BRIDGE SESSIONS

Innovative Bridge Applications
AND
Physical Testing for Bridge Load Rating

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Session Speakers

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

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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

Structural modeling

Model analysis and optimization with field collected data

Engineering based data interpretation

Accurate Assessment

Model analysis and optimization with field collected data

Structural modeling

Wireless truck position indicator

Accurate Assessment

Hardwired strain gages
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

Graph showing microstrain vs. truck position for different locations and paths.

- Top Flange, Path Y1, Location L10
- Bottom Flange, Path Y1, Location L10
- Bottom Flange, Path Y3, Location L5
- Top Flange, Path Y3, Location L5
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

![Graph showing typical modeling results with truck position in feet on the x-axis and microstrain on the y-axis. The graph includes analytical and experimental data for both bottom and top flanges.](image)
Typical Modeling Results

![Graph showing typical modeling results with axes for truck position and microstrain, and lines for top and bottom flange analytical and experimental data.](image-url)
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
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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
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