



State Aid Bridge

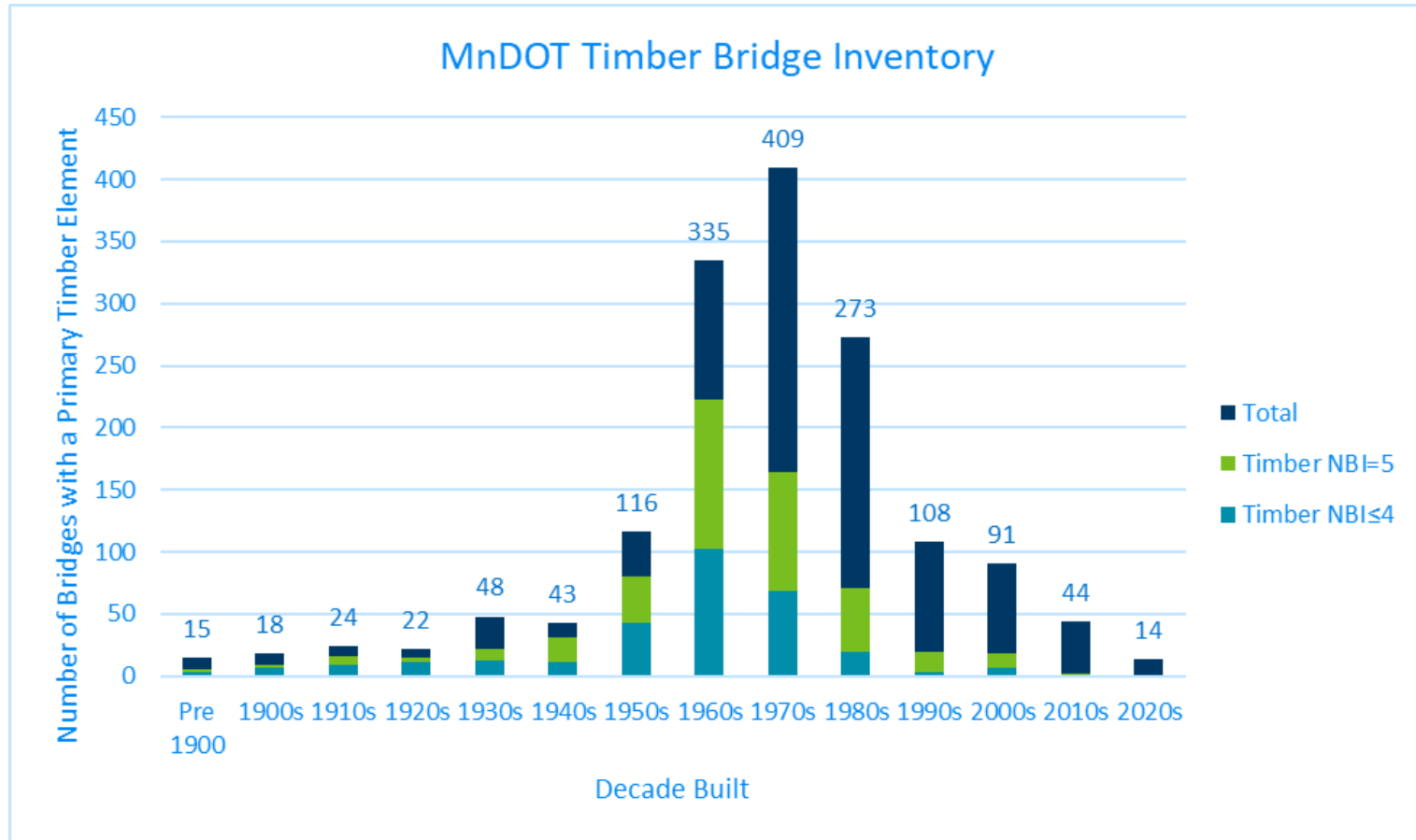
Timber Bridge Inspection

Presentation Overview

- Common timber bridge issues
- Critical inspection locations
- State Aid's risk mitigation efforts
- Common repairs and maintenance
- Best practices and lessons learned



Timber Bridge Inventory Status



Partial Collapse (2022)



Common Issues

Visible

- Splits/Checks/Shakes
- Member Distortion/Damage
- Abrasion/Weathering
- Staining/Fungus/Plant Growth

Invisible

- Internal Rot/Decay

Loading

- Extra Load (Wearing Course)
- Compromised Load Path



Internal Rot and Decay

Dissection of a Cap Removed from Service

Solid Section

1/2"-1" Creosote Penetration



Severe Decay

Outer shell relatively intact



Internal Rot and Decay

Dissection of a Cap Removed from Service



- Large checks allowed moisture to penetrate past creosote layer
- Cap rotted from inside out
- Section loss not visible from the exterior
- Utilize advanced inspection techniques
- Follow the water

Critical Inspection Locations: Pier Caps

- Points of bearing
- Connections
- Cap ends
- Look for checking, splitting, staining, discoloration, crushing, saturation, fungus, vegetation, etc.



Critical Inspection Locations: Piling

- Water/ground line
- Bracing locations
- Points of connection
- Top of pile

- Look for abrasion, misalignment, checking, splitting, discoloration, crushing, saturation, fungus, vegetation, etc.



Critical Inspection Locations: Below Joints / Gaps in Deck

These photos are from the same bridge



Critical Inspection Locations: Highly Stressed Areas

- Midspan for flexure (simple spans)
- Within member depth from bearing for shear
- Member end for bearing
- Interfaces between members



Critical Inspection Locations: Misalignment



Critical Inspection Locations: Loose Connections / Corrosion



Follow water!



Risk Mitigation

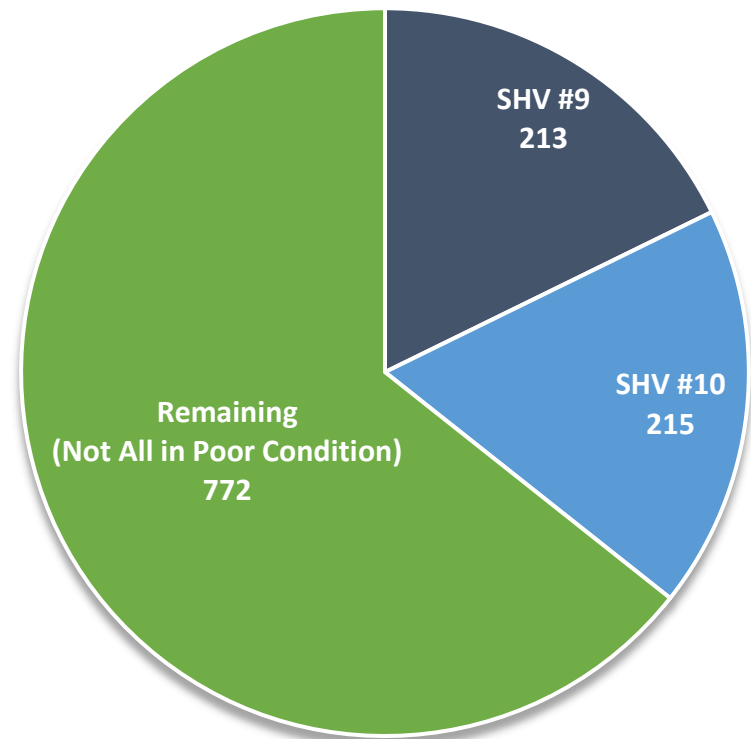
- SHV Load Rating contracts
 - Present/future focus on timber substructures
 - In-depth inspections
- Advanced Timber Bridge Inspection Manual update
- Use of advanced inspection techniques during routine inspections
- Statewide training



SHV Load Rating Outlook

- Previously focused on superstructures
- Superstructures are lasting longer than timber substructures
- New focus on timber, particularly substructures and in-depth inspections
- SHV #9
 - 493 bridges -> 213 timber
 - 15 closed due to timber substructures
 - 169 posted bridges (majority timber)

TIMBER SUBSTRUCTURE INVENTORY (1200 TOTAL)



SHV Load Rating #10 - 2026/2027

- Start Spring 2026
- ~500 bridges
- Focus on timber
 - Piles and pile caps



Contact Moises for specific rating requests:

Moises.Dimaculangan@state.mn.us

Advanced Timber Bridge Inspection Manual Update

Advanced Timber Bridge Inspection

Field Manual for Inspection of
Minnesota Timber Bridges

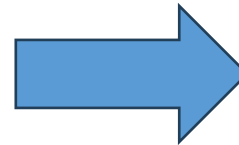
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Advanced Timber Bridge Inspection Manual Supplement

Final Document

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Timber Manual Supplement Contents

- Advanced Timber Inspection Equipment
- Inspection Procedures
- Inspection Documentation
- Revisions to Structural Element Condition Ratings
- Timber Element Load Ratings

Table of Contents	
Chapter 1: Introduction	6
1.1 Purpose	6
1.2 Executive Summary of Manual Supplement	7
Chapter 2: Advanced Timber Inspection Equipment	8
2.1 Common/Available Advanced Timber Inspection Equipment	8
2.1.1 Moisture Meter	14
2.1.2 Stress Wave Timer	20
2.1.3 Timber Resistance Microdrill	21
2.2 How to Request Equipment	21
Chapter 3: Inspection Procedures	22
3.1 General Methodology	22
3.2 Recommended Advanced Timber Inspection Frequency	22
3.3 Site Access	23
3.3.1 Preferred Time of Year for Inspections	23
3.3.2 Equipment	23
3.4 Critical Elements and Areas for Inspection	25
3.4.1 Piles	27
3.4.2 Pile Caps	28
3.4.3 Superstructure: Beams, Slabs and Decks	30
3.4.4 Culverts	30
Chapter 4: Inspection Documentation	30
4.1 Minimum Data Collection	30
4.2 Standardized Reporting Format	36
4.3 Importing Information into SIMS	36

4.4 Example Forms	36
Chapter 5: Revisions to Structural Element Condition Ratings	37
5.1 MnDOT Bridge Condition Ratings	37
5.2 Revised Structural Element Condition Ratings	38
5.3 Revised Timber Element Condition Ratings	49
5.4 Revised Timber Element Load Ratings	49
5.5 Revised Timber Element Inspection Procedures	50
5.6 Revised Timber Element Inspection Documentation	50
5.7 Revised Timber Element Inspection Equipment	51
5.8 Revised Timber Element Inspection Frequency	51
5.9 Revised Timber Element Inspection Site Access	51

4.1 Minimum Data Collection	30
4.2 Standardized Reporting Format	36
4.3 Importing Information into SIMS	36

Advanced Timber Inspection Equipment

Moisture Meter



VISUAL PROCEDURES

Turn on Deimhorst moisture meter

Press the cal check button

Use the Temp. button to select the testing temperature

Meter and slide hammers

Species button







Take reading and record on data sheet

A series of six images illustrating the visual procedures for using the Deimhorst moisture meter. The images are arranged in a grid. The top row shows the meter with the 'ON' button highlighted by a red arrow. The second row shows the 'CAL CHECK' button highlighted. The third row shows the 'TEMP.' button highlighted. The fourth row shows the 'SPECIES' button highlighted. The fifth row shows the meter and two slide hammers. The sixth row shows the meter with a reading on the screen and a red arrow pointing to the 'CAL CHECK' button.

Advanced Timber Inspection Equipment

Stress Wave Timer




VISUAL PROCEDURES	
 <p>Fakopp should be stored with all parts in durable case.</p>	 <p>Cap testing can be done in either the vertical or transverse direction. Start at midline near ends or areas of concern.</p>
 <p>Hold down reset button when turning on.</p> <p>Red/Start</p>	
<p>Insert probes across from each other in same plane.</p>	<p>Typical areas of concern are below the cap, at water line and slightly below water line. Waterproof transducers are available.</p>
	

Advanced Timber Inspection Equipment


Timber Resistance Microdrill




VISUAL PROCEDURES




IML PD and Case




Install battery by sliding it forward




Turn on the unit




Main menu allows changes to made




Press the red button to start drilling



Visually inspect drill tip after each drill.



Silicone Should be used to fill the tiny hole.



Press the drill firmly against the member, and press the start trigger, hold firmly until the drill reverses the bit out

Timber Bridge Inspection Procedures



Establish naming convention

Measure geometry

Visual inspection, sounding & probing

BASIC



Take Moisture meter readings at areas of high compression



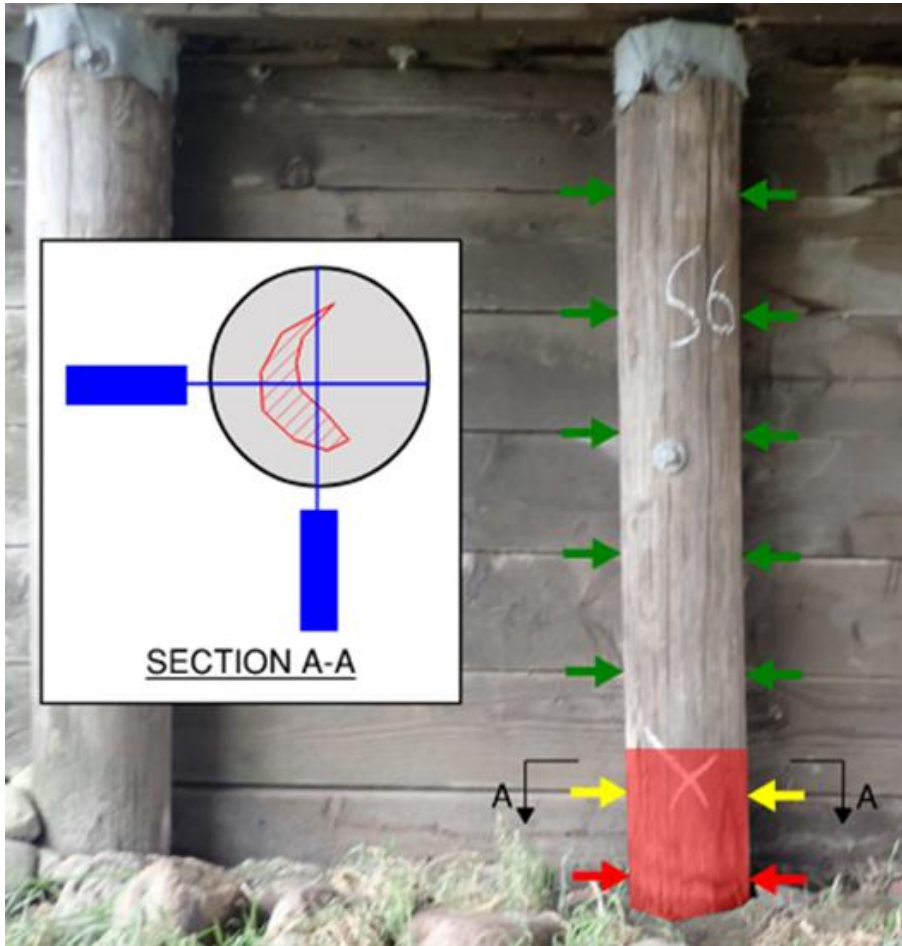
Perform stress wave timing at regular intervals along element



Perform timber resistance drilling at decayed areas indicated by stress wave timing/basic inspection

ADVANCED

Advanced Timber Inspection Example



- Arrows represent stress wave timing locations
- Drill locations with deterioration as indicated by stress wave timing (yellow and red arrows)
- Approximate section loss in red area based on drill records

Advanced Timber Inspection Frequency

Substructure Condition	Recommended Advanced Timber Inspection Frequency
Structural Elements in CS1 and Substructure SNBI ≥ 5	Perform advanced inspection on CS1 elements every 48-72 months.
Structural Elements in CS2 and Substructure SNBI ≥ 5	Perform advanced inspection on CS2 elements every 48 months.
Structural Elements in CS3 and Substructure SNBI ≥ 5	Perform advanced inspection on CS3 elements every 24 months.
Structural Elements in CS4 or Substructure SNBI ≤ 4	Perform advanced inspection on CS4 elements or elements responsible for SNBI rating every 12 months.

Inspection Documentation

Measuring / object data

Measurement no. : 17 Needle speed : 3000 r/min

Level : Diameter : 11.0"

Direction : Level : Start / stop : 0.567" / 11.925"

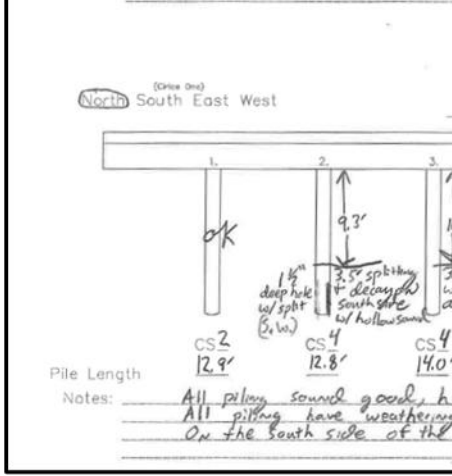
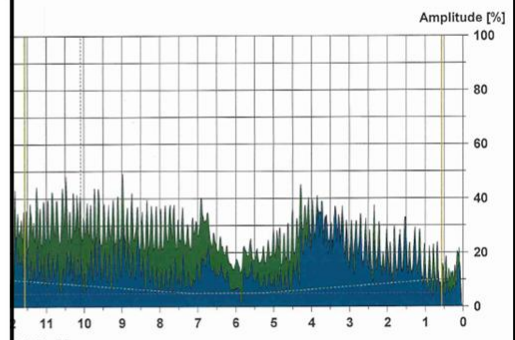
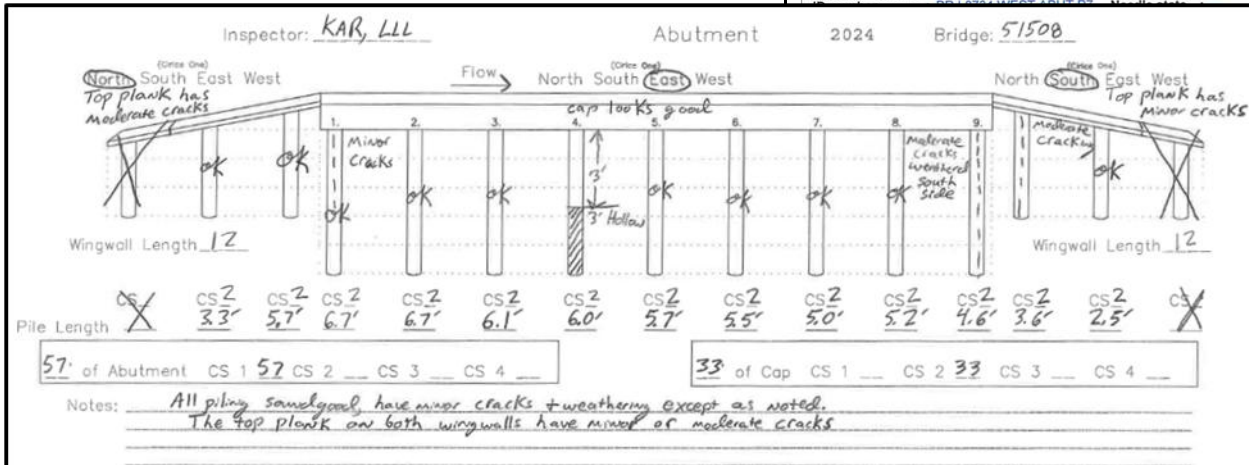
Species : Effective length : 11.358"

Location : Decay detection : 0.000" / 0%

Name : Cavity detection : 0.000" / 0%

Result : PASS

Wood Inspector



Substructure Stress Wave Timing Records

Bridge: XXXXX Location: West Abutment

Pier numbering from: West to East Pile numbering from: North to South

Distances along the piling are taken relative to the bottom of the pile cap.

Pile cap length (ft): 45.00 Measurements from N end of cap

Distance from cap end:	1.5'	2.4'	3.6'	4.9'	6.2'	7.4'	8.7'	10.0'	11.2'	12.4'	13.6'	14.9'	16.1'	17.4'	18.6'	19.9'	21.1'	22.4'	23.6'	24.9'	26.1'	27.4'	28.6'	29.9'	31.1'	32.4'	33.6'	34.9'	36.1'	37.4'	38.6'	39.9'	41.1'	42.4'	43.6'	44.9'	45.9'								
Stress wave time (µs/ft)	185	201	242	183	177	180	173	283	164	153	302	387	80	83	79	929	1027	776	367	386	307	241	776	371	290	264	249	278	206	211	150	221	159	209	191	157	283	280	254	219	278	187	218	193	156

Stress Wave Timing Legend:

- ≤ 290 µs/ft: Sound Timber
- 251 - 500 µs/ft: Moderate Decay
- > 500 µs/ft: Severe Decay
- *Investigate decay with timber resistance drill

Pile:	1	2	3	4	5	6	7	8	9
Exposed height (ft):	5.25	5.25	6.5	7.17	7.25	6.75	6.25	5.33	5.33
Distance along pile	1 ft 234	1 ft 190	1 ft 300	1 ft 396	1 ft 355	1 ft 210	1 ft 165	1 ft 238	1 ft 191
Stress wave time (µs/ft)	2 ft 156	2 ft 171	2 ft 161	2 ft 366	2 ft 343	2 ft 172	2 ft 238	2 ft 219	2 ft 271
	3 ft 232	3 ft 232	3 ft 284	3 ft 463	3 ft 407	3 ft 243	3 ft 243	3 ft 187	3 ft 294
	4 ft 164	4 ft 291	4 ft 249	4 ft 445	4 ft 313	4 ft 100	4 ft 234	4 ft 281	4 ft 200
	5 ft 179	5 ft 183	5 ft 249	5 ft 357	5 ft 218	5 ft 283	5 ft 203	5 ft 184	5 ft 260
	6 ft 74	6 ft 66	6 ft 223	6 ft 268	6 ft 397	6 ft 280	6 ft 168	6 ft 184	6 ft 200
	7 ft 74	7 ft 66	7 ft 223	7 ft 372	7 ft 292	7 ft 266	7 ft 168	7 ft 184	7 ft 200
	8 ft 74	8 ft 66	8 ft 223	8 ft 372	8 ft 292	8 ft 266	8 ft 168	8 ft 184	8 ft 200
	9 ft 74	9 ft 66	9 ft 223	9 ft 372	9 ft 292	9 ft 266	9 ft 168	9 ft 184	9 ft 200
	10 ft 74	10 ft 66	10 ft 223	10 ft 372	10 ft 292	10 ft 266	10 ft 168	10 ft 184	10 ft 200
	11 ft 74	11 ft 66	11 ft 223	11 ft 372	11 ft 292	11 ft 266	11 ft 168	11 ft 184	11 ft 200
	12 ft 74	12 ft 66	12 ft 223	12 ft 372	12 ft 292	12 ft 266	12 ft 168	12 ft 184	12 ft 200
	13 ft 74	13 ft 66	13 ft 223	13 ft 372	13 ft 292	13 ft 266	13 ft 168	13 ft 184	13 ft 200
	14 ft 74	14 ft 66	14 ft 223	14 ft 372	14 ft 292	14 ft 266	14 ft 168	14 ft 184	14 ft 200
	15 ft 74	15 ft 66	15 ft 223	15 ft 372	15 ft 292	15 ft 266	15 ft 168	15 ft 184	15 ft 200
	16 ft 74	16 ft 66	16 ft 223	16 ft 372	16 ft 292	16 ft 266	16 ft 168	16 ft 184	16 ft 200
	17 ft 74	17 ft 66	17 ft 223	17 ft 372	17 ft 292	17 ft 266	17 ft 168	17 ft 184	17 ft 200
	18 ft 74	18 ft 66	18 ft 223	18 ft 372	18 ft 292	18 ft 266	18 ft 168	18 ft 184	18 ft 200
	19 ft 74	19 ft 66	19 ft 223	19 ft 372	19 ft 292	19 ft 266	19 ft 168	19 ft 184	19 ft 200
	20 ft 74	20 ft 66	20 ft 223	20 ft 372	20 ft 292	20 ft 266	20 ft 168	20 ft 184	20 ft 200

Notes: Decay/section loss noted at Piles 4 & 5 - see timber resistance drill records.

Revisions to Structural Element Condition Ratings

Timber Substructure Elements				
		#208: Timber Trestle Tower (LF) #216: Timber Abutment (LF)	#235: Timber Pier/Bearing Cap (LF)	
These elements apply to timber substructure members of any type or shape.				
<ul style="list-style-type: none"> If impact damage is present, Element #880 (Impact Damage) must be added and rated. If settlement is evident, Element #884 (Settlement) must be added and rated. 				
Condition States				
Item or Defect	1 Good	2 Fair	3 Poor	4 Severe
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required or structural review has determined that the strength of the element has not been impacted.	Condition warrants structural review or structural review has determined that the strength of the element has been reduced.
Repairs	No repairs are present.	Existing repair in sound condition.	Repairs are recommended or existing repair is unsound.	Immediate repairs are required.
Decay, Weathering, Abrasion, or Fire Damage	Minor deterioration (no section loss).	Less than 10% section loss. Staining. Soot (superficial charring).	10% to 20% section loss. Negative camber. Significant charring.	More than 20% section loss. Crushing or severe sagging. Severe charring.
Connection or Misalignment	Components are properly aligned and securely connected.	Loose fasteners or slight misalignment of components.	Fasteners broken or missing. Components loose or significantly misaligned.	Failed connections. Components severely misaligned or missing.
Settlement, Scour, or Undermining	None	Slightly tipped or undermined. Within tolerable limits or arrested.	Significantly tipped or undermined. Exceeds tolerable limits.	Severely tipped or undermined. Stability of element has been reduced.
Shakes, Checks, or Splits	Penetrates less than 5% of member thickness.	Penetrates 5% to 50% of member thickness.	Penetrates more than 50% of member thickness.	Severe split or fracture that impacts the stability or capacity of the element.
<ul style="list-style-type: none"> Shake: A separation along the grain (between the growth rings). Usually forms within a standing tree or during felling. Check: A separation perpendicular to the grain (across the growth rings). Usually results from stress due to drying shrinkage. Split (or Thru Check): A check extending further through the timber member due to tearing apart of wood cells. 				

Reduced from 40%

Added charring criteria and removed crushing and sagging from C3.

Added tipping and undermining criteria.

Previously, "Penetrates through entire member (or more than 25% in a tension zone)."

2025 edition removed references to "tension zone" for Shakes, Checks, or Splits criteria to avoid confusion in the field.

Timber Piling and Column Elements	
Condition Rating Examples (Timber Piling and Column Elements)	
<p>Condition State 2 Timber piling with decay at waterline (less than 10% section loss)</p>	<p>Condition State 2 Surface check extending less than 50% through the pile diameter</p>
<p>Condition State 3 Shell damage (1/2" deep) on a timber piling (approximately 15% section loss)</p>	<p>Condition State 3 Surface check extending more than 50% through the pile diameter</p>

Timber Element Load Ratings

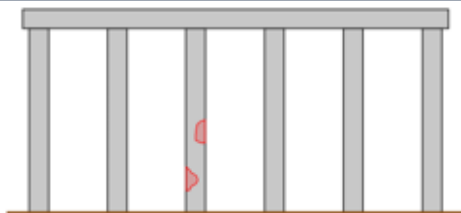
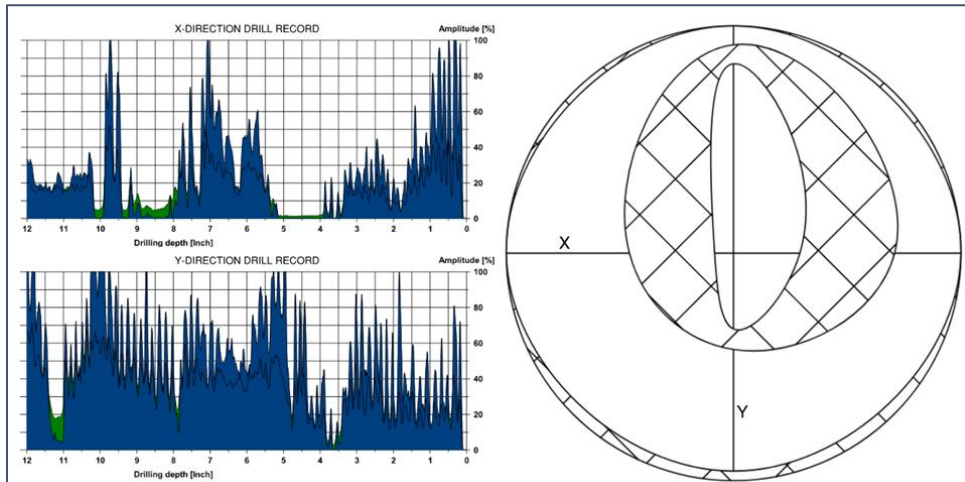


Figure 6.1 Timber substructure with deteriorated pile.



Figure 6.2 Assume deteriorated pile is ineffective.



Figure 6.3 Assume equivalent pile per section loss.

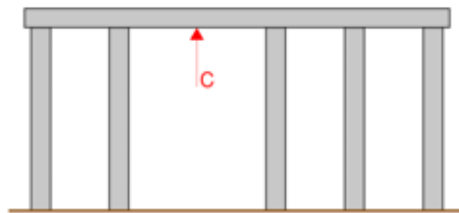
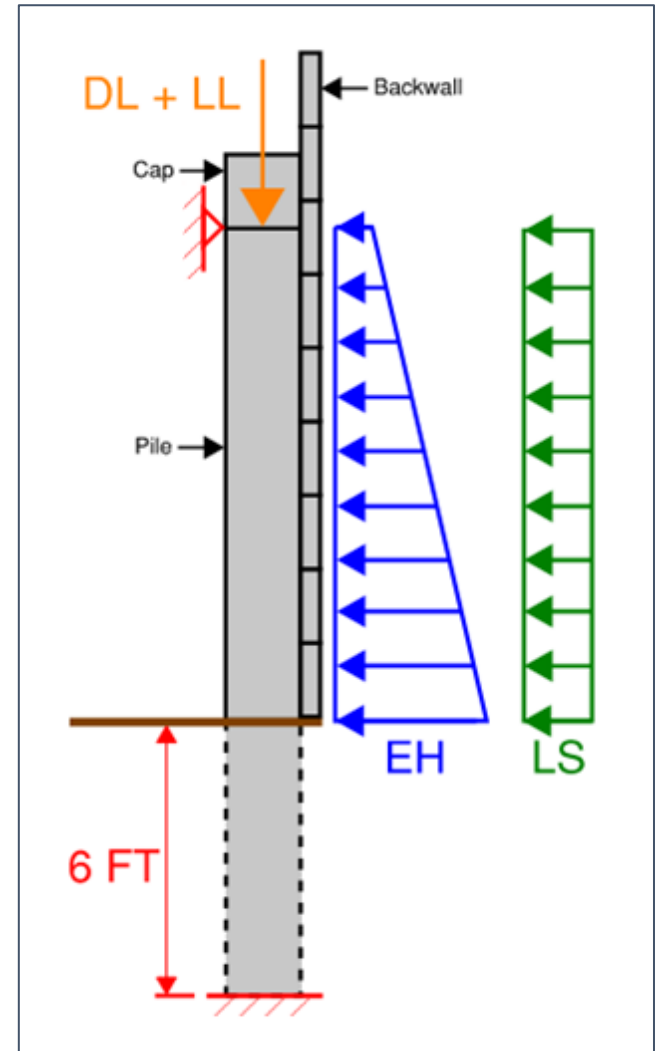
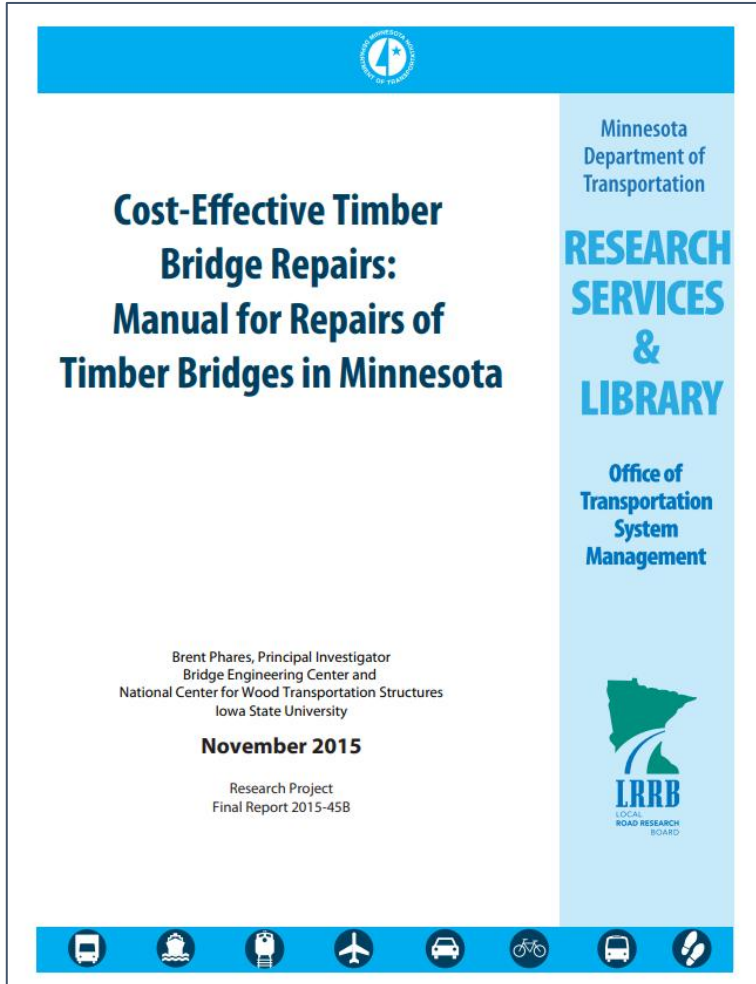



Figure 6.4 Replace pile with effective capacity.



Timber Bridge Repairs & Maintenance




The cover features a blue header with the Minnesota Department of Transportation logo. The main title is 'Cost-Effective Timber Bridge Repairs: Manual for Repairs of Timber Bridges in Minnesota'. It is published by the Minnesota Department of Transportation, Office of Transportation System Management, and the IRRB (Local Road Research Board). The principal investigator is Brent Phares from Iowa State University. The report is dated November 2015 and is a final report for research project 2015-45B. At the bottom, there is a row of icons representing various transportation modes: bus, boat, train, airplane, car, bicycle, and motorcycle.

 Minnesota Department of Transportation

**Cost-Effective Timber Bridge Repairs:
Manual for Repairs of Timber Bridges in Minnesota**

RESEARCH SERVICES & LIBRARY


Office of Transportation System Management

 IRRB
LOCAL ROAD RESEARCH BOARD

Brent Phares, Principal Investigator
Bridge Engineering Center and
National Center for Wood Transportation Structures
Iowa State University

November 2015

Research Project
Final Report 2015-45B



Chapter 4: Recommended Preventive Maintenance Practices

Relatively minor maintenance practices, when done routinely, can reduce the need for more extensive repair or rehabilitation. The inherent resiliency of timber can be leveraged with these minor procedures. Maintenance generally falls into one of three main categories: routine maintenance, periodic maintenance, or specific works.

Routine maintenance primarily consists of minor reactive type works, which are typically expected over the service life (completed annually), but the precise nature and location are not known in advance. Procedures are generally planned and carried out soon after the need is identified.

Periodic maintenance generally occurs at regular intervals of longer than one year with the intent of preventing occurrence or progression of deterioration. Unlike routine maintenance, periodic maintenance is most often undertaken on a proactive rather than reactive basis.

Specific works include planned and scheduled improvements to the bridge to maintain such things as strength, geometry, and safety. Usually, these maintenance items are scheduled at least two years in advance. The activities of specific works can be similar in scope to repair and rehabilitation activities, which is covered in Chapter 5, and, for that reason, the remainder of this chapter focuses on recommended routine and periodic maintenance.

4.1 General Timber Maintenance

4.1.1 Moisture Control

The best preventive maintenance method for timber is moisture control (White et al. 2007). Moisture control can be used as an effective technique to extend the service life of many timber piles, stringers, or other elements. For example, when exposure to moisture is reduced, timber piles will dry to moisture contents below that required for fungus and insect growth (Ritter 1992 and Seavey and Larson 2002). Timber abutments placed up and away from stream banks will have an extended service life compared to elements near the stream that are repeatedly going through wet and dry cycles. Given it is highly unlikely that pile locations will be moved on existing bridges, it is paramount to take note of particular piles that are apt to see wet and dry cycling like that shown in Figure 4-1 so special attention may be paid to these piles.

Timber Bridge Maintenance

- End grain/surface treatment (brushed on and/or capping)
- Replacing/retightening fasteners
- Debris removal
- Deck drainage
- Excessive overlay and vegetation removal
- Crack sealing (epoxy injection)



Timber Bridge Repairs: Superstructure (Beam Strengthening)



Timber Bridge Repairs: Superstructure (Spreader Beam Tightening)



Timber Bridge Repairs: Backwall



Timber Bridge Repairs: Pile Caps (Misalignment Prevention)



Timber Bridge Repairs: Pile Caps/Piling (Member Replacement/Avoidance)



Timber Bridge Repairs: Piling (Bracing Replacement/Additions)



Timber Bridge Repairs: Piling (Steel Sistering)



Timber Bridge Repairs: Piling (Posting/Splicing)



Timber Bridge Repairs: Piling (Reinforced Concrete Pile Jacketing)



Timber Bridge Repairs: Piling (Pile Encasement)

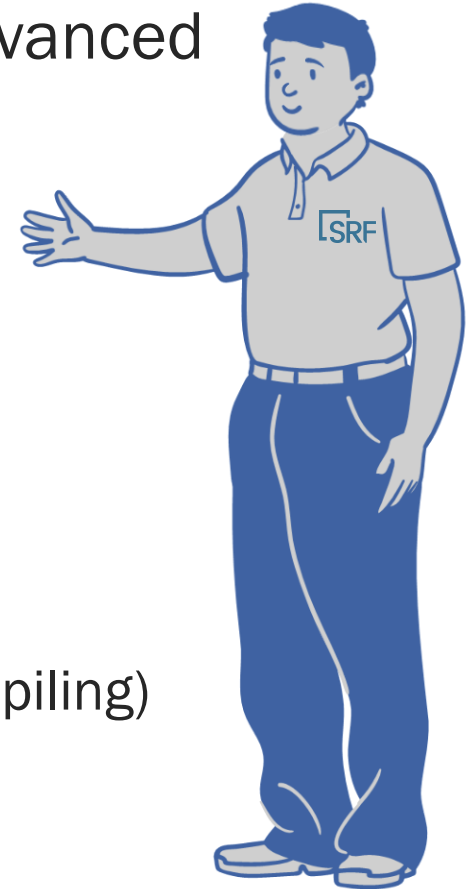


Timber Bridge Repairs: Other Considerations



Best Practices/Lessons Learned

- Establish a baseline condition using advanced equipment
- Act on CS3/CS4 findings
- Request inclusion in SHV contract
- Repair vs. replacement
 - Detour length
 - Criticality of function
- Replace with more modern methods
 - Steel piling (MnDOT no longer uses timber piling)
 - Internally treated timber
 - Waterproofing systems



Summary

- Timber inventory is aging
- In-depth inspections are critical
- Use advanced timber inspection equipment
- Establish a baseline condition
- **Follow water** when inspecting
- MnDOT resources
 - *Advanced Timber Bridge Inspection Manual & Supplement*
 - *Minnesota Timber Bridge Repair Manual*
- Contact Moises to include bridges in SHV #10

Statewide Timber Inspection Training

- End of 2026 (TBD)
- Half day session
- Hands-on
- Equipment usage
- Inspection procedures
- Critical locations
- Condition states
- Data management



Watch for announcement!