Use of Red Pine for Stress-Laminated Glulam Bridges in Wisconsin

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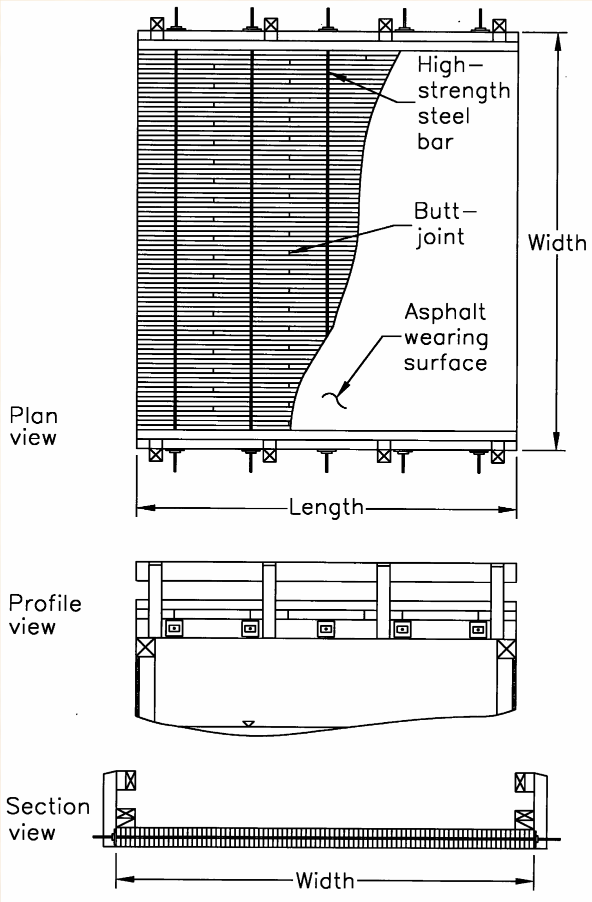
National Wood In Transportation

- Established 1988 by Congress and administered by the U.S. Forest Service
- Program Components:
  - Demonstration Timber Bridges
  - Research
  - Technology Transfer & Information Management
  - Rural Revitalization
- Main Emphasis Areas
  - Underutilized, locally-available wood species
  - Innovative material and bridge designs

What is a Stress-Laminated Bridge?

- Slab-type bridge deck
- Sawn lumber, glulam, or structural composite lumber (SCL)
- No mechanical fasteners or glue between adjacent lams
- High-strength steel bars
- Butt joints permitted
- Improved wheel load distribution
- Innovative superstructure design



Wisconsin Lumber Species

- *Pinus resinosa*
- Strength properties
- CCC plantations
- Good treatability

Red Pine as a Bridge Material

- Technical Obstacles
  - Design values for WI red pine lumber
  - Lumber sizes limited availability
  - Not recognized by AITC for glulam manufacturing
  - Not recognized by AWPA for pressure-treatment

- Development of glulam beam layups

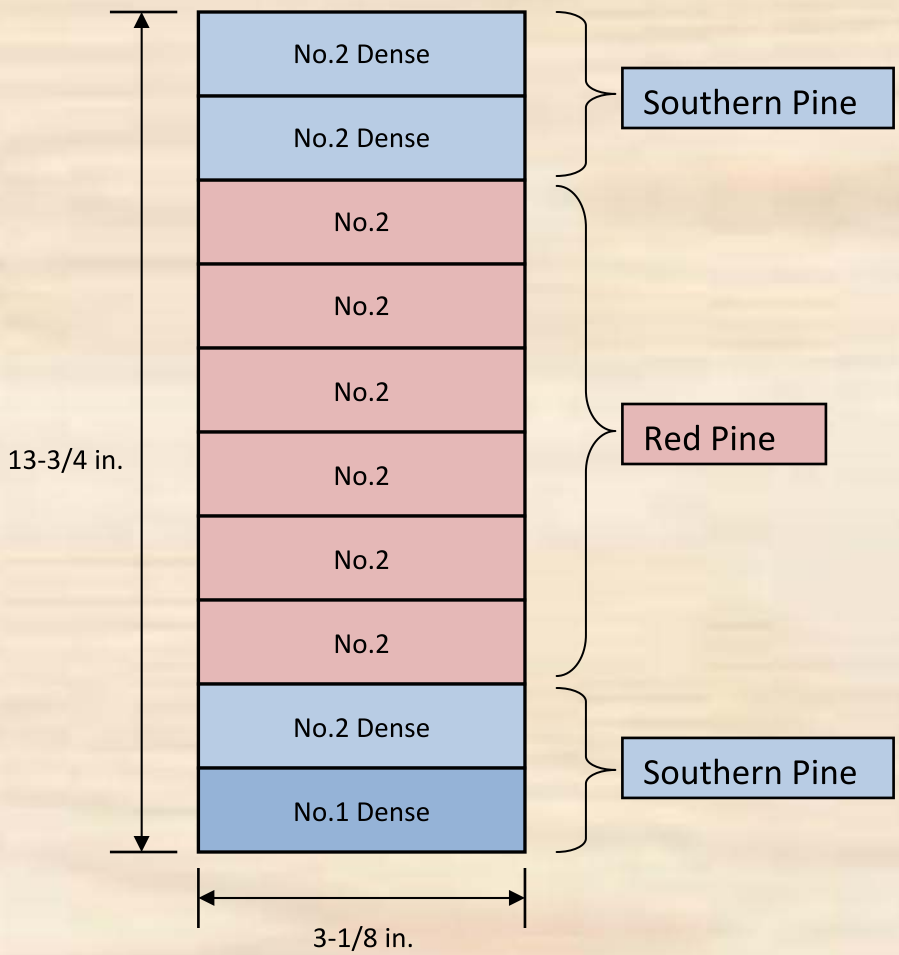
Advantages of Glulam for Bridges

- Utilization of small-diameter materials
- Longer span capabilities
- Deeper member sections
- Low quality material in low stress zones
- Conserve high quality material
- Dry moisture content at installation

Teal River Bridge - Description

- Double-lane bridge
  - Simple span
  - 32.5 ft long
  - 24 ft wide
  - HS20 loading
  - Penta treatment
  - 1” dia. steel bars @ 44in.
  - No butt joints
  - Red Oak glulam at edge lams

Teal River Bridge – Beam Layup



Combination of Pine Species

Visual Grading Techniques

Beam Design
F_b = 2,000 lb/in.^{2}
E = 1,600,000 lb/in.^{2}

Development of Red Pine Glulam

- E-rating of individual lams (by grade) at plant
  - dynaMOE and E-computer
- Stiffness testing of fabricated beams
  - dynaMOE and static beam deflection

Development of Red Pine Glulam

- Verifying beam design at the Teal River site

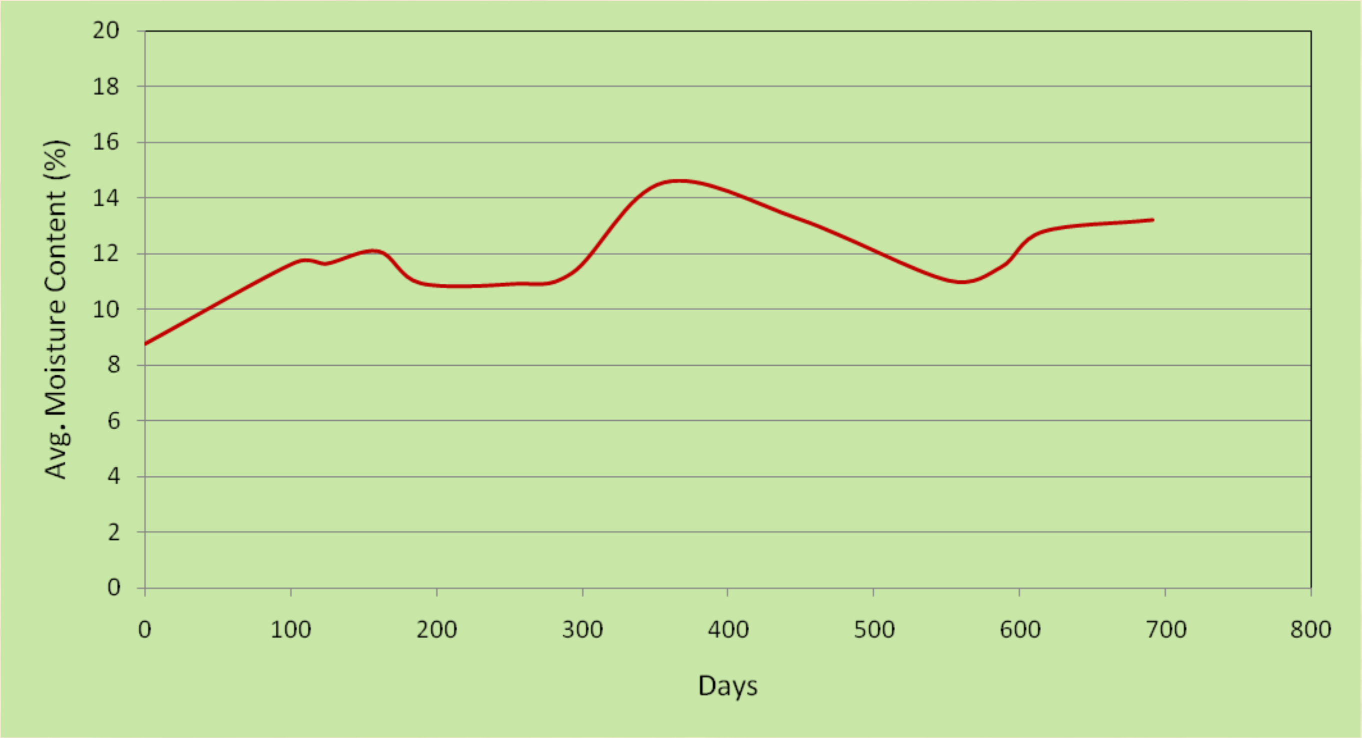
Teal River Bridge – Construction

Teal River Bridge – Construction

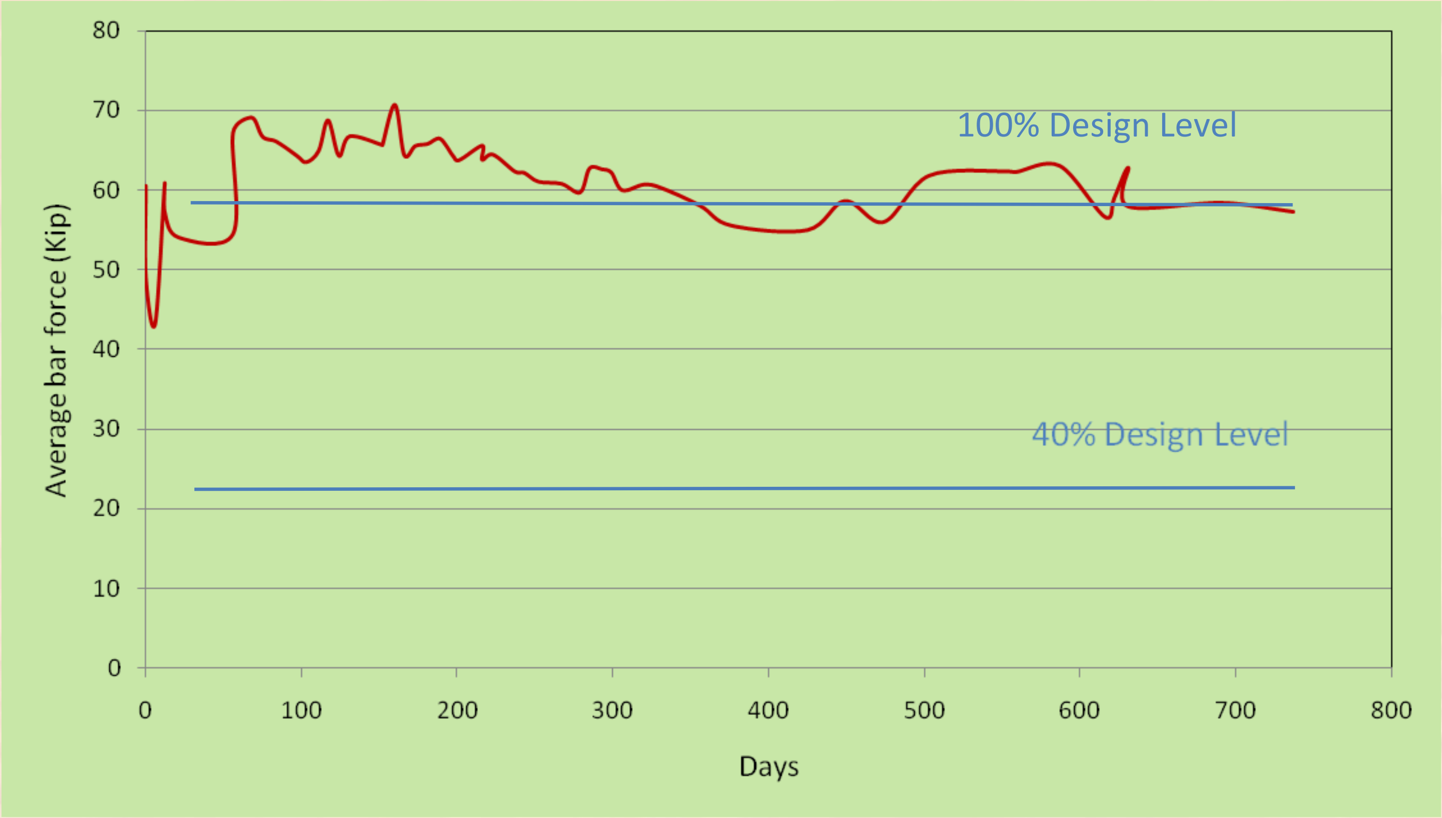
Teal River Bridge – Field Monitoring

- 2-year period after construction
  - Moisture content
  - Stressing bar force
  - Static load testing
  - General condition

Teal River - Moisture Content Trend



Teal River – Bar Force Trend



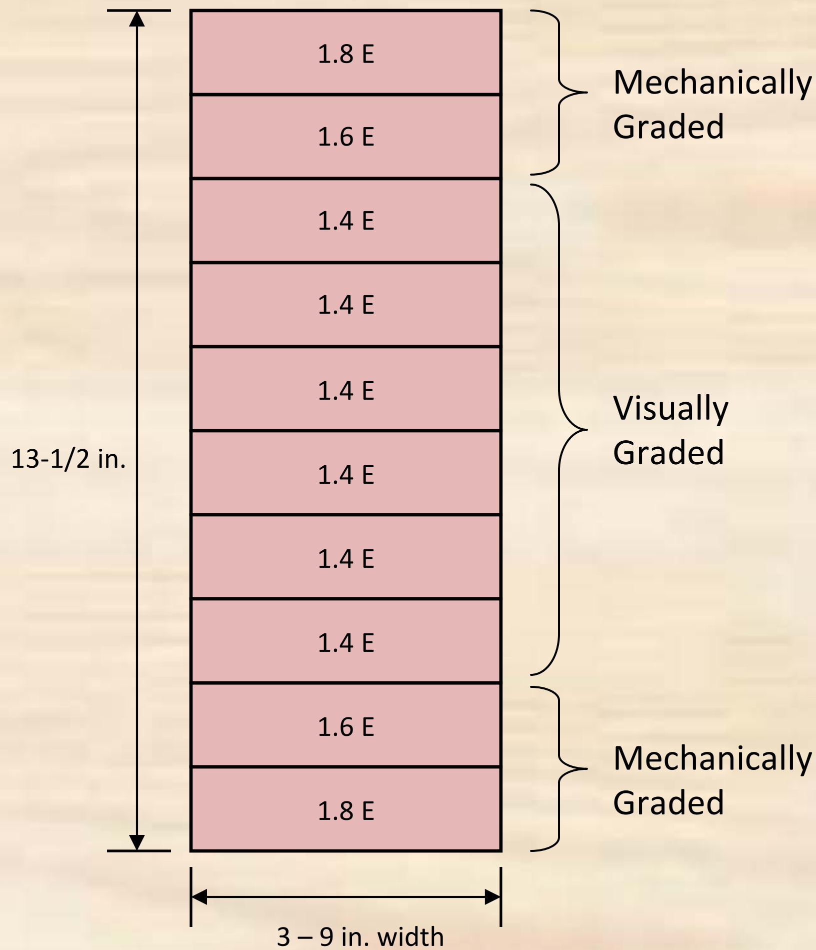
Teal River – Current Condition

- After 20 yrs of service

Pine River Bridge

- Double-lane bridge
  - 3-span continuous
  - 90 ft long
  - 38 ft wide
  - HS20 loading
  - Penta treatment
  - 1” dia. steel bars @ 40 in.
  - No butt joints
  - Red Oak glulam at edge lams

Pine River Bridge – Beam Layup



All Red Pine

Visual & Mechanical Grading Techniques

Beam Design
$E = 1{,}600{,}000\ \text{lb/in.}^2$

Lumber Stiffness – Flatwise Vibration

2 x 8 in. Nominal Red Pine			
		Modulus of Elasticity, MOE ($\times 10^6$ lb/in^2)	
Lamination Grade	No. Tested	Average	Coefficient of Variation
1.8 MOE bottom	49	1.66	16.7%
1.8 MOE top[b]	30	1.84	12.1%
1.6 MOE	24	1.35	13.9%
No. 2	7	1.10	----

Beam Stiffness – Static Deflection

13-1/2 in. deep Glulam Beams			
7-1/4 in. wide		9-1/4 in. wide	
Beam No.	MOE ($x10^6$ lb/in^2)	Beam No.	MOE ($x10^6$ lb/in^2)
31	1.35	2	1.10
13	1.43	7	1.15
30	1.47	3	1.18
23	1.49	9	1.21
21	1.51	6	1.25
5	1.52	5	1.28
22	1.53	1	1.31
7	1.54	4	1.35
Average	1.48	Average	1.23
C.O.V.	4.3%	C.O.V.	6.9%

Pine River Bridge – Construction

Pine River Bridge – Construction

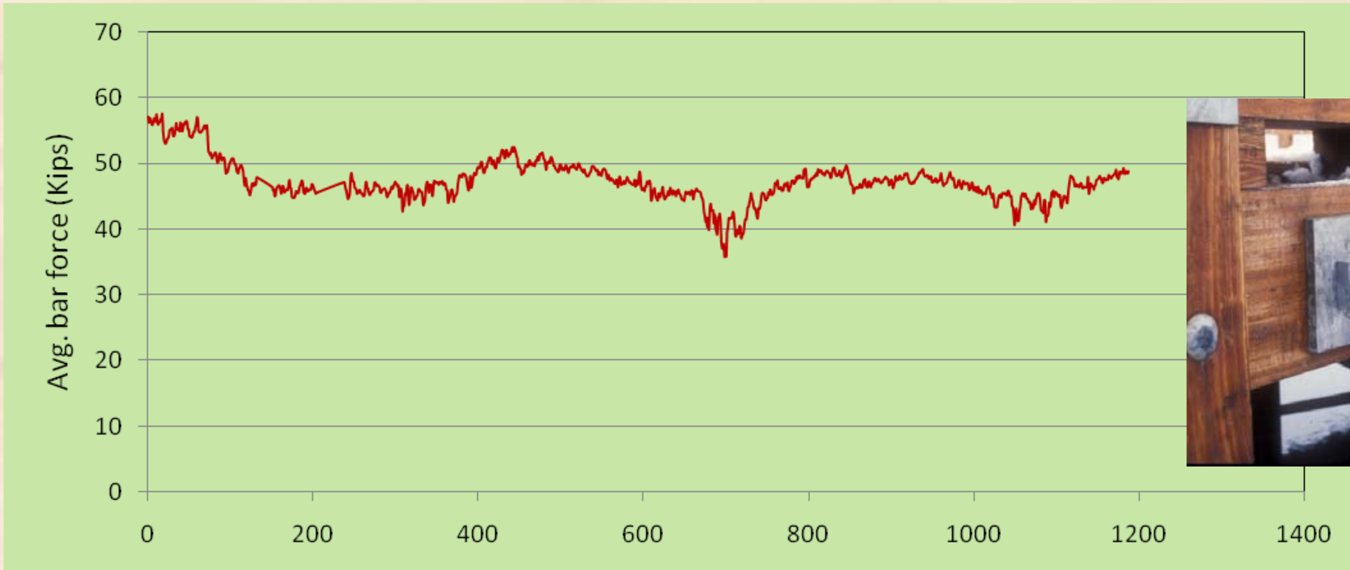
Pine River Bridge

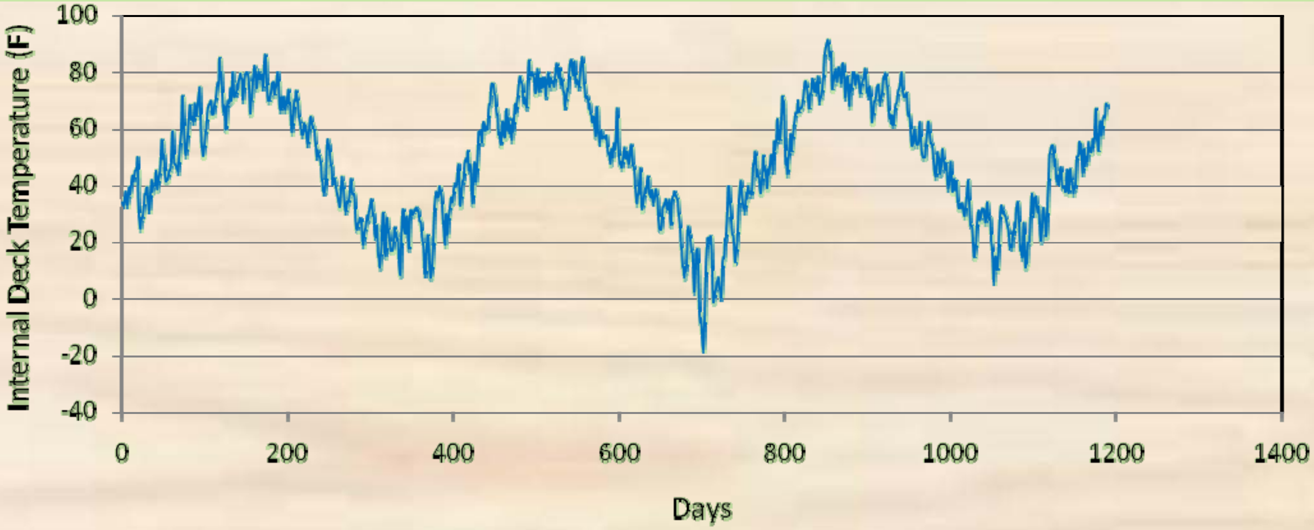
- Field Monitoring Study
  - 5 year monitoring
  - Moisture content
  - Stressing bar force
  - Deck temperatures
  - Static load testing
  - Overall condition

  - Datalogger utilized

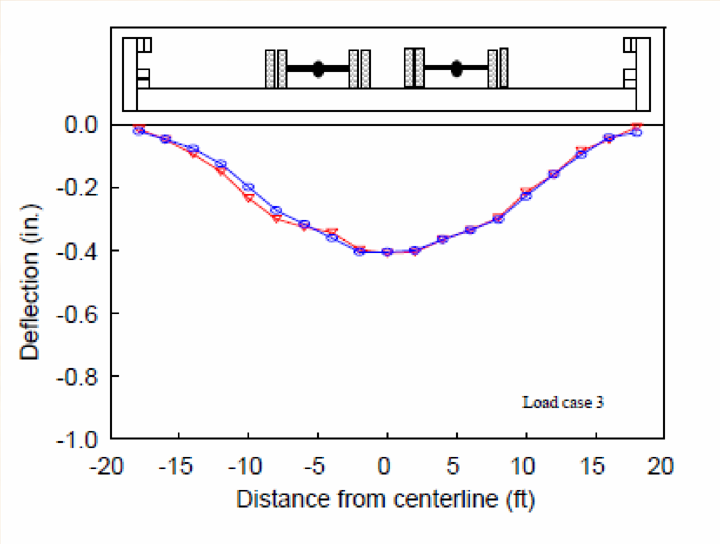
Pine River – Moisture Trend

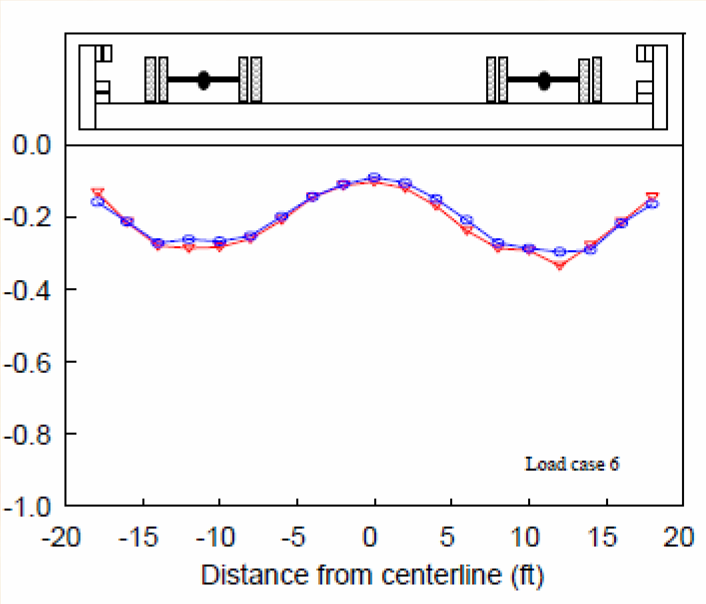
Pine River – Bar Force Trend





Pine River – Static Load Test

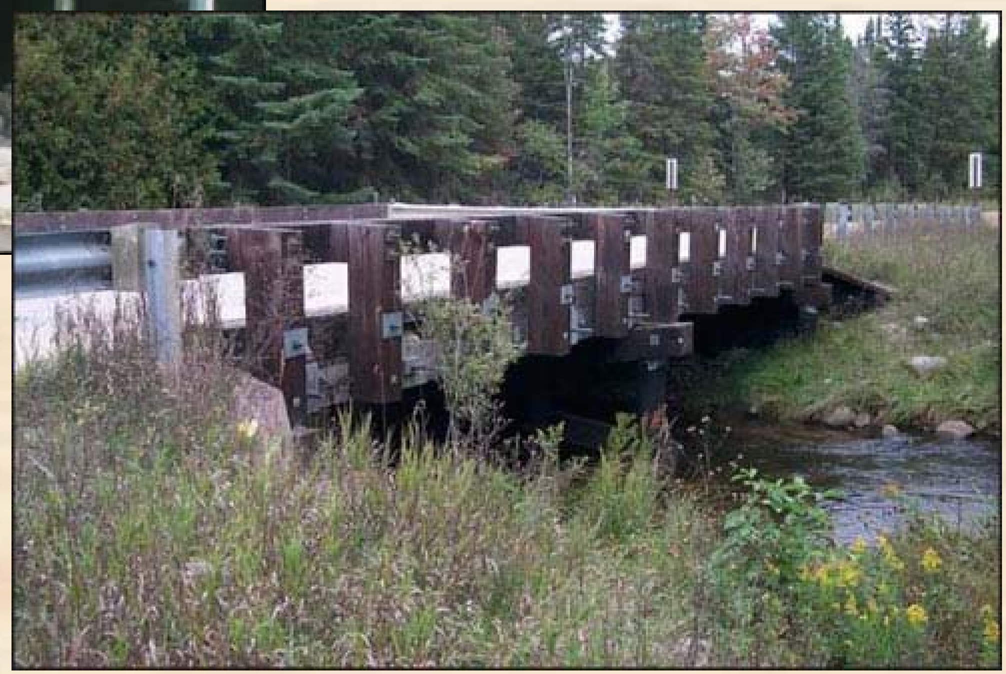




Pine River – Current Condition

- After 18 yrs of service

Red Pine Bridges (MI L.Peninsula)



Summary

- The former National Wood In Transportation Program facilitated the development of Red pine as a structural material.
- These two bridges were key in demonstrating the feasibility and potential for utilizing red pine for highway bridge applications.
- Additional glulam bridges have since utilized Red pine lumber and other small diameter species.
- Current condition of bridges is satisfactory after 20 years.

Acknowledgements

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- Glulam Supplier → Sentinel Structures, Peshtigo, WI

Questions?