, decay of pile caps, and piles. The application of a preservative treatment greatly enhances the durability of timber bridge components, but only inspections and timely repairs via a proactive maintenance program can prolong the life of timber elements on a bridge.

While the guidance in this appendix can be used for timber pile caps, decks, and superstructures, this specific guidance is focused mostly on timber pile bridges. A timber pile bridge is a bridge which contains at least one bent composed of exposed timber piles that are primary load carrying members. It may or may not have a timber bent cap. Bridge with timber piles concealed or buried at end bents or under footings are generally not considered a timber pile bridge unless determined to be one by a BITL. Other circumstances may require a structure to be considered a timber pile bridge and, thus, would subject that bridge to the requirements of this appendix as determined by a BITL.

Figure 1.0 Example of a Timber Pile Bridge (Timber Piles under Reinforced Concrete Cap)

Most timber substructures consist of southern yellow pine that has been treated with creosote. Pile end bents may have timber backwalls and wingwalls that retain the embankment material.

When making assessments, inspectors must also consider the whole structure and site conditions, as there may be clues to condition even in areas not visible. Pile embedment may not be available, but areas of scour and rock outcroppings may provide insight as to the global stability of the substructure unit (bent).

2.0 TIMBER INSPECTION EQUIPMENT

Comprehensive inspection protocols for timber bridges include a wide variety of techniques to assess the in-service condition of wood. The equipment listed in Table 2.0 is recommended for conducting timber inspections. Resistance drilling equipment is available from several manufacturers. All inspectors performing In-Depth Timber Inspections (IDTIs) shall have this equipment in the field during the inspection. This list is meant to be in addition to the standard equipment list presented in Chapter 5 in the BIGD.

Table 2.0 In-Depth Timber Inspection Equipment[1]

General Equipment
Pick Hammer
Awl, Pointed and Flat Probes
Cordless Drill and Drill Set
Resistance Microdrill[2]
Resistance Microdrill Supplies
Silicone Sealant or Marine Adhesive
Extra Batteries
Truck Charger/Inverter

[1] = Equipment required for an In-Depth Timber Underwater Inspection (IDTUWI) may be similar. The BITL shall confirm that appropriate equipment is on-site prior to the start of diving.

[2] = The BITL shall confirm that the resistance drill used for in-depth timber bridge inspections is appropriate for the drilling required.

3.0 TYPICAL TIMBER DEFECTS

3.1 Decay

It is important to assess the presence of decay using hammers and resistance microdrills to determine the actual cross-section and location of both sound and deteriorated material. Decay or deterioration in timber substructures can potentially control the load rating of the bridge (see LRGD). Because of the variability of timber substructures, such as cap dimensions, pile diameter, and pile spacing, decay or deterioration can have a large impact on the capacity of the bridge depending on whether it occurs in an exterior or interior pile, the pile cap, or any combination therein. Special attention should be focused on any steel connections (such as cross bracing connections) and looking for evidence of decay in timber adjacent to the connections. Decay is further discussed in the remaining chapters of this appendix. Other possible defects that may impact timber bridge members are included below.

Figure 3.1 Failed timber pile due to internal decay of the pile at a cross-frame through bolt.

3.2 Fruiting Bodies

Although they do not indicate the amount or extent of decay, fruiting bodies provide a positive indication of fungal attack. Some fungi produce fruiting bodies after small amounts of decay have occurred while others develop only after decay is extensive. The presence of fruiting bodies indicates the possibility of a serious decay problem. The presence of decay fungi and fruiting bodies indicate that the member has a high moisture content. If BITL requires moisture content testing of timber piles, it can be requested as a testing method.

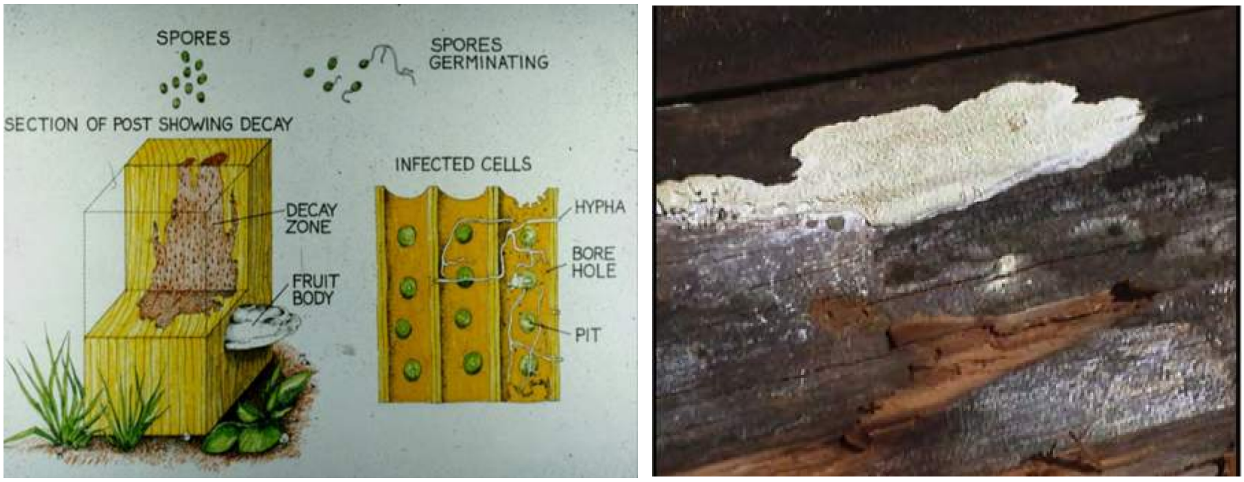


Figure 3.2 Diagram and image of fruiting body on the surface in addition to visual evidence of decayed timber. (Diagram reference from USDA Forest Service)

3.3 Sunken Faces or Localized Collapse

Sunken faces or localized surface depressions can indicate underlying decay. Decay voids or pockets may develop close to the surface of the member, leaving a relatively thin, depressed layer of intact or partially intact wood at the surface. Crushed wood can also be an indicator of decay.

Figure 3.3 Localized collapse of a timber bent cap.

3.4 Staining or Discoloration

Staining or discoloration of wood indicates that the wood has been subjected to water and potentially has high moisture content, making it susceptible to decay. Rust stains from connection hardware are also an indication of areas of moisture exposure.

Figure 3.4 Water staining and discoloration caused by water that infiltrated through the wearing surface.

3.5 Insect or Animal Activity

Insect activity is often identified by the presence of holes, frass, and powderpost beetles. For wood boring insects like carpenter ants, frass is defined as the mix of insect excrement and excavated wood material from timber members where they are active. The presence of insects may also indicate the presence of decay, as carpenter ants often create tunnels and nests in decay cavities. Carpenter ants deposit sawdust in gallery openings, trapping moisture and increasing the rate of decay of an element. In addition to insects, birds often nest under bridge decks, where the nests may trap moisture against a timber element and potentially increase the moisture content, resulting in localized decay.

3.6 Plant or Moss Growth

Plant or moss growth in splits and cracks, or soil accumulation on the structure, indicates that adjacent wood has been at a relatively high moisture content for a sustained period and may be susceptible to the growth of decay fungi.

3.7 Check and Splits

Timber members are susceptible to drying and weathering, which often result in surface and deep surface checks, ring shake, end checks, and through splits. Checks and splits in members can indicate a weakened member and create an entry for moisture to enter the element. If a check or split develops to a sufficient depth, the inner untreated wood is susceptible to moisture and decay fungi. This will create conditions that can result in severe decay and premature deterioration of a timber bridge element. Severe splits in timber end bent caps often lead to severe decay and should be thoroughly evaluated.

Figure 3.7 Timber members showing various types of deterioration. Top left shows ring shake. Top right shows severe through splits. Bottom picture is of a long horizontal split provides an opportunity for moisture passing through the timber deck to enter the cap, leading to substantial decay.

3.8 Weathering or Impact Damage

Frequently, weathering and aging of bridge elements has an impact on the performance and durability of timber bridges. This occurs with both the timber and the non-timber materials on the bridge, like bituminous or other wearing courses. Deterioration and cracking frequently occur above the timber end bents where the approach roadway meets the bridge panels, which are supported by the end bent.

Other natural weathering damage occurs to timber piles exposed to water and materials flowing down the river or stream. This can affect the structural performance both through loss of cross-section and the removal of the preservative treatment.

Additional damage to timber bridge components can be caused by impact from vehicle or boat traffic. Flotsam such as trees and logs can also damage timber substructures during high flow rates associated with heavy rain events or seasons.

Figure 3.8 Shell damage to timber piling at or near the water line or at the pile cap, often caused by construction damage (left photo) or debris floating down the waterway at the waterline (right photo).

3.9 Miscellaneous Conditions

During inspections of timber bridge elements, there are other conditions that need to be further explored using the full combination of inspection and assessment techniques. These conditions can include the rotation or misalignment of timber bents and end bents caused by the loss of fill behind the end bent backwall or by some other mechanism. A second significant condition is the build-up of road materials like gravel or sand that hold moisture in contact with structural timber elements.

Figure 3.9 Severe misalignment of the timber pile and timber pile cap.

4.0 ROUTINE TIMBER INSPECTION REQUIREMENTS

The simplest method for locating deterioration is visual inspection. An inspector observes bridge elements for signs of actual or potential deterioration, noting areas that require further investigation. When assessing the condition of a timber pile, visual inspection should never be the sole method used. All timber piles require sounding. Visual inspection requires strong light and is useful for detecting intermediate or advanced surface decay, water damage, mechanical damage, or failed members. Visual inspection cannot detect early-stage decay when remedial treatment is most effective. A visual inspection should focus on identifying, and assessing the extent of, the signs of deterioration examples of which are listed in Section 3.0.

Based on visual signs of deterioration, hammer sounding (on all timber piles) and probing (when required) are used in combination with visual inspection to conduct an assessment of the condition of a member. The underlying premise for such tests is that degraded wood is relatively soft and might sound hollow, with low resistance to penetration. The exposed length of every timber pile will be sounded during the routine inspection. The inspectors should take care to assess the condition of the through bolts and other connections and the timber around the through bolts and other connections. Based on the height of some piles, the inspectors will ensure that appropriate access equipment such as ladders, UBITs, or other aerial lifts are in place for the inspection.

Based on the sound quality or surface condition, an inspector can identify areas of concern for further investigation. Deteriorated areas typically have a hollow or dull sound that may indicate internal decay. A pick hammer, commonly used by geologists, is recommended for use because it allows inspectors to combine the use of sound and the pick end to probe the element.

Probing with a moderately pointed tool, such as an awl, locates decay near the wood surface. This is indicated by excessive softness or a lack of resistance to probe penetration and the breakage pattern of the splinters. A brash break indicates decayed wood, whereas a splintered break reveals sound wood. Although probing is a simple inspection method, experience is required to interpret results. Care must be taken to differentiate between decay and water-softened wood that may be sound but somewhat softer than dry wood. It is also sometimes difficult to assess damage in soft-textured woods. Probes can also be used to assess the depth of splits and checks in timber bridge elements. Flat bladed probes are recommended for use in this process. Using the right tool for investigation or for defects at the surface or other use of the appropriate advanced technique is also important to understand the impact of checks and cracks on the timber bridge element. Deeper investigations shall be done by resistance drilling, see Section 7.0.

5.0 IN-DEPTH TIMBER INSPECTION (IDTI) REQUIREMENTS

A timber pile bridge shall receive an In-Depth Timber Inspection (IDTI) according to the intervals listed in Table 5.0. A BITL may recommend a shorter interval for the inspection. IDTIs shall be considered a type of In-Depth Inspection per the NBIS. IDTIs may be performed in conjunction with other inspection types. The interval for the IDTIs can be controlled by the Substructure General Condition Rating (GCR) (NBI 60/SNBI B.C.03) or be controlled by the condition state of a pile.

Table 5.0 In-Depth Timber Inspection (IDTI) Interval

NBI 60 / SNBI B.C. 03 (Substructure Condition)	Any Timber Pile in Condition State[1]	Maximum In-Depth Timber Inspection Interval
9, 8, 7 and 6	CS1 and CS2	72 Months (6 Years)
5	CS3	24 Months (2 Years)
4, 3, 2 and 1	CS4	12 Months (1 Year)

[1] = As coded by the routine inspection (i.e. defects above water).

All requirements from a Routine Inspection (Section 4.0) shall be followed. In addition, inspectors shall perform the following in-depth exercises during an IDTI:

- Dig around the base of timber piles on land for a minimum of 12” to examine for hidden defect(s),
- Sound each through bolt and perform a hands-on inspection of the bolt (if any),

- Sound the timber around each bolt (above, below and on each side of the bolt on each face of the pile) and,
- If the controlling defect on the pile is decay (Defect 1140), resistance drill one (1) location on one timber pile on each bent for timber piles listed as CS3 or CS4. If results are unexpected, drilling may be warranted on a maximum of one (1) additional pile in that bent.

6.0 IN-DEPTH TIMBER UNDERWATER INSPECTION (IDTUWI) REQUIREMENTS

Timber piles are already inspected with advanced techniques during underwater inspections as required by the BIGD; an underwater bridge inspection includes a 100% FHWA Level I inspection and a 10% FHWA Level II inspection. It may also include additional FHWA Level II inspections and FHWA Level III inspections if included in a BSIP.

A timber pile bridge shall receive an In-Depth Timber Underwater Inspection (IDTUWI) according to the intervals listed in Table 6.0. An UW BITL may recommend a shorter interval for the inspection. IDTUWIs shall be considered a type of In-Depth Inspection per the NBIS. IDTUWIs may be performed in conjunction with underwater inspections. The interval for the IDTUWIs can be controlled by the Underwater Inspection Condition Rating (SNBI 600/SNBI B.C.15) or be controlled by the condition state of a single pile.

Table 6.0 In-Depth Timber Underwater Inspection (IDTUWI) Interval

SBI 600 / SNBI B.C. 15 (Underwater Inspection Condition)	Any Timber Pile in Condition State[1]	Maximum In-Depth Timber Inspection Interval
9, 8, 7 and 6	CS1 and CS2	Not Needed
5	CS3	60 Months (5 Years)
4, 3, 2 and 1	CS4	24 Months (2 Years)

[1] = As coded by the underwater inspection (i.e. defects below water).

All requirements from an Underwater Inspection (see Chapter 5 of the BIGD) shall be followed. In addition, inspectors shall perform the following in-depth exercises during an IDTUWI:

- Perform a FHWA Level II inspection on 50% of underwater timber pile elements,
- Sound each through bolt and perform a hands-on inspection of the bolt (if any),
- Sound the timber around each bolt (if any) (above, below and on each side of the bolt on each face of the pile) and,
- If the controlling defect on the pile is decay (Defect 1140), resistance drill one (1) location on one timber pile on each bent for timber piles listed as CS3 or CS4 (FHWA Level III Inspection). If results are unexpected, drilling may be warranted on a maximum of one (1) additional pile in that bent.

7.0 RESISTANCE DRILLING AND RESULTS

7.1 Use of a Resistance Drill

The resistance drill was originally developed in the 1980s for use by arborists and tree care professionals to assess tree rings, evaluate the condition of urban trees and locate voids and decay. This technology is now being utilized to identify and quantify decay, voids, and termite galleries in wood beams, columns, poles, and piles. This technique is now the preferred drilling and coring technique for timber elements.

The resistance drill equipment measures the resistance of wood members to a drill bit that passes through them. This drill bit travels through the member at a defined movement rate and generates information that allows an inspector to determine the exact location and extent of the damaged area. While the unit is usually drilled into a member in a perpendicular direction to the surface, it is also possible to drill into members at an angle.

Resistance drills collect the data electronically or produce a chart or printout showing the relative resistance over its drilling path. Modern tools are also promoting the ability to view the data on a tablet, computer, or phone. Areas of sound wood have varying levels of resistance depending on the density of the species and voids show no resistance. The inspector can determine areas of low, mild, and high levels of decay with this tool, and quantify the level of decay in the cross-section. All holes shall be filled after drilling by injecting a small amount of silicone sealant or marine adhesive into the drill hole. The location of drilling shall be field marked and photographed.

Figure 7.1 In field use of a resistance drill (left photo) and the field marking of a timber pile that has been drilled (right photo).

7.2 Drilling Locations

The BITL shall determine which locations on each timber pile are drilled. The BITL shall also review any drilling previous performed on the bridge. If the pile has previously been drilled and no or minimal defects have been noticed, a different pile should be selected for the current inspection. If decay is noted on the pile, the general area of the decay should be drilled again.

If inspectors are drilling with a resistance drill in a single pile during a single inspection, they are not required to notify the DBIS. If more extensive drilling per pile or per bent is required, the DBIS shall be notified and the inspector is required to get approval before more extensive drilling per pile is performed.

7.3 Interpreting Resistance Drill Data Charts

Review of the charts or printouts shall be conducted in the field and notes taken to ensure understanding of the testing location. It is recommended that notes be taken on a graphical data chart. Photos shall be taken of the core location on the timber member (general photo and close up photo) and of the charts or printouts as a form of backup. Care should be exercised to ensure that low profiles from intact but soft, low-density wood (such as conifers), not necessarily be misinterpreted as decay. It is also known that the very center of softwood species near the pith will have low resistance and lack the defined growth rings visible in the outer sections. It is also important to understand the type of wood that is being drilled. Sound wood from many hardwood species may have high levels of resistance over 50%, while sound wood from softwood conifers may have low levels of resistance in the range of 15-50+%, depending on its inherent density. It is important to evaluate the levels of decay across the full dimension, as some species have low resistance values, but are not decayed. Further, each piece of commercial equipment provides different scales and may have different resistance levels. Table 6.3 shows a general assessment rating index that can provide support for the bridge inspector in evaluating the resistance data collected during testing.

Table 7.3 General Assessment of Resistance Drilling Data (Southern Pine)

Drilling Resistance	Decay Level	Comments
0%	Severe	Decay resulting in an internal void
5-15%	Moderate	Often adjacent to the internal void areas.
20+%	Low to None	Sound material will have resistance that is often consistent across the full width.

Note: This data must be carefully interpreted by the BITL since there are differences between commercial equipment.

Printouts of drill data charts shall be included in both the inspection report and shall be uploaded to the 6 – Testing Folder of the Bridge File.

8.0 CONDITION ASSESSMENT

8.1 Element Guidance

A bridge inspection includes examining the structure, evaluating the physical condition of the structure, and reporting the observations and evaluations on the bridge inspection report. The information presented in this Appendix is not meant to replace, but rather to supplement the guidance, procedures, and protocols specified in the BIGD and its Technical Notes. In the event of a conflict related to the inspection of timber members, this Appendix shall supersede previous guidance and be considered the updated SCDOT TBIG.

Specific definitions for AASHTO Condition State Definitions should be utilized as published by AASHTO and SCDOT. Those criteria should be used in combination with this guidance. AASHTO provides specific information on the four standard condition states: good, fair, poor, and severe. Further, AASHTO recommends the following set of actions for each condition state as noted during required inspections for timber elements as noted in Table 8.1.1.

Table 8.1.1 Actions for AASHTO Condition States

	Condition State 1	Condition State 2	Condition State 3	Condition State 4
Feasible Actions	**Good**	**Fair**	**Poor**	**Severe**
	Do Nothing	Do Nothing	Do Nothing	Do Nothing[1]
	Protect	Protect	Protect	Protect
		Repair	Repair	Repair
			Rehabilitate	Rehabilitate
			Replace	Replace

1 – While no field work may be required, at a minimum, a structural evaluation (load rating) must be performed by a load rating engineer for a timber pile in CS4.

Typically, piles in CS3 should be protected or repaired, or in some cases, replaced. Typically, piles in CS4 should be repaired or replaced. Any pile requiring a structural review to determine strength or serviceability shall be rated as CS4 in accordance with the *MBEI*.

If a pile has been replaced or if a pile has received a repair equal to the original pile, then it shall be coded as CS1.

If a pile has received a structural repair and if the inspector determines the pile repair is not considered equal to the original member and can be coded as fair, then it shall be coded as CS2. The repairs may include structural pile jackets. While the capacity may have been improved, its lifespan likely remains shortened.

If a pile has been slightly repaired to improve the element, but the repaired state is not considered equal to the original, the pile shall be coded as CS3. These repairs may include pile splices or stud-up repairs. If the repair has not improved the element, it should be coded as either CS3 or CS4 depending on the degree of deterioration.

Timber Trestle #208
A bridge structure with framed timber supports that consist of beam or truss spans supported by bents, which are typically timber.

Timber Column #206
This is a general term that applies to a member resisting compressive stress and having a considerable length in compression as compared to its transverse dimensions.

Timber Pier #212
This element includes pile, timber sheet material and filler.

Timber Pier Cap #235
A sawn or glulam member placed horizontally on an end bent or bent to distribute and transfer load into piles or columns.

Timber Abutment #216
Timber end bents includes the sheet material retaining the embankment, integral wingwalls, and abutment extensions.

Timber Pile Bent Cross-Bracing #879
Linear footage of cross-bracing present on a timber pile bent.

Timber Piles

- **Timber Pile #228**
  These elements are typically pole-like members that are driven into the earth through weak material to provide a secure foundation for bridges built on soft, wet, or submerged sites. Areas to be inspected may be above and/or below the water line.

- **Existing Timber Pile under Crutch #870**
  Timber piles which are in-place but there is a crutch beam or crutch bent which is supporting the majority of the superstructure load.

- **Stubbed or Spliced Timber Pile #872**
  A portion of the timber pile is encased in concrete or is spliced.

- **Wrapped Timber Pile #874**
  A portion of the timber pile is wrapped in a material to prevent further deterioration.

- **Structurally Repaired Reinforced Pile (Rebar) #876**
  A pile structurally rehabilitated with reinforcing steel.

Timber Piles (continued)

- **Structurally Repaired Reinforced Pile (FRP) #877**
  A pile structurally rehabilitated with fiber reinforced polymer.

- **Structurally Repaired Reinforced Pile (Other) #878**
  A pile structurally rehabilitated with other materials (not reinforcing steel and not FRP).

Table 8.1.2 Condition State Definitions for Timber Substructure

Repair Recommendations (General Recommended Action)	*No repairs are present.*	*Existing repair in sound condition.*[1]	*Repairs are recommended* ***OR*** *Existing repair unsound.*[1,2]	*Critical Finding* ***OR*** *Repairs are recommended.*[2]
Actions and Defects	**Condition State 1**[1]	**Condition State 2**	**Condition State 3**	**Condition State 4**
	Good	**Fair**	**Poor**	**Severe**
Decay/Section Loss (including fire/damage) (1140)	None	Affects portion of the member cross-section. No crushing or sagging.	Affects some of the member cross-section. Minor crushing or sagging.	Affects most of member cross-section. Significant crushing or sagging.
Bent/Pile Misalignment (9001)	None	Slightly misaligned.	Significantly misaligned.	Severely misaligned.
Check/Shake (1150)	Penetrates less than 5% of member thickness.	Penetrates 5% - 50% of the member thickness; not in a tension zone.	Penetrates more than 50% of the member thickness or >5% of the member thickness in a tension zone.	Penetrates through entire member or more than 25% of the member thickness in a tension zone.
Crack (1160)	None	Crack or partial fracture that has been arrested.	Crack or partial fracture that has not been arrested.	Severe crack or fractured member.
Splits (1170)	None	Length less than the member depth or arrested with effective actions taken to mitigate.	Length greater than the member depth and does not require structural review.	Severe split.
Settlement (9002)	None	Within tolerable limits or arrested (no distress).	Exceeds tolerable limits.	Stability of element has been reduced.
Scour (6000)	None	Within tolerable limits or counter-measures installed.	Exceeds tolerable limits but less than critical scour limits.	Exceeds the critical scour limits.
Damage (7000)	Not applicable.	The element has minor damage.	The element has moderate damage.	The element has severe damage caused by impact.
Through Bolt Connection (9002)	Connection in-place and functioning as intended.	Loose fasteners, connection is in-place and functioning as intended.	Missing fasteners; broken welds; or pack rust with distortion. Connection is distressed.	Connection has failed (or failure is eminent).

Notes:

[1] = Repaired timber piles are quantified and assessed using Agency Defined Elements (ADEs). Inspectors shall not use Element #228 for repaired timber piles. Quantities for ADEs will be reported to FHWA as Element #228 since it is the only National Bridge Element (NBE) for timber piles. See language in Section 8.1 for additional guidance.

[2] = Piles with maintenance requests shall be coded in CS3 (Poor) or CS4 (Severe). Piles with a Critical Finding or an "A Flag" shall be reported as pile in CS4. Piles with a "B Flag" or a "C Flag" shall be reported as pile in CS3.

8.2 Assessment Considerations

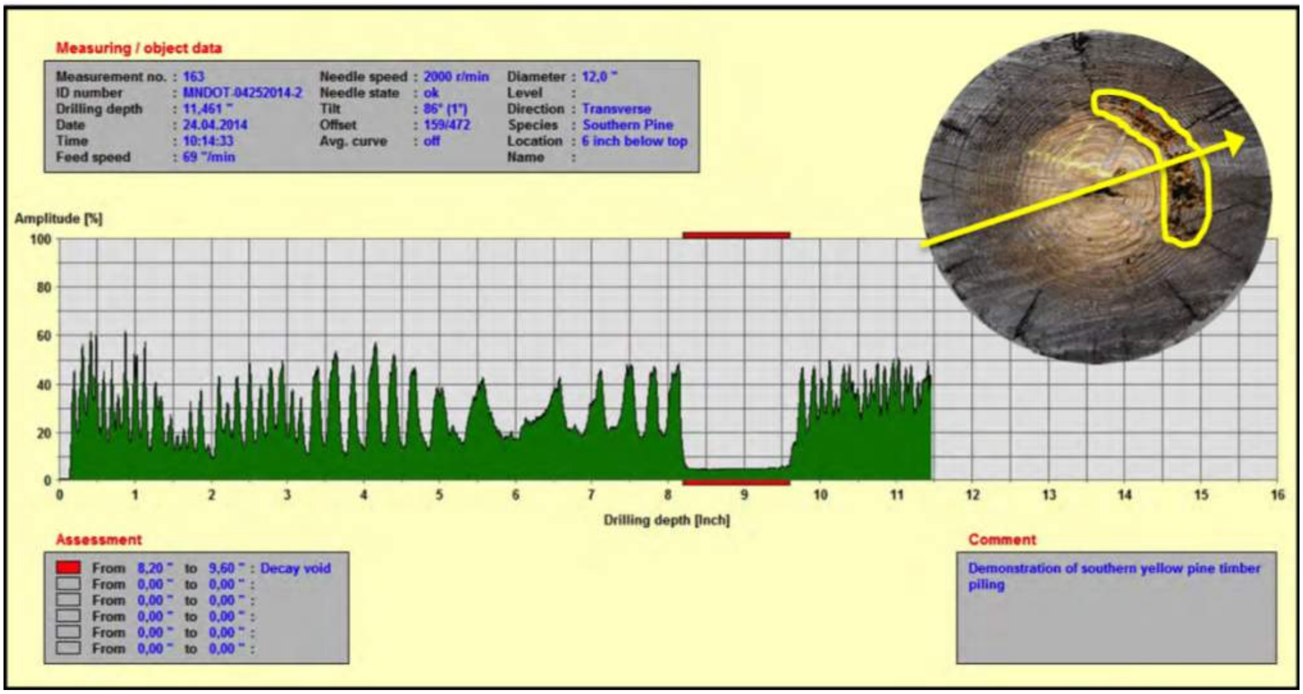
The use of inspection equipment can provide additional information to the definitions provided by AASHTO and SCDOT. It is important to determine the extent and depth of severe cracks using flat bladed probes or feeler gauges. It is important to assess the presence of decay using hammer picks or resistance microdrills to determine the actual cross-section and location of both sound and deteriorated material.

Because of the variability of timber substructures, such as cap dimensions, pile diameter, and pile spacing, decay or deterioration can have a large impact on the capacity of the bridge depending on whether it occurs in an exterior or interior pile, the pile cap, or any combination therein.

When using resistance drilling to determine pile decay (or section loss from fire or damage), inspectors shall drill across the diameter of the pile and determine the approximate length of decay. To determine the decay percentage, inspectors shall use the pile diameter and use the formula below.

$$Percent\ Decay = \frac{Length\ of\ Measured\ Decay}{Diameter\ of\ Decayed\ Pile} \times 100\%$$

Bridge inspectors are to consider both moderate and severe decay (per Table 7.3) as decay when determining the percent decay. Load rating engineers may consider moderate (or partial) decay by engineering judgement to more acurately determine the remaining pile capacity when performing a load rating on a timber member.



Measuring / object data

Measurement no.	: 163	Needle speed	: 2000 r/min	Diameter	: 12,0 "
ID number	: MNDOT-04252014-2	Needle state	: ok	Level	:
Drilling depth	: 11,461 "	Tilt	: 86° (1°)	Direction	: Transverse
Date	: 24.04.2014	Offset	: 159/472	Species	: Southern Pine
Time	: 10:14:33	Avg. curve	: off	Location	: 6 inch below top
Feed speed	: 69 "/min			Name	:

Assessment

🟥 From 8,20 " to 9,60 " : Decay void
☐ From 0,00 " to 0,00 " :
☐ From 0,00 " to 0,00 " :
☐ From 0,00 " to 0,00 " :
☐ From 0,00 " to 0,00 " :
☐ From 0,00 " to 0,00 " :

Comment

Demonstration of southern yellow pine timber piling

$$Percent\ Decay = \frac{Length\ of\ Measured\ Decay}{Diameter\ of\ Decayed\ Pile} \times 100\% = \frac{2\ inches}{12\ inches} \times 100\% = \mathbf{17}\%$$

Figure 8.2.1 Electronic view of a southern yellow pine timber piling showing a decay pocket between 8 and 10 inches of the drilling profile.

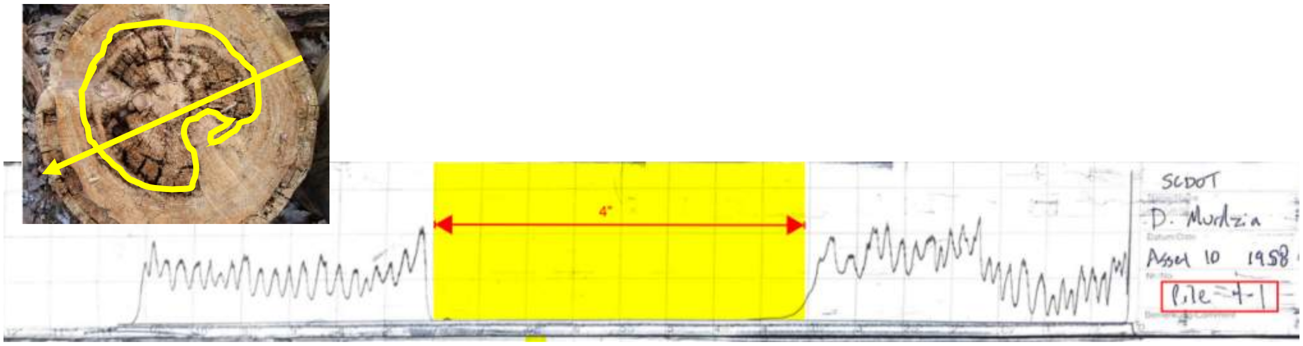


Figure 8.2.2 Paper copy (quiver tool) view of a southern yellow pine timber piling showing a decay pocket between 3.5 and 7.5 inches of the drilling profile.

$$Percent\ Decay = \frac{Length\ of\ Measured\ Decay}{Diameter\ of\ Decayed\ Pile} \times 100\% = \frac{4\ inches}{12\ inches} \times 100\% = \mathbf{33}\%$$

Figure O.3 in Appendix O shall be used to determine repair recommendations for a bent with 4 or more piles.

Figure O.4 in Appendix O shall be used to determine repair recommendations for a split cap bent.

Substructure members that do not conform to criteria in Appendix O Figure O.3 and Figure O.4 shall be assessed by the BITL according to this document and other AASHTO/SCDOT documentation.

8.3 Considerations for Timber Cross Bracing

Timber piles shall be supported with cross-bracing based on the recommendations in Tables 8.3.1 and 8.3.2. If bracing is missing, a Priority B “B Flag” shall be submitted by the BITL. Cross-bracing should be visually inspected and sounded if a defect is visually detected. Drilling or advance techniques are not required on the cross-bracing and the member should be recommended for replacement if in CS4 (Element #879).

10” piles or smaller lose capacity quickly under the conditions of either section loss or pile decay. The combination of either of these factors could warrant a Critical Finding as determined by the BITL.

Table 8.3.1 Unbraced Pile Height Recommendations (15’ Span Slab Bridge)

15’ Span Precast Reinforced Concrete Slab Bridge			
Timber Pile Diameter	10”	11”	12” +
Maximum Recommended Unbraced Pile Height	13 feet	15 feet	18 feet

Note: Recommendations are based on an average asphalt thickness of 2.5”. Unbraced pile heights should be reduced by one (1) foot if asphalt thickness exceeds 5”.

Table 8.3.2 Unbraced Pile Height Recommendations (30’ Span Channel Beam Bridge)

30’ Span Prestressed Concrete Channel Beam Bridge			
Timber Pile Diameter	10”	11”	12” +
Maximum Recommended Unbraced Pile Height	10 feet	12 feet	15 feet

Note: Recommendations are based on an average asphalt thickness of 2.5”. Unbraced pile heights should be reduced by one (1) foot if asphalt thickness exceeds 5”.