



In-Depth Timber Bridge Inspection And Load Rating

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Overview

- Introduction
- Why Do We Inspect and Load Rate Bridges in The United States?
- Bridge Inspection Types
- Bridge Inspection Procedures
- Load Rating
- Conclusion





Introduction

- FS has **3,450** Road bridges
 - Timber superstructures
 - Steel stringers with timber decks
 - FS is the #1 federal agency with timber bridges
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Why Do We Inspect and Load Rate Bridges in The United States?

- It is the Law – Title 23, Part 650 (23 CFR 650)
– Bridges, Structures, and Hydraulics
- Inspection – Maximum of every 24 months
- Load Rating – Safe load-carrying capacity
- AASHTO's *The Manual for Bridge Evaluation*



Bridge Inspection Types

- Types of inspections
 - Visual
 - In-Depth Inspections



Visual Inspections

- Most common method of inspection
- Use human senses
 - Vision, touch, hearing, and smell
- Non-specialized equipment



Visual inspections

- Two categories
 - Cursory
 - Hands-on



Cursory inspections

- Looking at the bridge as a whole
- Identifying possible defects or problems
 - Sagging beams
 - Water ponding
 - Uneven surfaces
 - Other things



Cursory Inspections





Hands-on Inspection

- Get within an arm's reach
- Defects are identified visually
- Physical procedures used to find out the extent of the deterioration or decay
- The basic methods for physical examination are:
 - Sounding - Hammer
 - Pick Test - Awl



Sounding

Interpreting Soundings:

- Sound timber gives a crisp sound.
- Defective timber gives a dull sound.
- Loose hardware will vibrate.

Note: A 2 inch thick shell of competent wood is sufficient to mask any interior rot.





Pick Test

- Probing with a pointed tool such as an awl will locate decay near the wood surface.
- Decay will be evidenced by excessive softness or lack of resistance to the probe penetration and the breakage pattern of the splinters.
- A brash break indicates decayed wood, whereas a crisp splintered break with the splinter hinging from one end indicates sound wood.



Pick Test



Decayed wood breaks abruptly across grain without splintering.



Sound wood pries out as long splinters.



In-Depth Inspections

- Non-Destructive Testing
 - Use specific equipment for type of material
 - Moisture Meter
 - Stress Wave Tester
 - Resistograph
-

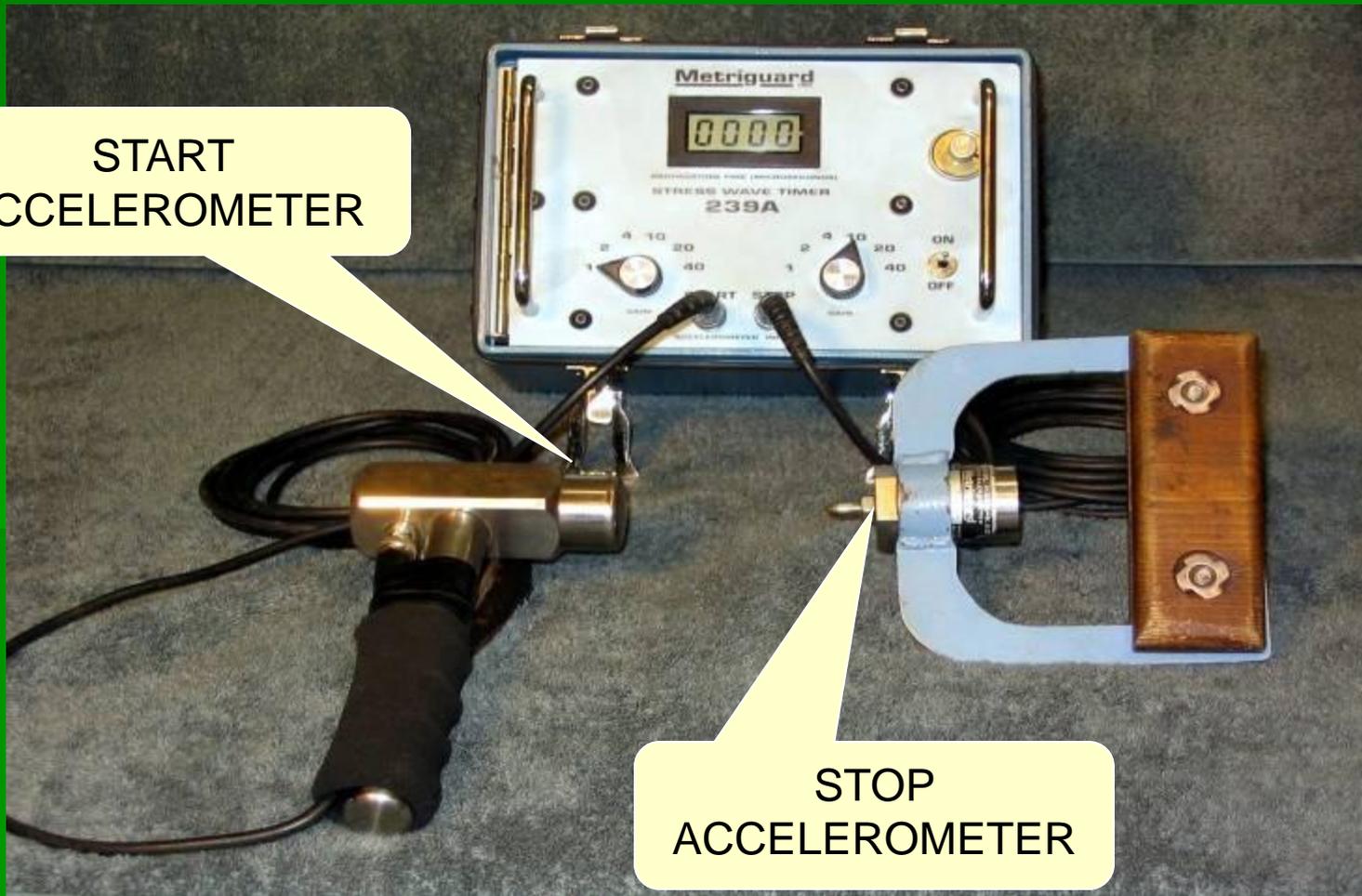
Moisture Meter

- Measure the percentage of water
- Decay may be present when the moisture content exceeds 25 percent





METRIGUARD 239A STRESS WAVE TIMER



START
ACCELEROMETER

STOP
ACCELEROMETER



RESISTOGRAPH DRILL

- NON DESTRUCTIVE TESTING OF WOOD BRIDGE MEMBERS
- DATA OUTPUT
 - A) PAPER COPY
 - B) DIGITAL FILE





Example Output



OLD GROWTH SHELL WITH
DECAY AT CENTER



Bridge Inspection Procedures

- Conduct a cursory inspection
- Conduct a hands-on inspection
- Conduct an in-depth inspection
 - Take moisture readings at areas of dampness, crushing, or any other signs of distress
 - Take stress wave readings along the entire length of the beam and marking high reading locations with chalk
 - Drill location high stress wave reading locations with the resistograph
 - Draw up a diagram of all problem locations



Bridge Inspection Procedures

- Collect data required for load rating:
 - Total deck width and clear travel width
 - Species and grade of beams and decking
 - Beam type, size, and spacing
 - Span length and bracing locations
 - Deck type and size
 - Moisture content of beams and decking
 - Section loss of beams and decking



Load Rating

- Forest Service uses two programs to load rate timber bridges
 - Timber Bridge Analysis and Rating (TBAR)
 - MathCad



TBAR – Version 2.1

- Developed for the Forest Service by HDR Engineering, Inc, through an A&E Service Contract
- Two earlier DOS programs
 - TBSR (R1 and R6)
 - Timber Bridge Rating Program (R4)
- In 2009, Revised and Enhanced



TBAR - Version 2.1

TBAR 2.1

File Tools Help

USDA

WELCOME TO TBAR

TIMBER BRIDGE ANALYSIS AND RATING PROGRAM

VERSION 2.1

U.S.D.A FOREST SERVICE

TBAR DISCLAIMER

This program and the related documentation was prepared for use by the United States Department of Agriculture Forest Service ('Forest Service') in accordance with established industry engineering principles, standards, and guidelines. The information contained herein should not be utilized for any specific engineering application without professional observance and authentication for accuracy, suitability, and applicability by a competent and licensed professional engineer. The Forest Service disclaims any liability arising from the use of any information contained in the documentation or as a result from any usage of the program.

TBAR 2.1 Analysis Results - TBAR Example 6B

File

Inputs

Rating Method:	Allowable Stress Design
Deck Type:	Glulam Panels, Non-interconnected
Stringer Type:	Glulam
Number of Lanes:	1
Number of Stringers:	5
Center Span:	40.00 (ft)
End Spans:	10.00 (ft)
E of Stringer:	2,400,000.00 (psi)
Stringer F_b :	2,400.00 (psi)
Stringer F_v :	165.00 (psi)
Deck Skew:	0.00 (deg)
Min. Panel Width:	48.00 (in)
Decking F_b :	1,650.00 (psi)
Decking F_v :	145.00 (psi)
Superimposed Dead Load:	200.00 (plf)
Wearing Surface Dead Load:	200.00 (plf)
Wheel/Track Gage:	6.00 (ft)
Effective Length of Deck Resisting Wheel Load:	20.13 (in)
Exterior Stringer Live Load Distribution Factor:	0.54 (wheel loads)
Interior Stringer Live Load Distribution Factor:	0.54 (wheel loads)
Stringer Width:	12.00 (in)
Stringer Depth:	26.00 (in)
C-C Ext. Stringers:	13.00 (ft)
Deck Thickness:	5.13 (in)
Deck Travel Clear Width:	14.00 (ft)
Total Deck Width:	16.00 (ft)

85 psf Pedestrian Load - Live Loading Results

Center Span:	40.00 (ft)
End Spans:	10.00 (ft)
Maximum Moment:	204.00 (kip-ft)
Maximum Moment Location From Left End:	30.00 (ft)
Maximum Moment (Positive):	204.00 (kip-ft)
Maximum Moment (Negative):	-68.00 (kip-ft)
Maximum Shear (at support):	27.20 (kip)
Maximum Reaction:	40.80 (kip)

Load Info

Uniform Load:	85.00 (psf)
Width of Load:	16.00 (ft)
Total Uniform LL:	1,360.00 (plf)

85 psf Pedestrian Load - Stresses and Ratios

Dead Load Stress

	Interior	Exterior
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TBAR 2.1 - Example 06B Glu_Glu__ASD.tbar

File Tools Help

Unit System: U.S. Customary

Effective Span Length: []

Distribution Options: []

Stringer Depth: 26.00 (in)

Stringer Width: 12.00 (in)

Deck Thickness: 5.13 (in)

C-C Ext. Stringers: 13.00 (ft)

Total Deck Width: 16.00 (ft)

Deck Travel Clear Width: 14.00 (ft)

Number of Lanes: 1

Number of Stringers: 5

Center Span: 40.00 (ft)

End Spans: 10.00 (ft)

E of Stringer: 2,400,000.00 (psi)

Stringer F_b : 2,400.00 (psi)

Stringer F_v : 165.00 (psi)

Deck Skew: 0.00 (deg)

Min. Panel Width: 48.00 (in)

Decking F_b : 1,650.00 (psi)

Decking F_v : 145.00 (psi)

Superimposed Dead Load: 200.00 (plf)

Wearing Surface Dead Load: 200.00 (plf)

Wheel/Track Gage: 6.00 (ft)

Override Calculated Factors?

Interior Stringer Live Load Distribution Factor: 0.54 (wheel loads)

Exterior Stringer Live Load Distribution Factor: 0.54 (wheel loads)

Effective Length of Deck Resisting Wheel Load: 20.13 (in)

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TBAR Capabilities

- Simple Span or 3-Span with Cantilevered Ends
- Rating Methods - ASD or LRFD
- Units - U.S. Customary (English) or Metric



Bridge Types

- Stringer Types
 - Timber girders
 - Solid sawn
 - Glued-laminated
 - Logs
 - Steel girders
 - Standard sections or the properties may be input.



Bridge Types

- Timber Slab Bridges
 - Longitudinal glued-laminated deck panels
 - Longitudinal nail-laminated deck
 - Longitudinal spike-laminated deck



Bridge Types

- Deck Types
 - Solid sawn planks
 - Non-interconnected glued-laminated panels
 - Interconnected glued-laminated panels
 - Nail-laminated decks



Mathcad

M Mathcad - [Naillaminated.mcd]

File Edit View Insert Format Tools Symbolics Window Help

NAIL LAMINATED BRIDGE RATING

The following program rates single span, one lane Glulam bridges using the procedure described in the Manual For Condition Evaluation of Bridges published by the American Association of State Highway and Transportation Officials, 444 North Capital Street, N.W., Suite 249, Washington, D.C. 20001. This worksheet considers interior stringers only.

General Information

Bridge_Span := 24.75 in feet. Measure from center to center of bearing. kips := 1000·lb

d := 51·in b := 8.5·in Num_of_Beams := 3 S_{Beam} := 5.5·ft Wt_{Wood} := 50 · $\frac{\text{lb}}{\text{ft}^3}$

d_{Reduction} := 0·in b_{Reduction} := 0·in t_{plank} := 6.75·in

Section Properties

b_{Effective} := b - b_{Reduction} b_{Effective} = 8.5 in d_{Effective} := d - d_{Reduction} d_{Effective} = 51 in

$I_x := \frac{b_{\text{Effective}} \cdot d_{\text{Effective}}^3}{12}$ I_x = 93961.12 in⁴ $S_x := \frac{I_x}{\left(\frac{d_{\text{Effective}}}{2}\right)}$ S_x = 3684.75 in³

Press F1 for help. AUTO NUM Page 1



Conclusion

- A good inspection and load rating program will help to ensure that bridges are safe for use.
- Using specialized inspection equipment for in-depth evaluation of timber bridges provides the necessary information needed to load rate these bridges.
- TBAR is available for use outside of the Forest Service.



References

- AASHTO. *The Manual for Bridge Evaluation*
- FPL-GTR-6. *Electric Moisture Meters for Wood*
- FPL-GTR-160. *Condition Assessment of Timber Bridges 2. Evaluation of Several Stress-Wave Tools*
- FPL-GTR-159. *Condition Assessment of Timber Bridges 1. Evaluation of a Micro-Drilling Resistance Tool*
- HDR Engineering. *USDA Forest Service TBAR User Manual, Version 2.1*



Questions?

