Wakota Bridge Monitoring and Analysis
Introduction

- Bridge thermal loadings play a significant role in Structural behavior.
- Well documented for superstructure.
- AASHTO does not specifically address provisions for piers in flexible pier systems.
- Investigate thermal behavior and provide insight into pier design in flexible pier bridge systems.
Outline

- Wakota Bridge Background Information
- Wakota Specifics
- Designing for thermal loads
- Instrumentation
- Modeling

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General Information

- Highway 494 over Mississippi River
- Connects Washington and Dakota Counties
- Replacing 4 lane tied-arch bridge built in 1959
- Westbound Span completed summer 2006
- Eastbound Span scheduled for opening summer 2010.
- Will be widest bridge in MN when completed
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Superstructure

- PT Reinforced Concrete structure
- Double box girder
- Total length = 1886 ft
- Width at center = 85 ft
- Longest span = 471 ft
- When completed – 5 lanes in each direction

Typical cross section near Piers

Typical cross Section at Midspan
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Substructure

- Reinforced Concrete
- No Prestressing
- Pile driven footing

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Piers 2, 3, 4

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Segmental Cast in Place Cantilever Construction

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Thermal Design

• Uniform temperature change
  – Greatest contributor to pier moment

• Temperature Gradients
  – Large component of stress in Superstructure

• Two Procedures in AASHTO
  – A: Based on ‘Moderate’ or ‘Cold’ climate
    • Cold = 0 - 80degF
  – B: Based on Contour maps

• MN requires procedure B for atypical bridges (150 deg temp. variation)
Flexible Pier Design

- Ductility for temp range
- Designer must consider variables affecting forces in piers
  - Pier stiffness - Cracked section properties
  - Foundation stiffness
  - A 3-D model may be required to determine appropriate cracked section.
  - Time dependant effects
- Designer Judgement
Instrumentation

- Designed to capture behavior of thermal movements of structure when combined with analysis.
- 84 vibrating wire strain gages with thermisters
  - Embedded in concrete
  - Ability to correlate strain changes with temp. changes
- 2 linear string potentiometers
- Data acquisition system from Campbell Scientific

Geokon Vibrating Wire Strain gage
Strain gages (44) located in piers most affected by temperature variation and lateral loads.
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Pier Wall Instrumentation

Both piers instrumented at two elevations, gages paired along width of wall

Representative Pier Cross Section
Superstructure Instrumentation

- Axial Stresses relieved in spans 1, 2, and 5 due to expansion joints
  - Spans 3 and 4 will have greatest stresses due to temperature variations
- Want strains and stresses due to mainly temperature
  - Place gages away from max LL stresses
- Overall expansion of Structure
  - String pot at abutments

HX-P420 String Pot
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Superstructure Instrumentation

- String Pot
- Section P2-4U instrumented
- Section P4-6D instrumented

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Superstructure Instrumentation

Gage Locations in cross sections with respect to section dimensions

= VW Gage

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Data Acquisition

• Equipment from Campbell Scientific
  – Dataloggers
    • Store and organize data
  – Vibrating wire interfaces
    • Reads frequency from VWSG’s
    • Performs FFT to determine resonant freq.
    • Can find change in L
  – Multiplexers
    • Allow up to 16 VW gages to be read by one input on Interface
  – Multidrops and wireless modem
    • Transmit all data via a cellular telemetry account
Analysis

- SAP2000 used to implement staged construction model
  - Time-dependent losses important
  - Future correlation with field data
    - Strains to stresses and forces
  - Specific iterative approach for evaluation of cracked stiffness in piers to be implemented and evaluated
    - Comparison to results from solid element model incorporating nonlinear material properties (ABAQUS)
Analysis

- Designer Approach to cracked stiffness
  - Stiffness updated along height of Pier for chosen number of updates
  - Analysis run using gross section properties
  - Moments plucked off model
  - Moments input into M-φ plot and curvature found.
  - New modulus for linear model found based on curvature
  - New modulus input into frame model
  - Repeat with updated stiffnesses until convergence (i.e. ΔE<1%)
Analysis

- Questions to be answered
  - How accurate is the updated stiffness method compared to a more complex model incorporating nonlinear materials?
    - Stiffness well predicted according to results so far.
  - How accurate compared to field data?
  - How many stiffness updates are appropriate?
  - Superstructure Behavior with temp loading.
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Summary

- Wakota Bridge instrumented for thermal loading analysis
- Staged construction model being built for data correlation, analysis and design considerations
- Cracked section properties and methods for design being investigated

Chris Scheevel
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Thank you

Questions?