INSPECTION AND LOAD RATING OF P-T SEGMENTAL BRIDGES

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PRESENTATION SUMMARY

1. About the Illinois Tollway
2. Project Location and Information
3. Scope of Work
4. Bridge Inspection
5. Load Rating
6. Condition Reports
7. Rehabilitation
8. Acknowledgements
ABOUT THE ILLINOIS TOLLWAY

294-mile system comprised of five tollways
Carries more than 1.6 million vehicles per day
User-fee system
- Only customers who use the Tollway pay for the Tollway
- No state or federal tax dollars used for maintenance and operations
PROJECT LOCATION AND INFORMATION

- Downers Grove
- Reagan Memorial Tollway (I-88)
  Veterans Memorial Tollway (I-355)
  Interchange and Finley Road
- Constructed in 1988
PROJECT LOCATION AND INFORMATION

BN 1435-Finley Road
- Six span, 558’ long
- 35’-11” out to out

BN 1437-Ramp EN
- Seven span, 908’ long
- 33’-2” out to out
- Horizontally curved: 2,162’ and 1,340’ radius

BN 1439-Ramp SW
- 14 span, 1,965’ long
- Out to out varies 33’-2” to 41’-2”
- Horizontally curved: 1,900’ and 760’ radius

BN 1441-Ramp SE
- 14 span, 2,015’ long
- 38’-8” out to out
- Horizontally curved: 760’ and 1,011’ radius
PROJECT LOCATION AND INFORMATION

Substructure
- Normally reinforced
- Pier heights up to 50’ tall
- Five post-tensioned piers
  - Straddle piers
  - C-shaped piers

Superstructure
- Match cast segments
- Longitudinal post-tensioning
- Transverse post tensioning in deck

Methods of construction
- Span by span
- Balanced cantilever
SCOPE OF WORK

Bridge Inspection
- Hands-on inspection
- In-depth post-tensioning evaluation (last done in 2003)

Bridge Condition Reports
- Evaluate repair options to prolong life of structures

Load Rating
- Load rating of substructure and superstructure
- Load rate for IL 120 truck permit loading
- Baseline load rating performed in 1998 with a load rating performed of Ramp EN in 2010

Rehabilitation Plans
BRIDGE INSPECTION

BN 1435-Finley Road
- ADT On: 10,400
- ADT Under (I-355): 160,500
- ADT Under (I-88): 132,000

BN 1437-Ramp EN
- ADT On: 55,000
- ADT Under (I-88): 132,000

BN 1439-Ramp SW
- ADT On: 13,800
- ADT Under (I-355): 86,000
- ADT Under (Finley): 10,400

BN 1441-Ramp SE
- ADT On: 30,500
- ADT Under (I-355): 86,000
- ADT Under (I-88): 132,000
- ADT Under (Finley): 10,400
BRIDGE INSPECTION

External structure inspection
- Over the course of three weeks
- Day and nighttime inspection
- Use of snoopers and man-lifts
- Traffic control
BRIDGE INSPECTION

External Inspection Findings

- Deterioration of substructure under joints
- Minor defects in overlay
- Parapet delaminations
- Small delaminations at segments
- **Overall in good condition for a 29 year old structure!**
BRIDGE INSPECTION

Internal Structure Inspection

- Confined space procedures
- Provide all lighting
- Hands on inspection of all elements
BRIDGE INSPECTION

Internal Inspection - Findings

- Internal anchorages in good condition
- Hairline cracking at anchor blocks
- Minor delamination at expansion anchorages
BRIDGE INSPECTION

P/T Inspection - Longitudinal Strands
- Use of GPR to locate internal tendons
- Impact Echo used on internal tendons
- Pulse Echo used on external tendons
- Transverse Strands evaluated
BRIDGE INSPECTION

P/T Inspection - Anchor Blocks
- Anchor Blocks at Expansion Joints
- Several pour backs at BN 1441 opened up to investigate condition of anchorages, trumpets and wedges
BRIDGE INSPECTION

P/T Inspection - Substructure
- Internal pier tendons evaluated
- No voids detected in any strands
BRIDGE INSPECTION

P/T Inspection - Grout Testing
- Air Content: 2-3%
- Water-Cement Ratio-0.38
- Petrographic Testing
BRIDGE INSPECTION

P/T Inspection - Repair of Openings
  - 3 Step Process for Grout Sample
  - Anchorage Opening Repair
LOAD RATING

Scope of Rating

- Utilize results from P/T investigation and hands on inspection
- Load rate superstructure
  - Longitudinal
  - Transverse
- Load rate all pier units
- Load rate for HS-20 as well as IL-120 truck load
- Load rate for single lane and two lanes of traffic

Design Criteria

- Use of LARSA 4D software
- LFR codes
- AASHTO Segmental Code
- CEB-FIP European Segmental Code
LOAD RATING

Construction of Model
LOAD RATING

Staged Construction
LOAD RATING

Comparison to Previous Vibration Tests
- Vibration Testing in 2003 after 15 years of creep/shrinkage
- 6 Tendons in each of the four bridges were tested
- LARSA 4D model utilizes time dependent analysis
- Validate the Ciorba model

<table>
<thead>
<tr>
<th>Tendon</th>
<th>Tendon Force, k (Measured)</th>
<th>Tendon Force, k (LARSA)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramp EN (BN 1437)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>636</td>
<td>681</td>
<td>-7.0%</td>
</tr>
<tr>
<td>2</td>
<td>649</td>
<td>676</td>
<td>-4.1%</td>
</tr>
<tr>
<td>3</td>
<td>659</td>
<td>682</td>
<td>-3.5%</td>
</tr>
<tr>
<td>7</td>
<td>644</td>
<td>683</td>
<td>-6.1%</td>
</tr>
<tr>
<td>8</td>
<td>651</td>
<td>678</td>
<td>-4.1%</td>
</tr>
<tr>
<td>9</td>
<td>676</td>
<td>688</td>
<td>-1.8%</td>
</tr>
</tbody>
</table>
LOAD RATING

Comparison to Baseline results

- Superstructure load rating performed in 1998
- Based on original condition
LOAD RATING

Transverse Rating
**LOAD RATING**

**Shear Check:**

\[
RF = \left[ \frac{0.6f'c - (F_d + F_{cs} + F_p + F_s)}{F_l} \right] \quad \text{(Concrete Compression I)}
\]

\[
RF = \left[ \frac{0.4f'c - 0.5(F_d + F_{cs} + F_p + F_s)}{F_l} \right] \quad \text{(Concrete Compression II)}
\]

Where:

- \( F_d \): Stress due to dead load
- \( F_{cs} \): Stress due to creep and shrinkage
- \( F_p \): Stress due to post-tensioning primary forces
- \( F_s \): Stress due to post-tensioning secondary forces
- \( F_l \): Stress due to live load plus impact

**Flexural Check:**

\[
\left[ \frac{ffM_n - (1.3MD + MCS + MS)}{2.17ML(1 + I)} \right] \quad \text{(Flexural Strength Inventory)}
\]

\[
\left[ \frac{ffM_n - (1.3MD + MCS + MS)}{1.3ML(1 + I)} \right] \quad \text{(Flexural Strength Operating)}
\]

Where:

- \( MD \): Dead load moment
- \( MCS \): Creep and shrinkage moment
- \( MS \): Secondary prestress moment
- \( ML \): Live load moment
- \( I \): Impact factor

**Shear Check:**

\[
\left[ \frac{fvV_n - (1.3VD + V_{cs} + VS)}{2.17VL(1 + I)} \right] \quad \text{Shear Strength Inventory)}
\]

\[
\left[ \frac{fvV_n - (1.3VD + V_{cs} + VS)}{1.3VL(1 + I)} \right] \quad \text{Shear Strength Operating)}
\]

Where:

- \( VD \): Dead load shear
- \( V_{cs} \): Creep and shrinkage shear
- \( VS \): Secondary prestress shear
- \( VL \): Live load shear

Presented by Elias Ajami and Brett Sauter on March 7, 2018
LOAD RATING

Substructure Rating
## LOAD RATING

### Results - HS 20 One Lane

<table>
<thead>
<tr>
<th>Bridge</th>
<th>Superstructure</th>
<th>Substructure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inventory Rating</td>
<td>Location</td>
</tr>
<tr>
<td>1435</td>
<td>Not analyzed for one lane due to current traffic configuration</td>
<td></td>
</tr>
<tr>
<td>1437</td>
<td>1.64</td>
<td>Transverse-Bottom of Top Flange at Center</td>
</tr>
<tr>
<td>1439</td>
<td>1.00</td>
<td>Transverse-Top of Top Flange at Center</td>
</tr>
<tr>
<td>1441</td>
<td>1.00</td>
<td>Transverse-Top of Top Flange at Center</td>
</tr>
</tbody>
</table>
## LOAD RATING

### Results-HS 20 Two Lanes

<table>
<thead>
<tr>
<th>Bridge</th>
<th>Inventory Rating</th>
<th>Location</th>
<th>Substructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1435</td>
<td>1.25</td>
<td>Transverse-Top of Top Flange at Web</td>
<td>5.40 Pier 4-Column</td>
</tr>
<tr>
<td>1437</td>
<td>1.10</td>
<td>Span 7-Positive Moment at Pier</td>
<td>0.85 Pier 3-Tensile Stress Back of Column</td>
</tr>
<tr>
<td>1439</td>
<td>0.50</td>
<td>Transverse-Top of Top Flange at Center</td>
<td>1.23 Pier 1-Column</td>
</tr>
<tr>
<td>1441</td>
<td>0.50</td>
<td>Transverse-Top of Top Flange at Center</td>
<td>1.24 Pier 2-Column</td>
</tr>
</tbody>
</table>
### LOAD RATING

#### Results-IL 120 Loading

<table>
<thead>
<tr>
<th>Bridge</th>
<th>Operating Rating</th>
<th>Location</th>
<th>Operating Rating</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1435</td>
<td>3.87</td>
<td>Span 2-Shear</td>
<td>2.26</td>
<td>Span 1-Negative Moment</td>
</tr>
<tr>
<td>1437</td>
<td>3.09</td>
<td>Span 7-Positive Moment</td>
<td>1.54</td>
<td>Span 7-Positive Moment</td>
</tr>
<tr>
<td>1439</td>
<td>2.37</td>
<td>Span 1-Shear Strength</td>
<td>1.28</td>
<td>Span 4-Positive Moment</td>
</tr>
<tr>
<td>1441</td>
<td>2.03</td>
<td>Span 1-Shear Strength</td>
<td>1.31</td>
<td>Span 1-Shear</td>
</tr>
</tbody>
</table>
CONDITION REPORTS

Report Content

- Bridge and P/T Inspection Results
- Load Rating Results
- Evaluate Future Traffic Demands
- Life Cycle Cost Analysis if needed
- Recommendations for Repair
  - Ultra High Performance Concrete Overlay evaluated
  - Interior Lighting Evaluated
REHABILITATION

Rehabilitation plans developed
- Bid opening scheduled April 2018

Scope of work
- Joint replacement and repair
- Anchor block replacements
- Substructure repair: conventional and fiber wrap
- Overlay repair and replacement
- No repair of P/T or strengthening required
ACKNOWLEDGEMENTS

Illinois Tollway
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THANK YOU!