The Use of Eastern Cottonwood for Stress-Laminated Sawn Lumber Bridges in Iowa

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Historical Reference

1988 - Timber Bridge Initiative

Legislation passed by Congress.

Objective: To establish a national timber bridge program to encourage the effective and efficient use of wood as a structural material for highway bridges

Historical Reference cont.

Responsibility for the development, implementation, and administration of the timber bridge program was assigned to the USDA Forest Service. The Forest Products Laboratory was responsible for the research portion of the TBI.

Historical Reference cont.

As part of this research program, FPL assumed a lead role in assisting local governments in evaluating the field performance of demonstration bridges, many of which used design innovations or materials that had not been previously evaluated.

Historical Reference cont.

Through such assistance, FPL collected, analyzed and distributed information on the field performance of timber bridges, thereby providing a basis for validating or revising design criteria and subsequently improving efficiency and economy in bridge design, fabrication, and construction.

Case Study

This case study presents information pertaining to 3 stress-laminated sawn lumber timber bridges constructed from Eastern Cottonwood in Iowa.

Iowa

- 99 counties
- extensive rural road network
- many short span crossings
- limited funds
- ideal situation for wood construction by local work crews

Eastern Cottonwood

- plentiful in Iowa
- lightweight containers
- plywood core stock
- pulp

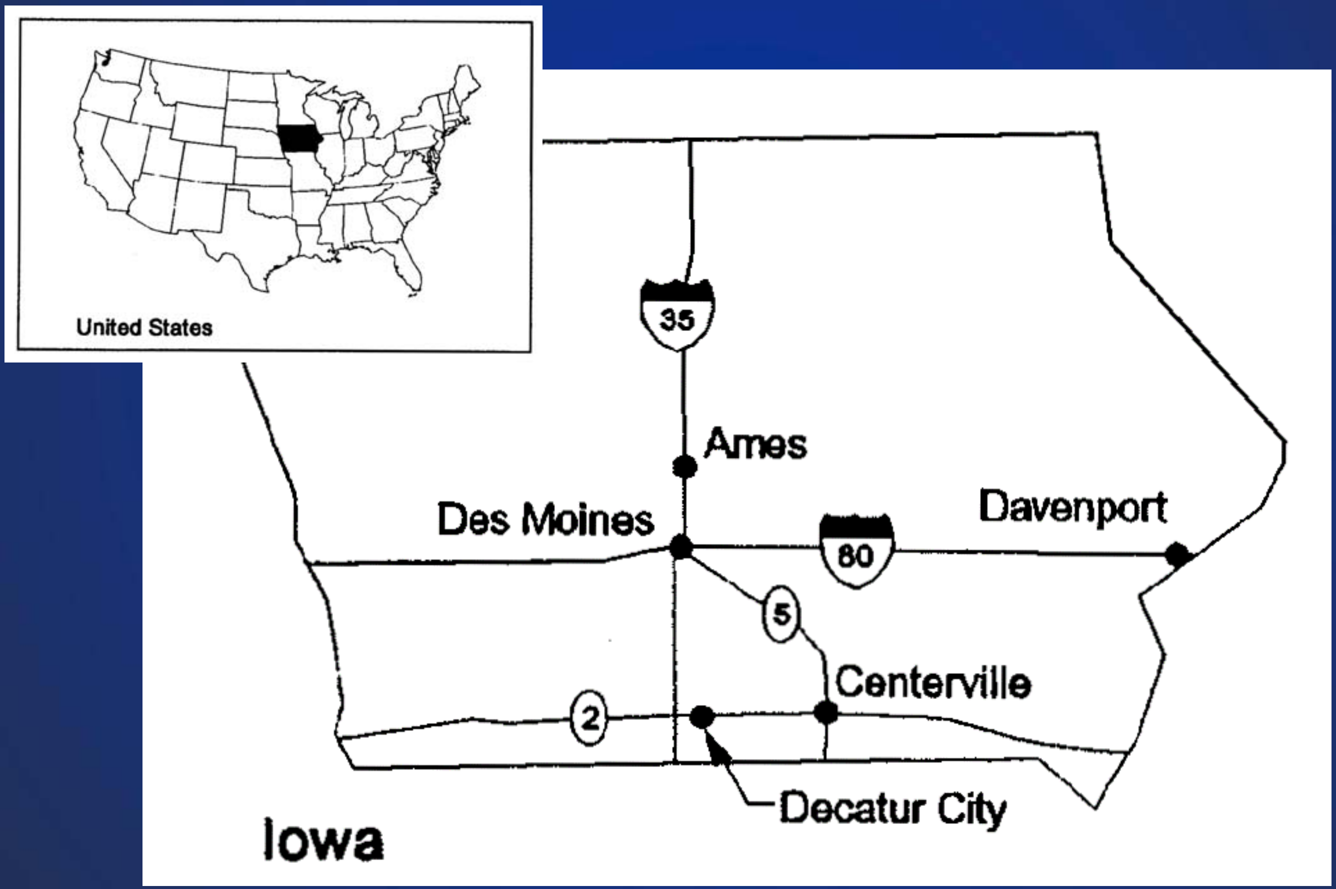
Iowa Bridges

Due to the success of the
Cooper Creek Bridge,
3 additional bridges were constructed.

The Chariton Valley Resource Conservation and Development Council provided the lamination material.

- 2 in Appanoose County
- 1 in Decatur County

Bridge Locations



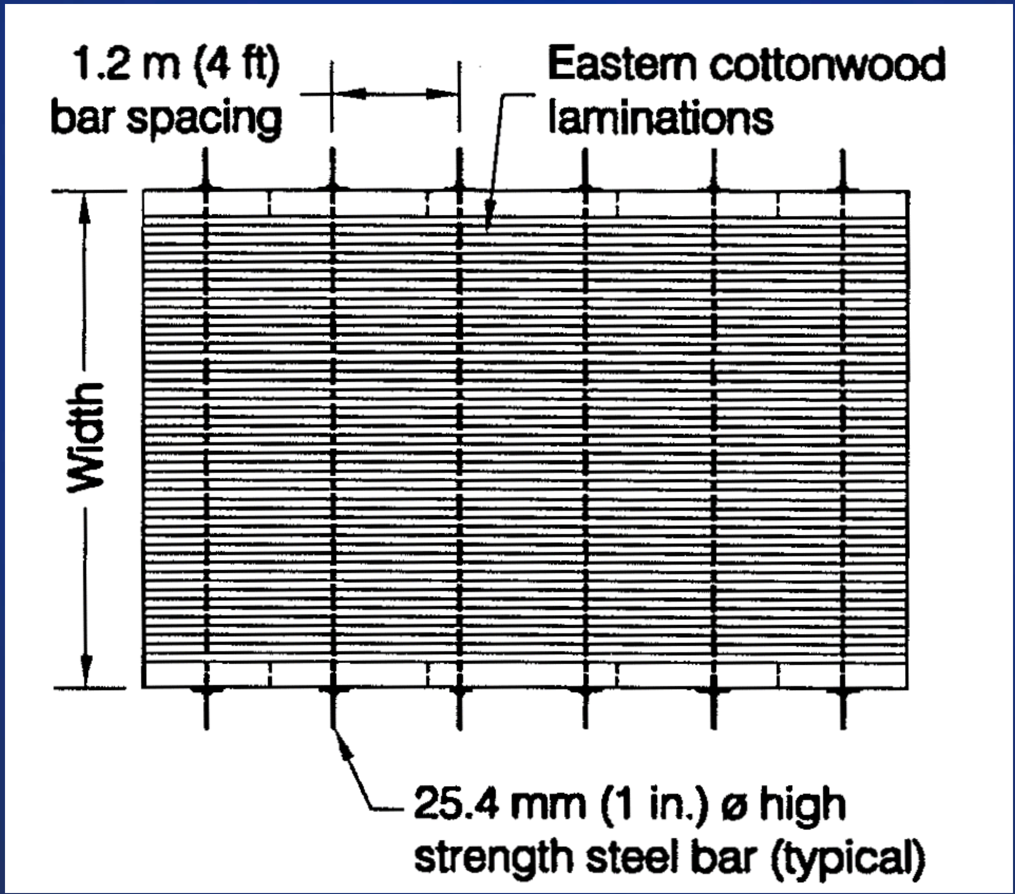
Design Configuration

	Width	Length	Deck Thickness
Dean	23 ft. (7m)	24 ft. (7.3m)	15 in. (381mm)
Hibbsville	17 ft. (5.2m)	24 ft. (7.3m)	14 in. (356mm)
Decatur	21 ft (6.4m)	24 ft. (7.3m)	14 in. (356mm)

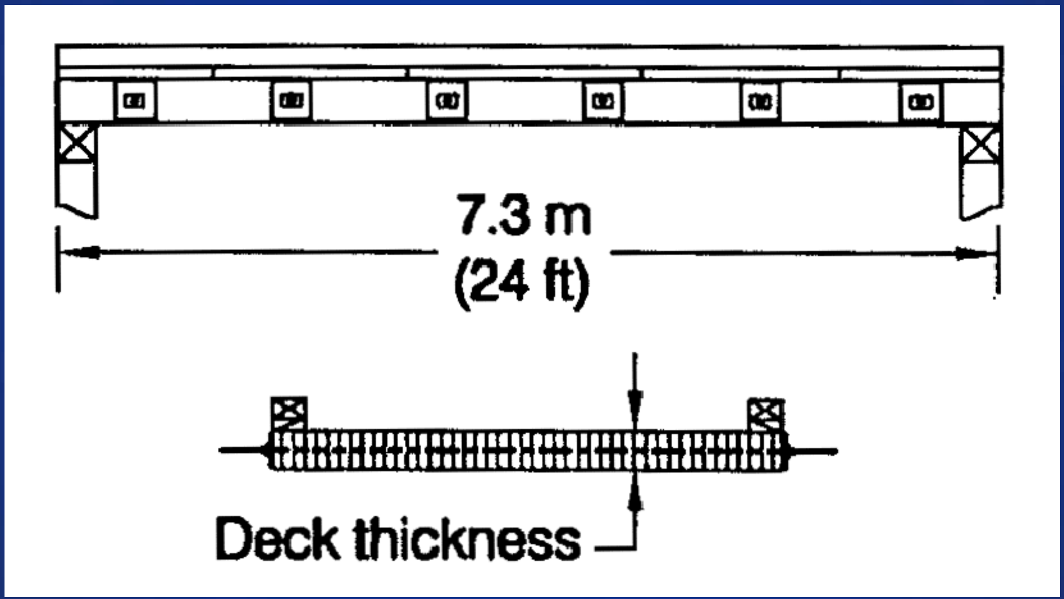
Design Loading: AASHTO HS20-44

Butt joint configuration: 1 in 4 at 4 ft. o.c.

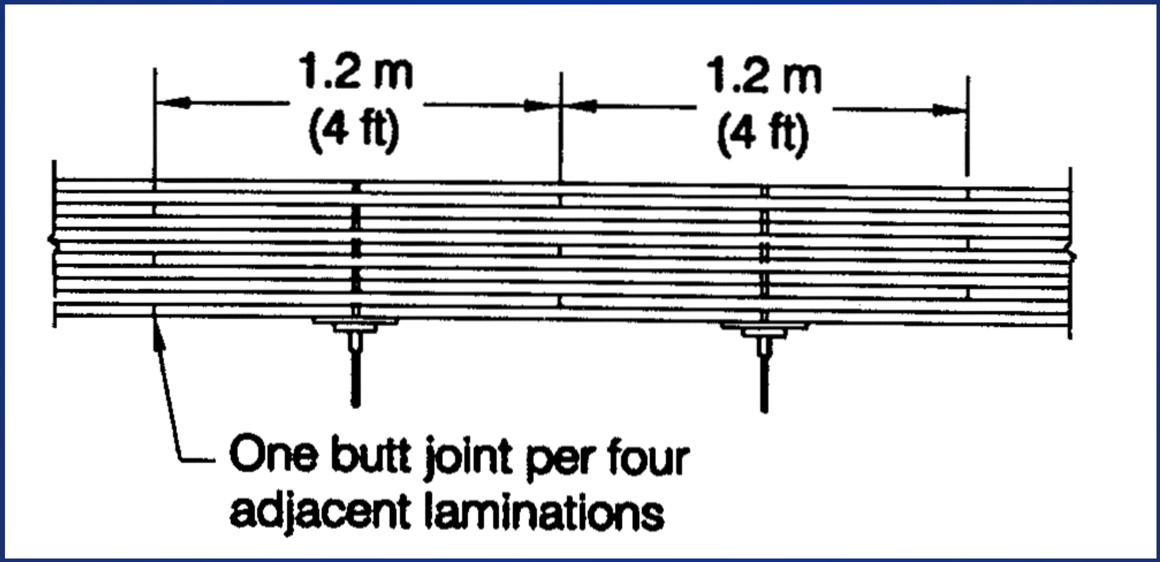
Typical Bridge Plan



Typical Bridge Elevation/Section



Typical Bridge Butt Joint Configuration



Design Configuration

	Wearing Surface	Design Bar Force
Dean	gravel	72k (320 kN)
Hibbsville	none	67.2 k (299 kN)
Decatur	gravel	67.2 k (299 kN)

Design Interlaminar Compressive Stress: 100 psi

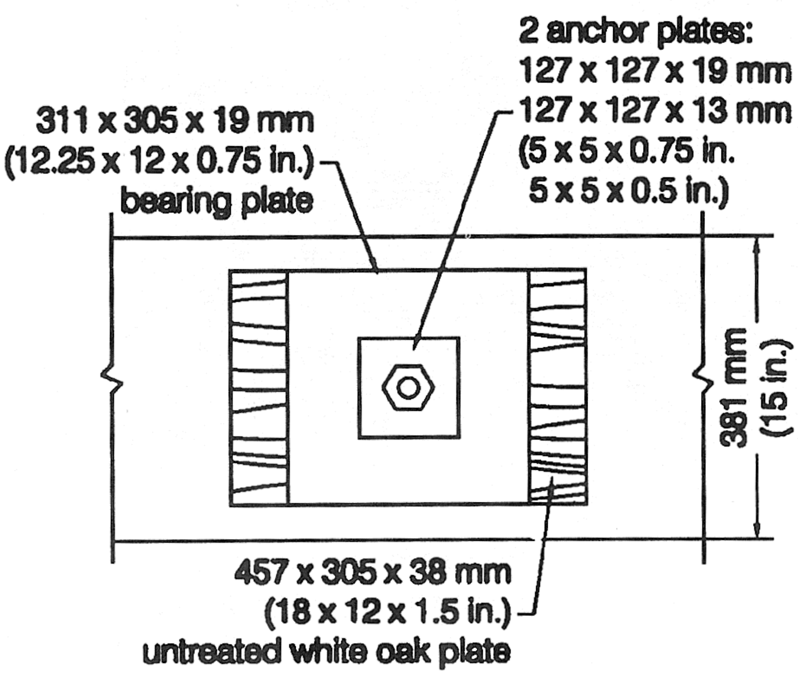
Preservative Treatment: Creosote

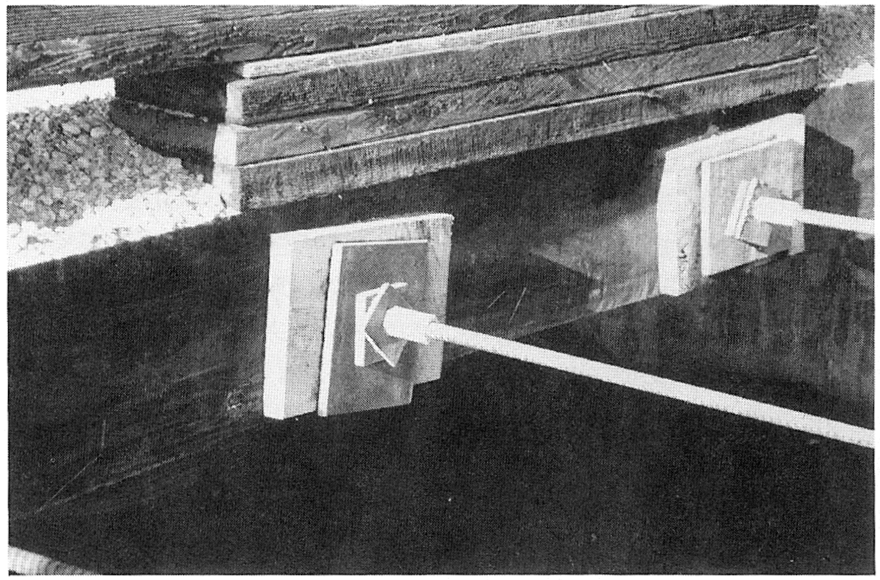
Design Configuration

Anchorage System

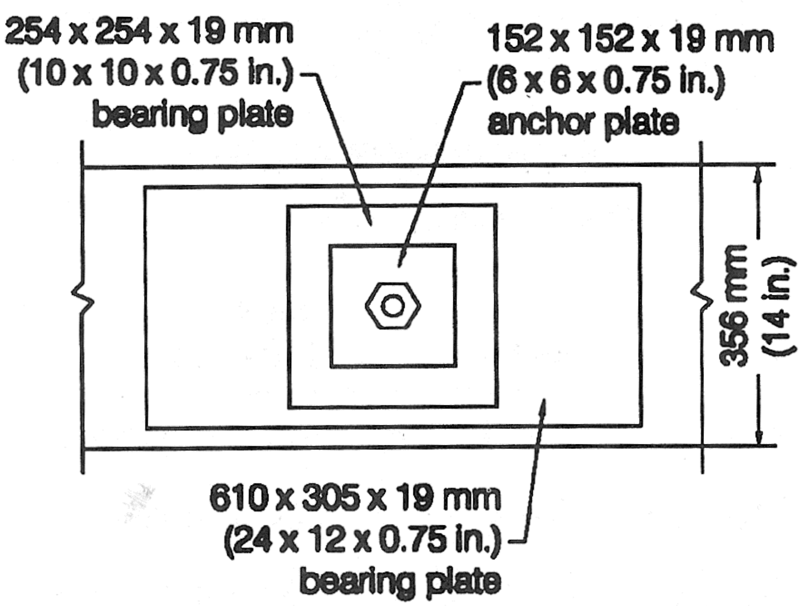
- Six 1-in. (25.4mm) dia. high strength steel bars at 4 ft. (1.2m) o.c.
- Galvanized bars and anchor nuts
- Steel bearing and anchor plates
- White oak anchor plates *(Dean and Decatur)*

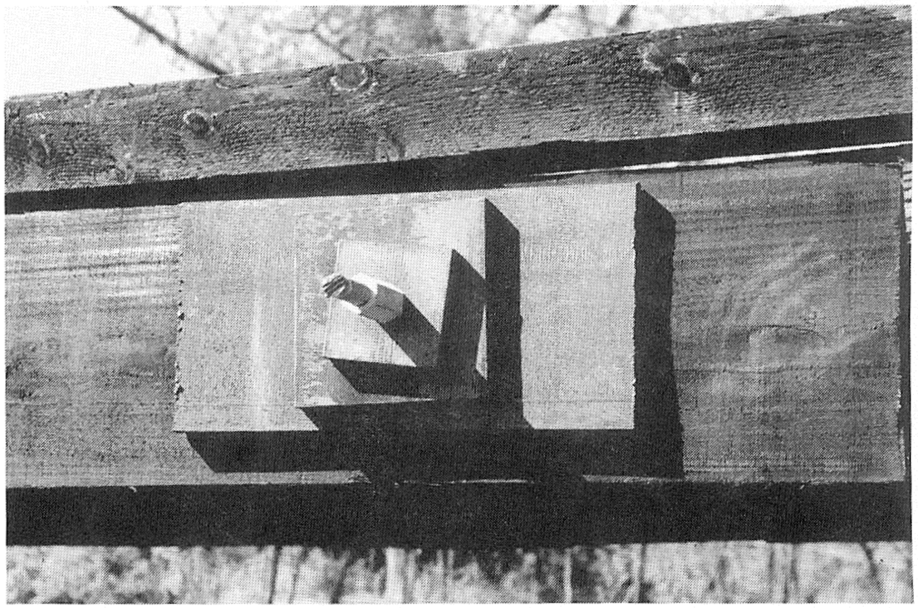
Dean Anchorage Configuration



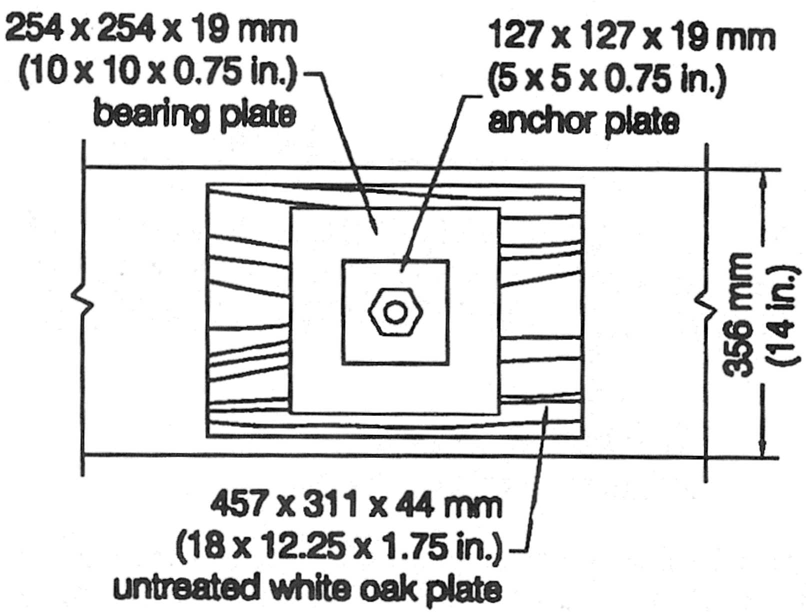


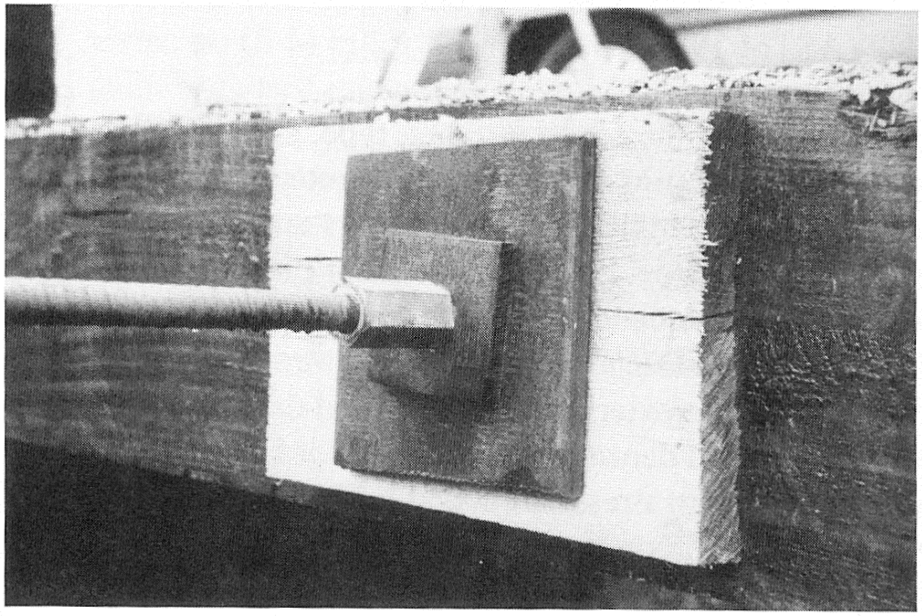
Hibbsville Anchorage Configuration





Decatur Anchorage Configuration





Construction

	Substructure	Date Built
Dean	Concrete abutments and wingwalls	October 1993
Hibbsville	Timber piling with backwall planks and timber pile caps	January 1994
Decatur	Timber piling with backwall planks and steel I-beam pile caps	June 1994

All bridges were built adjacent to sight and lifted or skidded into place.

Dean

Hibbsville

Decatur

Evaluation

To evaluate the structural performance of these bridges, the Chariton Valley RC&D officials contacted FPL for assistance. As a result the bridges were included in the FPL/FHWA timber bridge monitoring program. Through mutual agreement, a bridge monitoring plan was developed and implemented.

Evaluation Methodology

2 year time period

- Moisture Content
- Bar Force
- Vertical Creep
- Load Test Behavior
- Condition Assessment

Moisture Content

Measured at beginning and end of monitoring period and on a bi-monthly basis for Hibbsville.

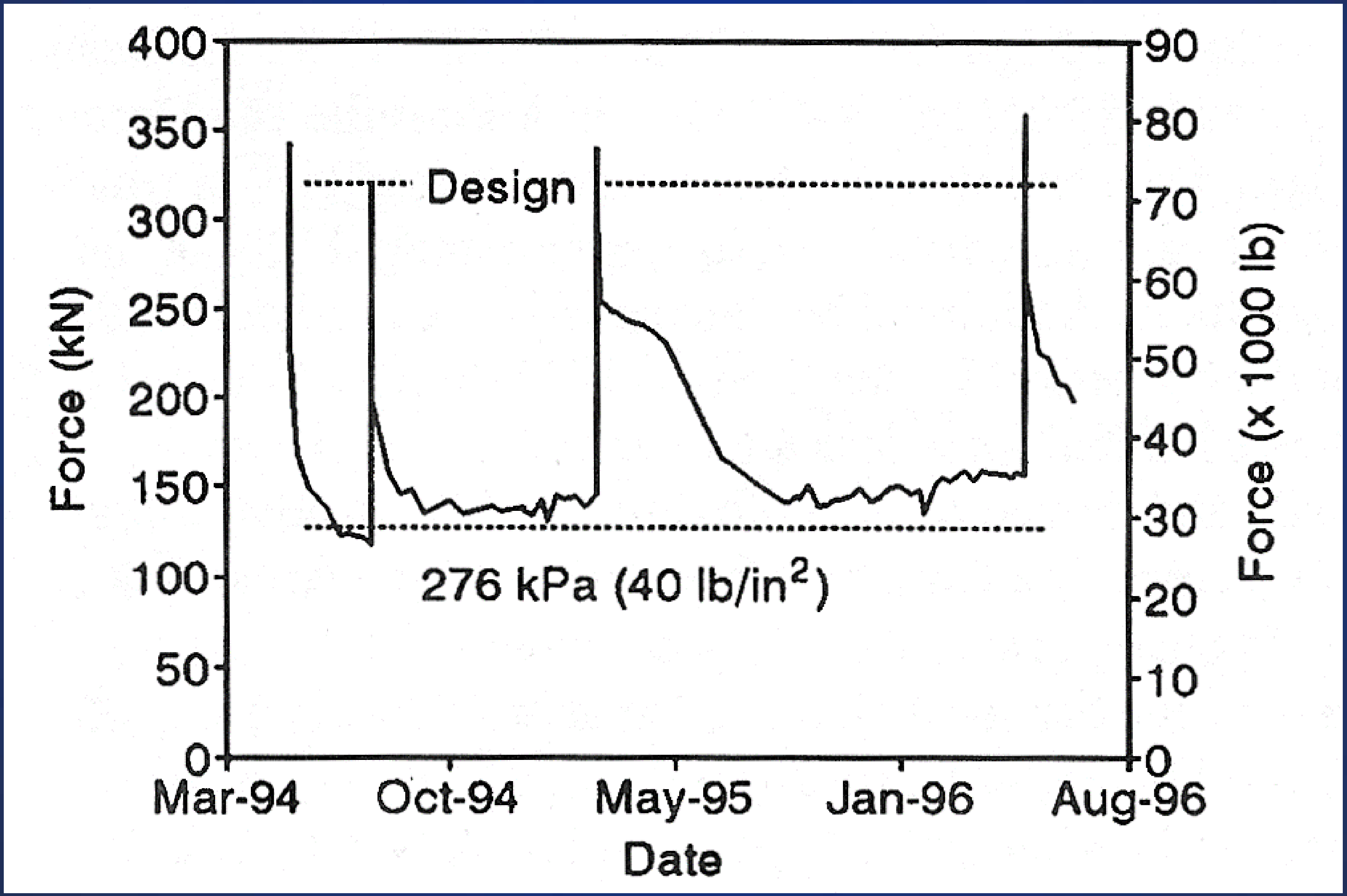
	Beginning	End	
Dean	24%	24%	
Hibbsville	24%	24%	2 to 3% fluctuations throughout monitoring
Decatur	21%	26%	

Moisture Content

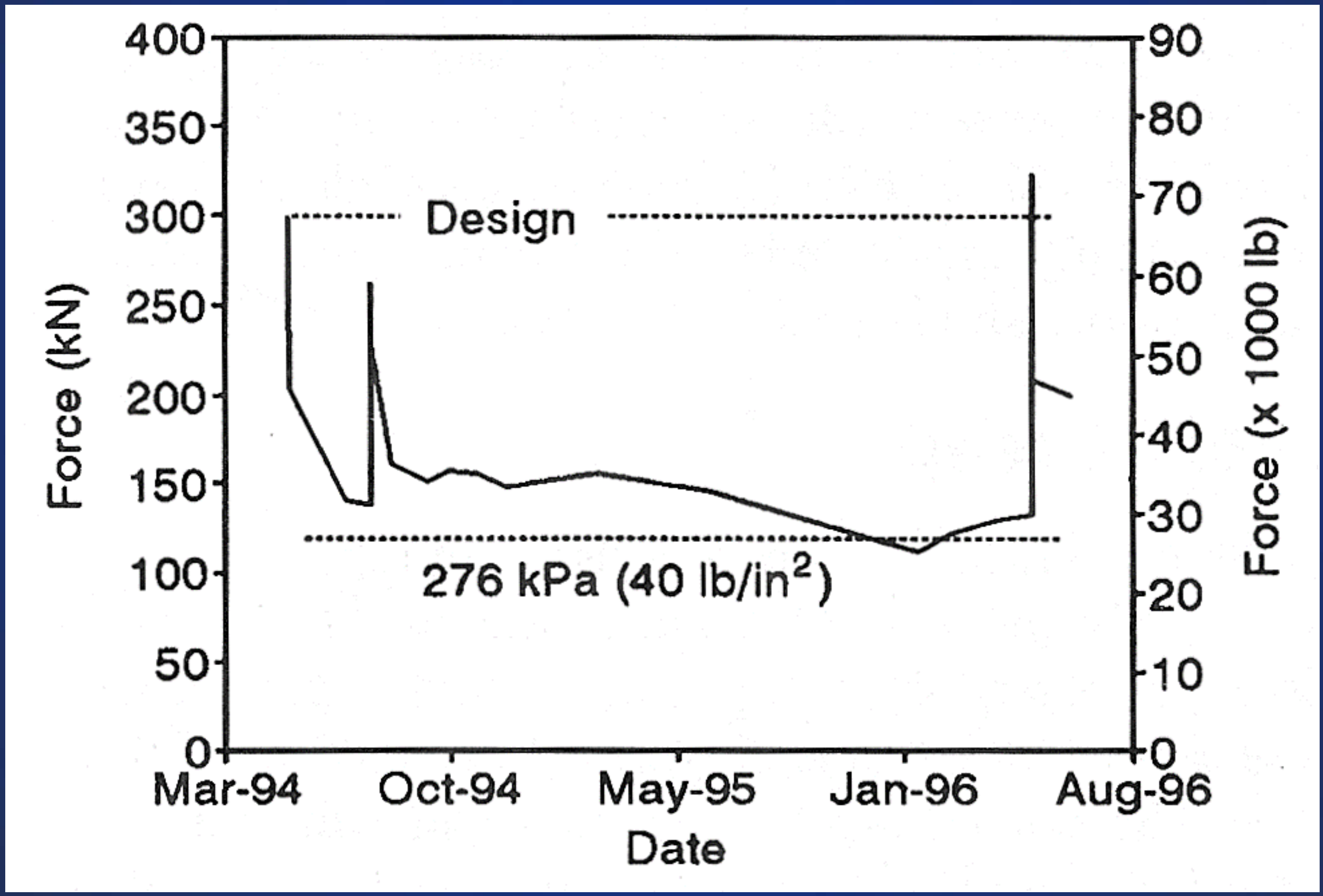
The primary contributing factor to the continued high moisture content was the absence of a watertight membrane over the surface of the deck. The gravel wearing surfaces inhibit drying of the deck surface.

Hibbsville

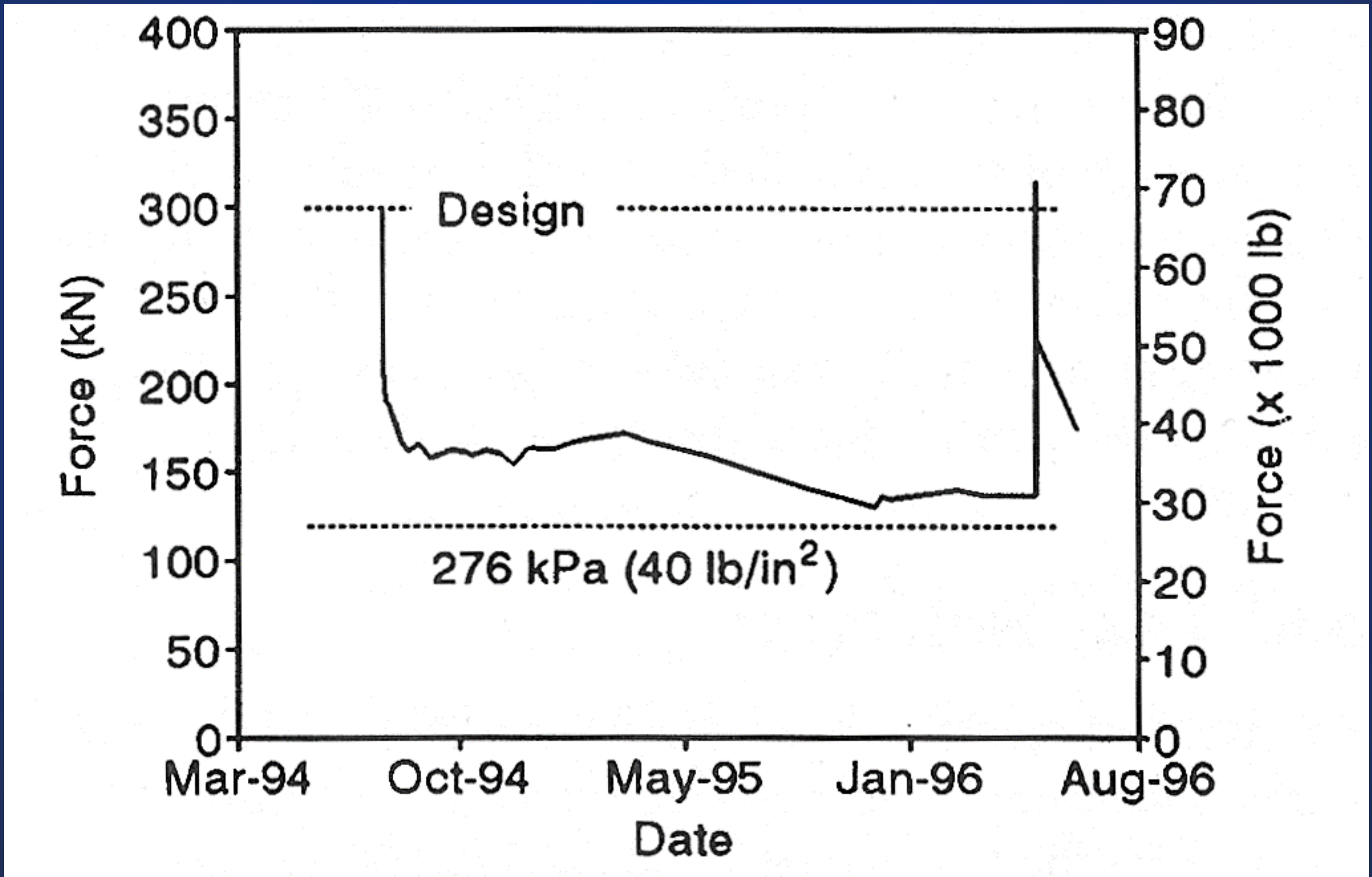
Bar Force – Dean



Bar Force – Hibbsville



Bar Force – Decatur



Bar Force

The majority of the bar force loss is attributed to stress relaxation of the lumber laminations, augmented by the high moisture content of the laminations.

Vertical Creep

	Beginning	End	Vertical Creep
Dean	unknown	-22 mm (-0.875 in.)	unknown
Hibbsville - average	+41mm (+1.625 in.)	-38mm (-1.5 in.)	79mm (3.125 in.)
Decatur - s. edge	+38mm (+1.5 in.)	+38mm (+1.5 in.)	none

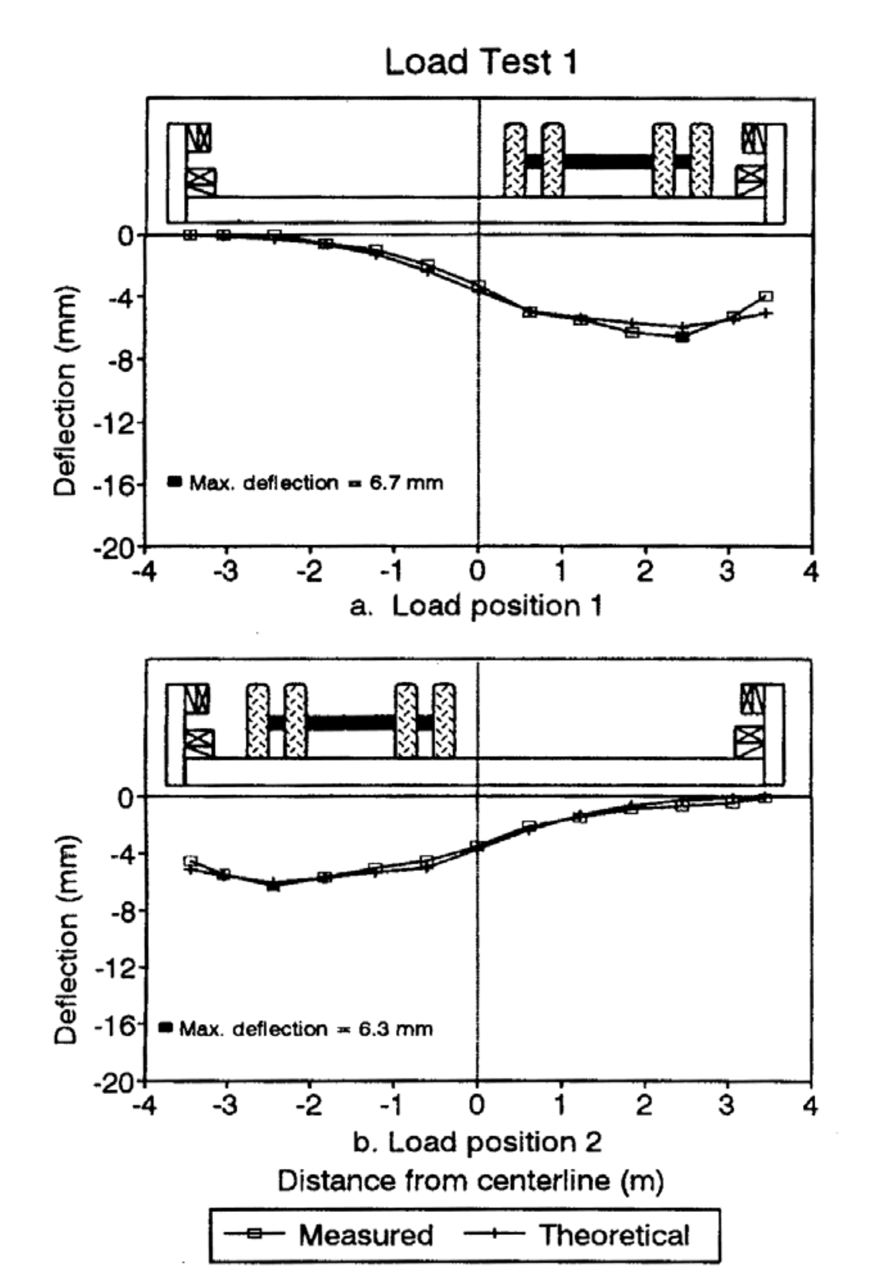
Vertical creep was influenced by high moisture content of laminations.

Load Test Setup

Load Test Behavior

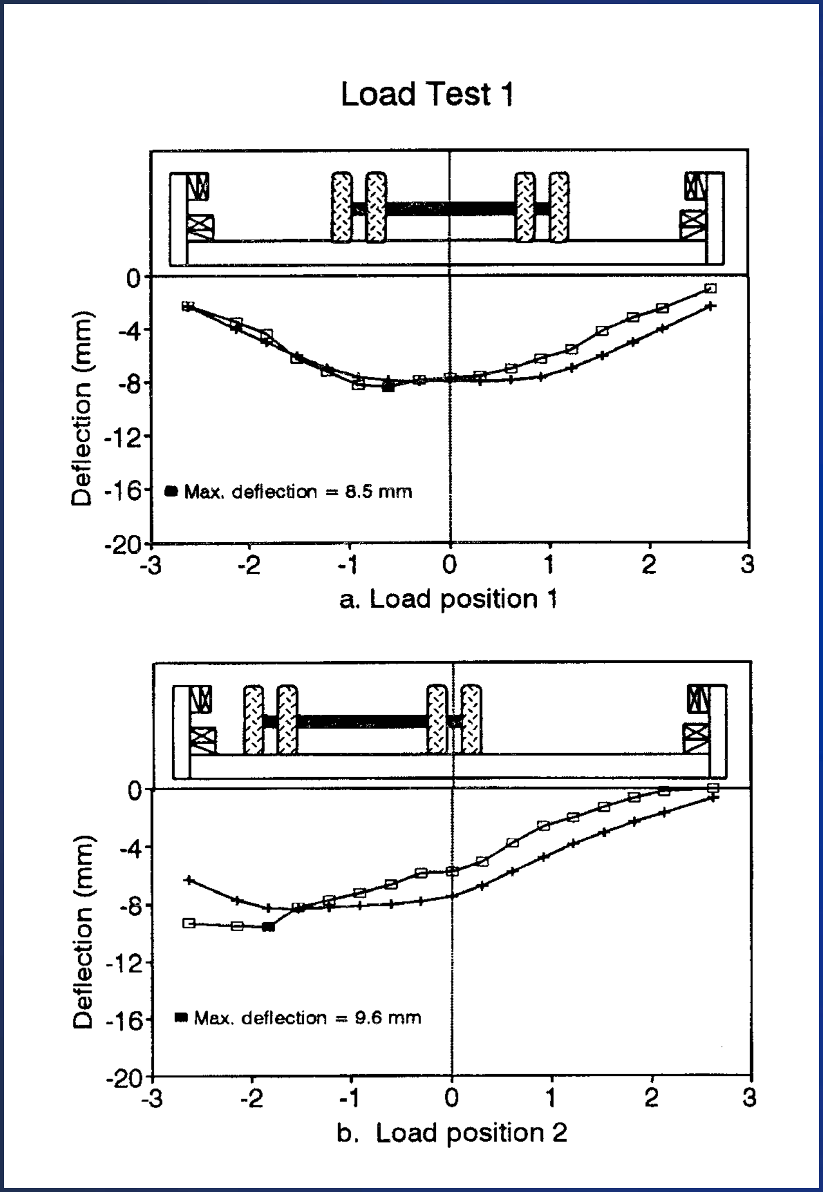
- Two static load tests were conducted at each bridge.
- Deflections were measured at midspan of bridge
- Deflections were typical of orthotropic plate behavior.

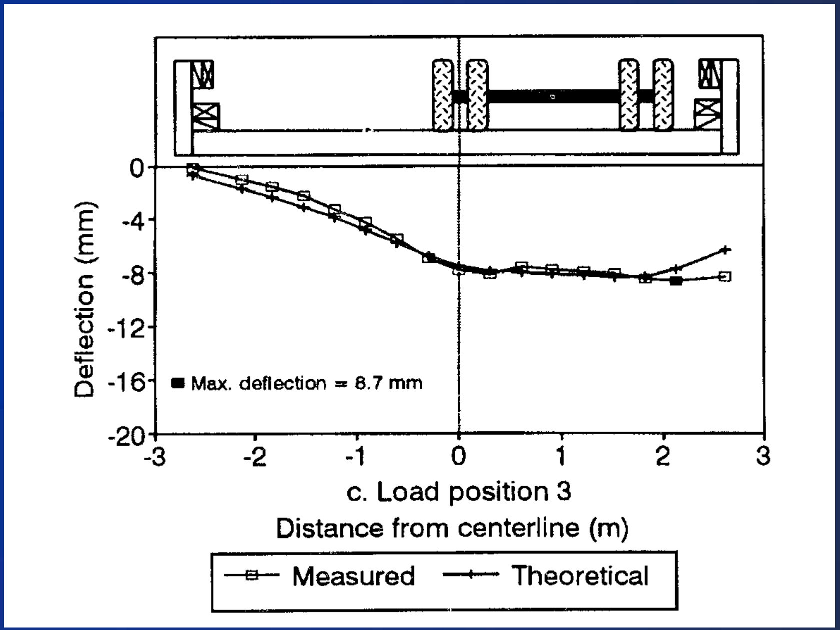
Dean



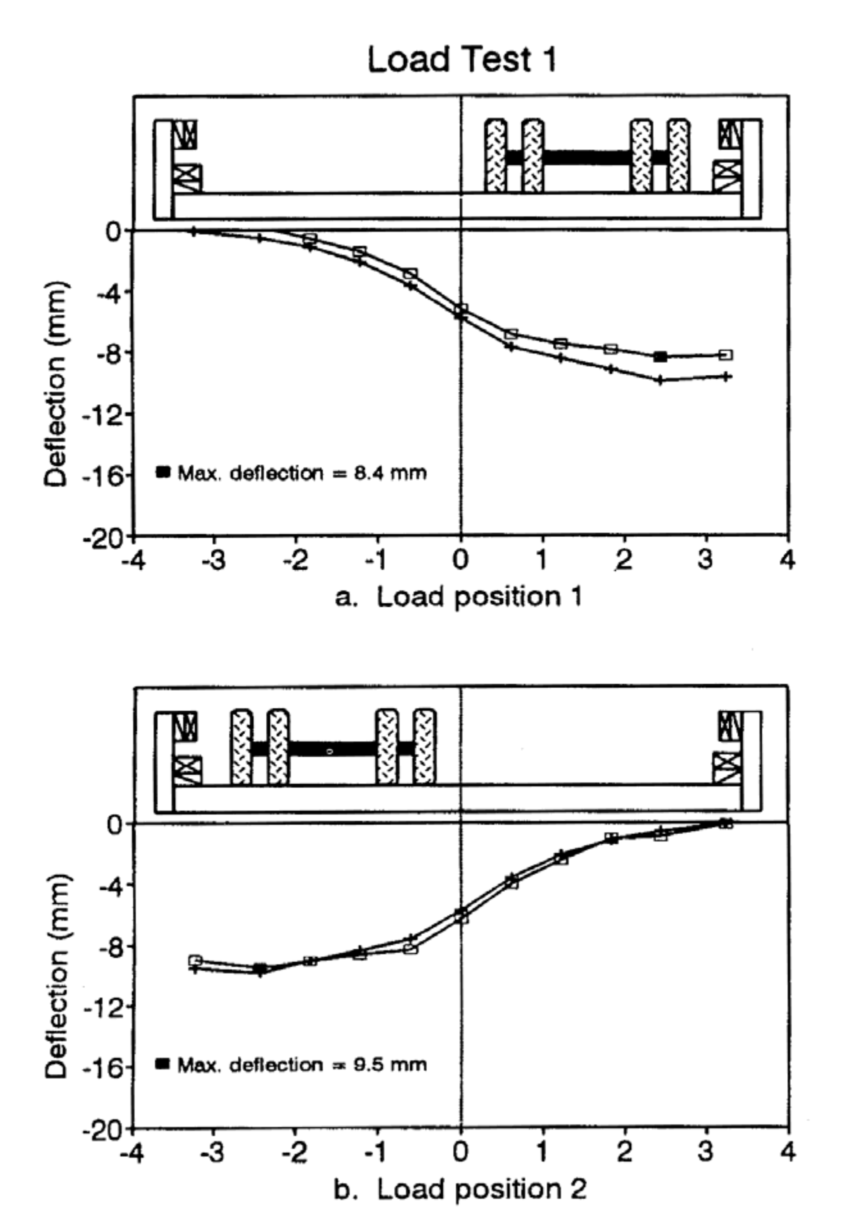
Load Test 1
Deflection (mm)
0
-4
-8
-12
-16
-20
Max. deflection = 6.7 mm
-4
-3
-2
-1
0
1
2
3
4
a. Load position 1
Deflection (mm)
0
-4
-8
-12
-16
-20
Max. deflection = 6.3 mm
-4
-3
-2
-1
0
1
2
3
4
b. Load position 2
Distance from centerline (m)
Measured
Theoretical

Hibbsville

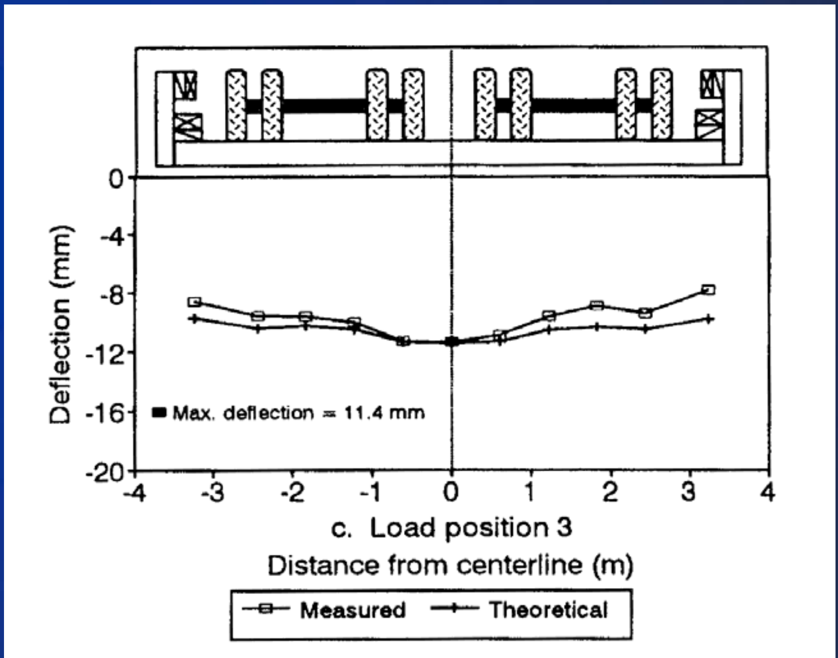

Load Test 1
Deflection (mm)
0
-4
-8
-12
-16
-20
Max. deflection = 8.5 mm
-3
-2
-1
0
1
2
3
a. Load position 1
Deflection (mm)
Max. deflection = 9.6 mm
b. Load position 2


Deflection (mm)
0
-4
-8
-12
-16
-20
Max. deflection = 8.7 mm
-3
-2
-1
0
1
2
3
c. Load position 3
Distance from centerline (m)
Measured
Theoretical

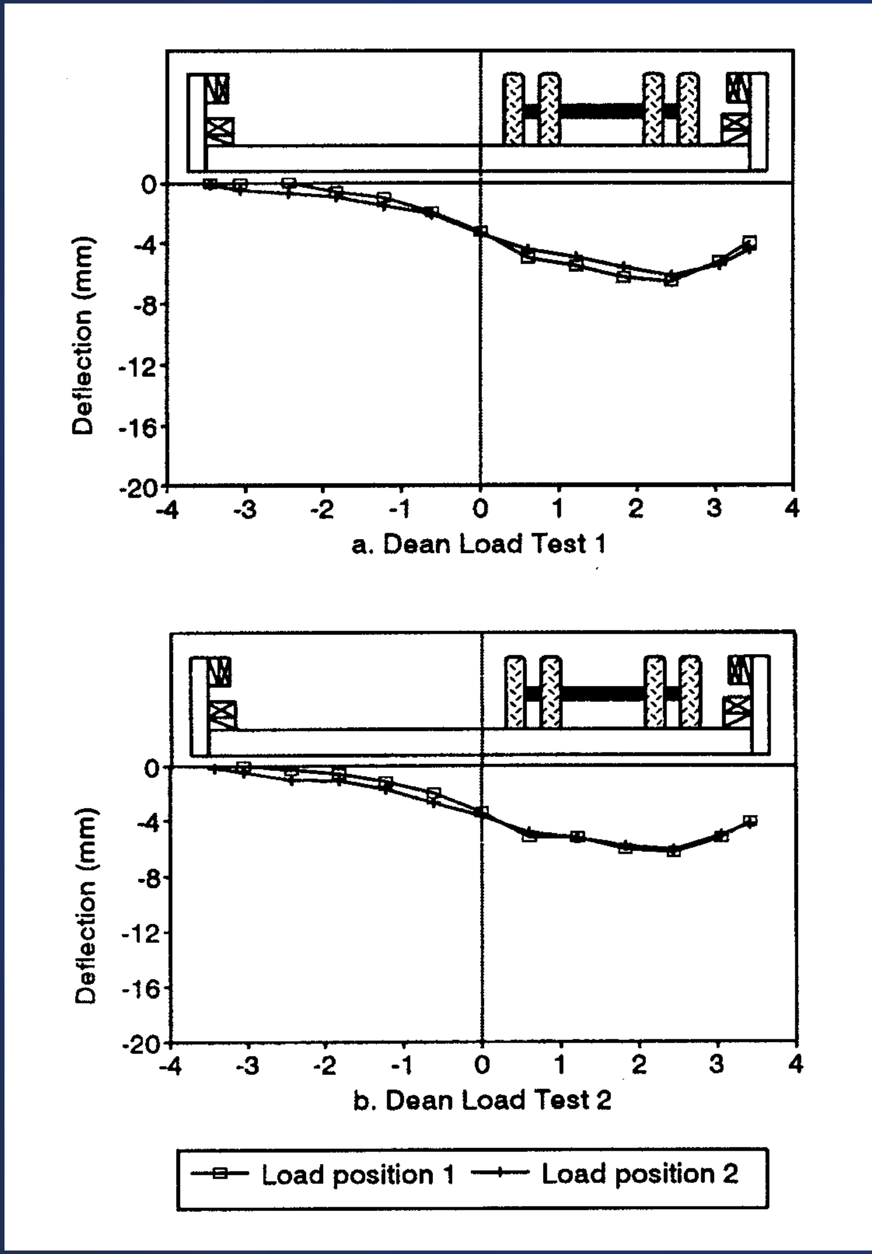
Decatur



Load Test 1
Deflection (mm)
Max. deflection = 8.4 mm
a. Load position 1
Max. deflection = 9.5 mm
b. Load position 2



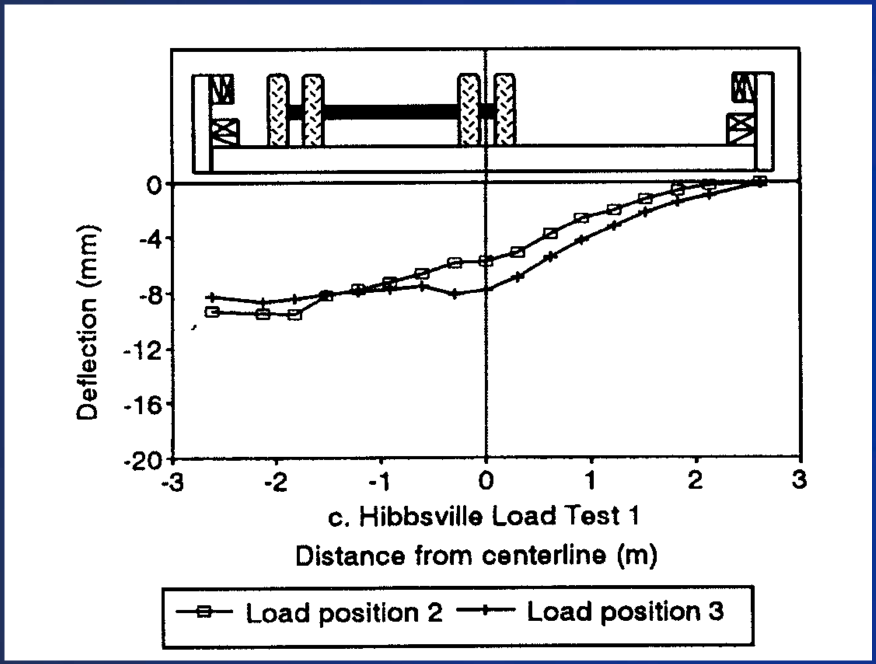
Deflection (mm)
Max. deflection = 11.4 mm
c. Load position 3
Distance from centerline (m)
Measured
Theoretical



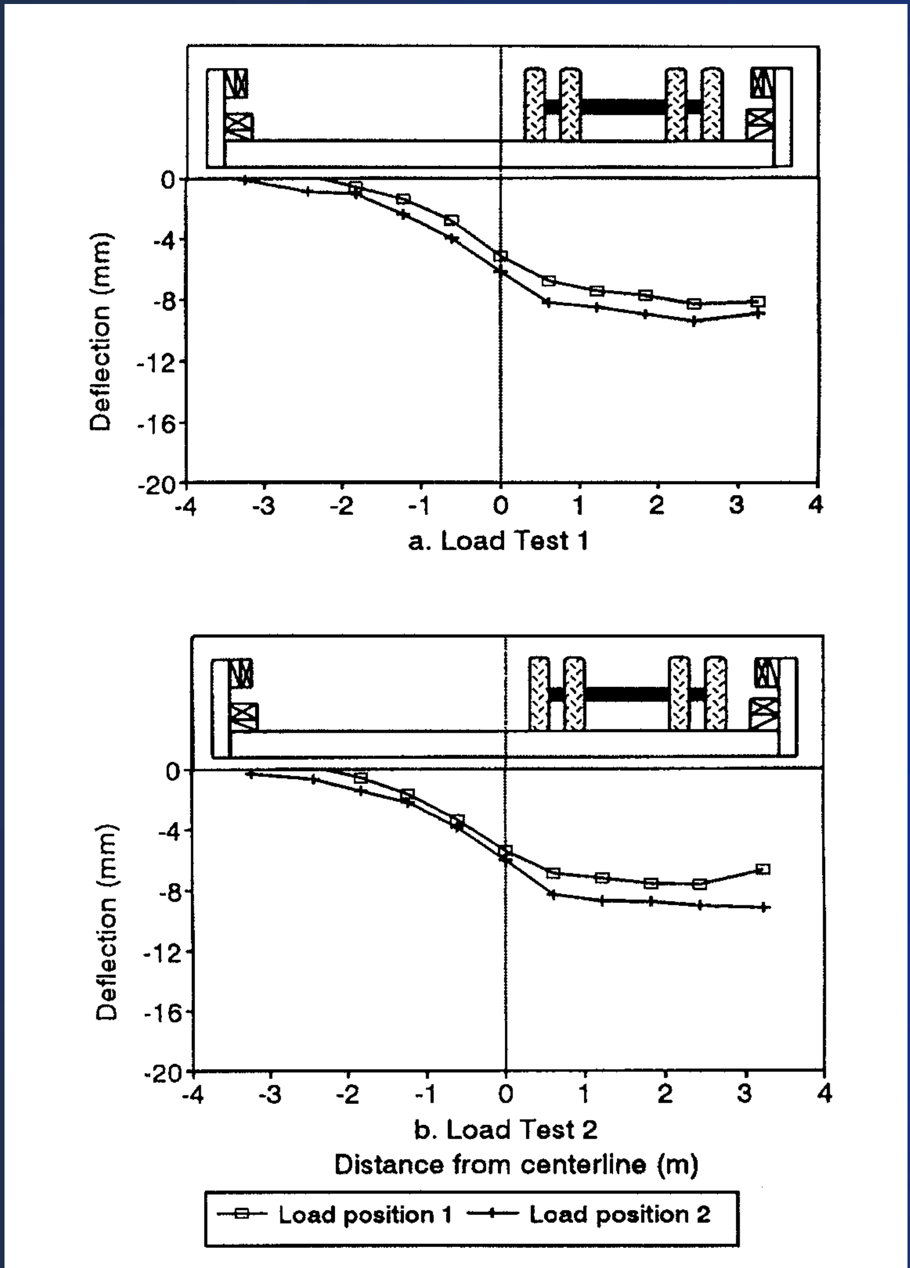
Dean Comparison

Shows actual deflection of load position 1 and mirror image of load position 2.

Hibbsville Comparison

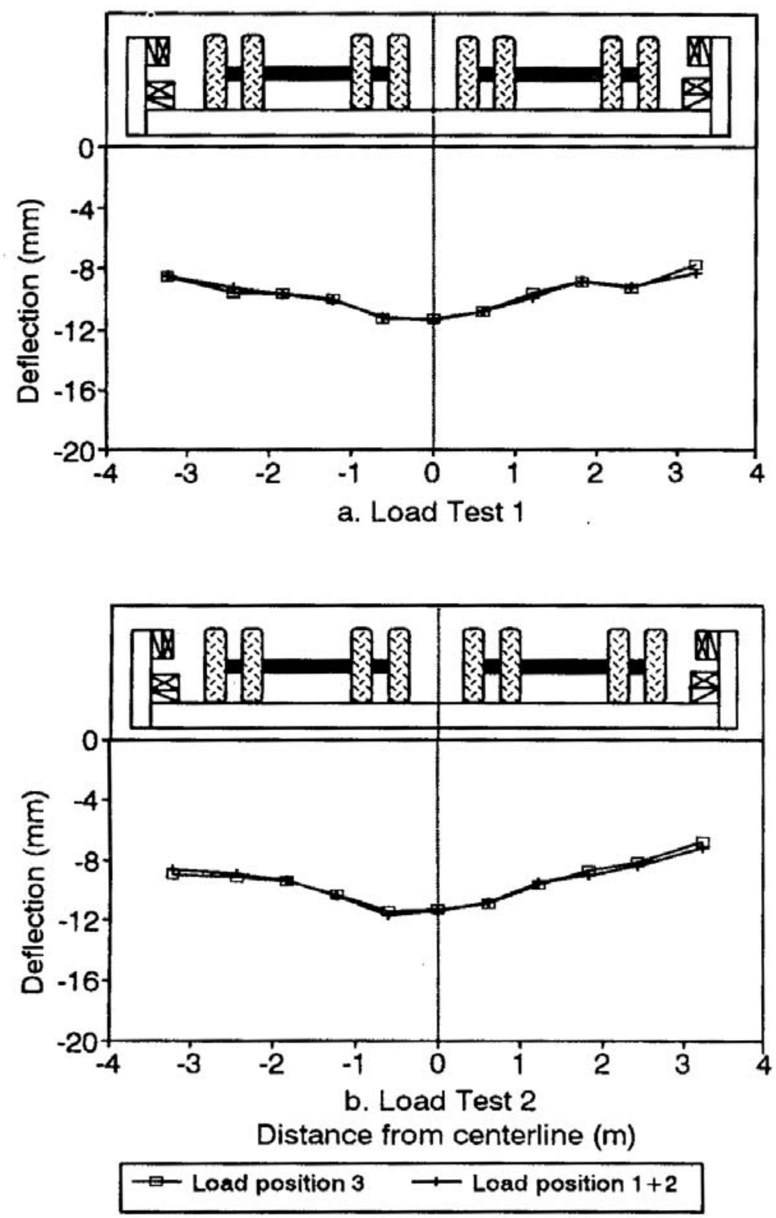


Shows actual deflection of load position 2 and mirror image of load position 3.



Decatur Comparison

Shows actual deflection of load position 1 and mirror image of load position 2.



Decatur Comparison

Shows sum of load positions 1 and 2 and load position 3.

Analytical Conclusions

- Bridge decks act as orthotropic plates
- Increase in interlaminar compression results in an increase in stiffness of the deck
- Theoretical deflections are generally similar to those measured

Analytical Conclusions

Assuming uniform material properties,
proper vehicle placement and
linear elastic bridge behavior:

Analytical Conclusions

- Deflections resulting from a single test vehicle placed in symmetrical load positions should be a mirror image
- Summation of deflections resulting from 2 separately applied truck loads should equal the defection of both trucks applied simultaneously

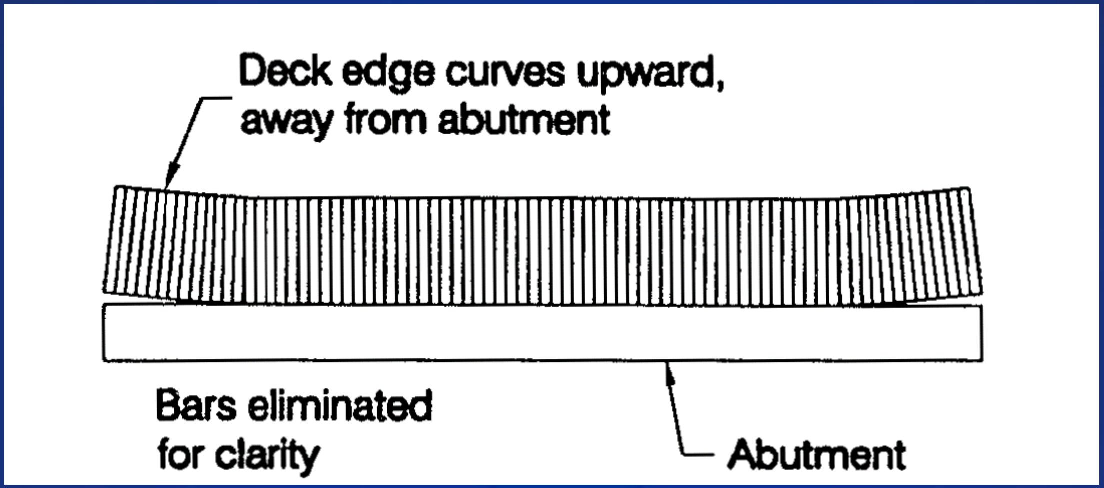
Condition Assessment

Dean Bridge Geometry

at LT1 8.5 inches narrower at midspan of north edge

Attributed to layout of laminations that varied in width as much as 0.5 inches

Condition Assessment



Dean and Decatur Bearing Condition

Unchanged throughout monitoring period.

Likely result of constructing deck
on uneven temp. supports

Condition Assessment

- *Anchorage system performing as designed.*
- *Crushing of plates into outer lamination negligible.*
- *No distortion visible.*
- *Corrosion of plates minimal because roads are unsalted.*

Condition Assessment

- *White oak plates will eventually deteriorate, negatively affecting the bar force.*

Conclusions

- *Bars for each bridge have been re-tensioned at least once since the time of the 2nd load test.*
- *County officials report bridges are performing well with no problems.*