INSPECTION AND LOAD RATING OF P-T SEGMENTAL BRIDGES

Elias Ajami, PE
Illinois Tollway
Brett Sauter, PE, SE
Ciorba Group

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

294-mile system

Carries more than 1.6 million vehicles per day

- 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

IL-120 TRUCK

AXLE LOADS AND SPACING

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

	Tendon	Tendon Force, k (Measured)	Tendon Force, k (LARSA)	Difference
Ramp EN (BN 1437)	1	636	681	-7.0%
	2	649	676	-4.1%
	3	659	682	-3.5%
	7	644	683	-6.1%
	8	651	678	-4.1%
	9	676	688	-1.8%

LOAD RATING

Comparison to Baseline results

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

LOAD RATING

Transverse Rating

LOAD RATING

Shear Check:

$$RF = \frac{[0.6f'_c - 0.5(F_d + F_{cs} + F_p + F_s)]}{F_l} \quad (\text{Concrete Compression II})$$

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

Where:

M_d	=	Dead load moment
M_{cs}	=	Creep and shrinkage moment
M_{ss}	=	Secondary prestress moment
M_s	=	Stress due to creep and shrinkage
M_L	=	Live load moment
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

LOAD RATING

Substructure Rating

LOAD RATING

Results-HS 20 One Lane

	Superstructure		Substructure	
Bridge	Inventory Rating	Location	Inventory Rating	Location
1435	Not analyzed for one lane due to current traffic configuration			
1437	1.64	Transverse-Bottom of Top Flange at Center	1.28	Pier 3-Tensile Stress Back of Column
1439	1.00	Transverse-Top of Top Flange at Center	1.23	Pier 1-Column
1441	1.00	Transverse-Top of Top Flange at Center	1.24	Pier 2-Column

LOAD RATING

Results-HS 20 Two Lanes

	Superstructure		Substructure	
Bridge	Inventory Rating	Location	Inventory Rating	Location
1435	1.25	Transverse-Top of Top Flange at Web	5.40	Pier 4-Column
1437	1.10	Span 7-Positive Moment at Pier	0.85	Pier 3-Tensile Stress Back of Column
1439	0.50	Transverse-Top of Top Flange at Center	1.23	Pier 1-Column
1441	0.50	Transverse-Top of Top Flange at Center	1.24	Pier 2-Column

LOAD RATING

Results-IL 120 Loading

	One Lane		Two Lanes	
Bridge	Operating Rating	Location	Operating Rating	Location
1435	3.87	Span 2-Shear	2.26	Span 1-Negative Moment
1437	3.09	Span 7-Positive Moment	1.54	Span 7-Positive Moment
1439	2.37	Span 1-Shear Strength	1.28	Span 4-Positive Moment
1441	2.03	Span 1-Shear Strength	1.31	Span 1-Shear

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

Vector Corrosion Services

Ciorba Group Staff

Primera Engineering

THANK YOU!

CIORBA GROUP
Consulting Engineers