Implementation of Physical Testing for Typical Bridge Load and Superload Rating

Bridge Engineering Center
Iowa State University

Phares, Wipf, Klaiber, Abu-Hawash, Neubauer

Bridge Rating

- Evaluation based on:
  - Visual inspection
  - Code based
- Iowa has 25,000 bridges
  - 4,000 on primary highway system
- Invest in innovative solutions to supplement existing rating procedure

Iowa Load Testing Needs

- More accurate ratings for:
  - Older bridges with unknown or insufficient design data
  - Assessing need for temporary load restriction on damaged bridges
  - Possibly reducing the number of bridges that restrict a reasonable flow of overweight trucks

Iowa Load Testing Needs

- More accurate ratings for:
  - Verifying the need for and the effectiveness of new strengthening techniques
  - Removing load restrictions imposed on additional bridges due to the implementation of new weight laws
  - To determine the behavior of structures under heavy load (superload) that have calculated load ratings below anticipated capacity needs

The Problem

- Unknown bridge conditions
  - Live load distribution
  - End restraint
  - Edge stiffening
  - Composite action
  - Effectiveness of specific bridge details
  - Other details contributing to bridge capacity

Other Methods

- Proof load testing
- Destructive testing (laboratory)
  - Use to complement diagnostic testing for better understanding

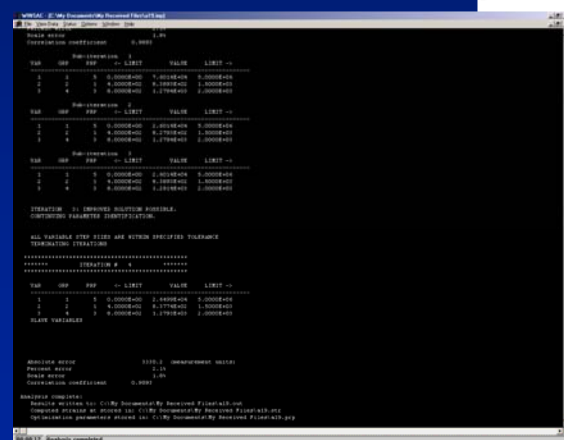
The Diagnostic Testing Solution

- Physical testing to understand the specific characteristics of each bridge
- Field collected data to calibrate a bridge computer model
- Accurate, calibrated computer model to determine bridge response to rating vehicles and other loads

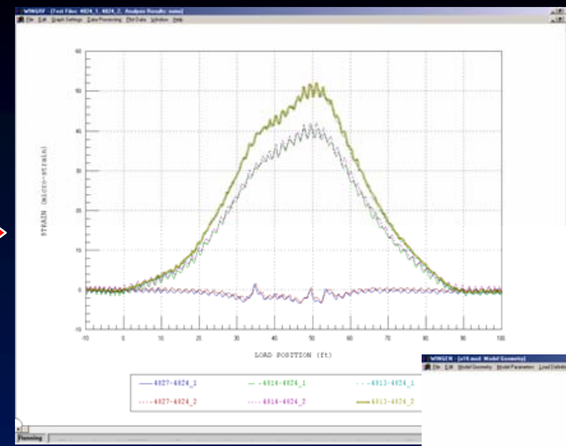
Hardwired strain gages

Wireless truck position indicator

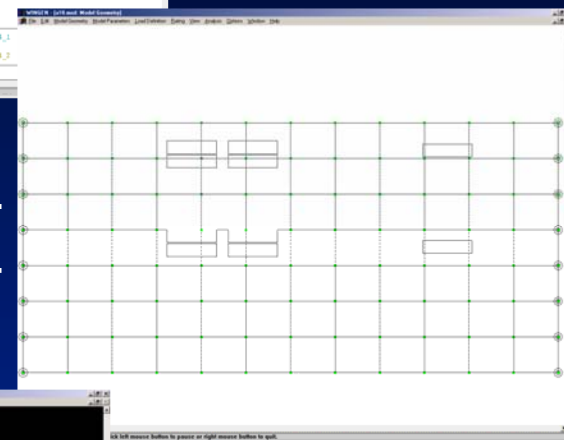
Accurate Assessment



Engineering based data interpretation



Structural modeling



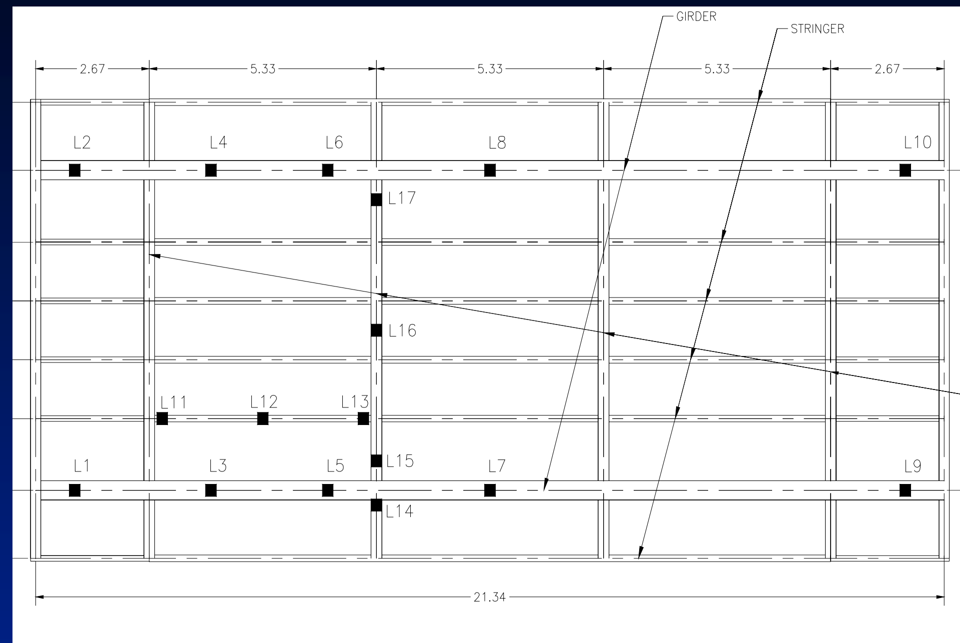
Model analysis and optimization with field collected data

Diagnostic Testing of a Bridge-Brief Case Study

- Carries US 6 over a small stream
- 21.34 m single span
- Two main girders w/ floor beams & stringers
- Welded plates & strengthening angle on girders

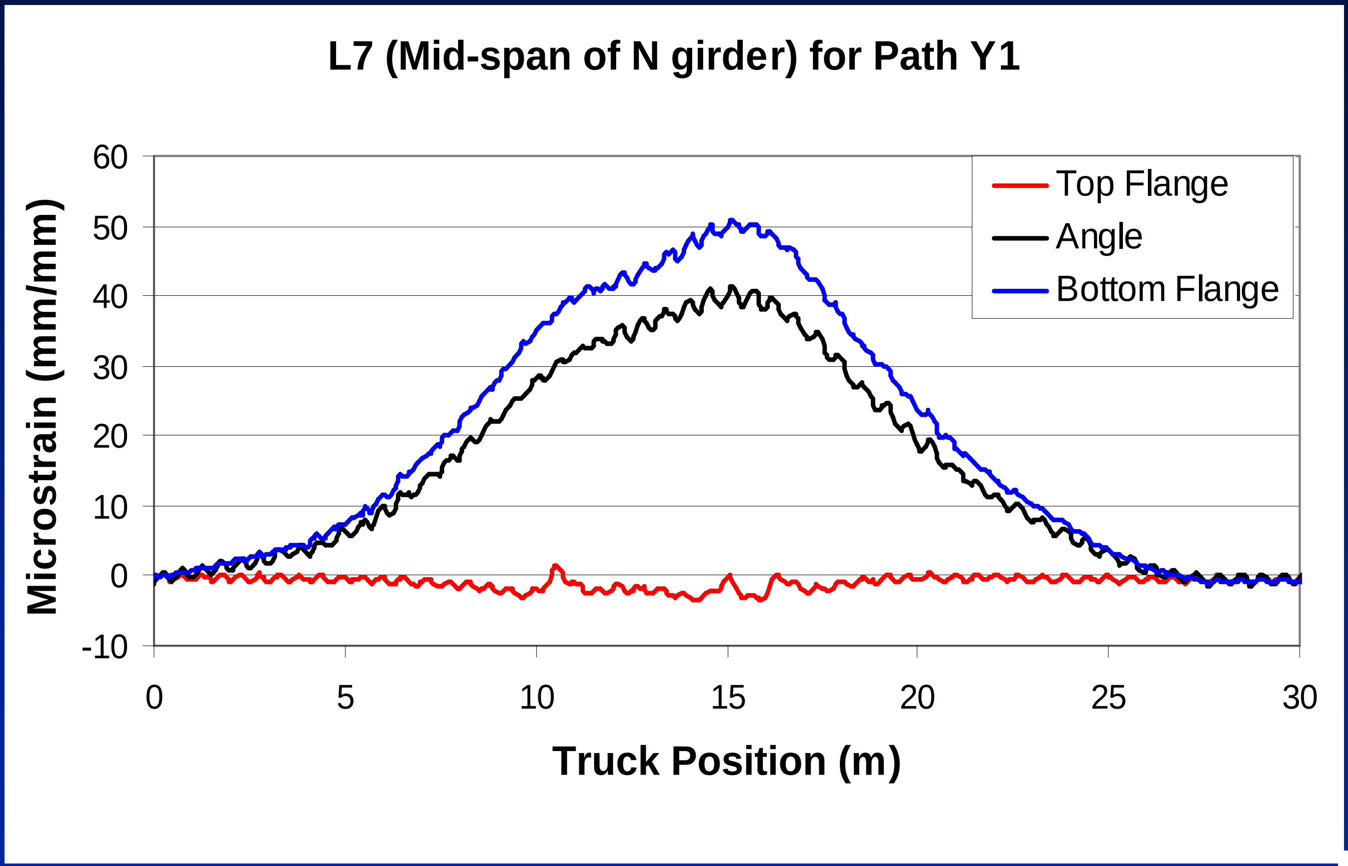
Instrumentation

- 36 Intelliducers at 17 locations used
- Focused on:
  - Effectiveness of angles
  - End restraint
  - Load distribution
- Instrumented:
  - Both girders
  - Typical floor beam and stringers



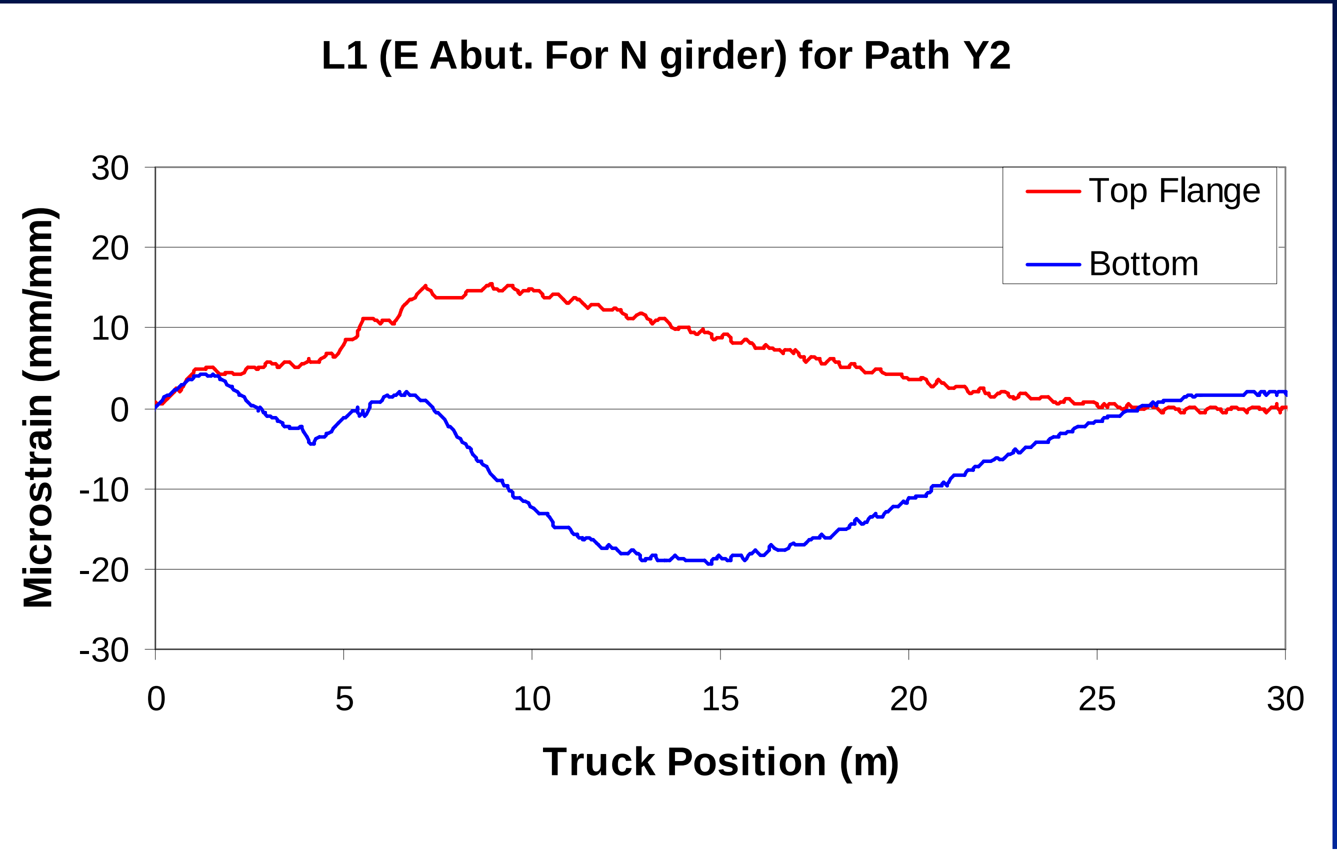
Test Results

- Strengthening angles are effective



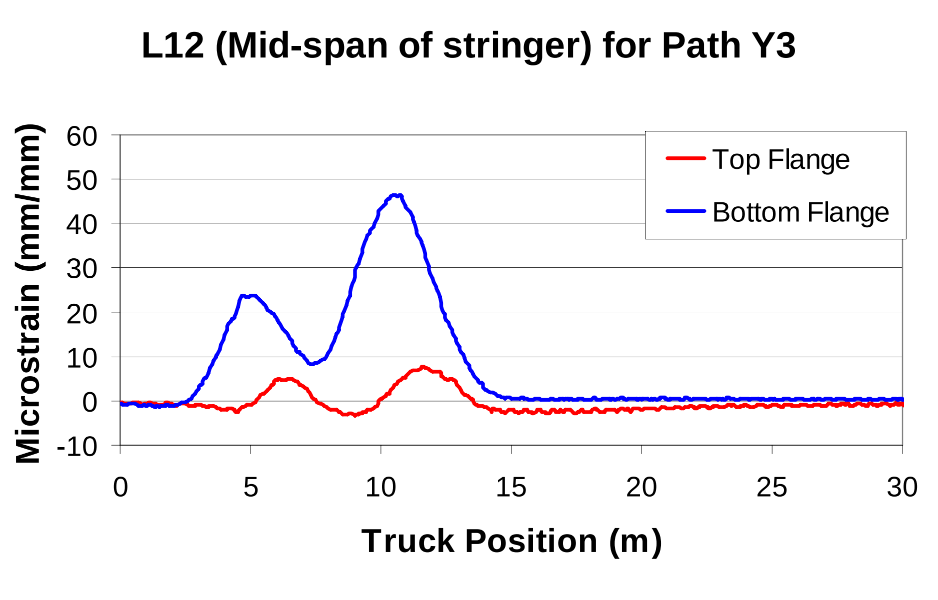
Test Results

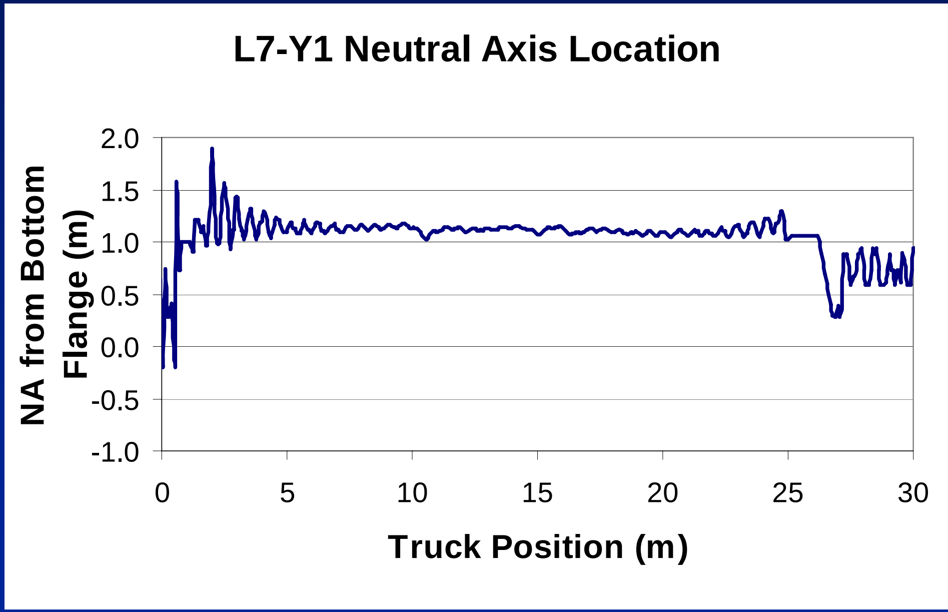
- Significant end restraint identified



Test Results

- Composite action determined





LFD Rating for HS-20 Vehicle

Conventional AASHTO LFD

- Shear (stringer)
  - 2.44
- Flexure (girder)
  - 2.39

WinSAC LFD

- Shear (stringer)
  - 1.79
- Flexure (floor bm)
  - 3.67

Results of Diagnostic Testing

- General increase in flexural rating of all members
- Shear rating decreased and controlled for this bridge
- Effectiveness of unknown structural elements identified

Superload Evaluation

- Summer 2003 – Passage of 6 superloads ranging from 600,000 lb. to 900,000 lb.
- Most bridges along route acceptable by traditional calculations
- Hand calculations for one bridge – rating factor of approximately 0.5
- Physical test needed

Bridge Characteristics

- Six pre-stressed concrete girder lines
- Critical span ~ 122 ft (37 m)
- 40 ft (12 m) roadway carrying two lanes of traffic

Initial Testing

- Tested with combinations of one and two loaded tandem axle dump trucks
- Much learned about behavior
  - Composite action
  - End restraint
  - Live load distribution
    - » Improved load distribution characteristics used in hand calculations changed RF to 0.9

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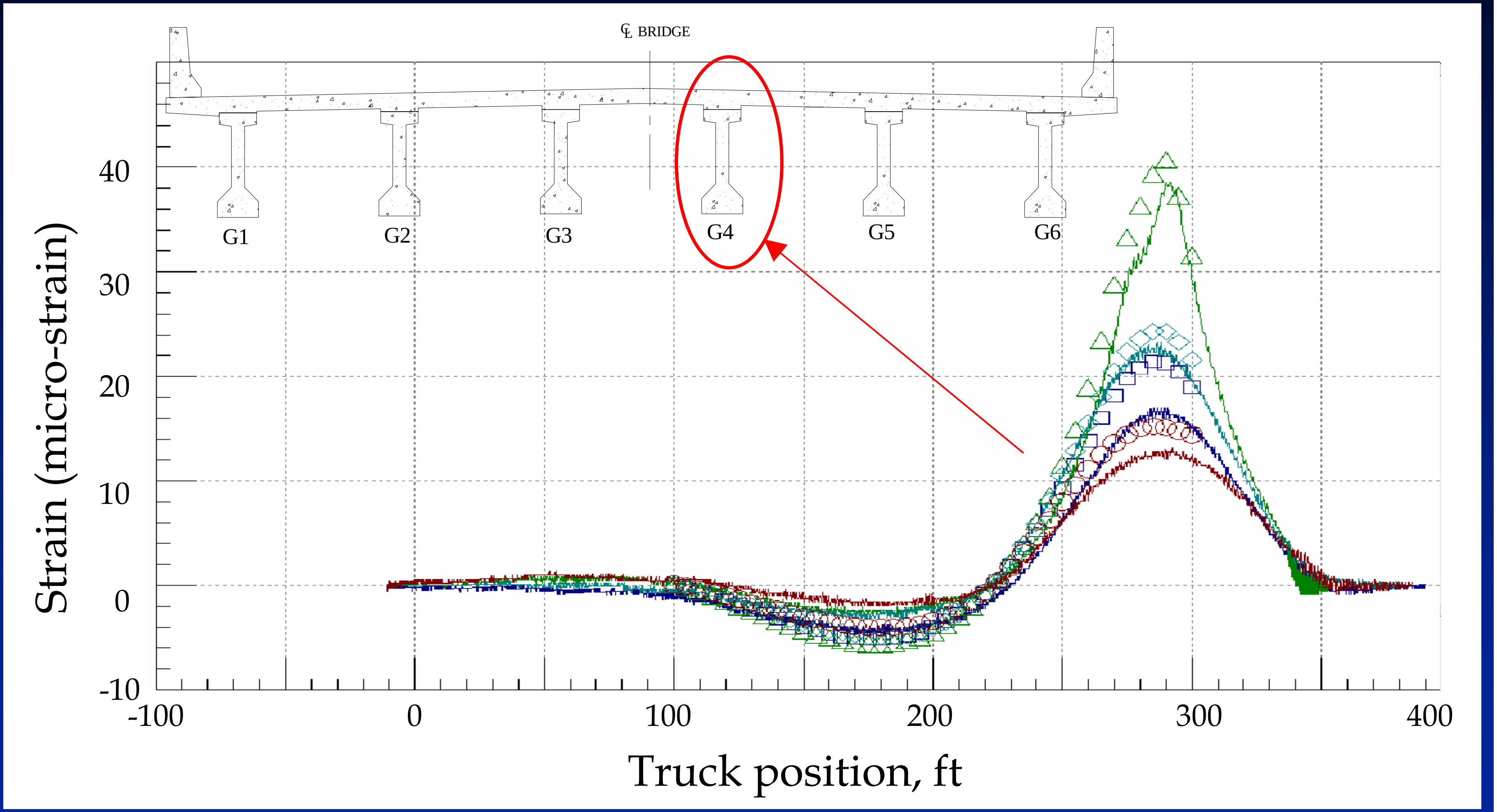
Analytical Modeling

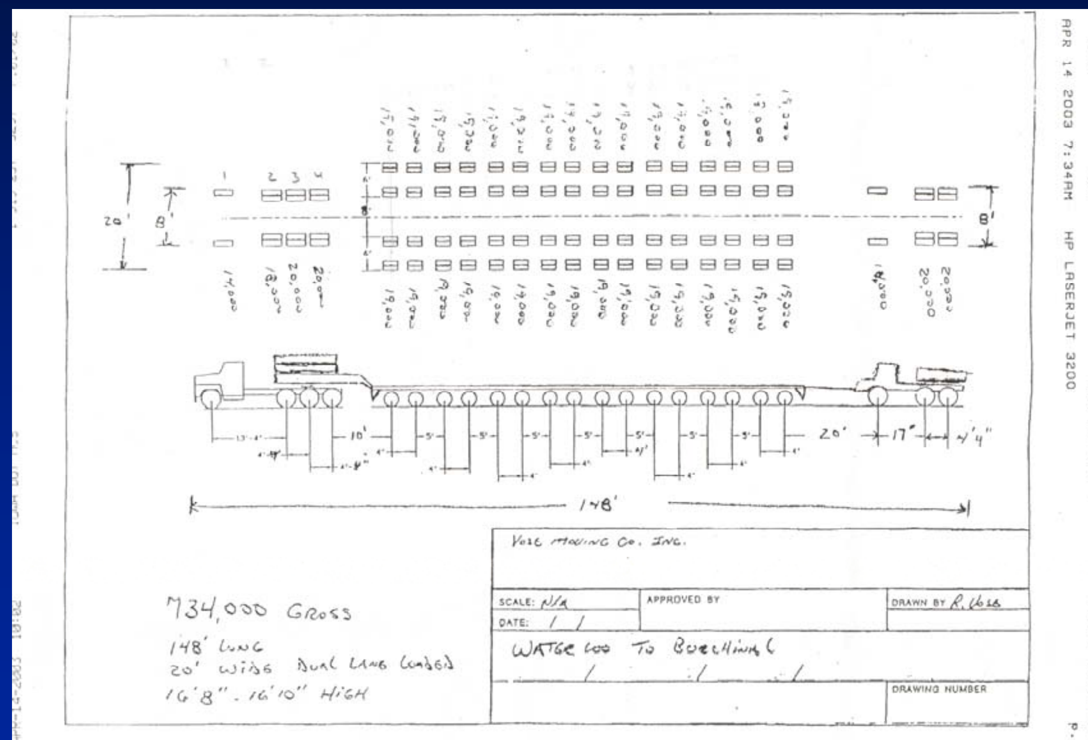
- Bridge modeled using WinGEN
  - 7 elements groups created and optimized
- Less than 10% error

Preliminary testing (one load truck)



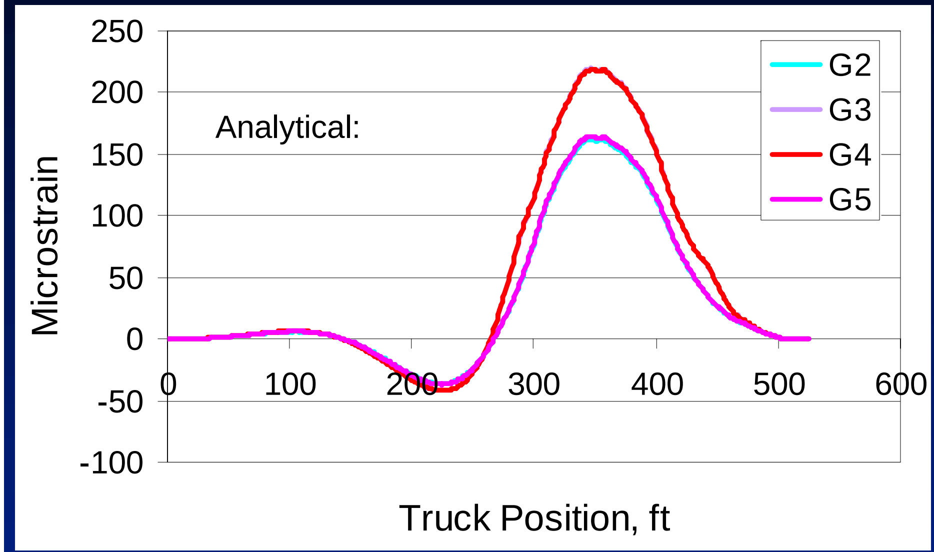
Analysis with Superload

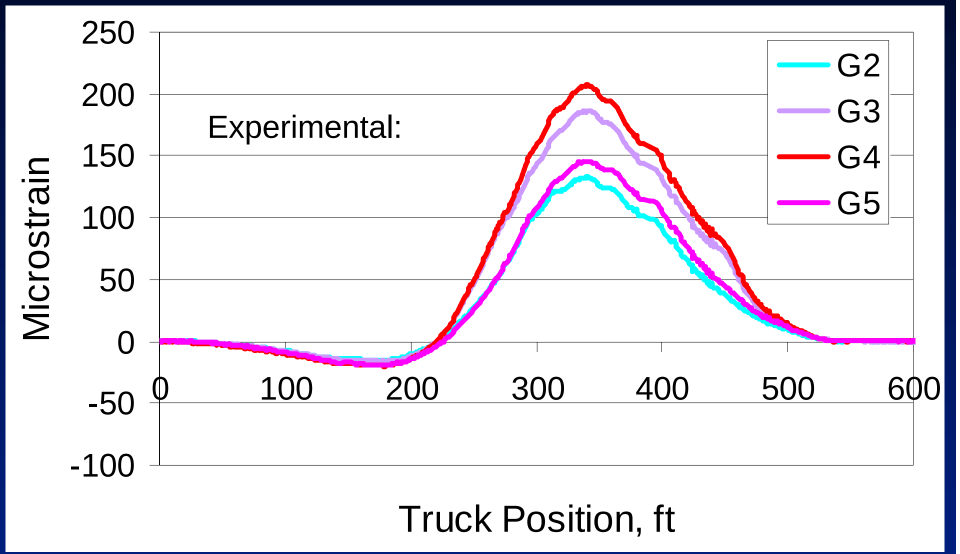
- Optimized model used to predict bridge behavior to anticipated load
- Determined to be acceptable

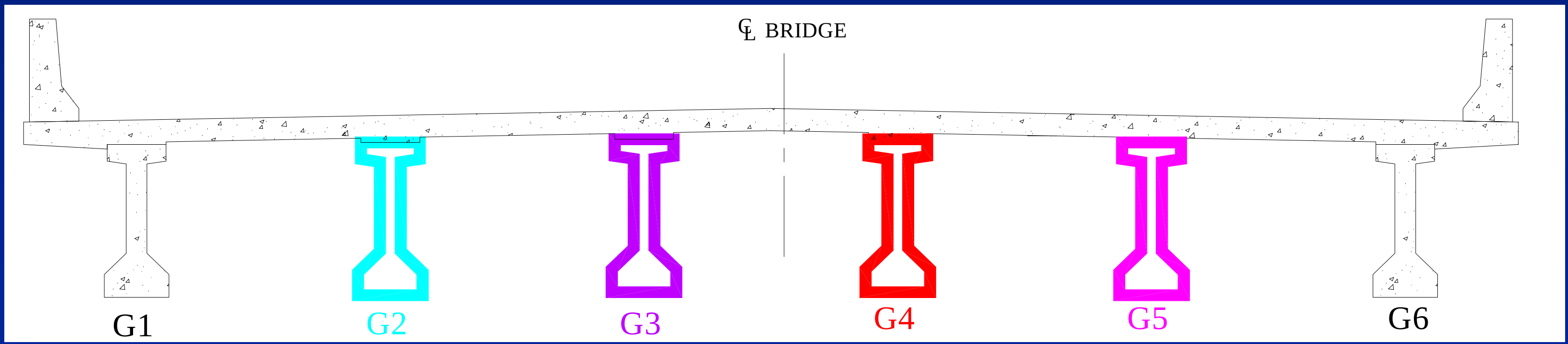


Monitoring During Passage

Accuracy of Prediction







Conclusions

- System is well suited to rating "typical" highway bridges
  - Materials
    - » Steel
    - » Concrete
    - » Timber
  - Type
    - » Simple span
    - » Continuous span
    - » Truss

Conclusions

- Expect more opportunities to obtain superload data
- Other "bridge fleet" research underway