BRIDGE SESSIONS

Innovative Bridge Applications AND Physical Testing for Bridge Load Rating

ICEA Midyear Meeting

July 10, 2003

Session Speakers

- Justin Doornink, Ph.D. Student
- Travis Konda, Ph.D. Student
- Van Robbins, M.S. Student
- J. S. Ingersoll, WHKS & Co.
- Terry Wipf, ISU
- F. Wayne Klaiber, ISU
- Brent Phares, CTRE
- Scott Neubauer, Iowa DOT

Evaluation and Use of an Integrated Bridge Load Testing/Rating System

Brent M. Phares, Terry J. Wipf, F. W. Klaiber and D. L. Wood
Bridge Engineering Center
Iowa State University

Scott Neubauer
Office of Bridges and Structures
Iowa Department of Transportation

The Problem

- Posted bridges and bridges with unknown strength and behavior
- Limited financial resources
- Code equations that are usually very conservative at predicting bridge behavior

The Problem

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

The Solution

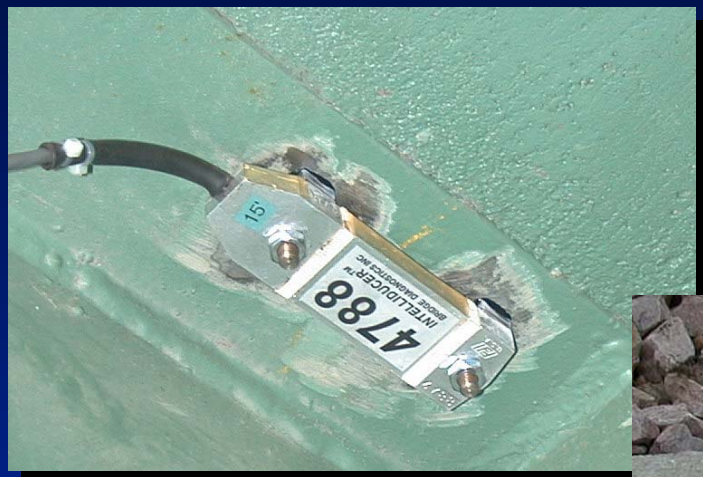
- Use physical testing to understand the specific characteristics of each bridge
- Use field collected data to calibrate a computer constructed model of the bridge
- Use the accurate, calibrated computer model to determine bridge response to rating vehicles and other loads

An Integrated Testing System

- Hardware and software suite
- Integrated and seamless through all steps
  - Field testing
  - Data presentation
  - Model generation
  - Model calibration
  - Rating

Data Collection Hardware

- Hardwired strain gages with variable gage lengths

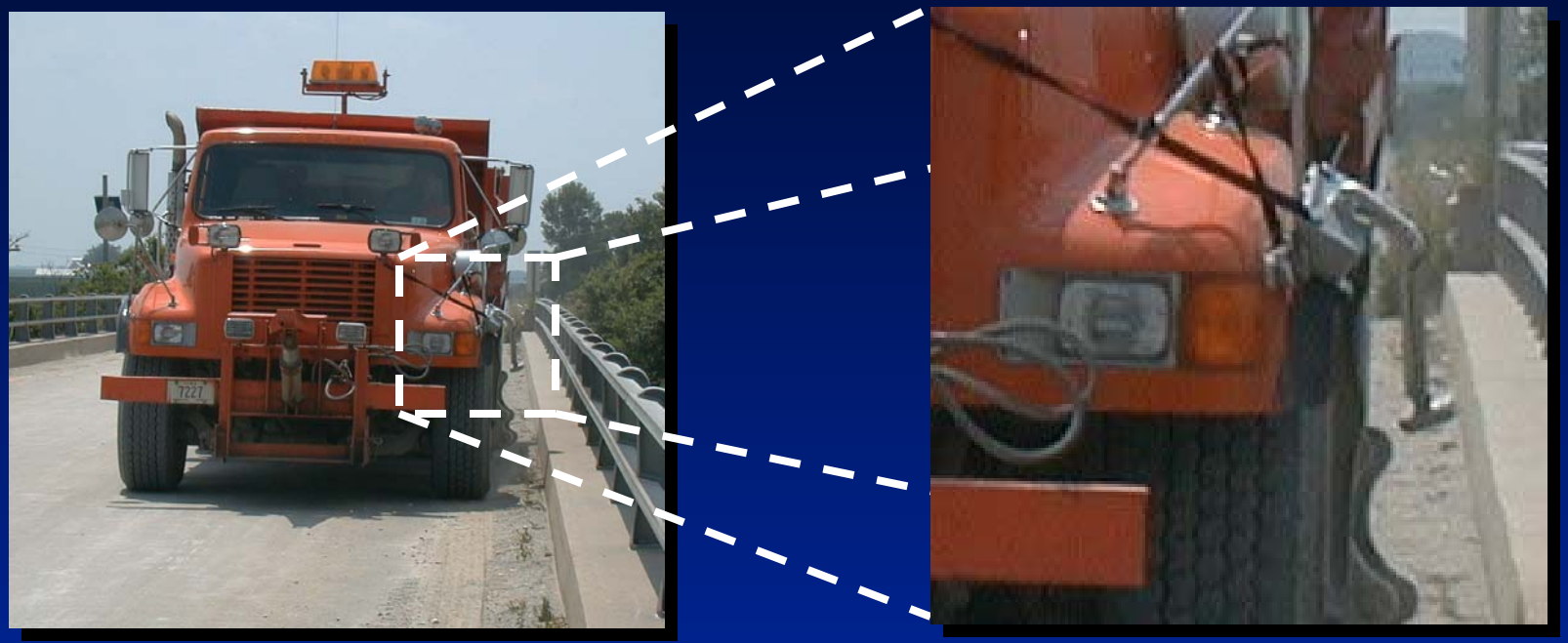


Data Collection Hardware

- Strain gage junction box
  - Balance and control strain gages
  - Collect and temporarily store data
  - Communicate with PC

Data Collection Hardware

- Wireless truck position indicator



Data Collection Hardware

- Power unit and PC
  - Power and control entire system

Software Suite

- WinGRF
  - Relates truck position with strain data
  - Prepare visual summaries of data
    - » Strain
    - » Neutral axis location
    - » Curvature
  - Allows engineer to study the data for behavioral interpretation

Software Suite

- WinGEN
  - Construct bridge model
    - » Overall geometry
    - » Material characteristics
    - » Section properties
    - » Support conditions
  - Define loading conditions
  - Establish optimization parameters
  - Create analysis file

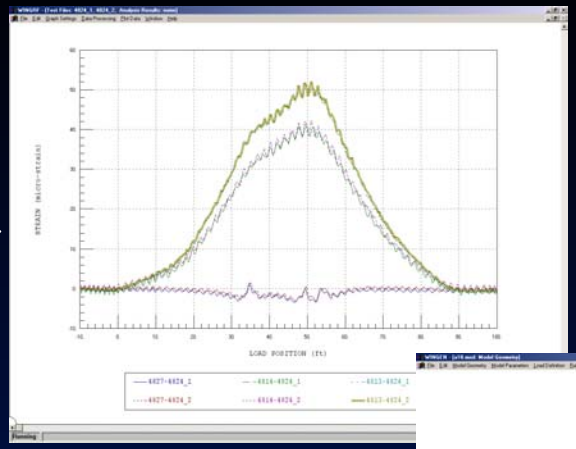
Software Suite

- WinSAC
  - Performs analysis
  - Performs optimization calculations
    - » Linear least squares method of error reduction

Hardwired strain gages

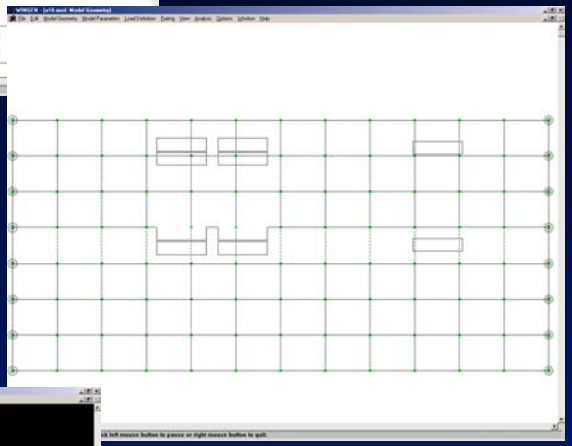
Wireless truck position indicator

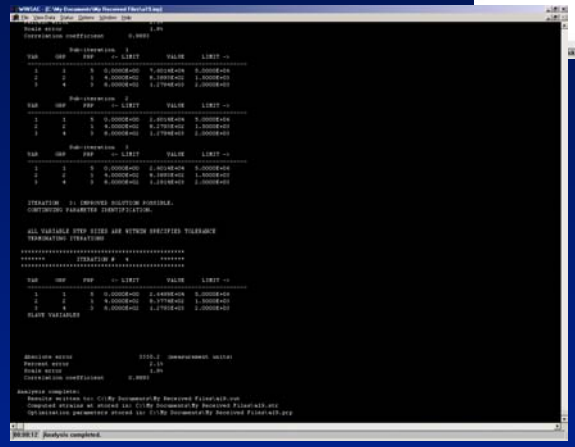
Accurate Assessment



Engineering based data interpretation

Structural modeling





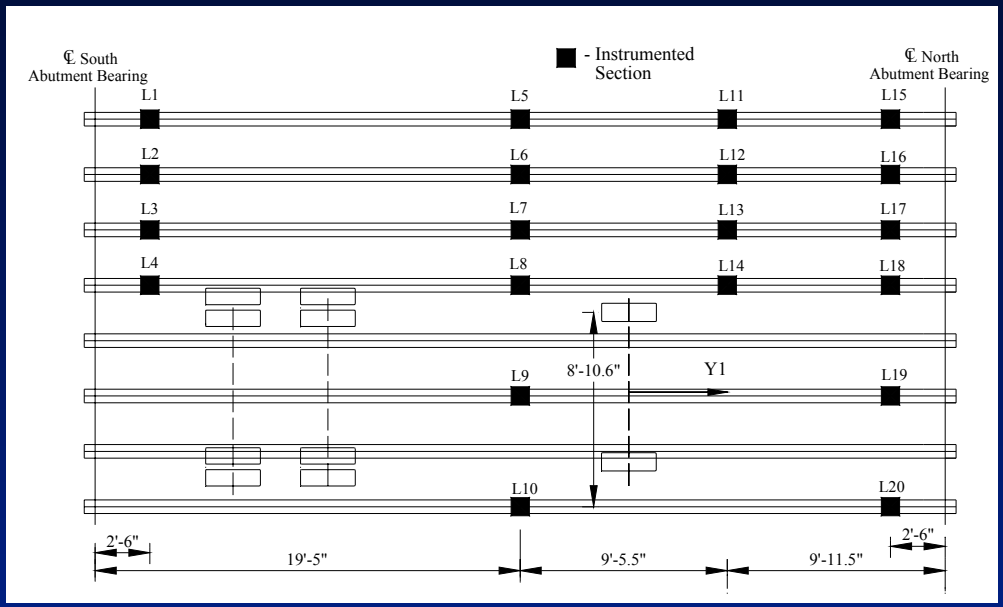
Model analysis and optimization with field collected data

Diagnostic Testing of a Bridge

- Boone County Bridge #11 on L Road
- 38 ft - 10 in. single span
- Eight girders with timber deck
- Damaged exterior girder

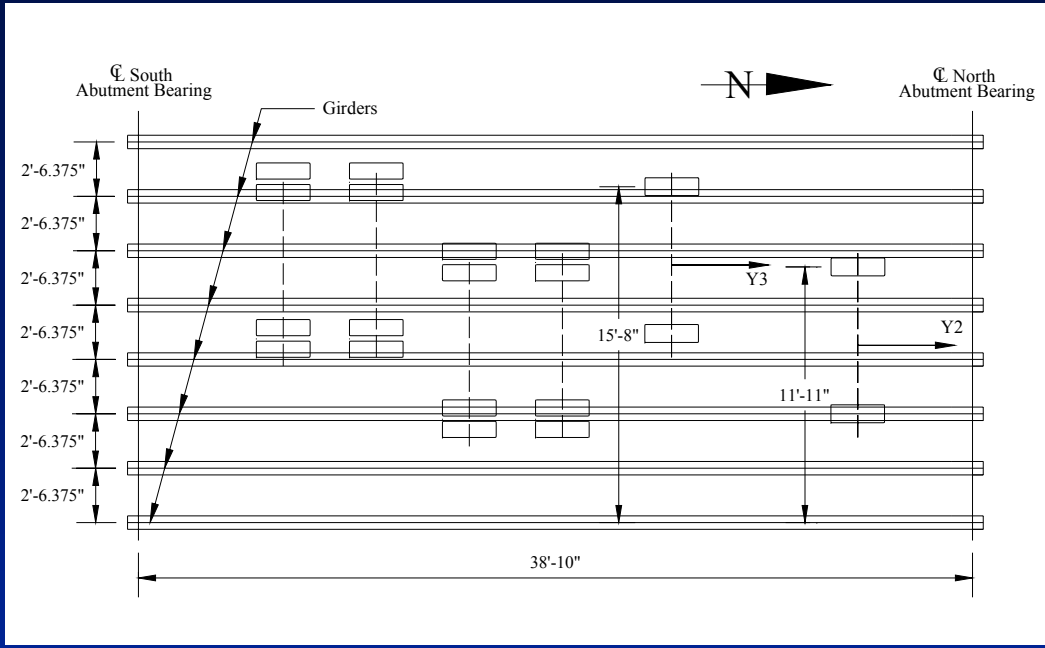
Instrumentation

- 40 Intelliducers at 20 locations used
- Focused on:
  - Composite action
  - End restraint
  - Load distribution
- Instrumented:
  - Six of eight girders

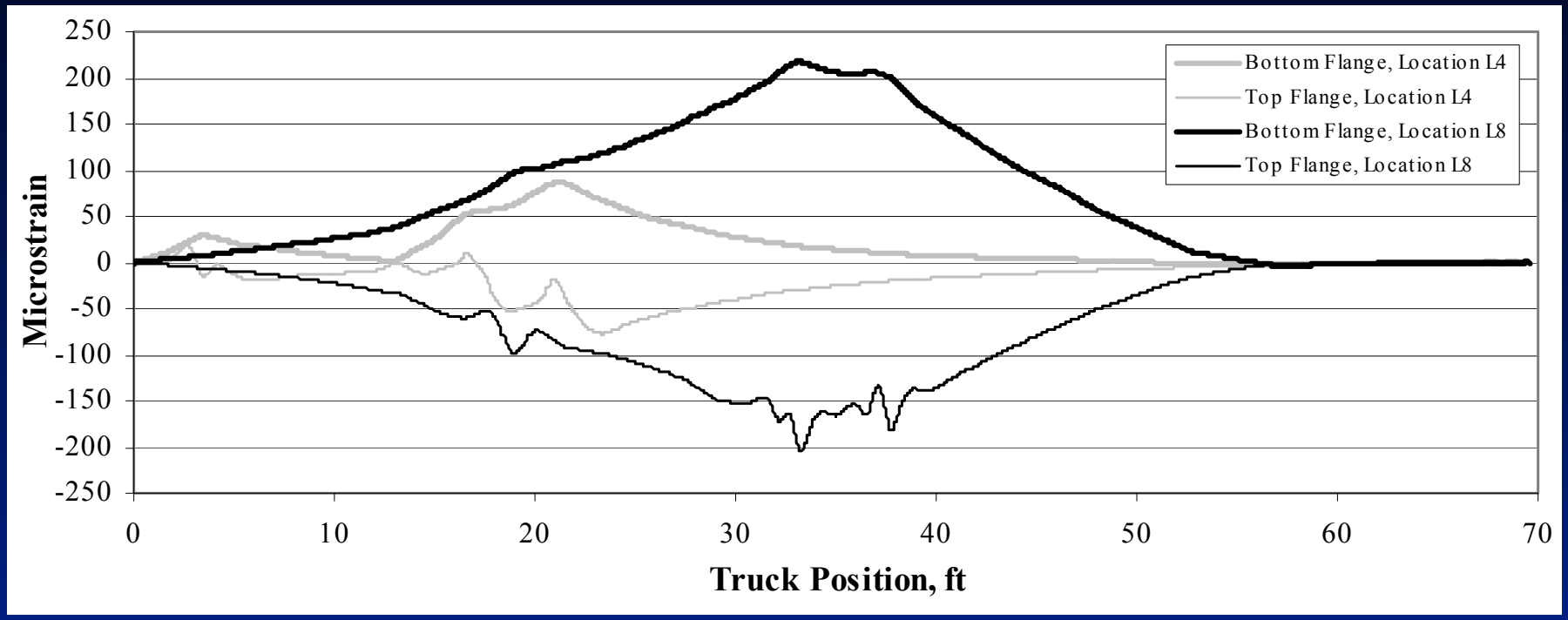


Load Position

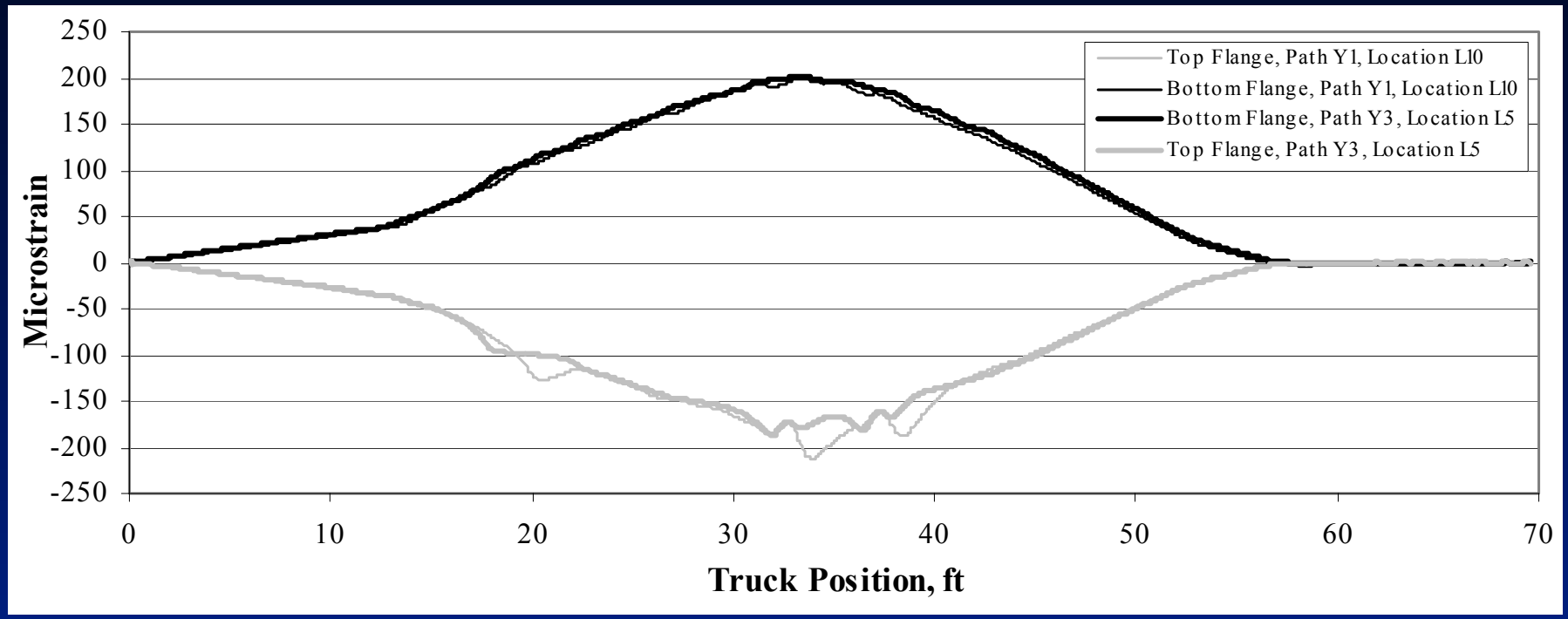
- Three different load paths defined - loaded truck tandem axle dump truck
- Each path addressing a key attribute



Test Results-Minimal End Restraint



Test Results-Transverse Symmetry



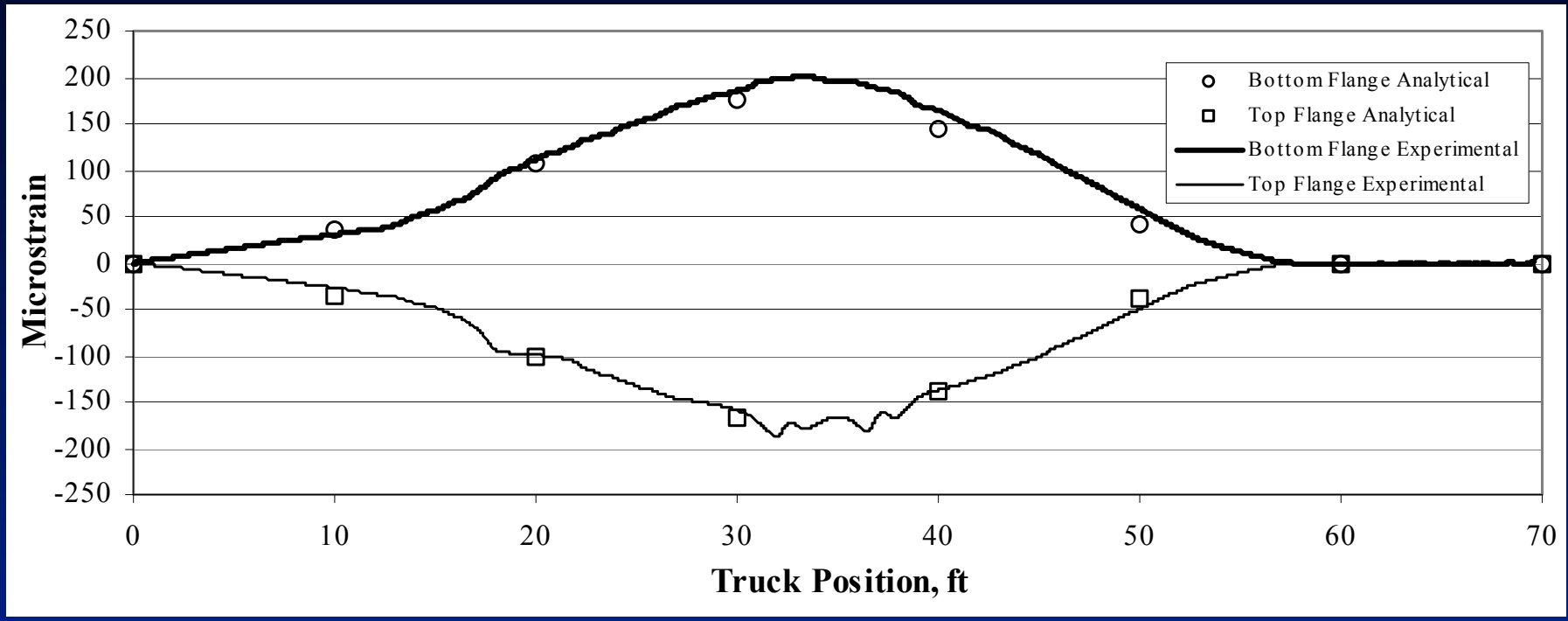
Modeling

- Model created using WinGen
- Based on plan geometry and field measurements
- 3 total element groups
  - Steel girder stiffness (I_y)
  - Timber deck stiffness (E)
  - Abutment stiffness (K_y)

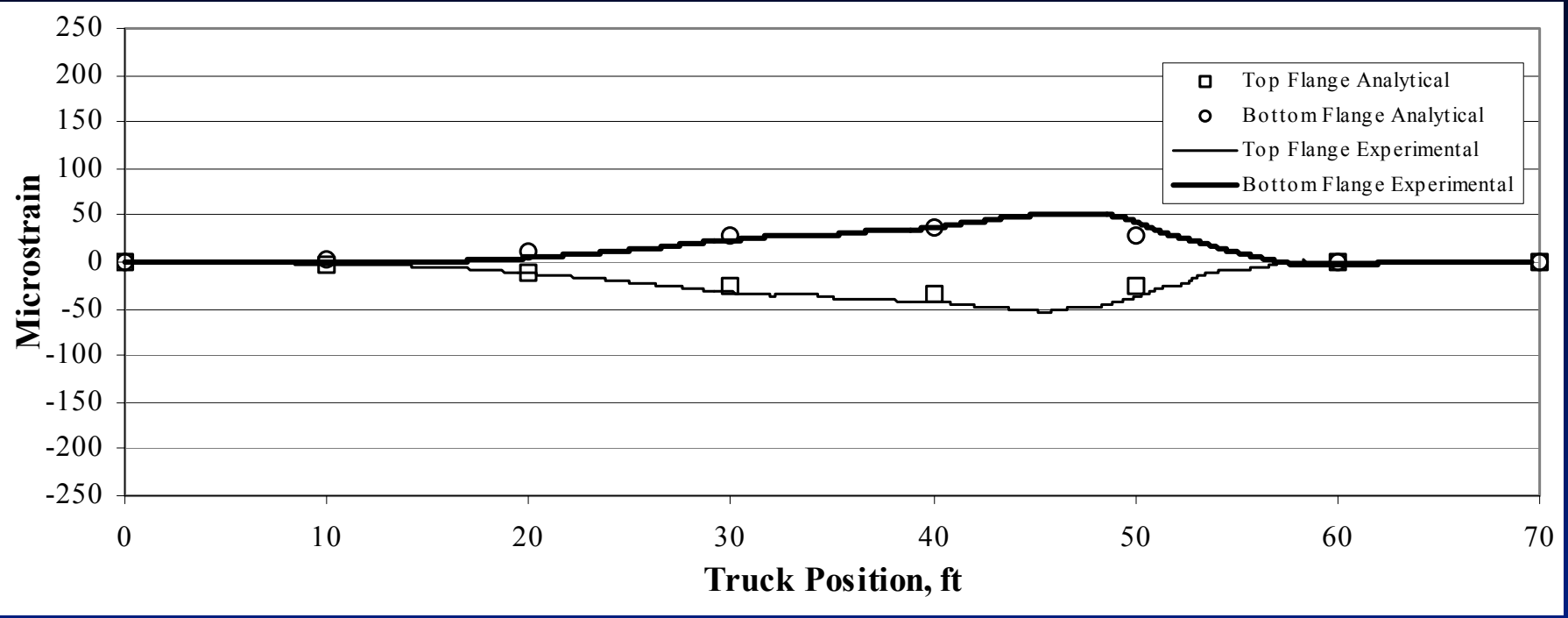
Modeling Results

- All elements groups optimized
  - Girders found to have higher stiffness than code predicted
  - Deck found to have less stiffness than code predicted
  - Approximately 8% fixity
- Resulted in 1.8% error when optimized

Typical Modeling Results



Typical Modeling Results



Rating

- Traditional AASHTO LFD Calculations
- HS-20 Load Vehicle
- Shear limit:
  - 3.94 Inventory
  - 4.22 Operating
- Flexural limit:
  - 0.92 Inventory
  - 1.52 Operating

- Physical Test Based Calculations
- HS-20 Load Vehicle
- Shear limit:
  - 4.78 Inventory
  - 7.61 Operating
- Flexural limit:
  - 1.31 Inventory
  - 1.54 Operating

Results of testing

- Impact of damaged member verified
- Increased rating
  - 42.4.% for flexure
  - 21.3% for shear

Conclusions

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

Acknowledgements

- Sponsor: Iowa Department of Transportation, Highway Division and the Iowa Highway Research Board
- Sponsor: USDA FPL and FHWA
- DOT Office of Bridges and Structures
- Buchanan and Winnebago Counties
- Delaware County
- Boone County

Acknowledgements

- Tama County
- Cedar County
- Butler County
- Blackhawk County
- ISU Research Laboratory Manager
- ISU graduate and undergraduate students

Iowa Department of Transportation
Bridges & Structures

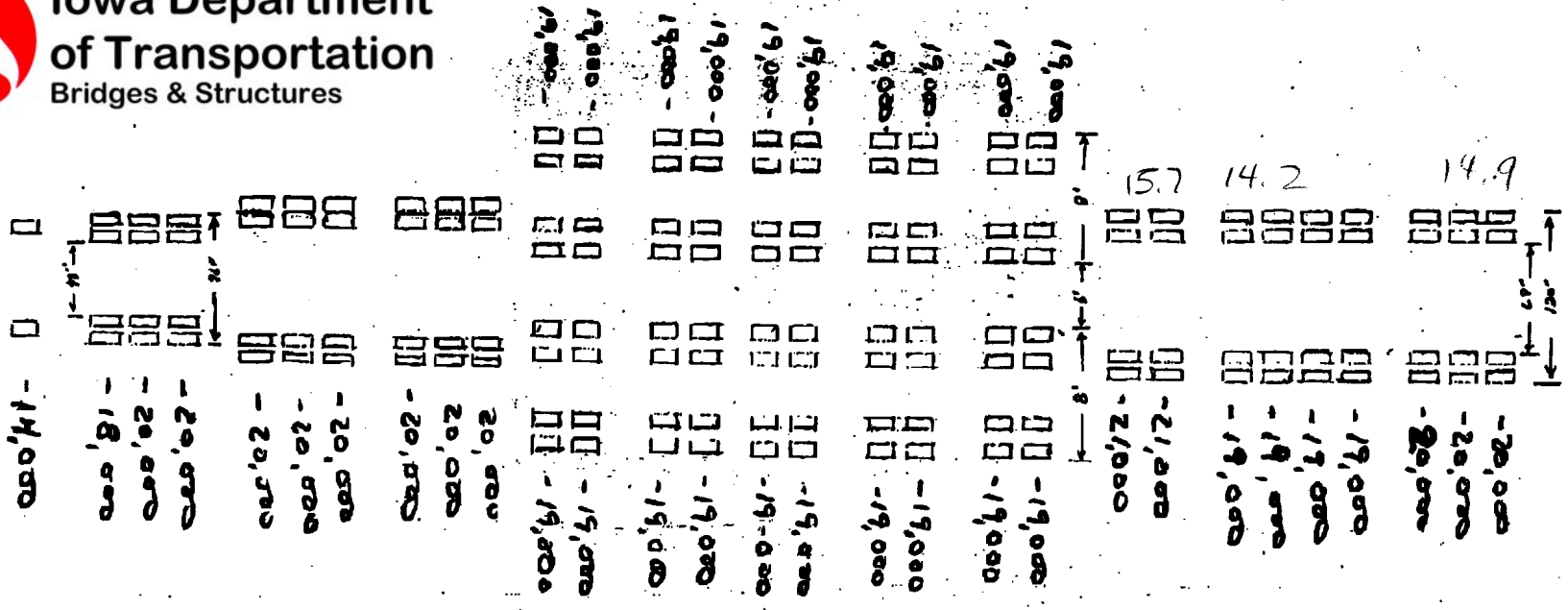
Load Testing At the Iowa D.O.T.

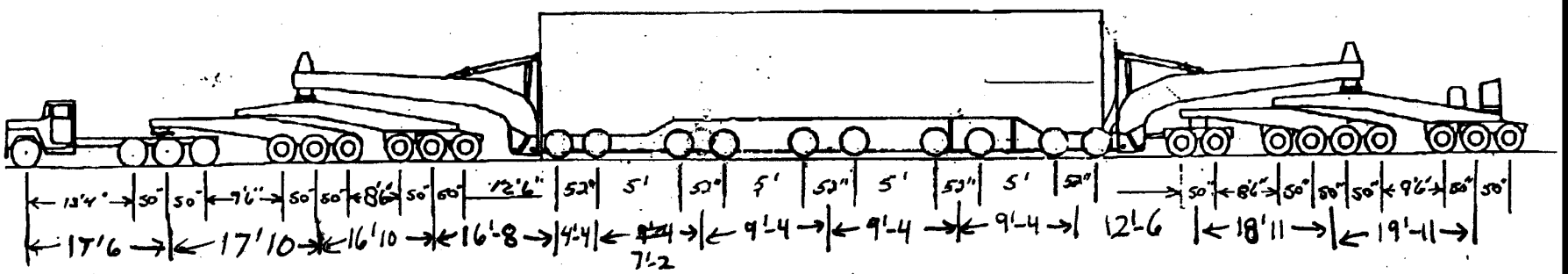
Reason's for Load Testing Bridges

- To Evaluate the Need for Posting
- To Create a Model of a Bridge for determining Heavyload Capacity
- To Determine the Effectiveness of a Strengthening System
- To Determine the Need for a Strengthening System

Oversized Loads

Iowa Department of Transportation
Bridges & Structures





Total Gross 750,000 lbs

Waterloo, Ia to Burchinal, Ia

6 units - 3 at 750,000 + 3 at 560,000 lbs

Vole Moving Co. Inc.

[redacted]

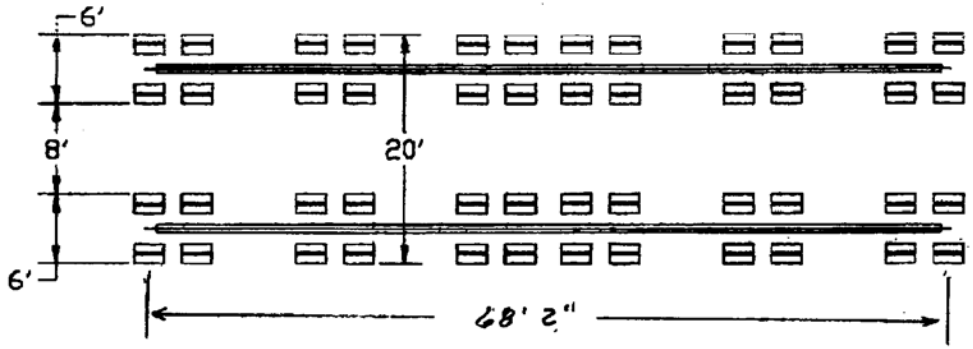
SCALE: N/A | APPROVED BY | DRAWN BY R. Voss

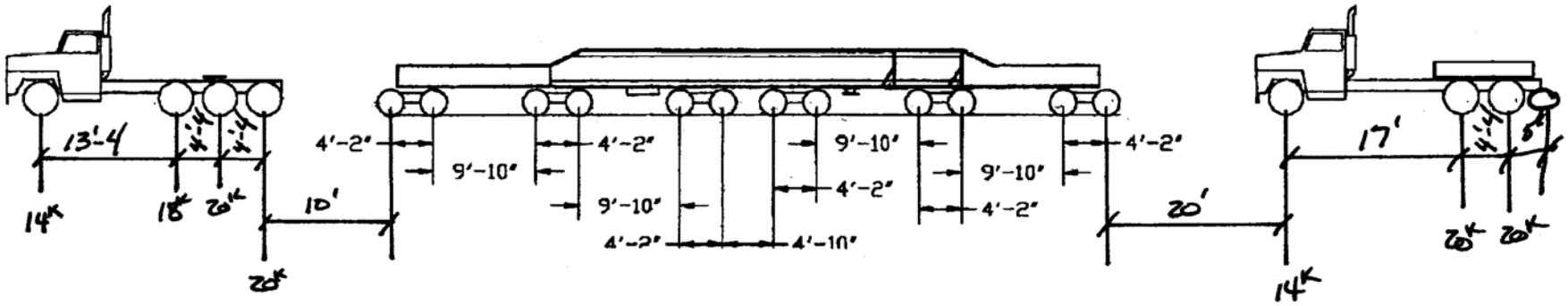
DATE: / /

170'L / 22' W / 16'H /

Turbine component

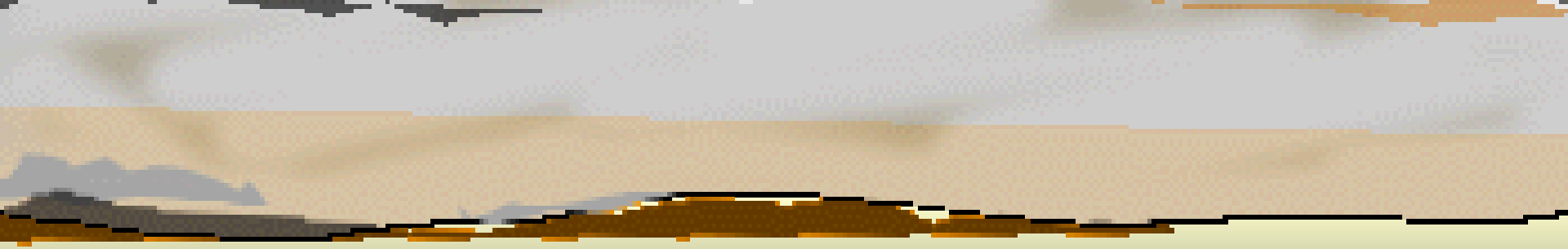
DRAWING NUMBER





SCALE:	APPROVED BY:	DRAWN BY:
DATE:		
All Axles - 20,000 lbs		
Gross 640,000 - Length 132' - Width 20' - Height 19'		
Load will hydraulicly lower to 16'6"		DRAWING NUMBER:

Iowa Department of Transportation
Bridges & Structures



Scott Neubauer, P.E.
Bridge Rating Engineer
Office of Bridges and Structures
Iowa D.O.T.

Iowa Department of Transportation
Bridges & Structures