Implementation of Physical Testing for Typical Bridge Load and Superload Rating

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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

Engineering based data interpretation

Structural modeling

Model analysis and optimization with field collected data

Accurate Assessment
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

**L7 (Mid-span of N girder) for Path Y1**

![Graph showing microstrains for Top Flange, Angle, and Bottom Flange](chart)

- **Microstrain (mm/mm)**
- **Truck Position (m)**
- **Top Flange**
- **Angle**
- **Bottom Flange**
Test Results

- Significant end restraint identified

L1 (E Abut. For N girder) for Path Y2

![Graph showing microstrain vs. truck position](image)

- Truck Position (m)
- Microstrain (mm/mm)

Lines represent:
- Top Flange
- Bottom
Test Results

- Composite action determined

L12 (Mid-span of stringer) for Path Y3

L7-Y1 Neutral Axis Location
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
  \( \sim 122 \text{ ft (37 m)} \)
- 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
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

Analytical:

Experimental:

Truck Position, ft

Microstrain

G2
G3
G4
G5

G1 G2 G4 G3 G5 G6

$L$ BRIDGE
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