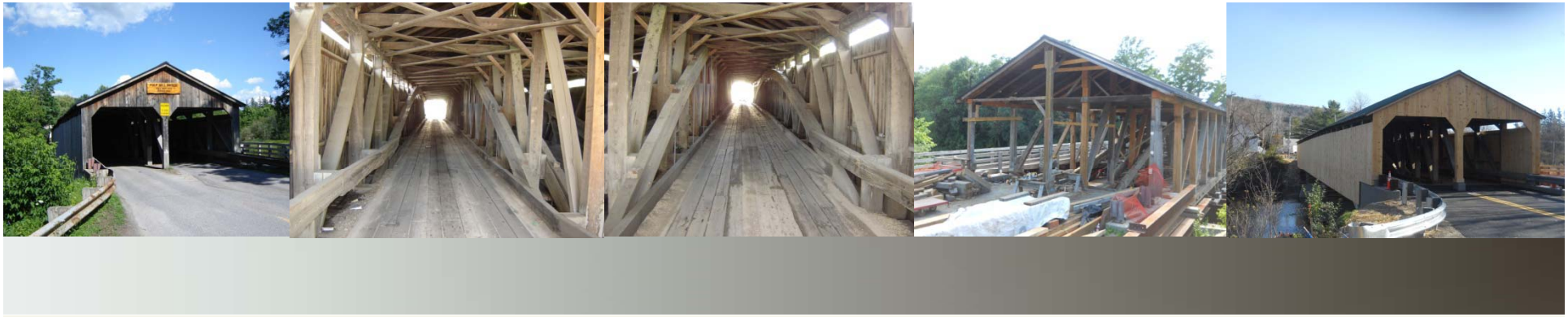

Rehabilitation of a Two-Lane Covered Bridge

Presented to:

Second National Covered Bridge Conference
June 6, 2013

Presented by:

Sean T. James, P.E. – Project Manager
(sjames@hoyletanner.com)
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(jbicja@hoyletanner.com)

Hoyle, Tanner & Associates, Inc.
Manchester, NH USA

Presentation Outline

- Background
- Bridge Description
- Project Purpose and Need
- Structural Analysis
  - Geometric Limitations / Load Cases/ Live Load Selection
  - Computer Model
  - Arch Interaction
  - Observations & Results
  - Proposed Modifications
- Rehabilitation Project

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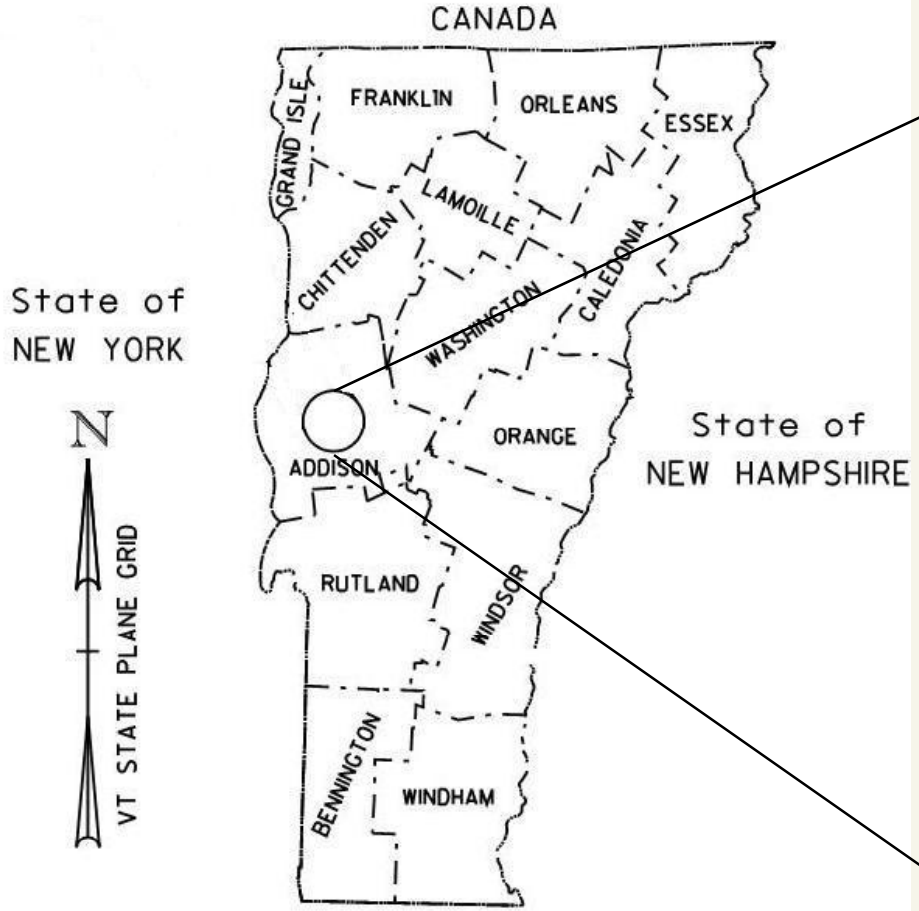
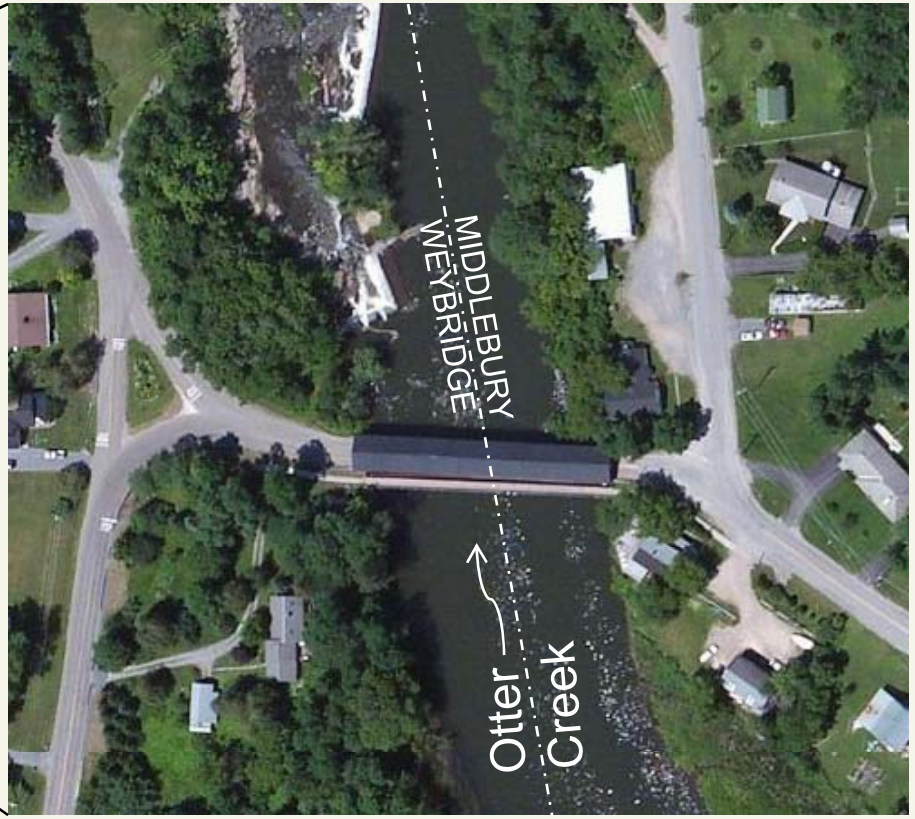
Background



Project Location



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Background

- 5 Remaining Double Barrel Covered Bridges
  - Roberts Covered Bridge, Eaton OH, 1829, 79’ Long Single Span, Multiple Kingpost w/Arches, Pedestrian Only.
  - Ramp Creek Covered Bridge, Nashville IN, 1838, 96’ Long Single Span, Multiple Kingpost w/Arches, Vehicular.
  - Philippi Covered Bridge, Philippi WV, 1852, 286’ Long Four Span, Long Truss, Vehicular.
  - Shelburne Museum Covered Bridge, Shelburne VT, 1845, 168’ Long Single Span, Multiple Kingpost w/Arches, Pedestrian Only.
  - Pulp Mill Covered Bridge, Middlebury/Weybridge VT, 1853, 200’ Long Three Span, Multiple Kingpost w/Arches, Vehicular.

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Background

- Pulp Mill Covered Bridge
- Frequently Cited Built From 1805 and 1820
- VTrans Record Built in 1853
- National Register of Historic Places in Sept. 10, 1974
- AADT Volume of 1,900 Vehicles
- Originally Built as 180’ Single Clear Span, Extensive Sagging
- Nail Laminated Wood Arches Added in 1859-60
- Two Stone Masonry Piers with Timber Cribbing in Late 19th Century

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Background

- Major Rehabilitation in 1979-80
  - Stone Masonry Piers Encased in Concrete
  - New Concrete Facing of Abutments and New Backwalls
  - Portions of Arches and Truss Bottom Chords Replaced
  - New Steel Hanger Rods Added to Connect the Arches to the Bottom Chord at Each Panel Point
  - New 6” x 6” Pressure Treated Lower Lateral Braces Installed
- North Truss and Arch (West Span) Rehabilitated in 1991
- Interior Truss and Arch (East Span) Rehabilitated in 2002
- A Pedestrian Bridge Constructed in Mid-1990’s

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Bridge Description

- 200’, 3 Span Continuous, over Otter Creek
- M. Kingpost Trusses w/Arches
  - 3 Trusses, 4 Arches
- 2 Lanes, 8’-6” Wide Curb-Curb, 26’ Out-Out
- 10’-6” Vertical Clearance
- 4 Tons Live Load Capacity Goal

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Bridge Description

Upstream Elevation

Downstream Elevation

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Bridge Description

East Approach

West Approach

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Bridge Description

Roof Framing

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Bridge Description

Upstream Barrel

Downstream Barrel

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Bridge Description

Bridge East Pier & Floor Framing

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Project Purpose and Need

- Bridge in Poor Condition
  - Broken, Rotted, Impact Damaged Members
  - Truss Vertical Member Issues
  - Previous Repairs
  - Sag in Truss Spans
  - Snap Through Buckling of Arches
- Preserve Historic Covered Bridge
- Critical Link Between Towns

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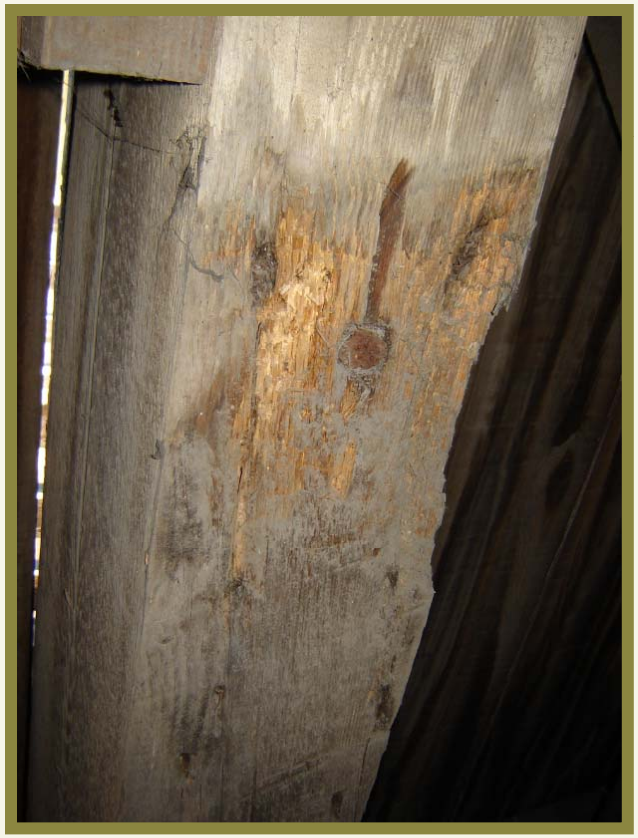
Project Purpose and Need

Member Split



Member Impact Damage

Member Split

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Project Purpose and Need

Break

Rot

Break

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Project Purpose and Need

Broken Tenon – Truss Vertical

Broken Tenon – Truss Vertical

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Project Purpose and Need

Undersized Verticals At Notch

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Project Purpose and Need



Split Verticals

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Project Purpose and Need

Previous Repairs

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Structural Analysis

- Geometric Limitations
  - Lane Width of 8’-6”
  - Vertical Clearance – 10’-6” @ Center, 8’-0” @ Edge
- Allowable Stress Rating and Design
- Load Cases
  - Dead + Live @ Inventory
  - Dead + Live + Snow @ Operating

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Structural Analysis

- Live Load
  - Lane Load Evaluated
  - H4 (4 Tons)
  - Truck Train
  - 5 Load Cases, Both Lanes Loaded
  - 3D Computer Model

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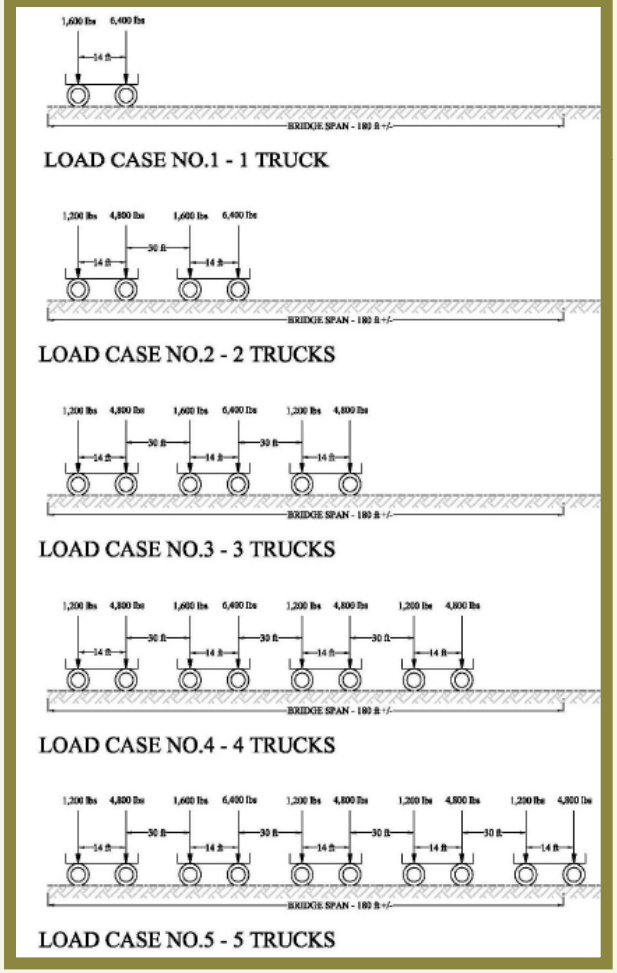
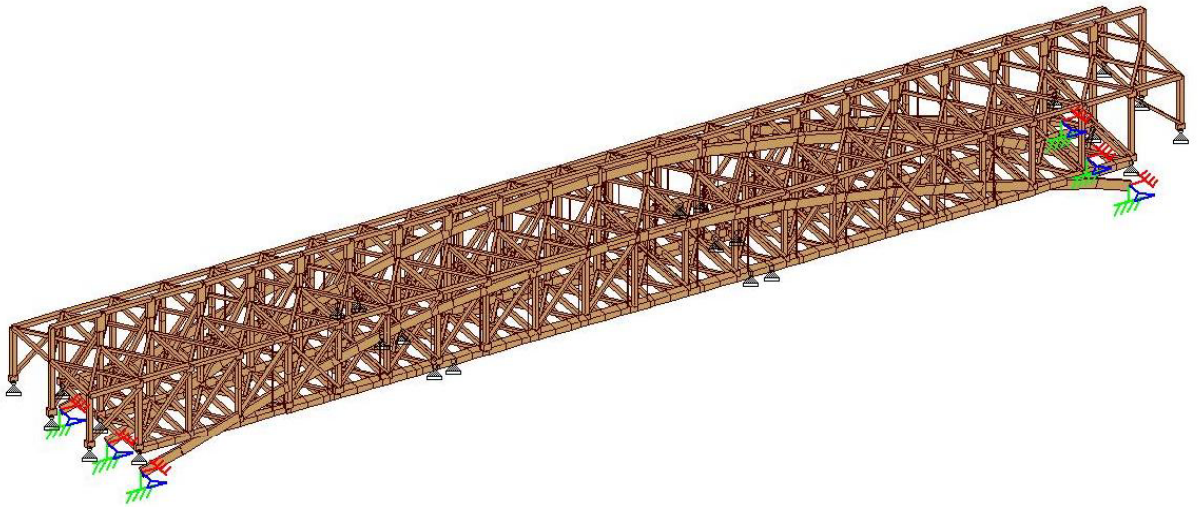
Structural Analysis

H4 Load Cases





Three-Dimensional Computer Simulation of the Pulp Mill Covered Bridge - Unloaded

Load 1

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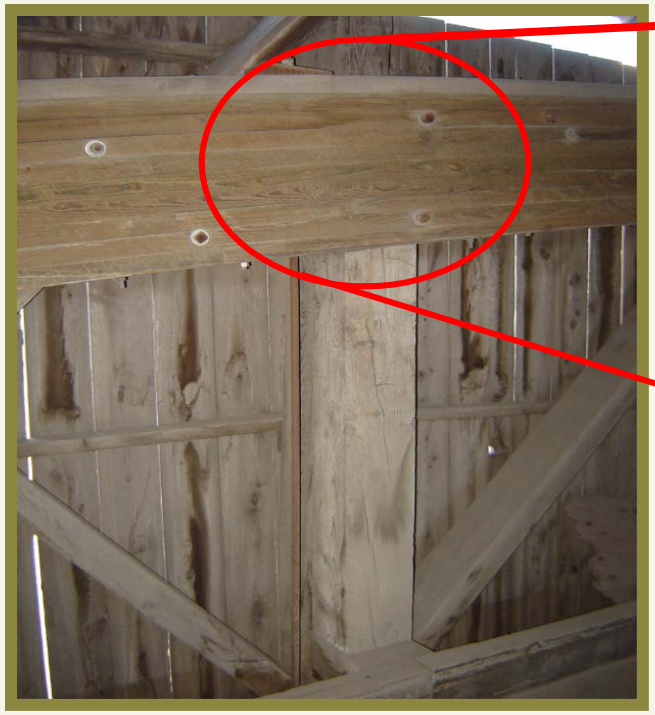
Structural Analysis



Arch Interaction / Condition

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Structural Analysis

- Observations & Results
  - Poor Connection Capacity of Vertical to Chord
  - 3 Span Configuration Results in Member Stress Reversals
  - Load Sharing of Trusses and Arches Critical
    - Relative Stiffness Determined to Share Load
    - Limited by Bolted Connection
  - Live Load Stresses Approx. 30-40% of Dead Load Stresses
  - Most Members Controlled by Multiple Truck Load Case

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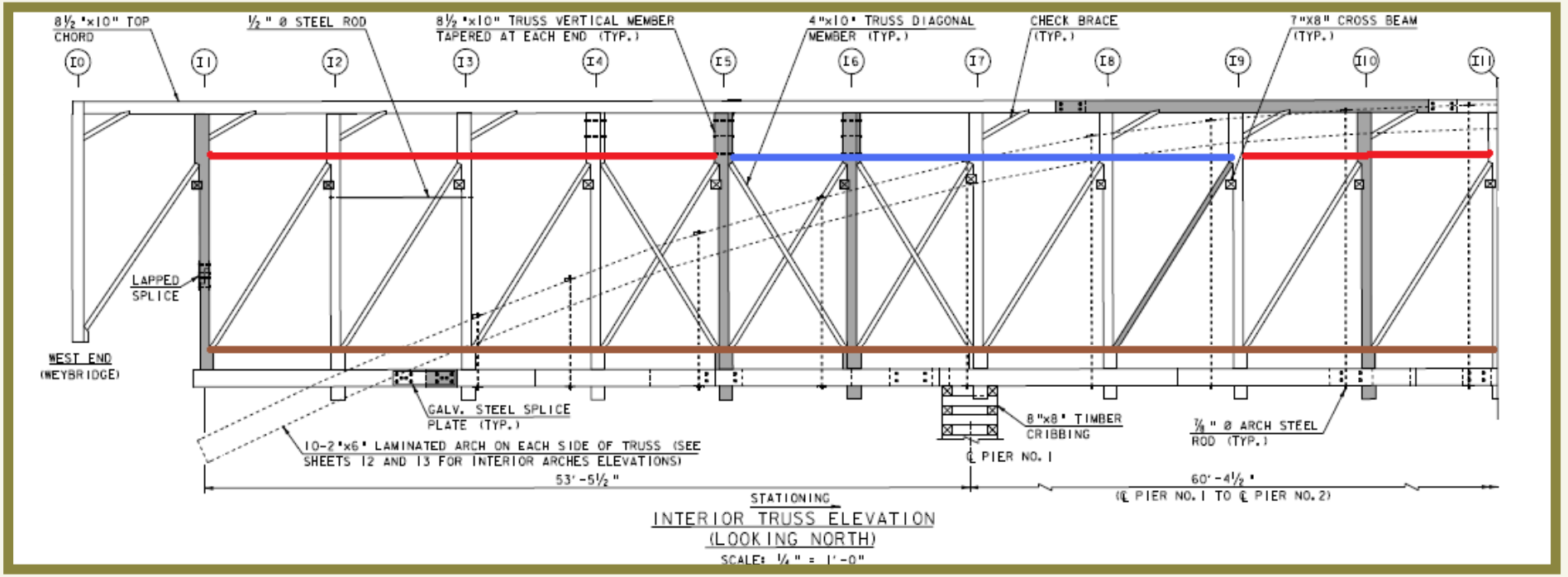
Structural Analysis



Proposed Modifications to the Interior Truss

Legend:

- **5”x5” Timber**
- **½” Steel Rod**
- **Solid Blocking**

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Rehabilitation Project

- Three Ends of Arches Rebuilt
- Several Truss Member Replaced or Repaired due to Strength & Condition
- All Arch Hanger Rods Removed
- Connections of Arches to Verticals Strengthened
- Bottom Chord Replaced
- Reversible Modification to Interior Truss
- Several Roof Rafters Replaced In-Kind or Sistered

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Rehabilitation Project

- New Upper Lateral Bracing Installed
- Several Knee Braces and Cross Beams Replaced In-Kind
- All Stringers Removed
- Several Floor Beams Replaced In-Kind
- Existing Decking Replaced
- Limited New Lateral Bracing Installed
- New Wood Curb Installed

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Rehabilitation Project

- Trusses and Arches Realigned
- Protectowire and Lighting Installed
- Fire Retardant/Insecticide Coatings Applied
- Minor Approach Work
- Minor Repairs to Existing Substructure
- Total Construction Cost $1.7 Million

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Rehabilitation Project

Temporary Shoring System Below the Bridge

Temporary Shoring System Above the Deck

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Rehabilitation Project

New Truss Verticals

New Bottom Chord

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Rehabilitation Project

Rebuilt East End of North Arch

Sistered Roof Rafters

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Rehabilitation Project

Typical Floor Framing at Arch Locations

Fire Detection Wires
Underside of Bridge

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Rehabilitation Project

1St Car to Cross the Bridge
November 9, 2012

Ribbon Cutting Ceremony
November 9, 2012

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Rehabilitation Project

Question & Answer

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