Investigation of Two Prestressed Concrete Box Beam Bridges with Diagonal Cracking

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Overview

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Bridge Configurations

- Prestressed, precast box beams
- Composite concrete deck
- County Road 37 – 37 ft wide by 94 ft long, 30 degree skew
- Brownsville Road – 41 ft wide by 84 ft long
- Transverse post-tensioned tendons, grouted keyways
CR 37

Constructed 1997
Brownsville

Constructed
1993
Cracking Issues

Cracking first reported:
2004 Brownsville
2005 CR 37
Initial Assessment County

- Consult NYSDOT R4
- Visual Monitoring
- Inventory Assessment
- Con-Span Analysis
- Root Cause
Investigation Objectives

1. Determine if design meets Code requirements.
2. Determine potential cause(s) of the cracking.
3. Assess live load capacity and load posting value.
4. Develop repair concepts.
Consultant Selection Process

- Considered 3 firms
  - Structural Evaluation
  - Legal Resolution
- Non Destructive Testing (NDT)
  - Surface Penetrating radar
  - Impact Echo
  - Impulse Response
  - Half-cell potential
- WJE – less NDT, full-scale load testing
WJE Approach

- Design review
- Field inspection & NDT
- Load testing
- Structural evaluation
- Repair recommendations
Design Review

- Contract documents, design calculations, and shop drawings
- AASHTO 15th Ed. (1992) LFD and NYSDOT provisions
- Independent structural calculations

Typical Section CR 37
Design Review

• Shop drawings consistent with design
• Design consistent with AASHTO & NYSDOT
• Appropriate load and load distribution
• Adequate flexural capacity and prestressing to prevent flexural cracking under service loads
• Adequate shear strength despite non-Code conforming lap length
Field Inspection

- No flexural cracks
- CR37 deck cracking
- Limited distress in approach slab & EJ
- Unchanged fascia beam cracking
- Uniform camber and bearing joint filler thickness
Field Inspection

- NDT - spacing of shear reinforcement consistent with drawings
- Corrosion staining
- Cracks along strands near ends
Load Testing

- Load testing not proof testing
- Static not dynamic
- Box beam and crack behavior under known load configuration
- Displacement dial gages and Whitemore strain gages
Load Testing
Load Testing
Load Test at Mid-span

Wheel Locations Transverse to Roadway

Box 1  Box 10

Brownsville Load Test

Case 1  Case 2  Case 3  Case 4
Load Test at Mid-span

Wheel Locations Transverse to Roadway

Box 1

Box 9

CR37 Load Test

Deflection (inches)

Box Beam
Load Test at Mid-span

- Efficient transfer of load between box beams
- Load sharing at mid-span reasonably consistent with that predicted by Code
Load Test at Beam Ends
Load Test at Beam Ends
Load Test at Beam Ends

- No additional cracking or extension of cracks due to loading
- Cracks did not appreciably widen under load (typically between 0.0002 and 0.0006 inches)
- Indicates effective mechanism for shear transfer
Structural Evaluation – Cracking

- Section analysis shear cracking
- Response 2000 (University of Toronto) for Modified Compression Field Theory (MCFT)
- AASHTO LFD loads
- Maximum M/V ratio
- Effect of strand debonding
Structural Evaluation – Cracking

- No cracking at service
- Good correlation with observed crack angles
- Unlikely result of temporary overload per LFD
- LRFD load sharing vs. LFD
- Per LRFD, cracking could possibly occur under HS-25 for CR37 only

Response 2000 section
Structural Evaluation – Cracking

Possible causes:
- Strand slippage
- Creep and shrinkage
- Unintended restraint
Structural Evaluation – Load Rating

- Inventory and Operating Ratings per AASHTO Manual for Condition Evaluation of Bridges, 2003
- No reduction in flexural capacity
- Shear
  - MCFT for angles that differ from 45 degrees
  - Concrete contribution
  - Strand slippage
  - Ultimate capacity
Structural Evaluation – Load Rating

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WJE Ratings:  
- Brownsville: 1.04 (Inventory), 1.82 (Operating)  
- CR 37: 1.00 (Inventory), 1.38 (Operating)
Conclusions

1. Design generally conforms to Code requirements

2. Cause for Cracking
   • Not a design issue
   • Not likely temporary overload
   • Possible contributors include:
     • Strand slippage
     • Creep and shrinkage
     • Unintended restraint
     • Vehicle overload in combination with above

3. Load posting
   • Do not recommend temporary overloads
Recommendations

• Perform crack injection and install flexible sealant at fascia spalls as soon as practical
• Inspect end regions at 6-month intervals for next two years
• Perform additional evaluation if cracks widen or additional cracks form
• Limit loads to HS-25 design load unless additional evaluation conducted
Lessons Learned

- Concrete Cracks-Bridge Performs
- Spread Layout vs. Adjacent
- Jointless Details
- Difficult to find “Smoking Gun”
Thank you