



Simplified Analytical Model of a Covered Burr-Arch-Truss Timber Bridge

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Objective

- Develop a simple analytical model
 - Approximately predicts behavior
 - Assist in load rating calculations
- Include as built characteristics – eccentric connections, splice joints, material properties, etc.

Finite Element Analysis

- Development of 2-D and 3-D finite element models for each bridge

Selected Bridges

- Indiana & Vermont
- Burr-Arch and Queen-Post Truss Bridges

Recommendation

- From comparison of displacement and strain values of field and analytical – recommend appropriate modeling approach

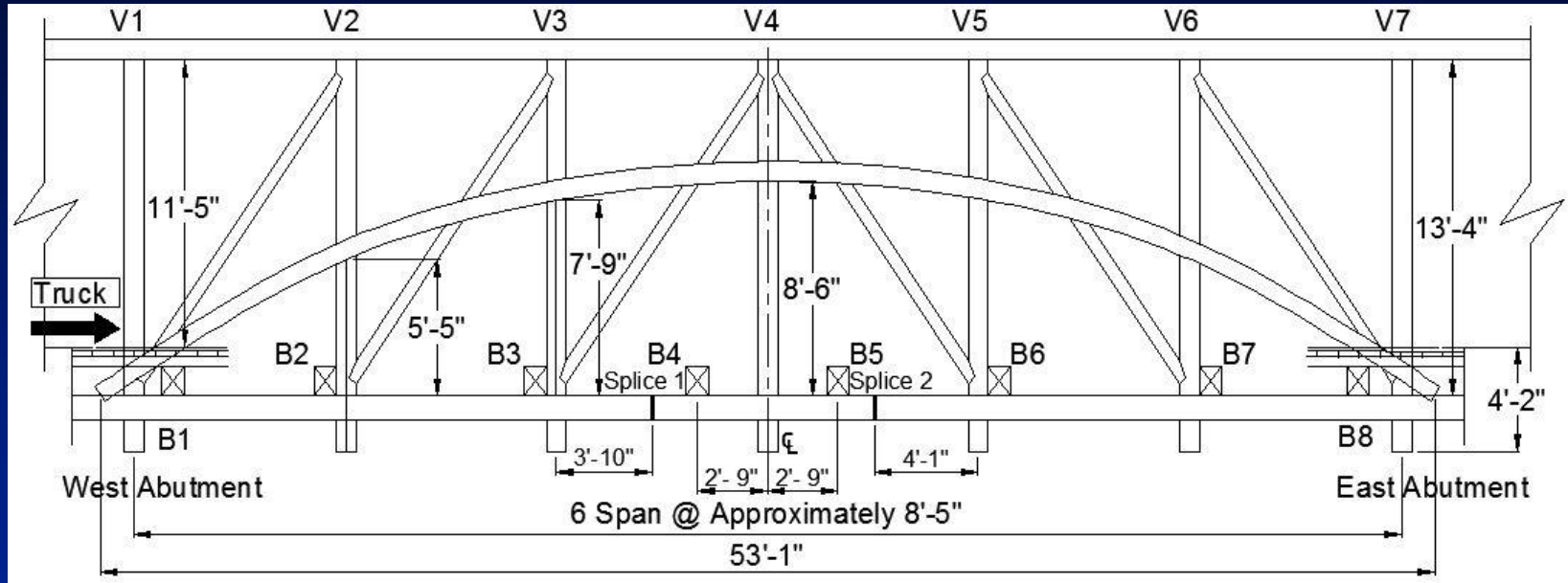
Bridge Descriptions

Zacke Cox Bridge



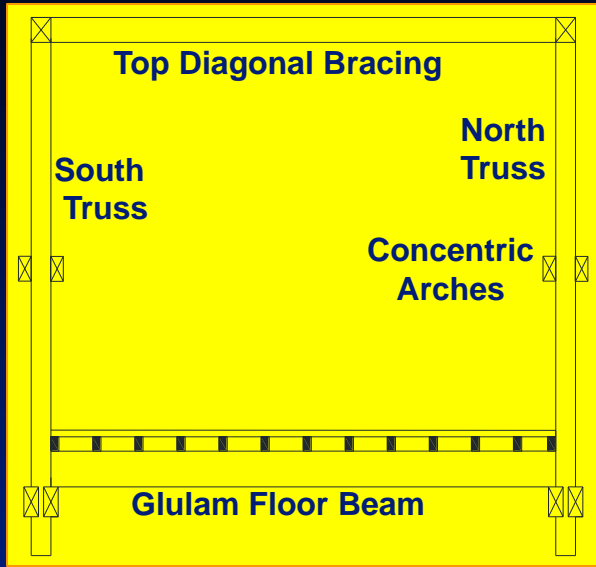


Views of the Zacke Cox Bridge



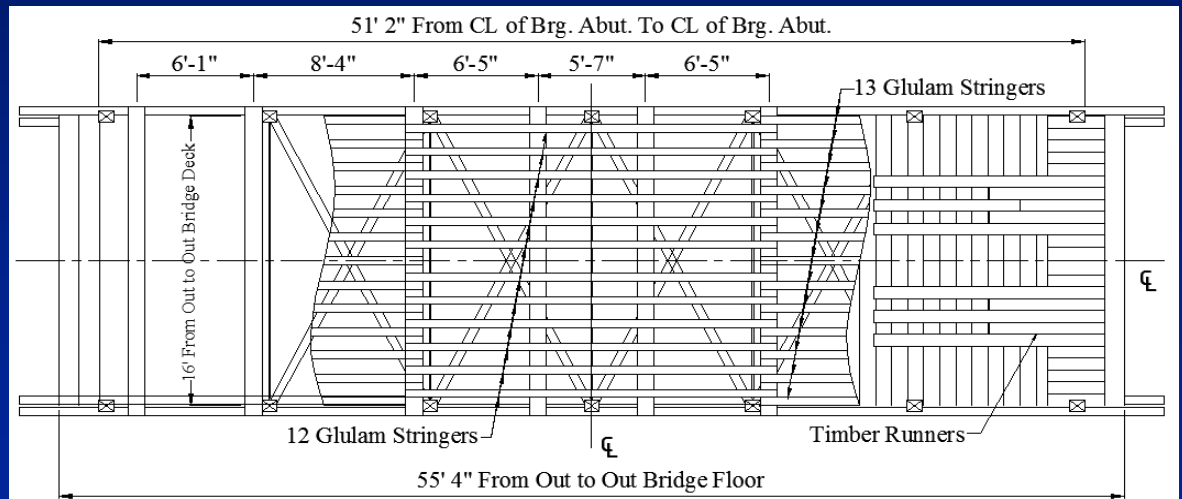
Elevation View

Views of the Zacke Cox Bridge – Cont.



Cross Sectional View

Double Bottom Chord

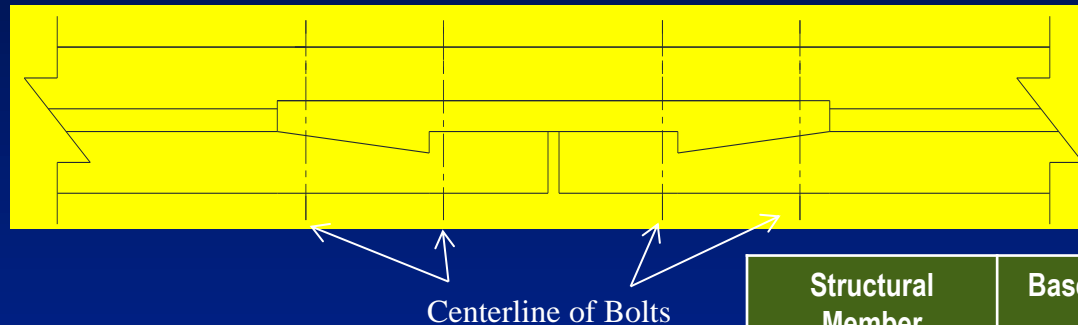


Plan View

Bridge Descriptions

- **Bottom Chord Splice Joints**

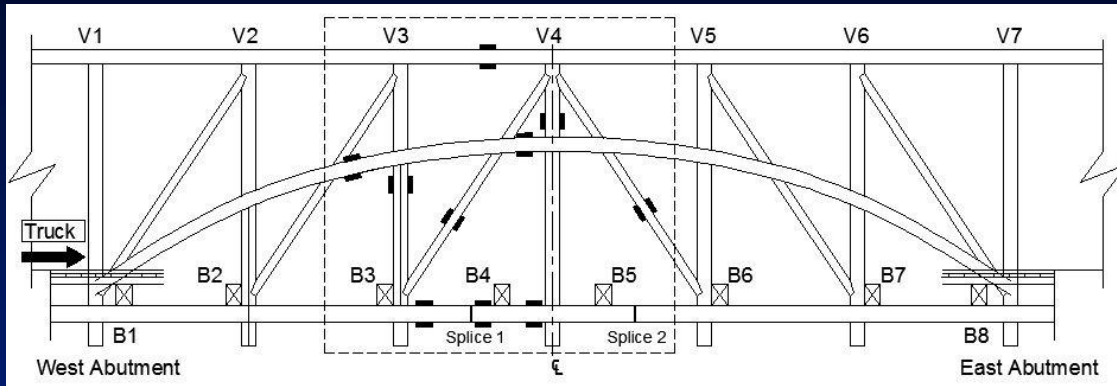
- Single headed hook fishplate and iron shoe splice joint (Marston (2006))
- Total of 4 splice joints – 2 within each truss element



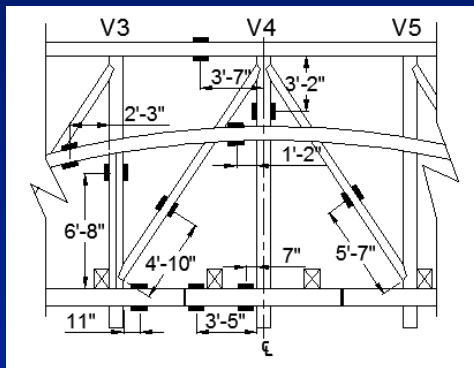
- **Field Measured Timber Dimensions**

Structural Member	Base length (in)	Height Length (in)
Bottom Chord	5.5	11.5
Floor Beam	10.5	13.8
Verticals	7.5	9.5
Diagonals	7.5	7.5
Arch	4.75	9.5
Top Chord	7.5	9.8

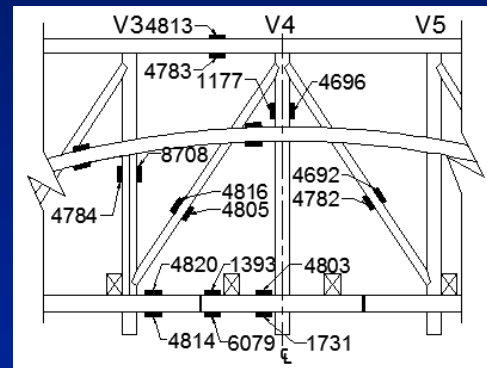
Bridge Schematics – Strain Gage Locations



South Truss



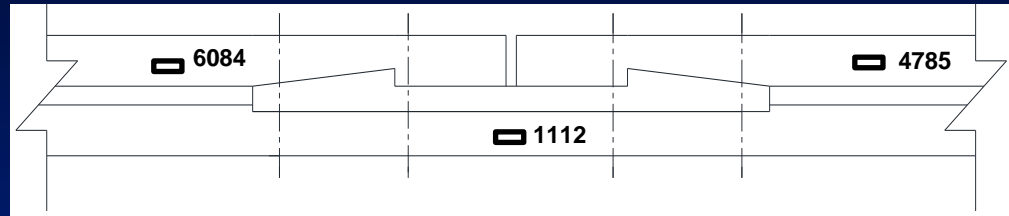
Strain sensor locations



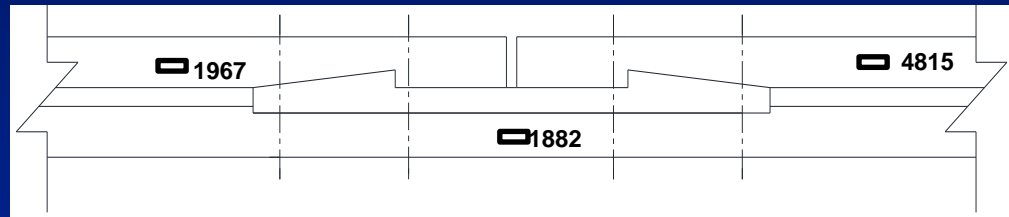
Strain sensor details

Strain Gage Locations – Near the bottom Splice

Top View



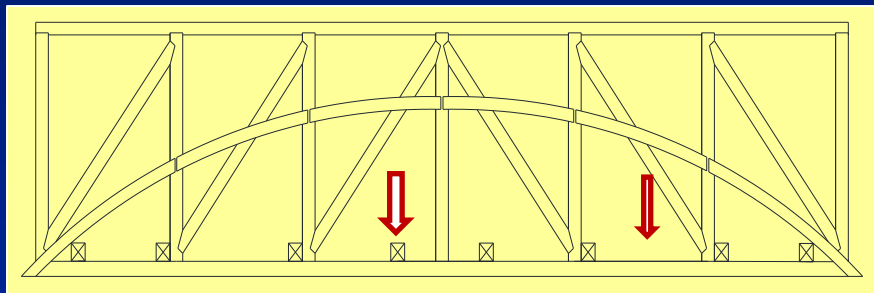
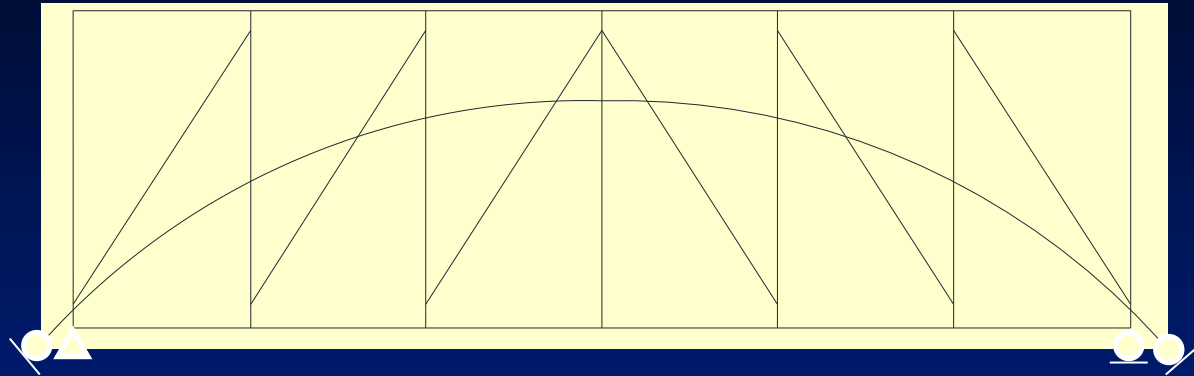
Bottom View



Finite Element Analysis

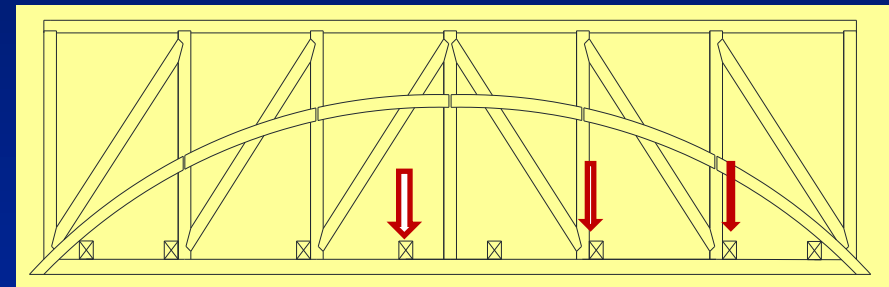
ANSYS - Software

- **Boundary Conditions**
 - Truss
 - Arch
- **Truck Loading**
 - Small Truck



Back Axle

Front Axle



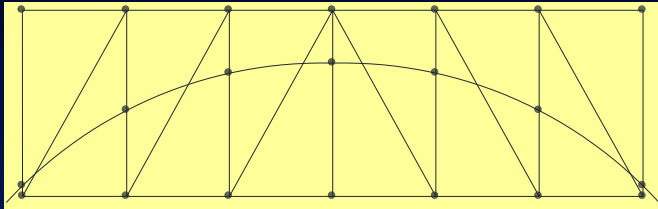
Back Axle

% Front Axle

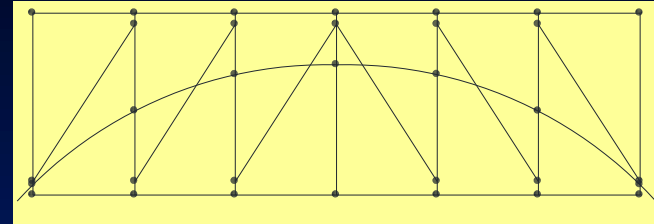
% Front Axle



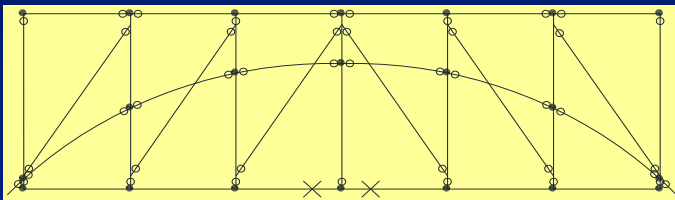
Different modeling



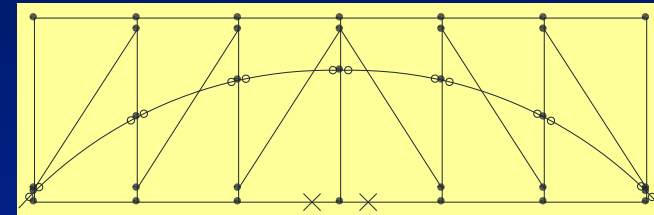
2-D model Ignoring joint eccentricities



2-D model considering joint eccentricities



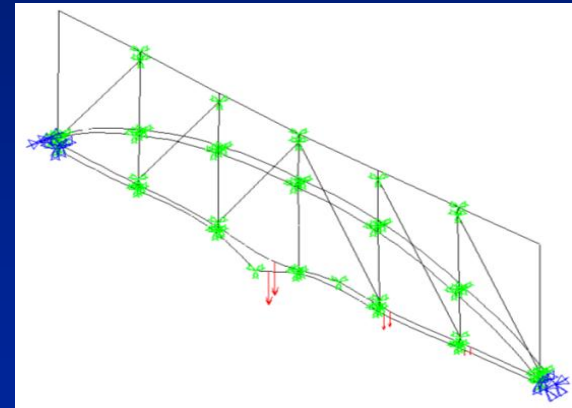
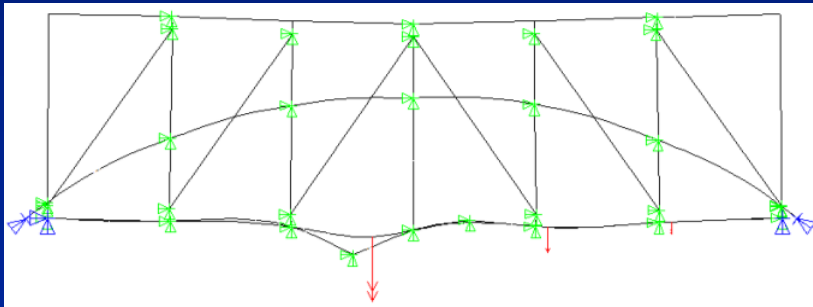
2-D model Including joint eccentricities
splice joints and the as built top chord



2-D model Including joint eccentricities
and splice joints

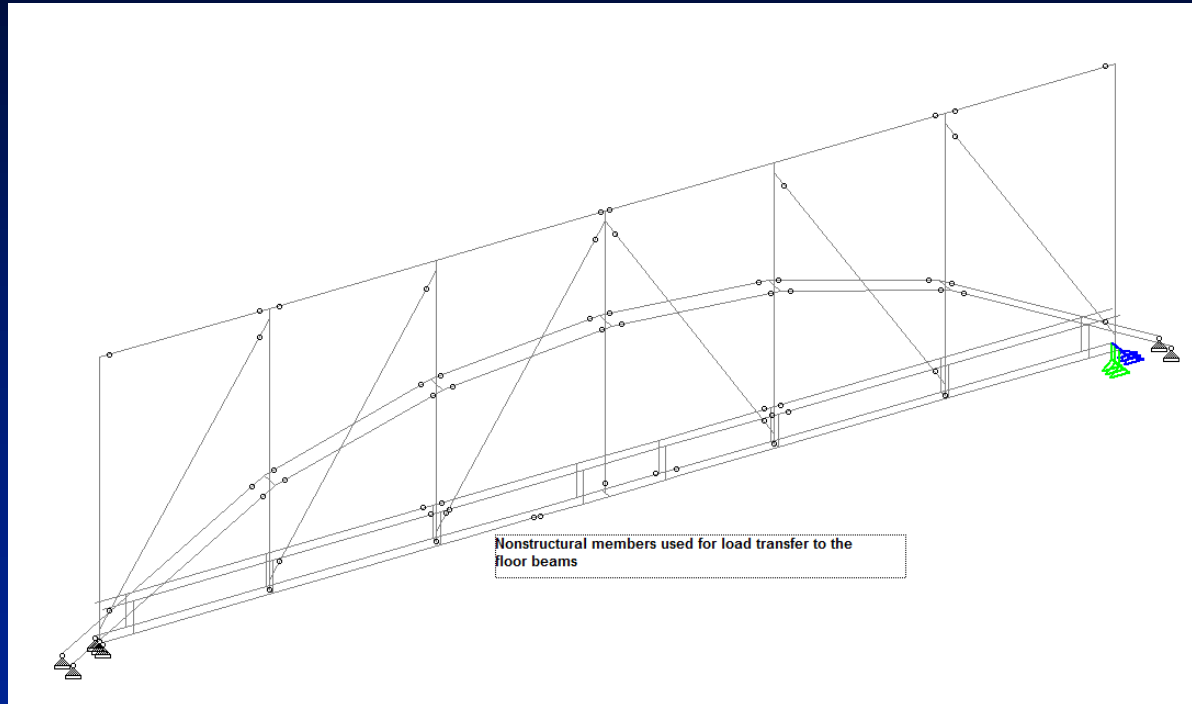
Small Truck

- Deflection in the Vicinity of the Splice Joint
 - Analytical deflected shapes
 - Discontinuous member – top (tension) and bottom (compression)
 - Continuous member – top (compression) and bottom (tension)
- Deflection and Deformation



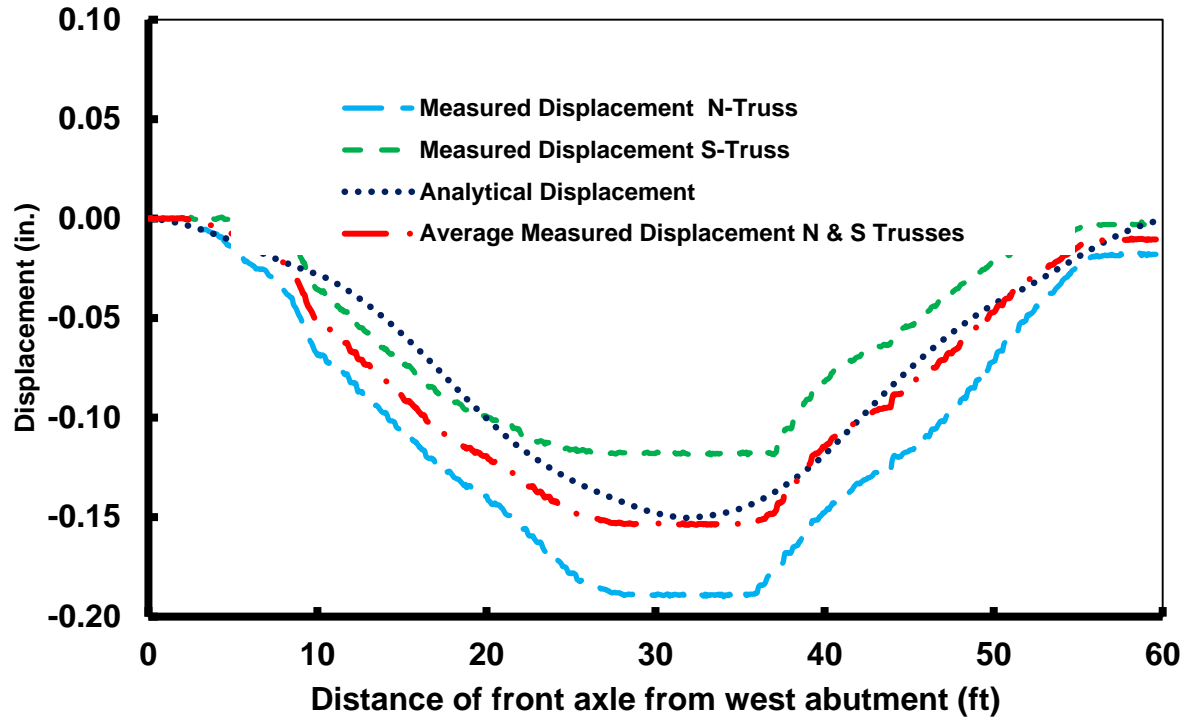


Analysis using STAAD Software





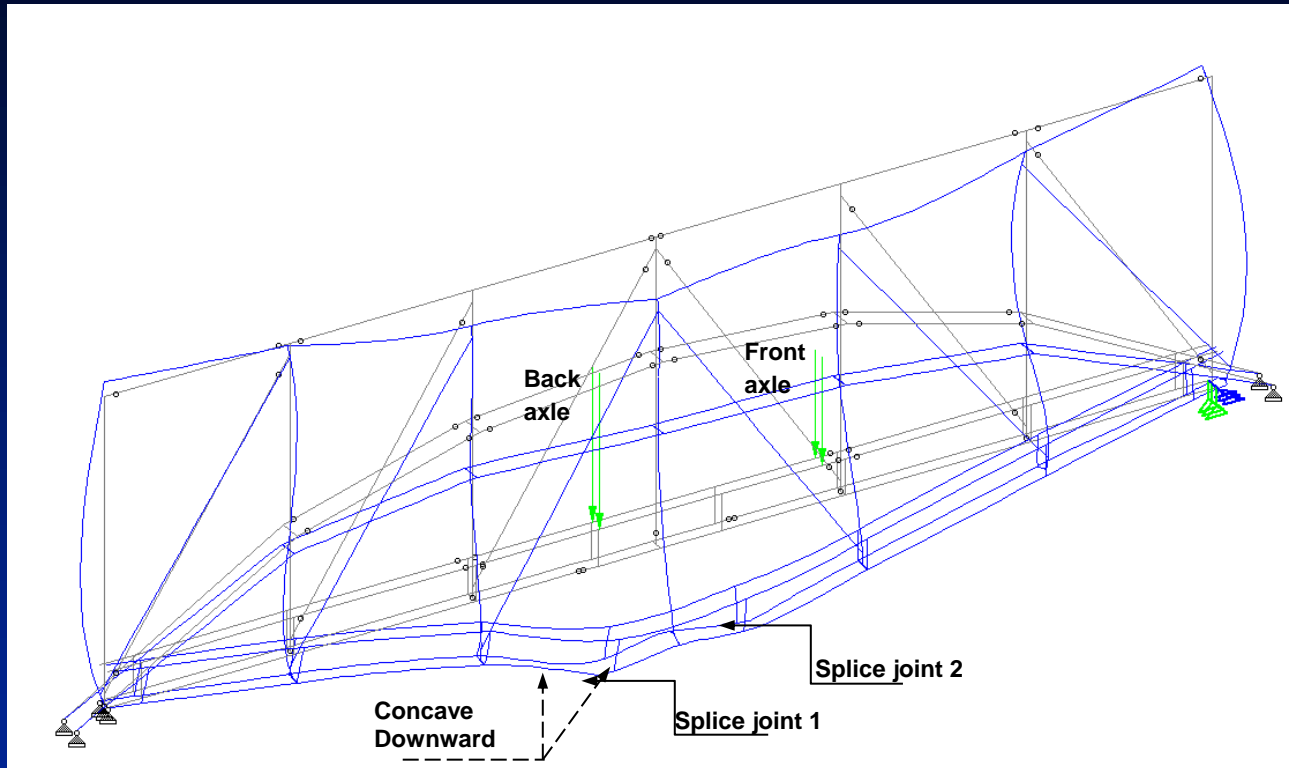
Measured and Calculated Deflection



Front Axel 44.75 kN
Front Axel 68.7 kN
Distance 3.07 m

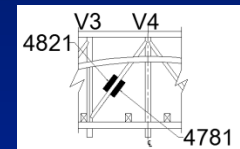
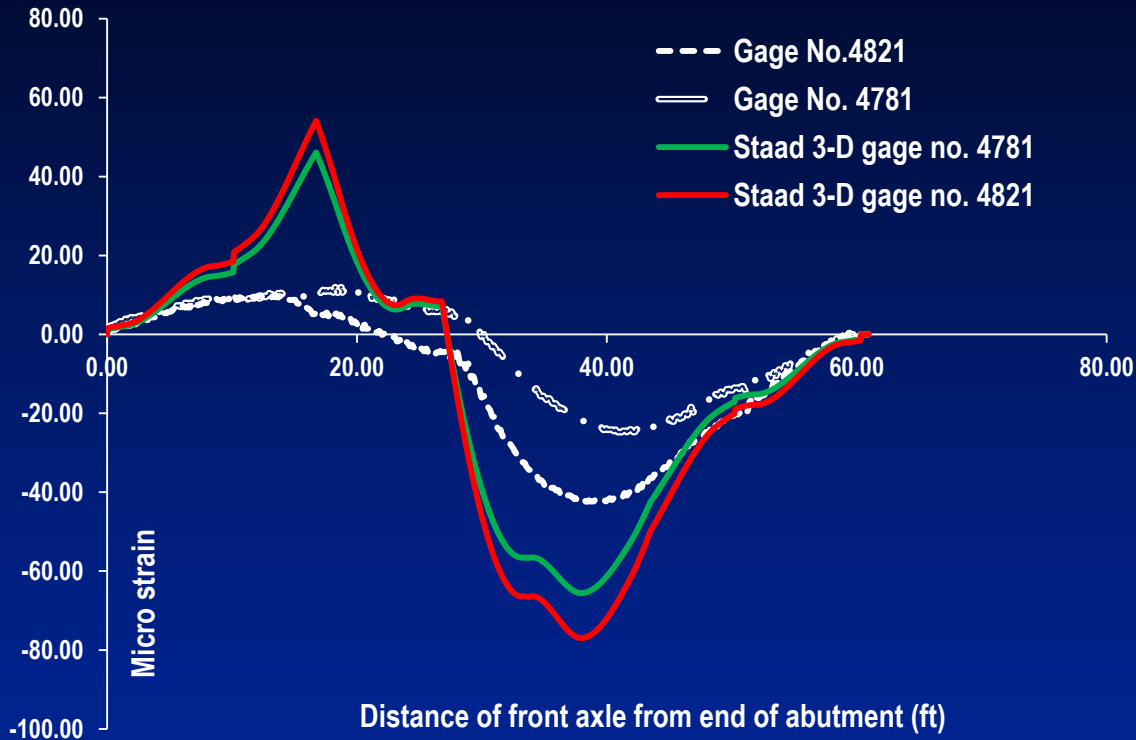


Deformed Shape





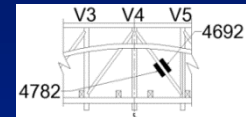
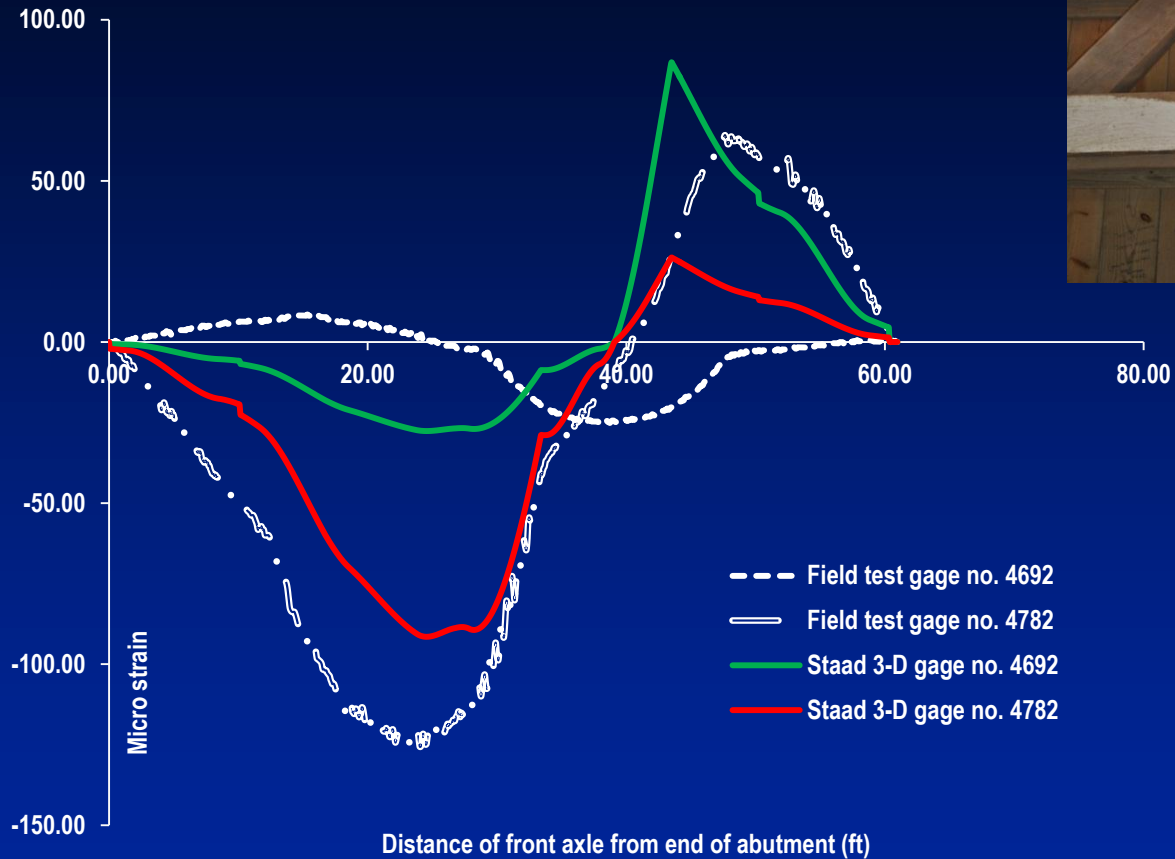
Strain Comparison



Diagonal member - Gages 4821 and 4781

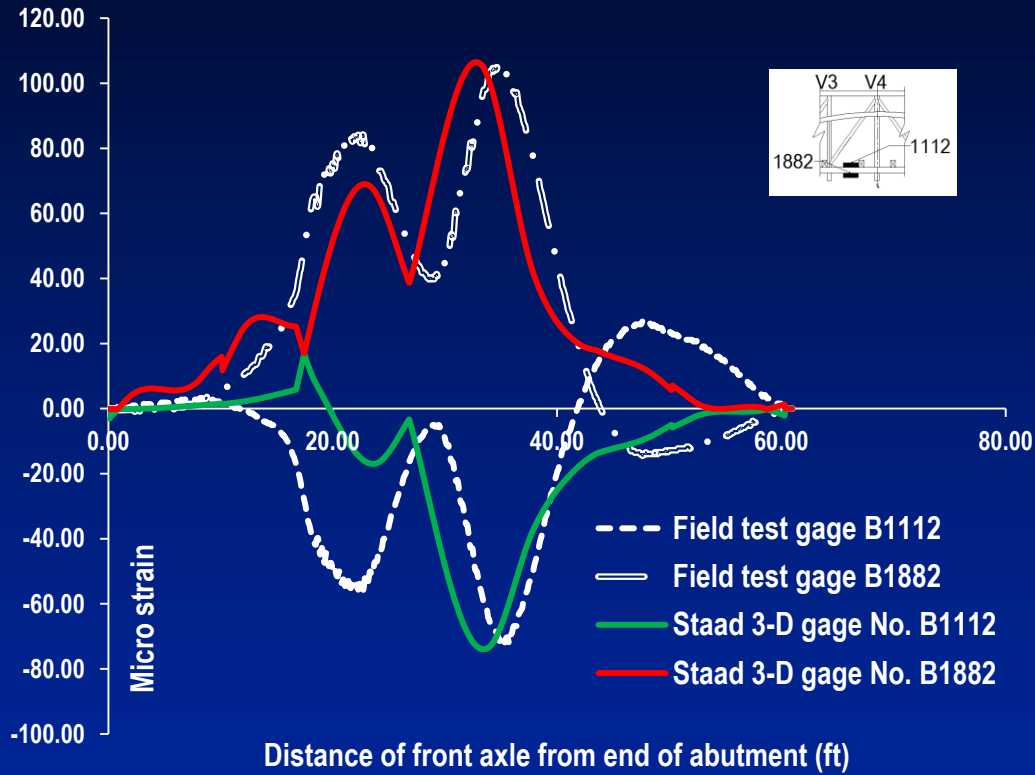


Strain Comparison –Cont.





Strain Comparison –Cont.



Splice Joint – Gages B1112 and B1882



Source of Discrepancies

- Data Collection Method
- Modeling
- Member Conditions
- Material Properties





Source of Discrepancies – Cont.

- Load Distribution
- Geometric Irregularities
 1. Out of plan
 2. Sag of the bottom Chord
 3. Connections





Summary & Conclusions

- 2-D and 3-D Analysis
- ANSYS & STAAD
- Analytical Vs. Field Test Results
- Factors affecting Analysis Accuracy
 - Splice Joints
 - Member Conditions
 - Joint Eccentricities



Acknowledgement

This study is part of the Research, Technology and Education portion of the **National Historic Covered Bridge Preservation** (NHCBP) Program administered by the Federal Highway Administration. The NHCBP program includes preservation, rehabilitation and restoration of covered bridges that are listed or are eligible for listing on the National Register of Historic Places; research for better means of restoring, and protecting these bridges, development of educational aids; and technology transfer to disseminate information on covered bridges in order to preserve the Nation's cultural heritage.

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- Questions

