KANSAS
DEPARTMENT OF TRANSPORTATION

PRESENTATION

US-54 Central Business District Viaduct

KDOT Project No. 54-87 KA-1647-02
Bridge No. 54-87-25.88 (374)
Bridge No. 54-87-25.95 (375)
Bridge No. 54-87-25.94 (376)
Bridge No. 54-87-25.86 (377)

BRIDGE REHABILITATION

City of Wichita, Sedgwick County

Presented to:

KANSAS STATE UNIVERSITY BRIDGE DESIGN WORKSHOP

Presented by:
Abdul Hamada, P.E.
Nichole Witushynsky, P.E.

October 9, 2015

Outline

Presentation Outline

- **Introduction**
- **Background**
- **Site Investigation**
- **Bridge Repair Plans & Repairs**
  - Clean Bridge & Install Bird Screens
  - Epoxy Resin Crack Repair
  - Blister Pour-backs/Anchorage Repair
  - Duct Grouting Operations
  - NDT Grout Verification
  - Test Lead Wire Installation
- **Conclusions**

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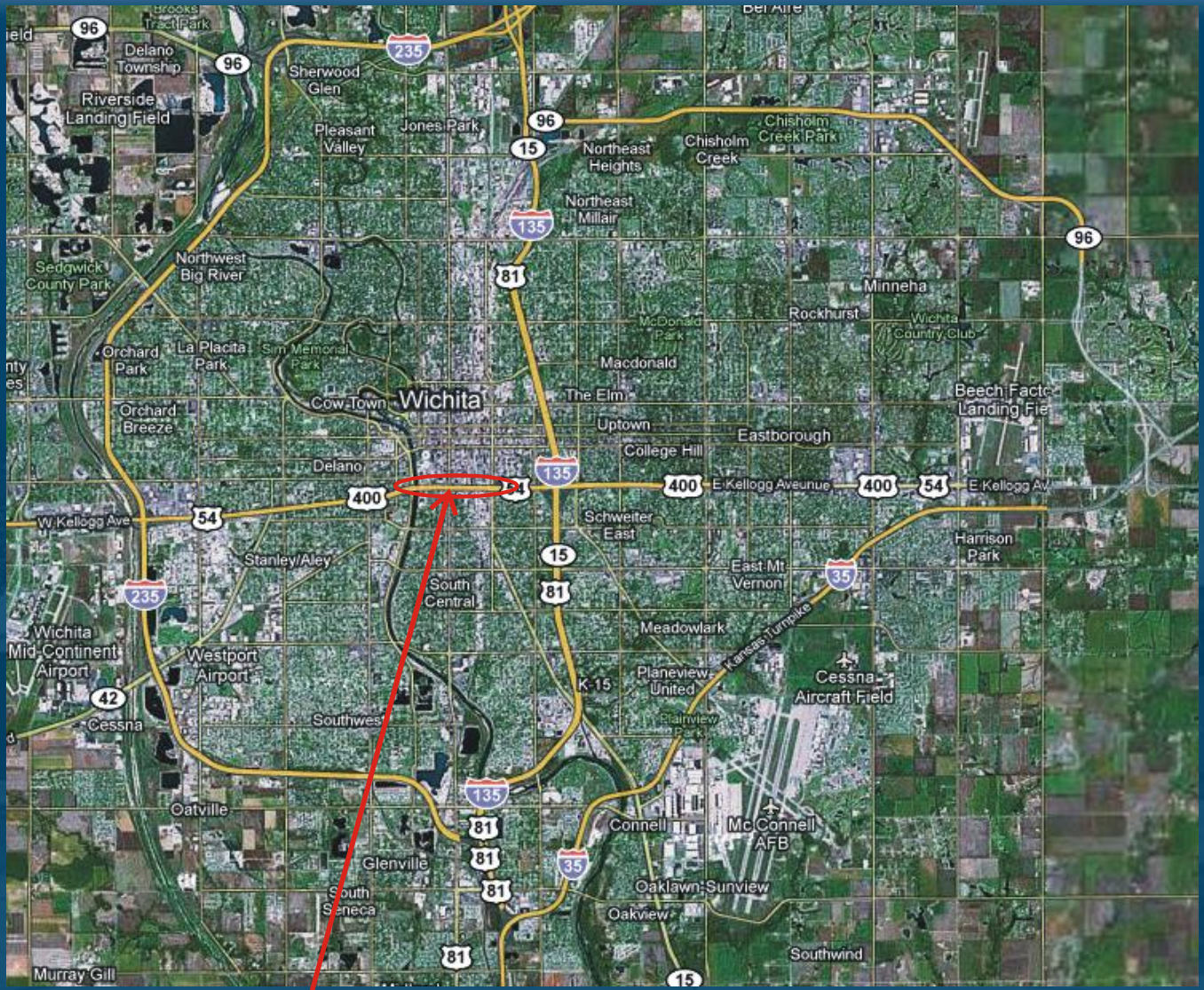
Aerial View of US-54 CBD Viaduct



US 54 CBD VIADUCT

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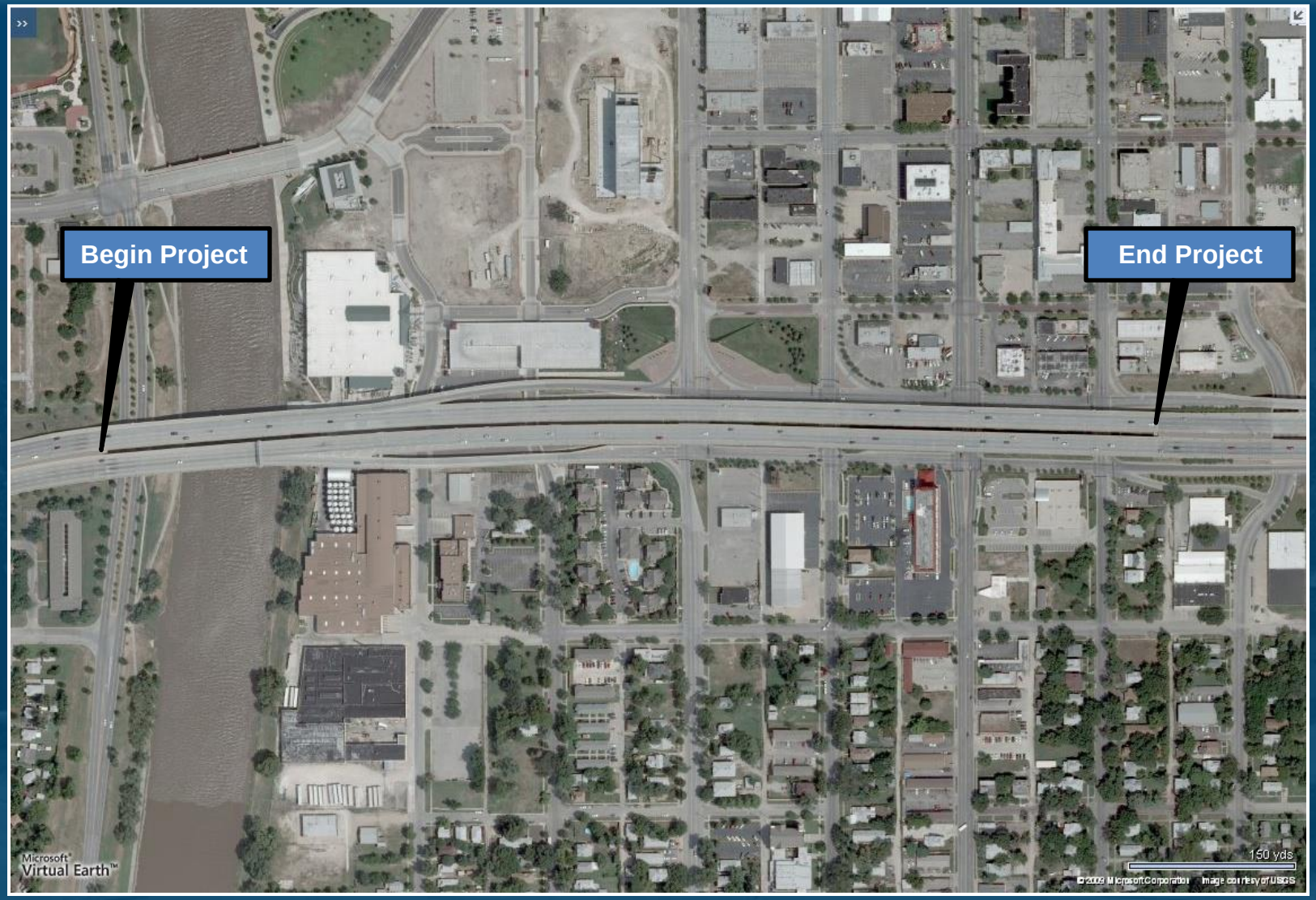
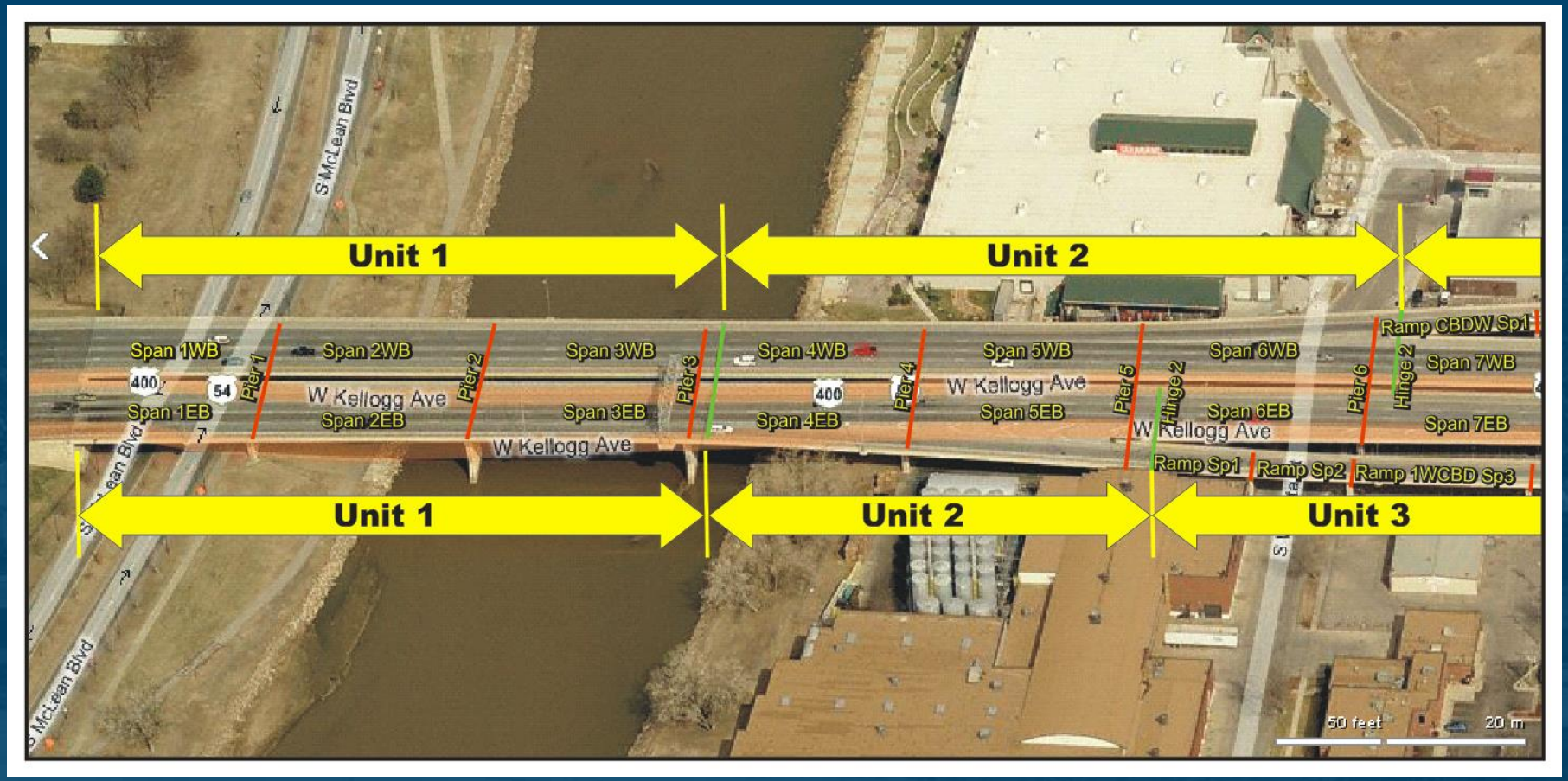
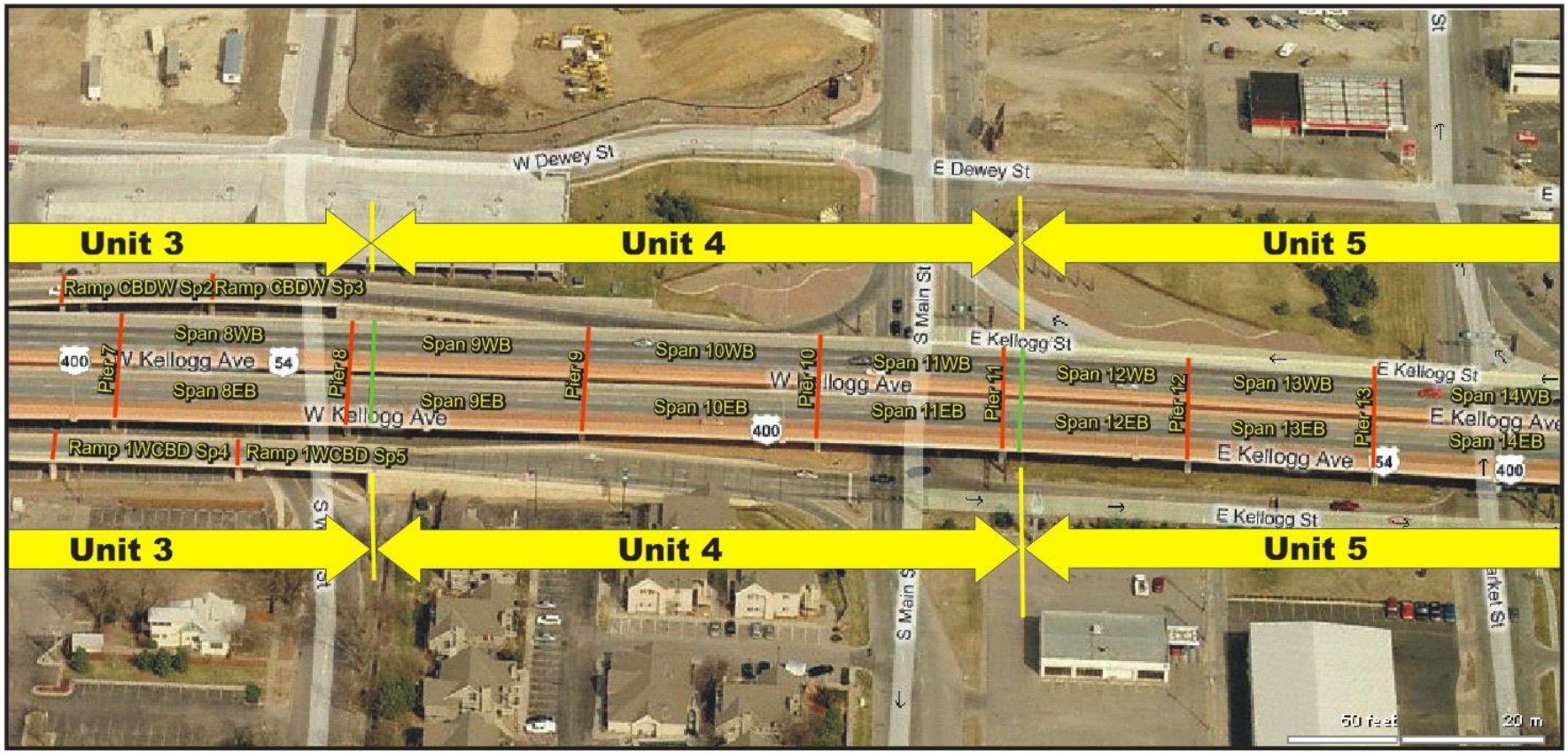
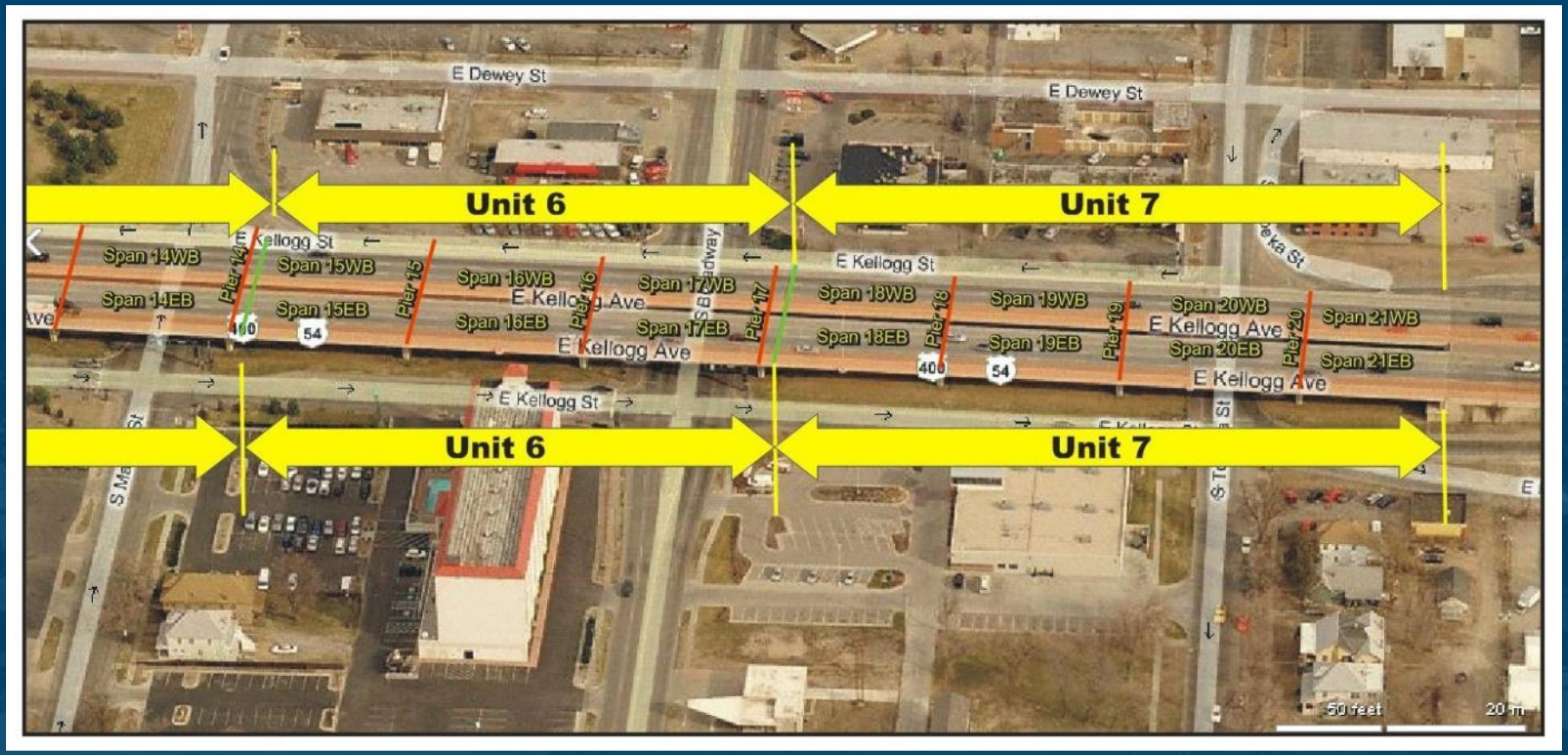
Aerial View of US-54 CBD Viaduct



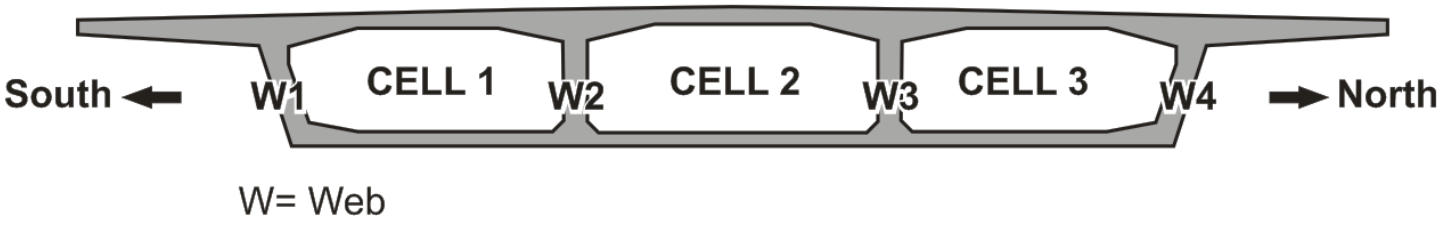

Unit 1
Unit 2
Span 1WB
Span 2WB
Span 3WB
Span 4WB
Span 5WB
Span 6WB
Ramp CBDW Sp1
Span 7WB
Pier 1
Pier 2
Pier 3
Pier 4
Pier 5
Hinge 2
Pier 6
400
54
W Kellogg Ave
Span 1EB
Span 2EB
Span 3EB
Span 4EB
Span 5EB
Span 6EB
Span 7EB
S McLean Blvd
Ramp Sp1
Ramp Sp2
Ramp 1WCBD Sp3
Unit 1
Unit 2
Unit 3
50 feet
20 m


Unit 3
Unit 4
Unit 5
W Dewey St
E Dewey St
Ramp CBDW Sp2
Ramp CBDW Sp3
Span 8WB
Span 8EB
Span 9WB
Span 9EB
Span 10WB
Span 10EB
Span 11WB
Span 11EB
Span 12WB
Span 12EB
Span 13WB
Span 13EB
Span 14WB
Span 14EB
Pier 7
Pier 8
Pier 9
Pier 10
Pier 11
Pier 12
Pier 13
400
54
W Kellogg Ave
E Kellogg St
E Kellogg Ave
S Main St
Ramp 1WCBD Sp4
Ramp 1WCBD Sp5
Unit 3
Unit 4
Unit 5
50 feet
20 m


Unit 6
Unit 7
Unit 6
Unit 7
E Dewey St
E Dewey St
E Kellogg St
E Kellogg Ave
E Kellogg St
E Kellogg Ave
E Kellogg St
E Kellogg Ave
Span 14WB
Span 14EB
Span 15WB
Span 15EB
Span 16WB
Span 16EB
Span 17WB
Span 17EB
Span 18WB
Span 18EB
Span 19WB
Span 19EB
Span 20WB
Span 20EB
Span 21WB
Span 21EB
Pier 14
Pier 15
Pier 16
Pier 17
Pier 18
Pier 19
Pier 20
400
54
400
54
50 feet
20 m

Segmental Box

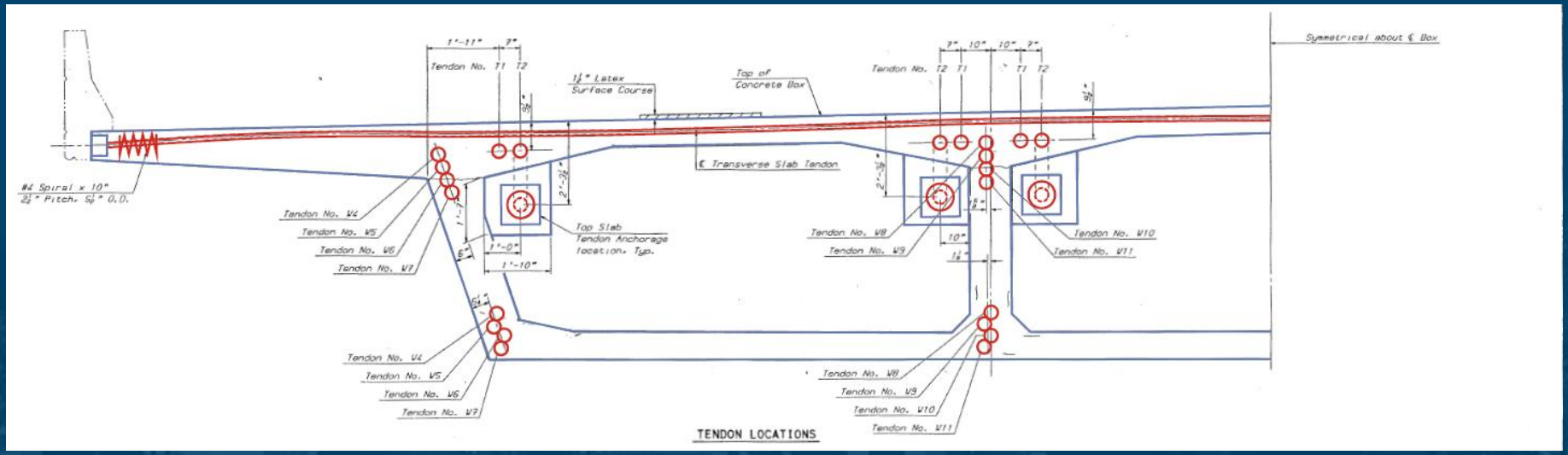
Segmental Box Cross Section

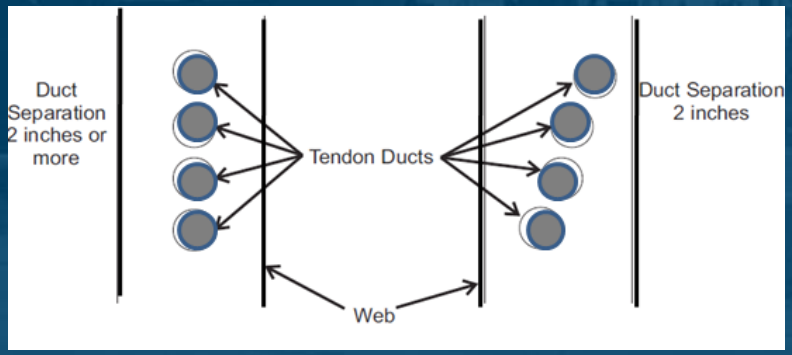


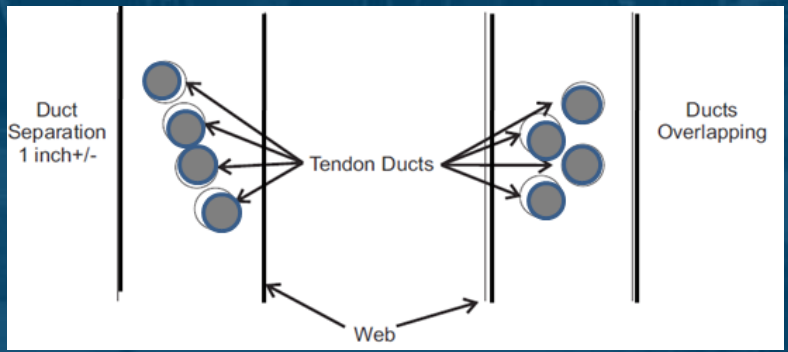
W= Web

Segmental Box

Post-tension Duct Cross Section

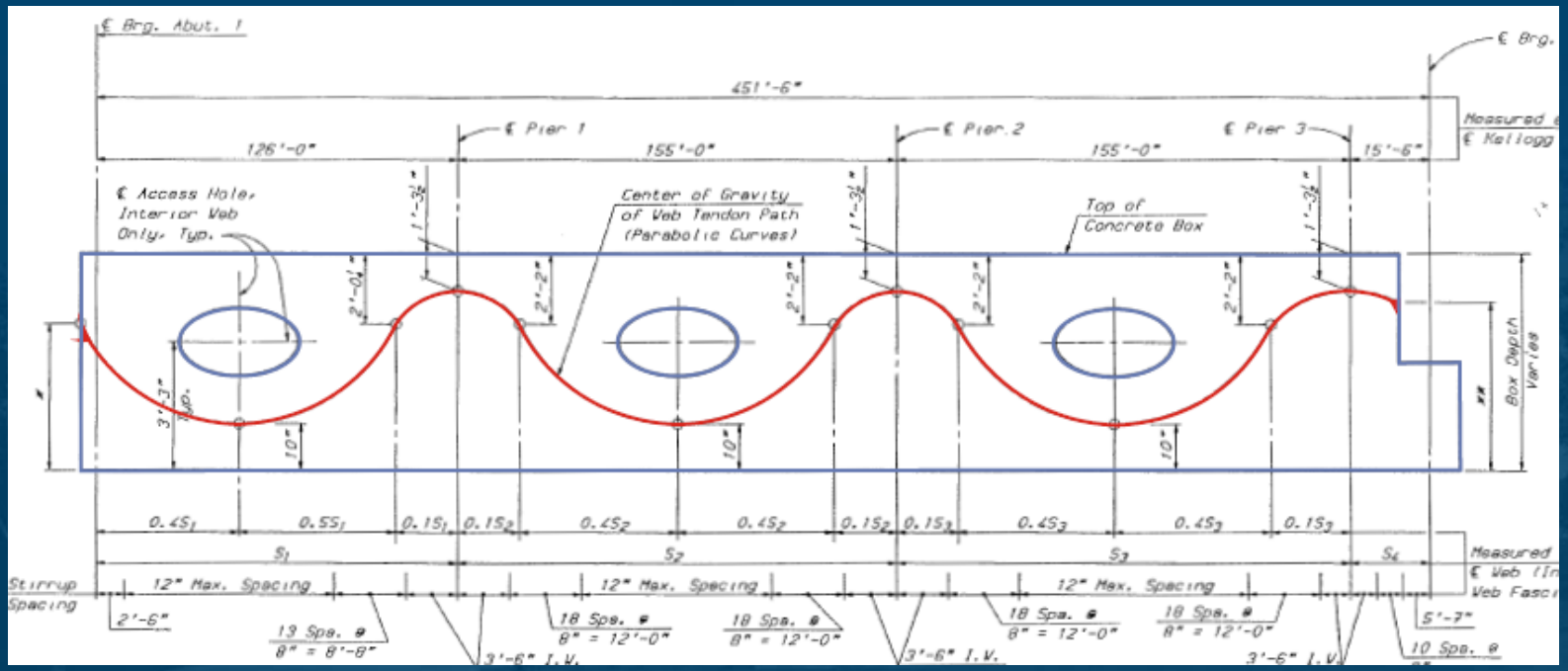






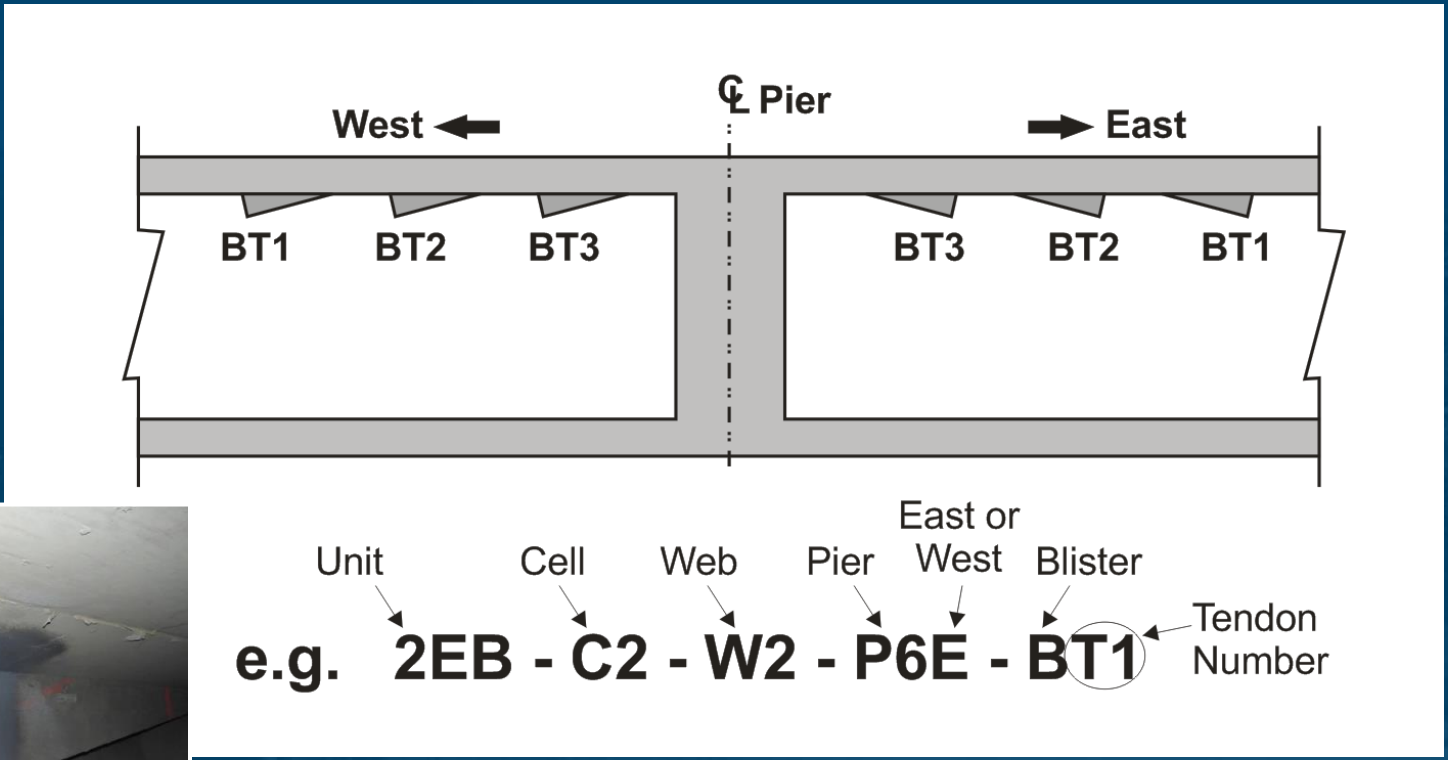
Segmental Box

Post-tension Duct Elevation



Segmental Box

Post Tension Duct Anchorages



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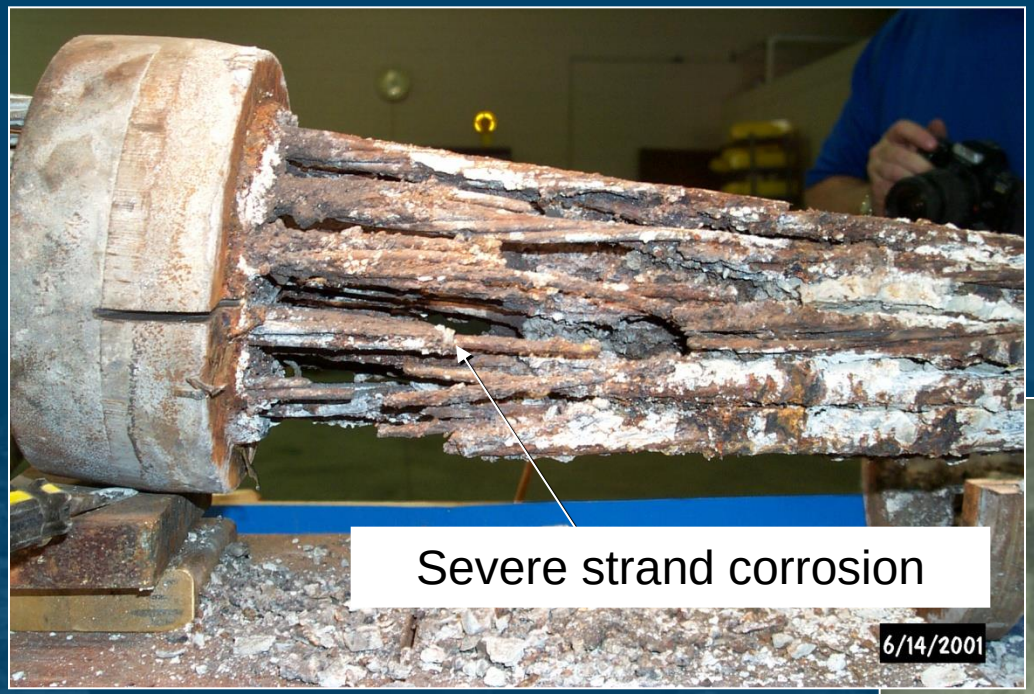
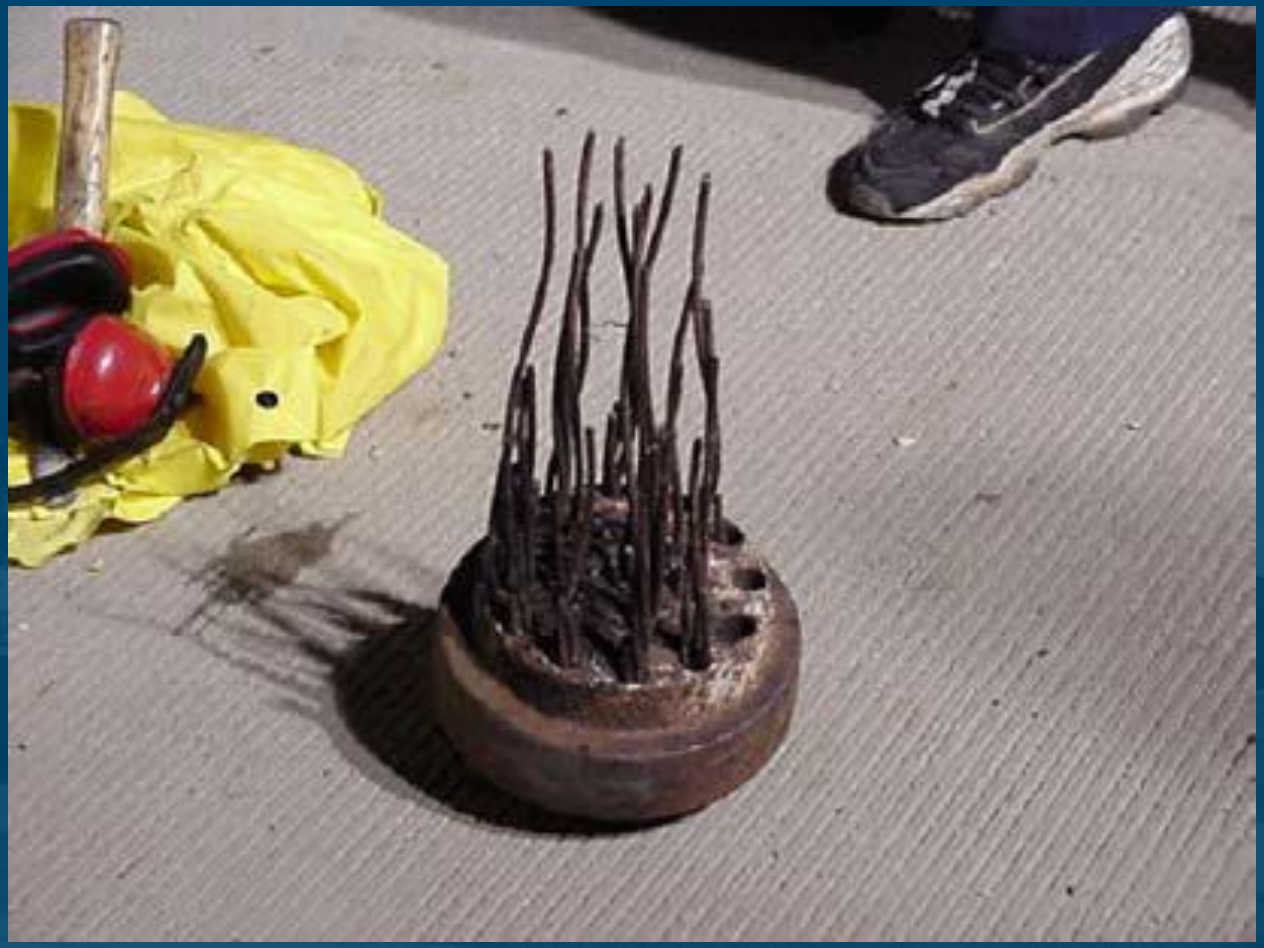
Sunshine Skyway Bridge, FL

Sunshine Skyway Bridge, FL



Column 133 NB
NE Tendon

Mid Bay Bridge, FL



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Jamestown-Verrazzano Segmental Bridge, RI

Jamestown-Verrazzano Segmental Bridge, RI

Pier 13
Center Web
Vertical Tendon
3

Void in Pier With Dywidag Bar
Instead of Tendons

Span 9
Westbound
Draped Web
Tendon 21

Corrosion on Duct

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Jamestown-Verrazzano Segmental Bridge, RI

Pier 14
Werstbound
Vertical Tendon
8

View of Void Bottom
Corrosion on Duct and Tendons

Pier 14
Eastbound
Vertical Tendon
5

Corrosion on Both Duct and Tendon

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Jamestown-Verrazzano Segmental Bridge, RI

Pier 14
Westbound
Vertical Tendon
2

Close-up of Anchor. Top of Tendons Show some Corrosion

Pier 14
Center Web
Vertical 3

Tendon Found with Standing Water inside

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US-54 Wichita CBD Viaduct, KS

Project Issues

Known Project Issues (prior to investigation)

- PT Tendons used old generation of grout material and procedures
- Old generation of post-tensioning hard-wares system
- Lack of anchorage corrosion protection system
- The presence of PT blisters, deck, and web cracks
- In-span hinge

Investigation Strategy

- Phase 1: Planning
- Phase 2: Walk-through inspection
- Phase 3: Limited site investigation
- Phase 4: Report of Condition assessment and recommendations
- Phase 5: Completion of the investigation and repair plans
- Phase 6: Rehabilitation

Project Timeline Highlights

- **US – 54 CBD Preliminary Engineering for Investigation and Evaluation: NTP / project award on 8/20/2009**
- **Visual Site Inspection : October 16 to 21, 2009**
  - **Final Report submitted in November 2009**
- **Limited Site Investigation : Dec. 15, 2009 to March 27, 2010**
  - **Final Report submitted in June 2010**
- **Project Repair Plans:**
  - **Final Plans submitted in June 2013**
- **Bridge Rehabilitation: April 2014 to June 2014**
  - **Final Report submitted in October 2014**

Limited Site Investigation

Tested 10% Critical PT Elements

Tendon Type	Number Tested	Number with Voids	Percentage Voided	Total Feet Tested	Approximate Feet Voided
Longitudinal Web	32	19	59%	5,718 Feet	630 Feet
Longitudinal Top Slab	67	6	8.9%		
Hinge	6	0	0		
Diaphragm	11	3	27%		
Transverse Top Deck	4	1	25%		

Strategically selected elements were inspected

Site Investigation

Tested ALL Accessible Critical PT Elements

- Draped Web tendons: *46%* of tendons inspected have voids
- Longitudinal Top tendons: *6%* of tendons inspected have voids
- Diaphragm Transverse Tendons: *25%* tendons inspected have voids
- Transverse Deck Tendons: *5%* tendons inspected have voids
- Hinge Tendon: *5%* of tendons inspected have voids
- Soft grout in the duct at six locations
- Water in the duct at multiple locations; some voids dry
- Low rates of corrosion at present

Grout Repair

Repair Options

- Vacuum Grouting
- Vacuum Assist Grouting
- Pressure Grouting

Note: Due to tendon failure of Varina-Enon Bridge in Virginia after re-grouting of the tendon, there is a concern on the potential formation of corrosion cell when re-grouting of old / existing grout with new grout. "Dissimilar Grout Research" was initiated by PB/KDOT

Grout Sampling

Existing Grout

- Showed presence of portland cement based grout
- Showed negligible chloride content

Sample	pH, 1:1 by mass
Sample 1 Station 14	12.74
Sample 2 Station 87	12.54
Sample 3 Tendon T1	12.61

Sample	Acid-Soluble Chloride, % by mass of sample
Sample 1 Station 14	<0.006
Sample 2 Station 87	0.030
Sample 3 Tendon T1	<0.006

KU Dissimilar Grout Research

Research Approach

- Determine if using a second grout will provide improved corrosion protection for prestressing strands or result in accelerated corrosion
- Determine the possible consequences of leaving the voids unfilled

Testing Methods

- Half-cell Potential Test (probability of corrosion)
- Macro-cell Current Test
- Linear Polarization Resistance (corrosion rate)

FDOT Dissimilar Grout Research

Grouting Systems Examined

- SikaGrout 300PT (Sika Corp.)
- MasterFlow MB1205 High Performance Duct Grout

Testing Methods

- Half-cell Potential Test (probability of corrosion)
- Macro-cell Current Test
- Linear Polarization Resistance (corrosion rate)
- Electrochemical Impedance Spectroscopy (corrosion rate)
- Chemical analysis and pH of grouts

KU/FDOT Conclusions

- Leaving prestressing strands unprotected from elements has the potential to result in rapid corrosion of the exposed strands
- Significant corrosion activity developed in the presence of bleed water
- When paired with Portland cement grout, the pre-packaged anti-bleed grouts resulted in corrosion losses
- Of the anti-bleed grout materials evaluated, Masterflow 1205 appears superior

Condition of Bridge

LFD Load Rating

BRIDGE NO.: 54-87-25.95 (375)

CARRIES: US 54 WESTBOUND (WB KELLOGG CBD VIADUCT)

BRIDGE COMPONENT	INVENTORY RATING LOAD FACTOR METHOD (RATING FACTOR)					OPERATING RATING LOAD FACTOR METHOD (RATING FACTOR)							
	H	TYPE 3	HS	TYPE 3S2	TYPE 3-3	H	TYPE 3	HS	TYPE 3S2	TYPE 3-3	T130	T170	HET
TRANSVERSE - MULTI CELL													
Serviceability Concrete	1.87	2.49	1.73	2.49	2.49	3.66	4.93	3.42	5.16	5.93	4.58	4.10	2.31
LFD - Flexural Strength	2.64	3.15	2.26	3.37	3.82	4.41	5.26	3.78	5.61	6.36	4.05	3.52	2.18
LONGITUDINAL													
Serviceability Concrete	1.28	1.10	0.79	0.88	0.88	2.05	1.76	1.26	1.41	1.41	1.52	1.40	0.78
LFD - Flexural Strength	2.05	1.65	1.15	1.18	1.12	3.42	2.76	1.92	1.97	1.86	1.70	1.46	0.90
LFD - Shear Strength	2.04	2.18	1.67	1.61	1.56	3.40	3.64	2.78	2.69	2.61	2.85	2.53	1.42

For Joint Locations of Transverse Top Deck and Longitudinal Box Girder, see Appendix C.

BRIDGE 375 - SUMMARY OF BRIDGE RATING

CITY (COUNTY): WICHITA (SEDGWICK)

BRIDGE NO.: 54-87-25.95 (375)

CARRIES: US 54 WESTBOUND (WB KELLOGG CBD VIADUCT)

OVER: LOCAL URBAN STREETS, ARKANSAS RIVER

RATINGS (TONS)

Load Factor Ratings for Load Posting Purposes Load Ratings in English Tons		
VEHICLE TYPE	INVENTORY	OPERATING
H	25.6	41.0
TYPE 3	27.5	44.0
HS	28.4	45.3
TYPE 3S2	31.6	50.7
TYPE 3-3	35.2	56.4
T130	--	98.8
T170	--	119.0
Heavy Equip. Transporter	--	85.7

MS18 Load Factor Ratings in Metric Tons (tonne) Provided in Compliance with the Decemeber 1995 FHWA NBIS Coding Guide			
INVENTORY		OPERATING	
Item 66	MS Equivalent	Item 64	MS Equivalent
25.7	14.3	41.0	22.8

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Access (exterior)

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Access (Span 3)

Access (Span 1)

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Access (interior)

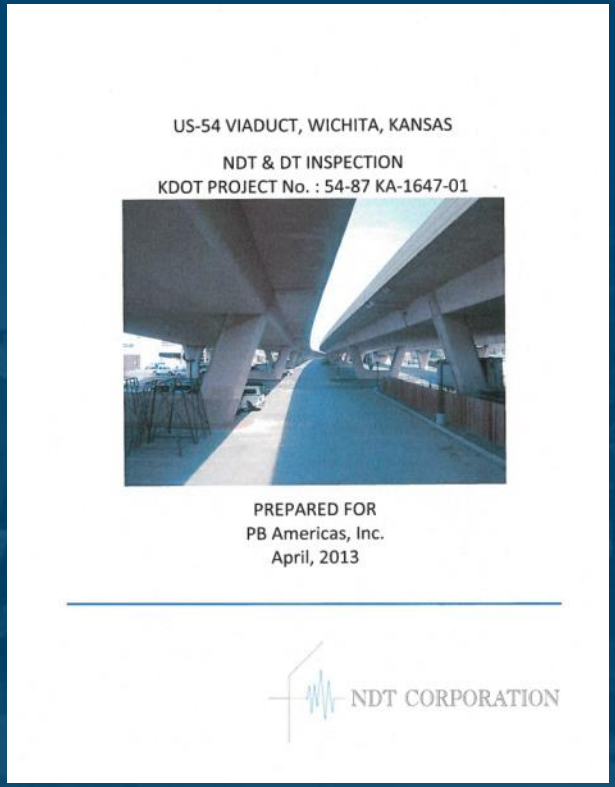





Site Investigation

NDT Inspection

- **Non-destructive Testing**
  - Void detection by sonic/ultrasonic testing concrete
  - All accessible draped web, longitudinal top deck, diaphragm, and transverse tendons were tested
- **Verification Testing**
  - Void verification by drilled holes identified by sonic testing
  - Boroscope used to find limits of void


US-54 VIADUCT, WICHITA, KANSAS

NDT & DT INSPECTION
KDOT PROJECT No. : 54-87 KA-1647-01

PREPARED FOR
PB Americas, Inc.
April, 2013

NDT CORPORATION

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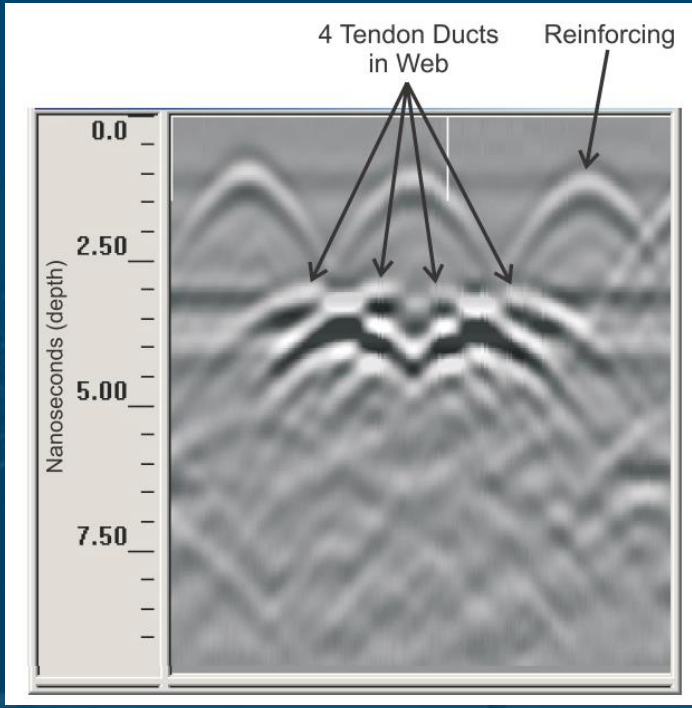
Site Investigation



GPR to Accurately Locate Ducts

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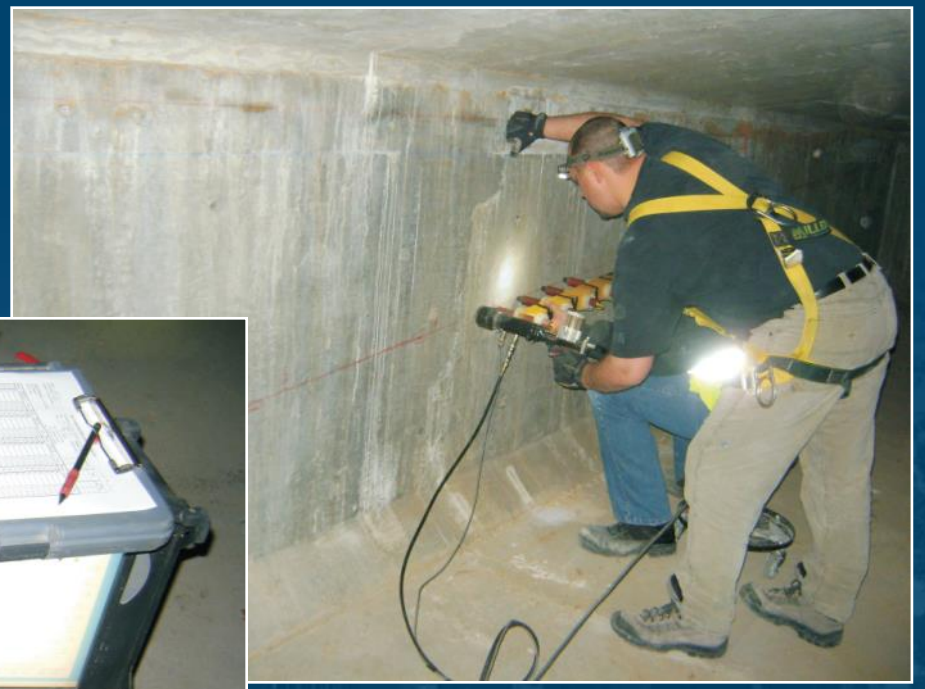
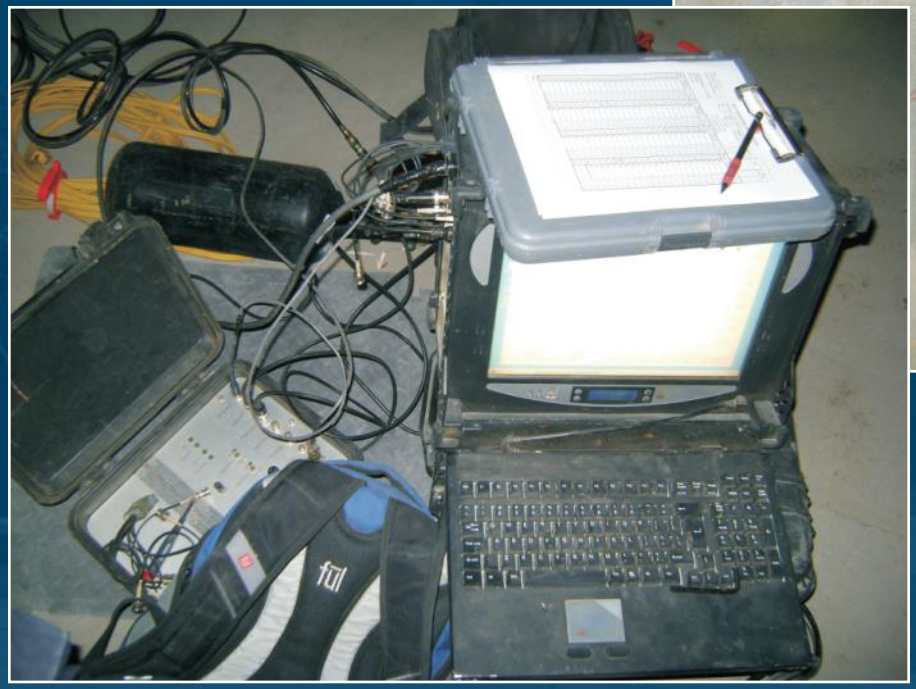
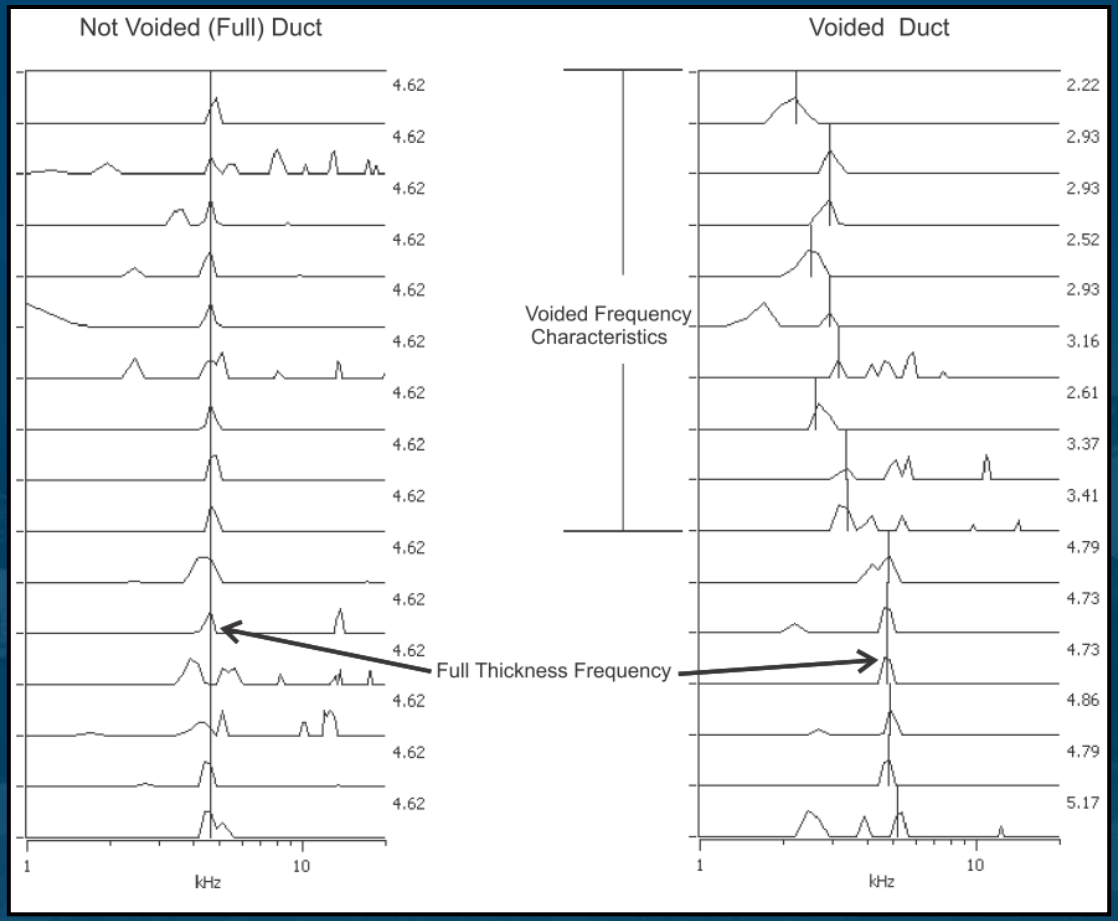
Site Investigation





Sonic/Ultrasonic Void Detection

Site Investigation



Detection of Voided Tendons

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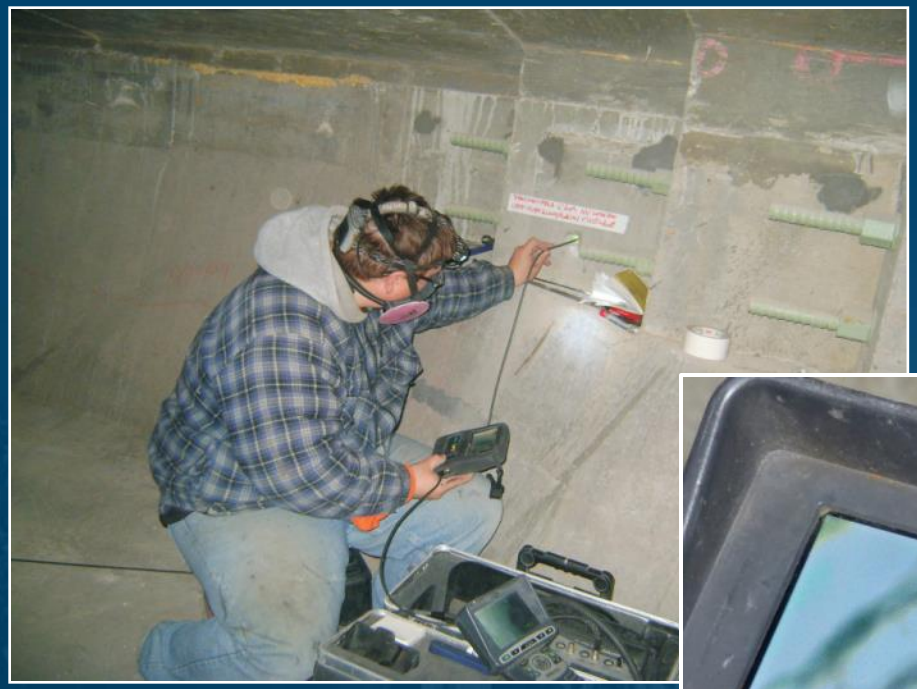
Site Investigation

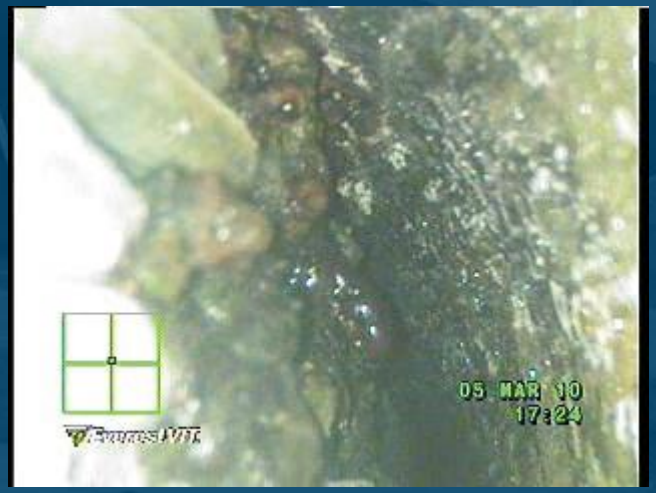
Drilling Verification of Voided Ducts

Site Investigation



Video Borescope Inspection of Ducts

Site Investigation



Borescope Images & Video

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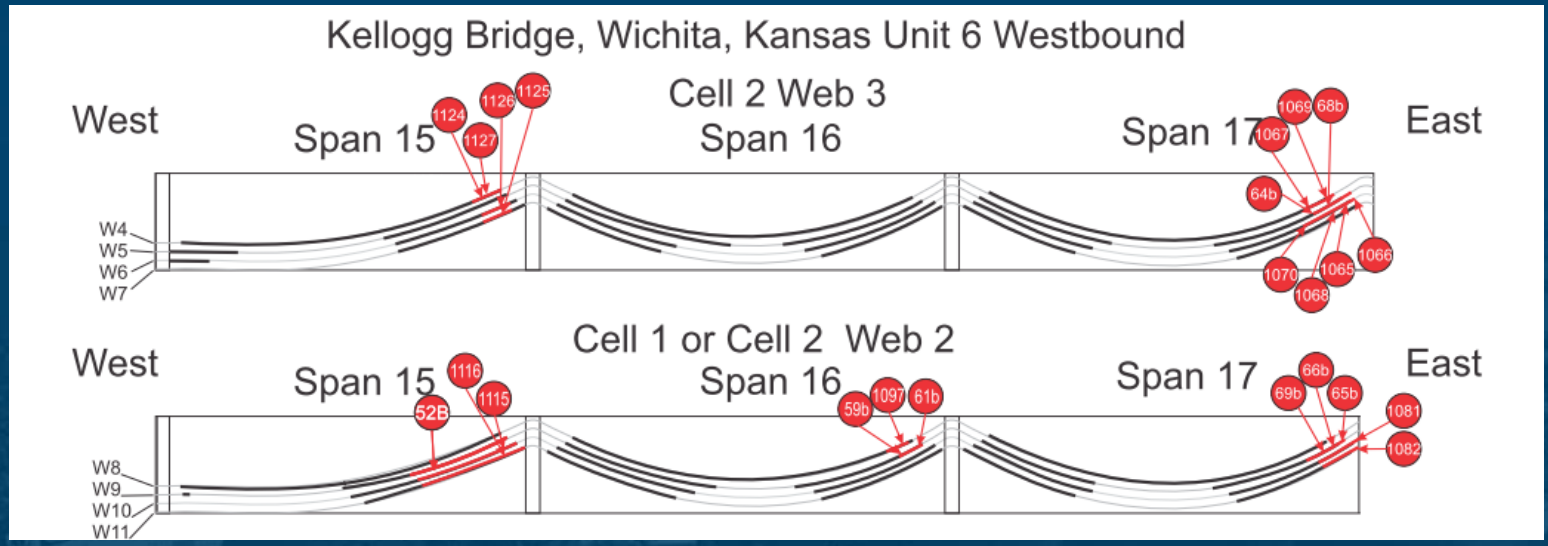
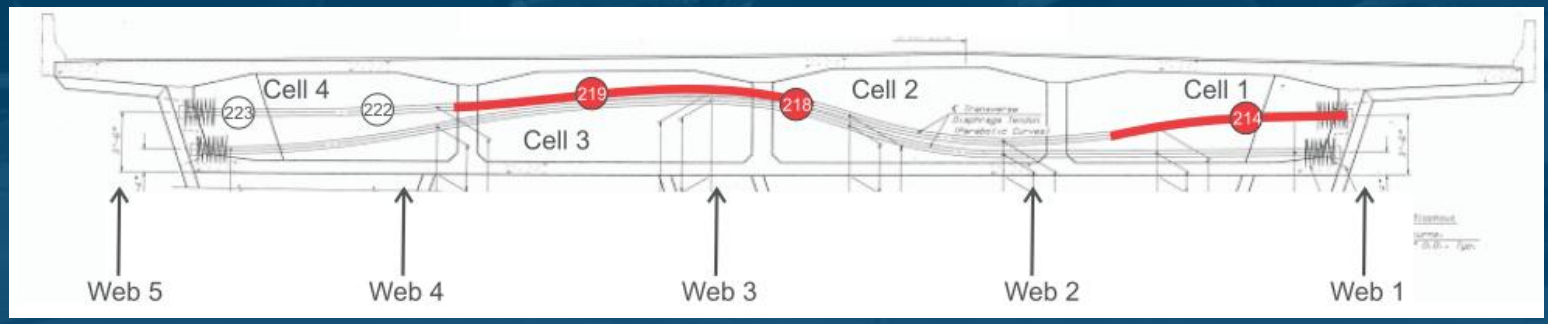
Inspection Findings

Web Post-tensioned Ducts



Diaphragm Post-tensioned Ducts



Inspection Findings

Temporary Repair of Grout Voids

Inspection Findings

Hinge Inspection

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Hinge

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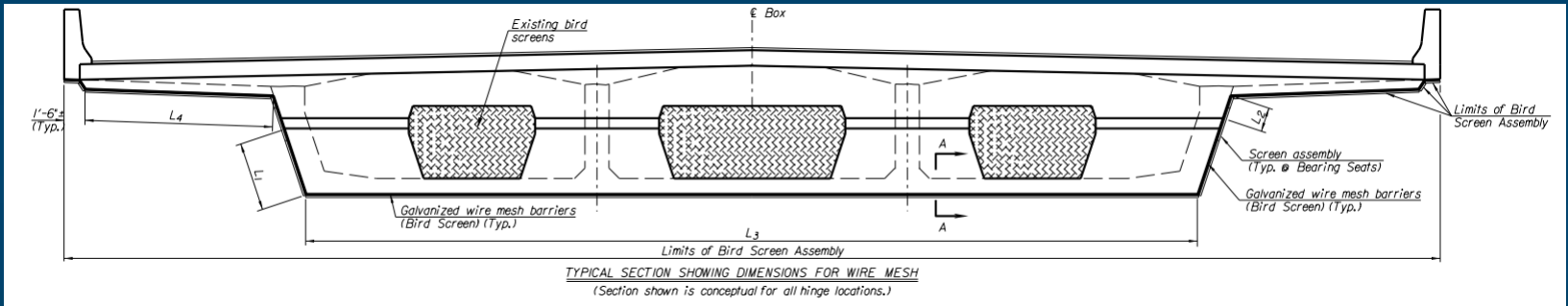
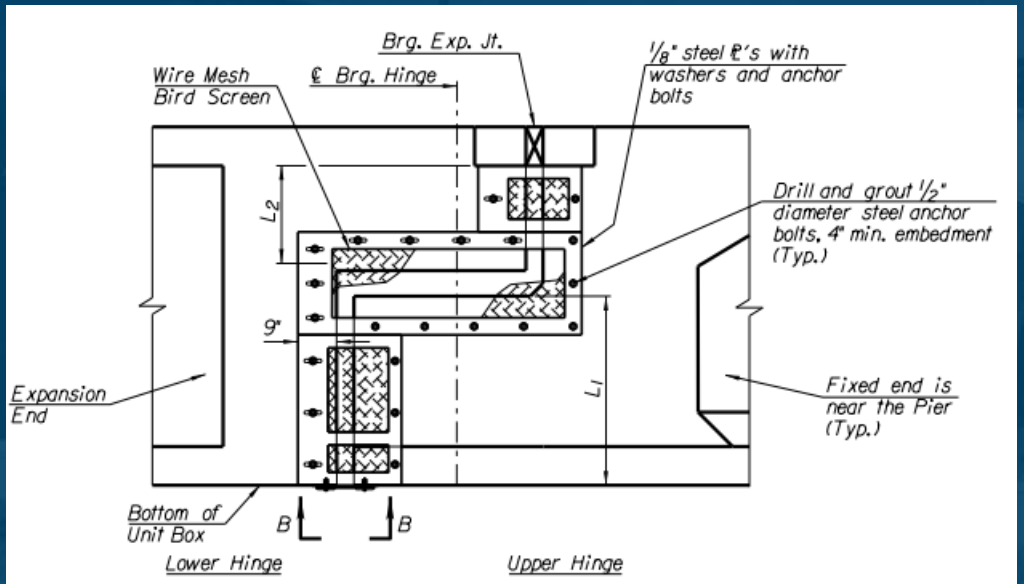
Bridge Interior

Repair Plans



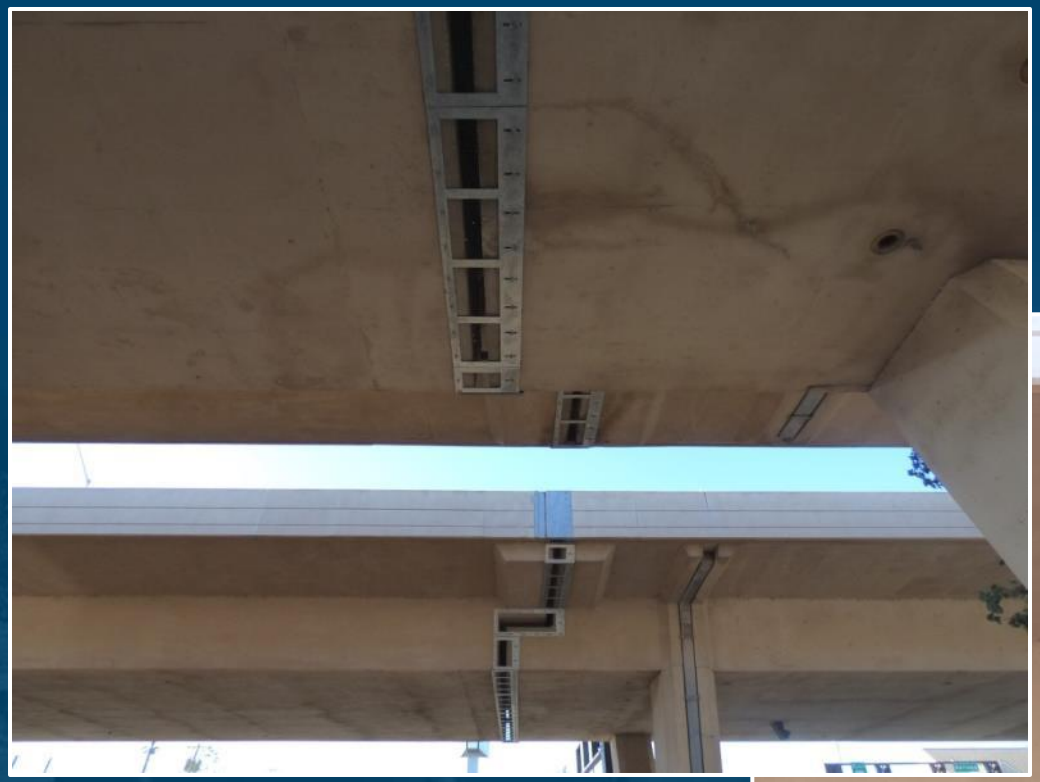
TYPICAL SECTION SHOWING DIMENSIONS FOR WIRE MESH
(Section shown is conceptual for all hinge locations.)



ELEVATION OF HINGE FOR BIRD SCREEN REPAIRS

Adjust spacing of anchor bolts as needed to avoid conflict with existing reinforcement. Contractor shall check for conflicts in the field prior to fabrication.

Bird Screens



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Bridge Interior

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Concrete Cracks

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Concrete Crack Repair

EPOXY RESIN CRACK REPAIR: Pressure inject epoxy grout into the cracks on the Blisters and Webs in accordance with the manufacturer's specifications and as directed by the Engineer. Repair the cracks that are 0.02" wide or larger. Work shall be performed by individuals qualified to work with this form of rehabilitation. Pay limits for this bid item are estimated crack lengths. Perform work and supply materials and equipment in accordance with KDOT specifications (Section 730). All work and materials required shall be included in the bid item "Bridge Repair", Lump Sum.

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Blister / Tendon Anchorages

Repair Plans

NO POUR-BACK
(Type 1)
(Anchor Only)

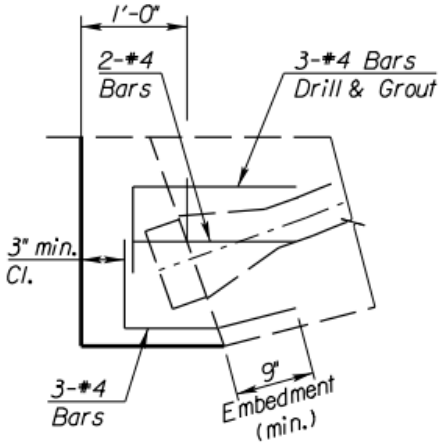
PARTIAL POUR-BACK
(Type 2)

FULL POUR-BACK
(Type 3)

EXISTING POUR-BACK CLASSIFICATION

EASTBOUND TABLE OF BLISTER POUR-BACKS				
UNIT NO.	SPAN NO.	STR.	NUM. OF BLISTERS	TYPE OF ANCHOR
1	1	EB	12	Partial
1	2	EB	24	Partial
1	3	EB	18	Partial
2	4	EB	8	Full
2	5	EB	16	Partial
3	6	EB	12	Anchor Only
3	7	EB	24	Anchor Only
3	8	EB	16	Anchor Only
4	9	EB	12	Anchor Only
4	10	EB	20	Anchor Only
4	11	EB	8	Anchor Only
5	12	EB	No Blisters	-
5	13	EB	4	Partial
5	14	EB	4	Partial
6	15	EB	No Blisters	-
6	16	EB	4	Full
6	17	EB	4	Full & Partial
7	18	EB	No Blisters	-
7	19	EB	4	Partial
7	20	EB	4	Partial
7	21	EB	No Blisters	-

WESTBOUND TABLE OF BLISTER POUR-BACKS				
UNIT NO.	SPAN NO.	STR.	NUM. OF BLISTERS	TYPE OF ANCHOR
1	1	WB	12	Anchor Only
1	2	WB	24	Anchor Only
1	3	WB	18	Anchor & Partial
2	4	WB	8	Anchor Only
2	5	WB	16	Anchor Only
2	6	WB	16	Anchor Only
3	7	WB	12	Anchor Only
3	8	WB	16	Partial
4	9	WB	12	Anchor Only
4	10	WB	20	Partial
4	11	WB	8	Partial
5	12	WB	No Blisters	-
5	13	WB	4	Partial
5	14	WB	4	Partial
6	15	WB	No Blisters	-
6	16	WB	4	Partial
6	17	WB	4	Partial
7	18	WB	No Blisters	-
7	19	WB	4	Anchor Only
7	20	WB	4	Anchor Only
7	21	WB	No Blisters	-



POUR-BACK REPAIR DETAIL

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Blister Repair

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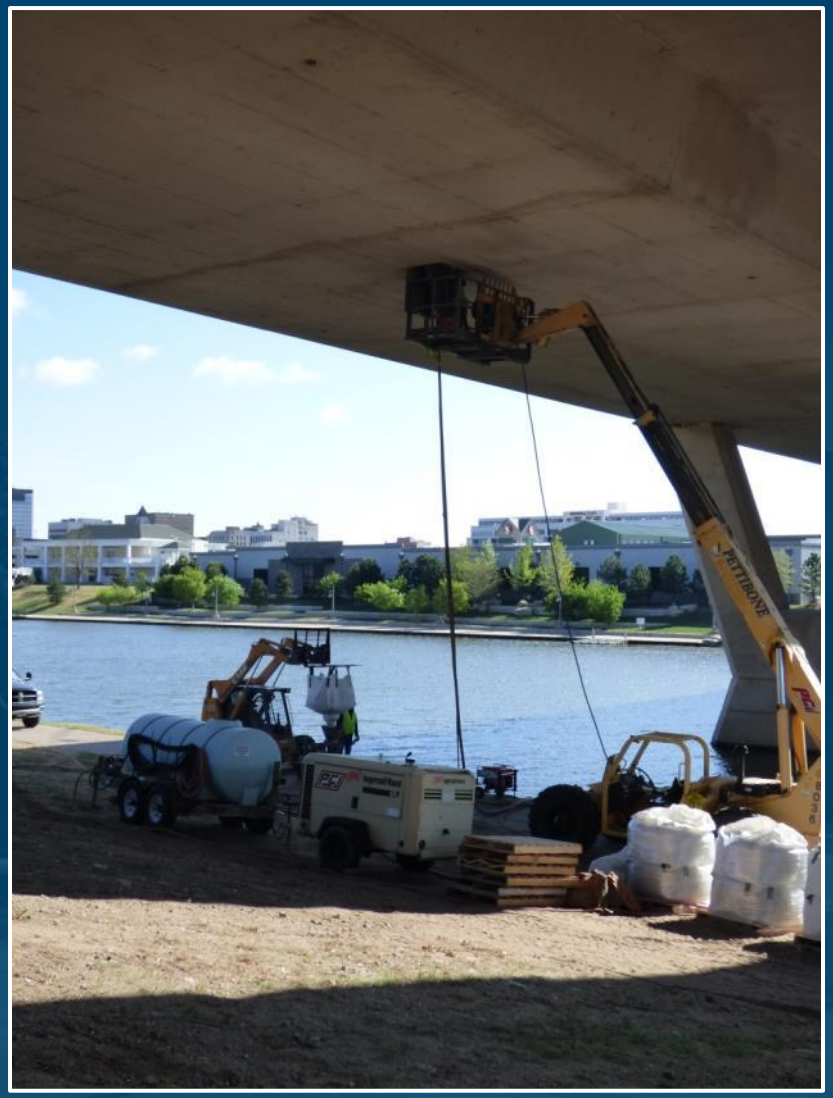
Blister Repair



Blister Repair

Blister Repair

Outline

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- **Conclusions**

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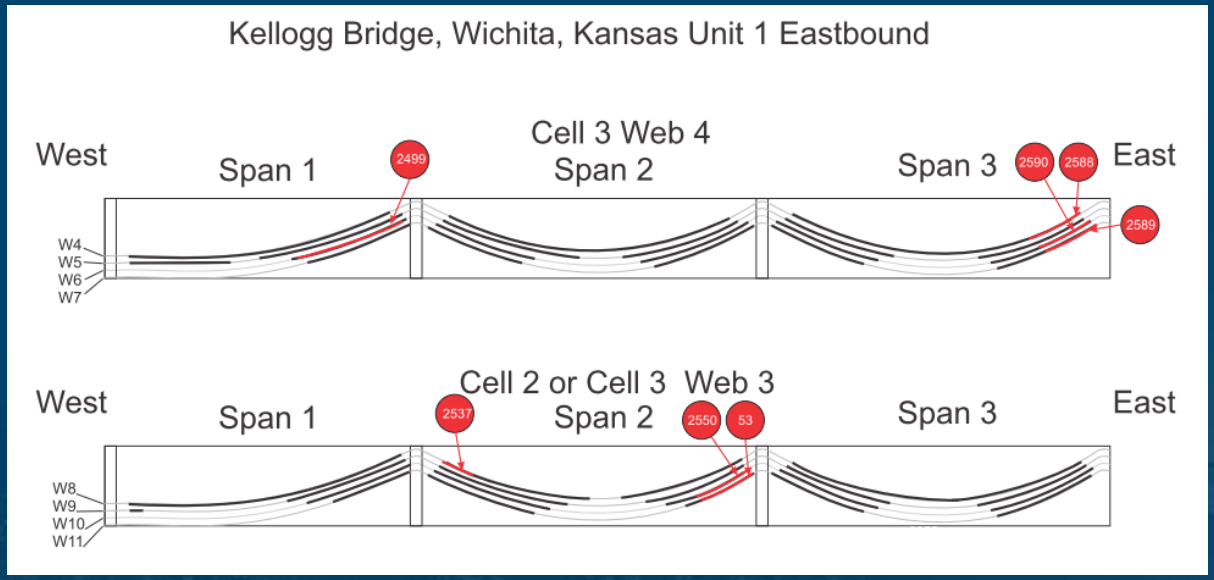
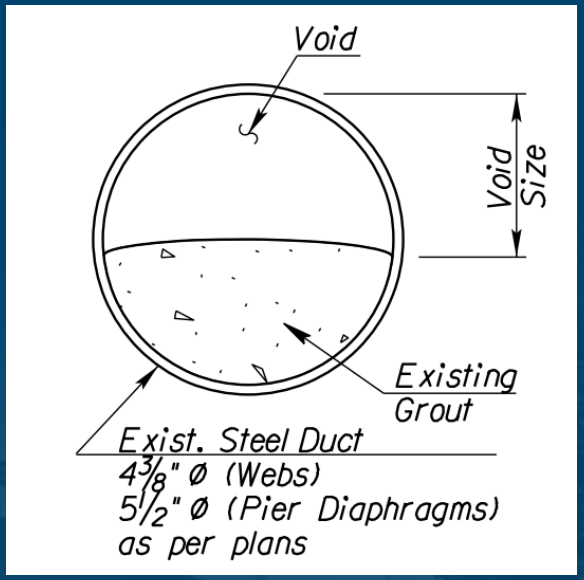
Grouting Operations





Open/Drill Holes/Install Valves

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Grouting Operations

Grout Mixing/Testing/Transport

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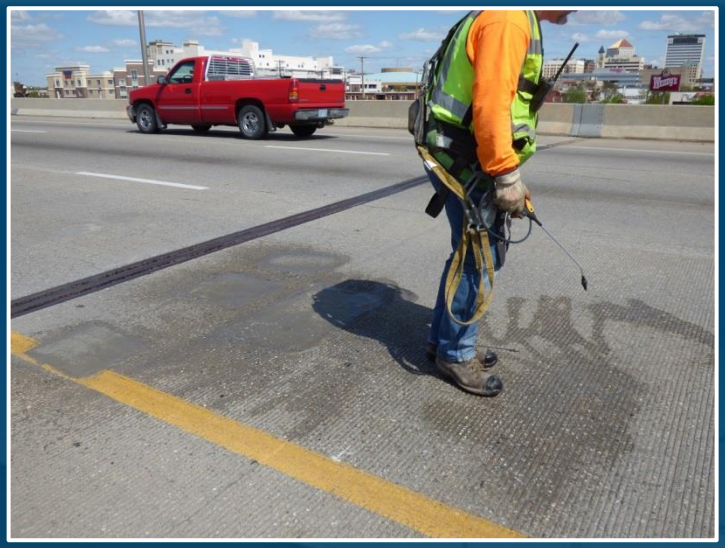
Grouting Operations



Span 16WB – Tendon with Water

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Grouting Operations

Span 16WB – Tendon with Water

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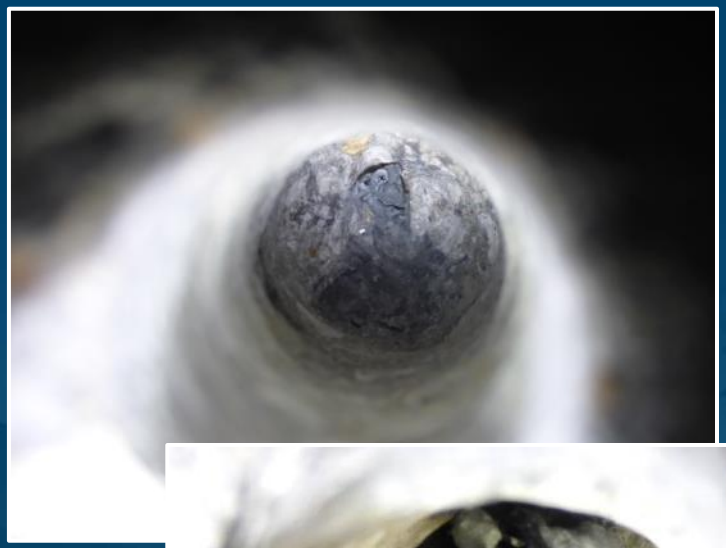
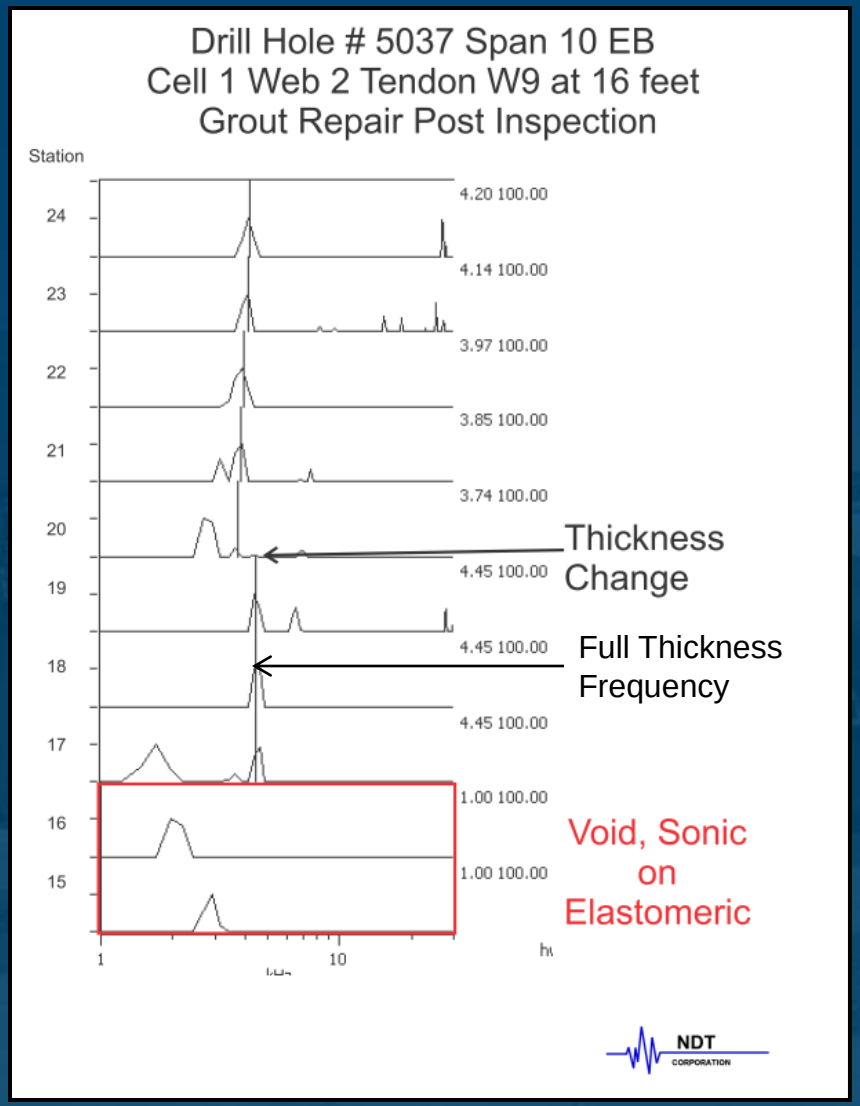
NDT Verification



Sonic UltraSonic/Drill Holes

NDT Verification



Void Found

NDT Verification

Void Found

NDT Verification

Void Found

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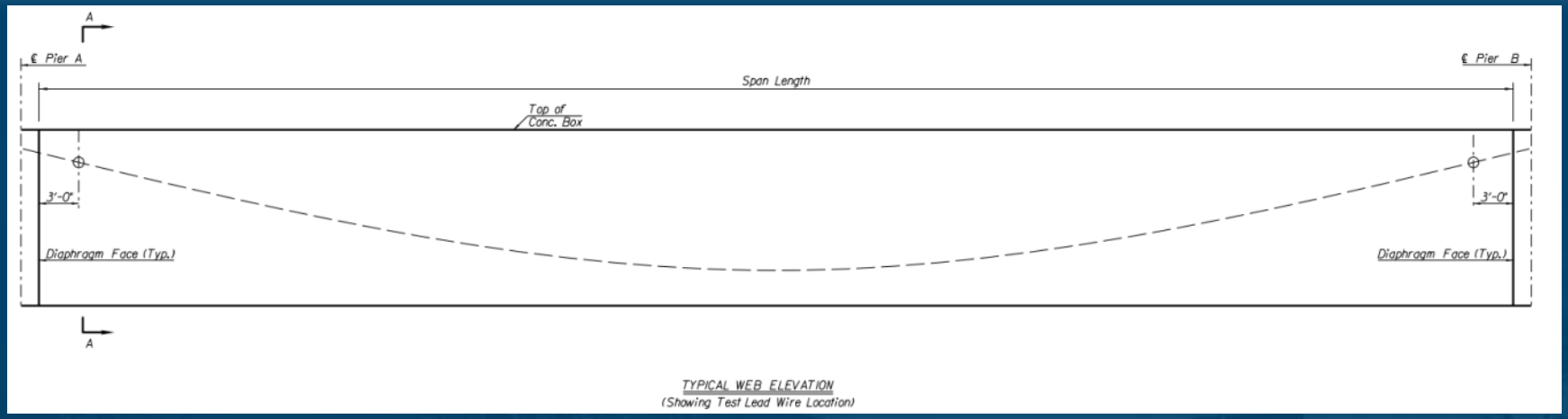
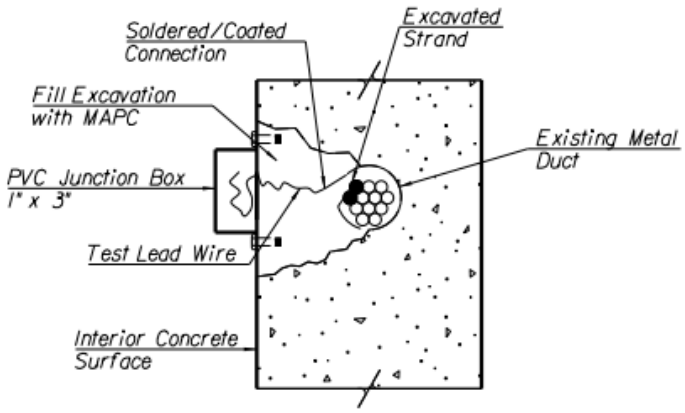
Repair Plans



TYPICAL WEB ELEVATION
(Showing Test Lead Wire Location)



SECTION A-A
(Test Lead Wire for corrosion monitoring)

✳ The listed tendons contain Soft Grout and will be monitored for potential corrosion as shown on this sheet See elevation view for location of test lead wires.

Testing per ASTM C876

✳ TEST LEAD WIRE LOCATIONS

UNIT NO.	SPAN NO.	DIR.	CELL NO.	WEB NO.	TEND. NO.	QUANTITY EACH
3	6	EB	2	2	W8	2
3	8	EB	2	2	W8	2
4	11	EB	2	2	W9	2
5	14	EB	2	3	W6	2
W-CBD	3	-	-	2	W1	2
W-CBD	3	-	-	2	W3	2
W-CBD	4	-	-	2	W1	2
W-CBD	4	-	-	2	W3	2

WATER FILLED TENDON

UNIT NO.	SPAN NO.	DIR.	CELL NO.	WEB NO.	TEND. NO.	DEFICIENCY
6	16	WB	1	1	W5	Water

This Tendon shall be drained and re-grouted as per project plan notes.

Test Lead Wires

Test Lead Wires

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Half-Cell Potential Readings

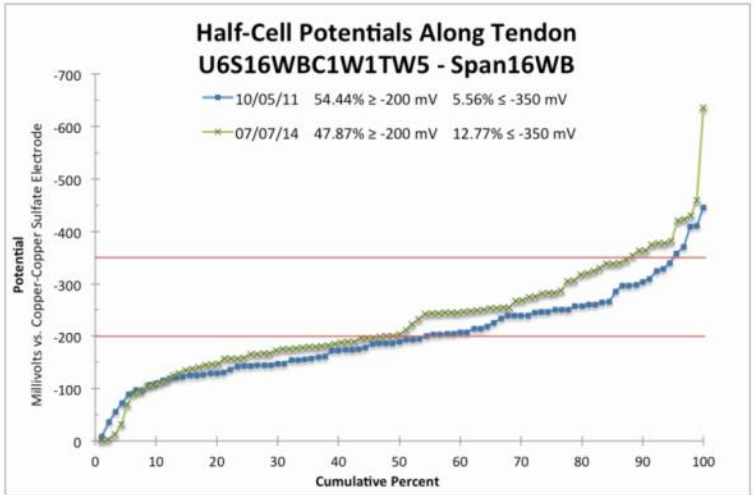

Figure 1 (Void with water 2011)

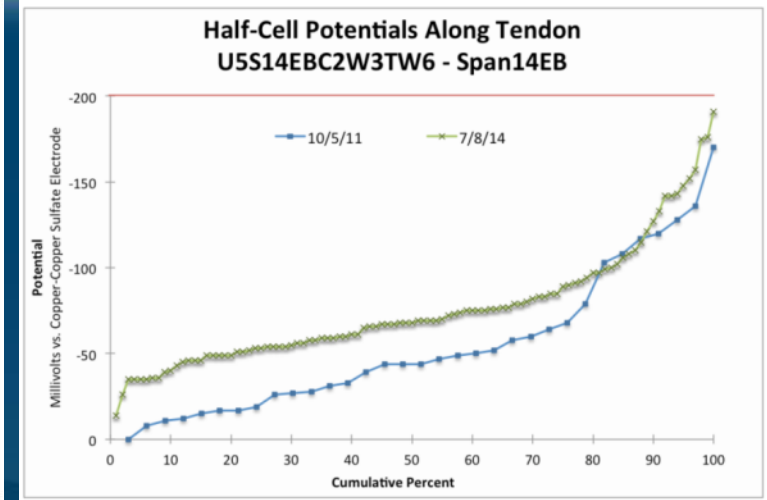

Figure 2 (Voids with soft/wet grout in 2010 but dry at STA 110 in 2011)

- More positive than -200 mV: 90% probability of no corrosion
- Range of -200 and -350 mV: Corrosion is uncertain
- More negative than -350 mV: 90% probability of corrosion

(Note: Potentials versus copper copper-sulfate electrode)

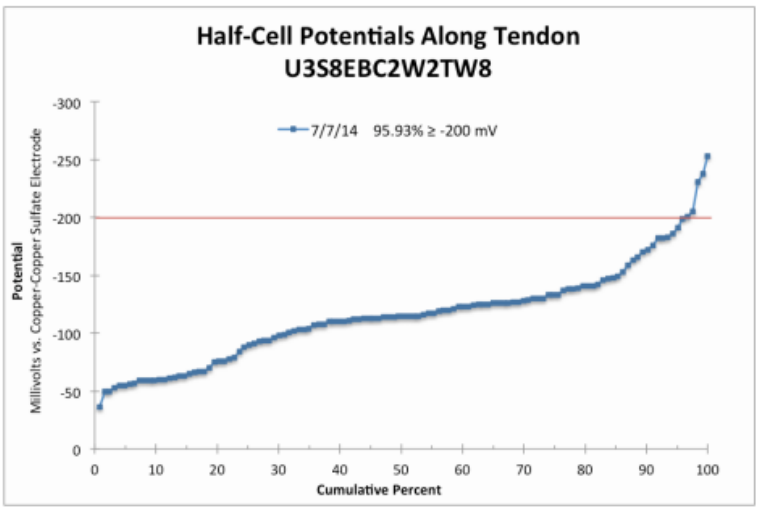

Figure 4 (Void with soft/wet grout and/or accumulated water 2011)

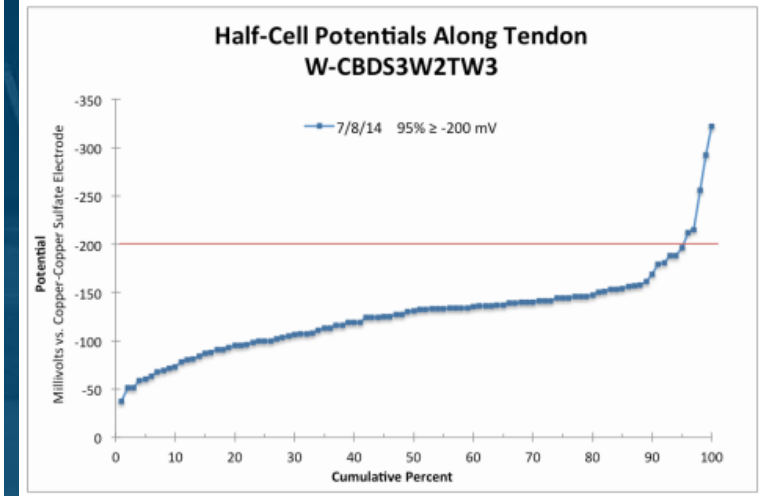

Figure 7 (Void with soft/wet grout and/or accumulated water 2011)

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Summary

- **14 Bird Screens**
- **1,236 Linear Feet of Crack Repair (>0.020” wide)**
- **268 Blister Pour-Backs Replaced**
- **380 Blister Pour-Backs Coated (all in bridge)**
- **147 Voids Filled (with 142 ft^3 grout, approx. 290 bags)**
  - 15% vacuum grouted
  - 1% vacuum assist
  - 84% pressure grouted
- **119 Tendons Tested by NDT for Verification**
  - 119 tendons tested by sonic/ultrasonic (80% of filled voids)
  - 64 tendons verified by drilled holes (43% of filled voids)
  - 1 voided tendon found, re-grouted on 8/20/2014
- **18 Test Lead Wires (on 9 tendons)**

Conclusions

SUCCESS !



Recognition

- Ken Hurst & Loren Risch – KDOT State Bridge Engineer
- Mark Hurt – KDOT Sr. Squad Leader
- Calvin Reed – KDOT State Bridge Engineer (current)
- Annette Ratcliff – KDOT Inspector
- Hideki Fields – KDOT Construction Engineer
- Pci Roads – Contractor
- VSL – Subcontractor
- NDT Corporation – Field Investigation
- Rodney Powers & Associates – Field Investigation
- Wildcat Construction – Field Investigation
- University of Kansas – Dr. David Darwin
- PB Staff
  - Teddy Theryo – Technical Director
  - Rick Earley – ASBI Certified

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Questions?