Diagnosing Deficiencies in Post Tensioned Bridges

OTEC CONFERENCE 2018

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Engineers ■ Architects ■ Planners

Ideas in motion.

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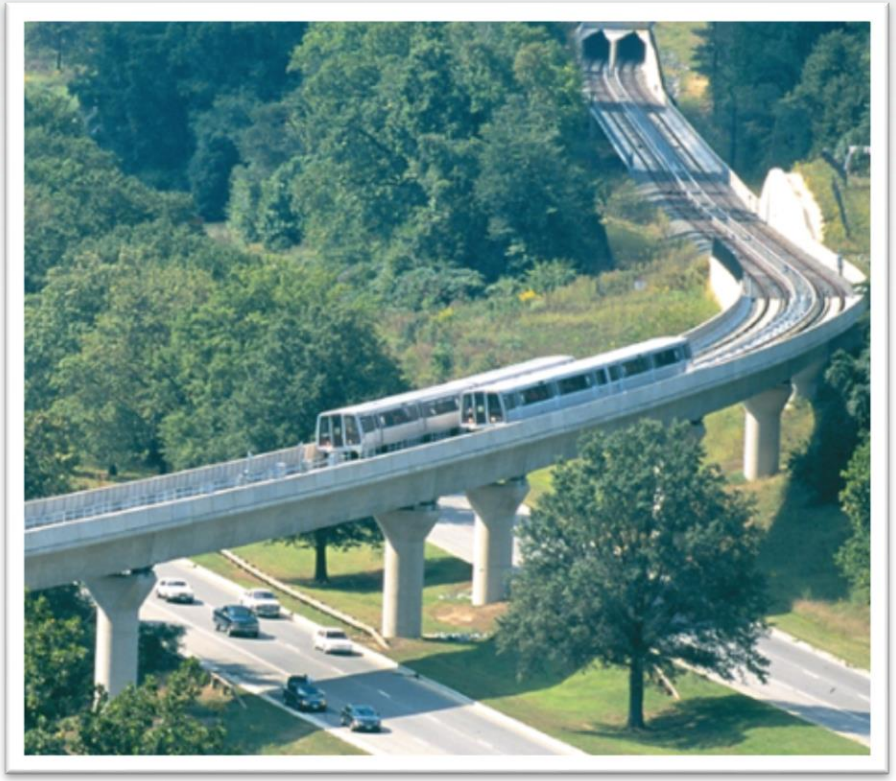
Team Work Experience

- **50+ PT bridges**
  - Segmental box girders
  - Cast in place box girders
  - Straddle bents
  - Pier caps
  - Cable stay
- **Worked together as a team for the past 13 years**



structural TECHNOLOGIES
A Structural Group Company

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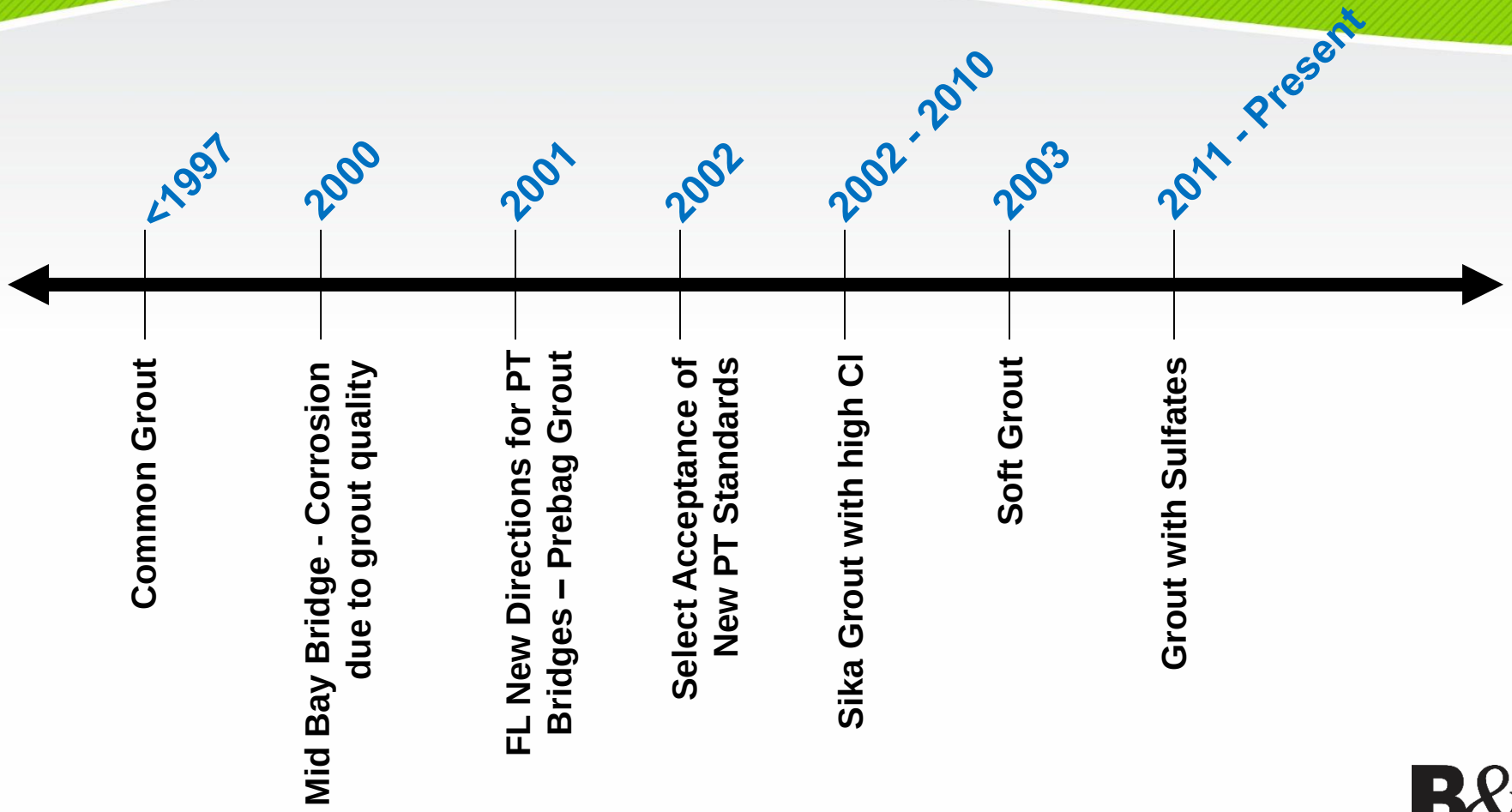
Timeline of PT Issues



Scope of Services

- Phase 1
  - Visual inspection, 10 post-tensioned system (PTS) bridges utilizing “New Directions for Florida PT Bridges, Volume 9”
  - Contract documents review
  - Select bridges whose PTS were at a high risk of deficiencies
- Phase 2
  - Determine type of NDT and/or IT of tendons and locations
  - Perform NDT and IT of tendons using a statistical approach
- Phase 3
  - Generation of Rehabilitation Documents

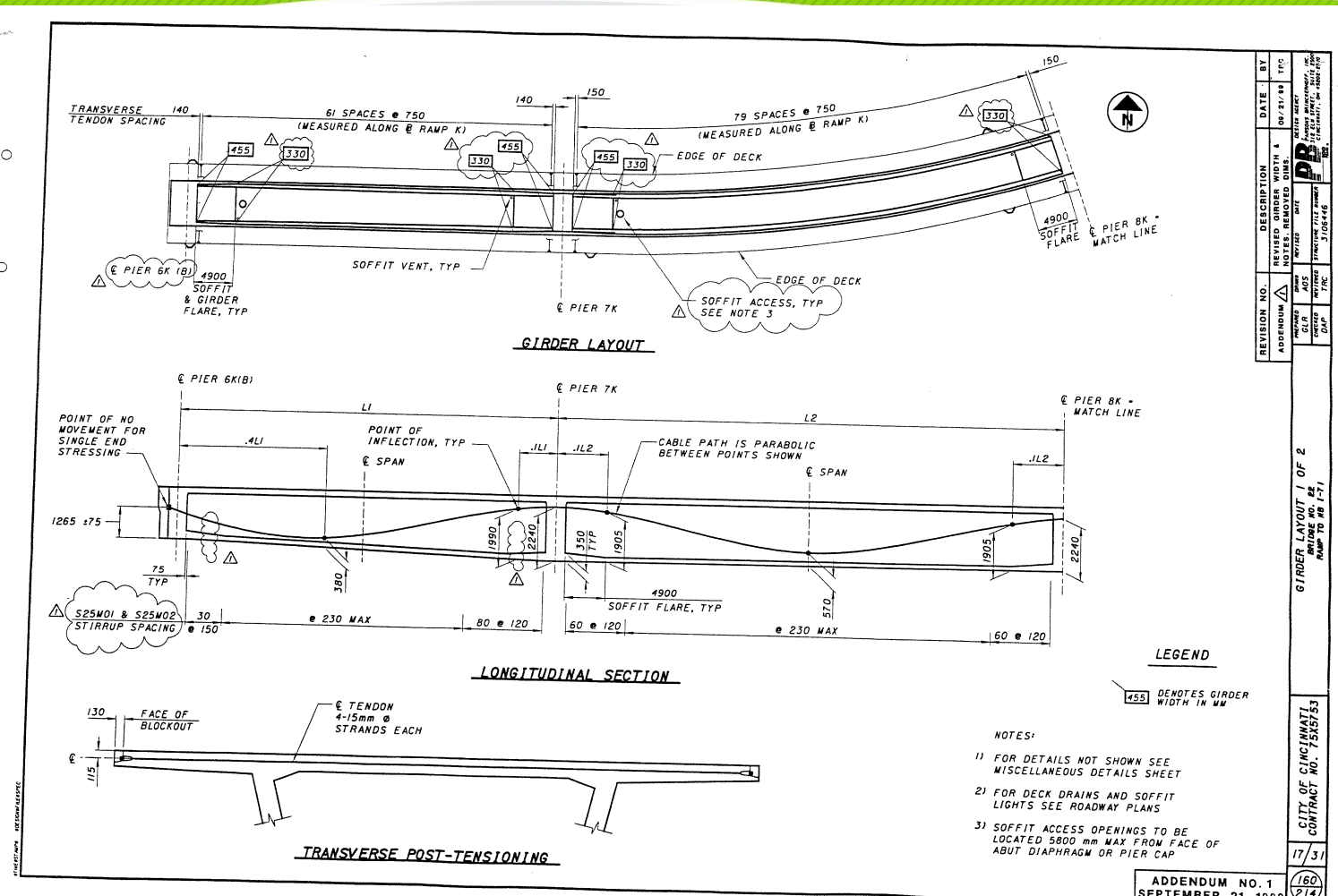
Three Bridges were Selected for NDT and IT

HAM-71-0111L over 3rd St & Broadway PTS Pier Cap 2

HAM-50-2138R over Broadway 5 Span

HAM-71-0110 I-71 over Broadway 3 Span

Elevation View of Spans 1 and 2 of 5 Span PTS Bridge

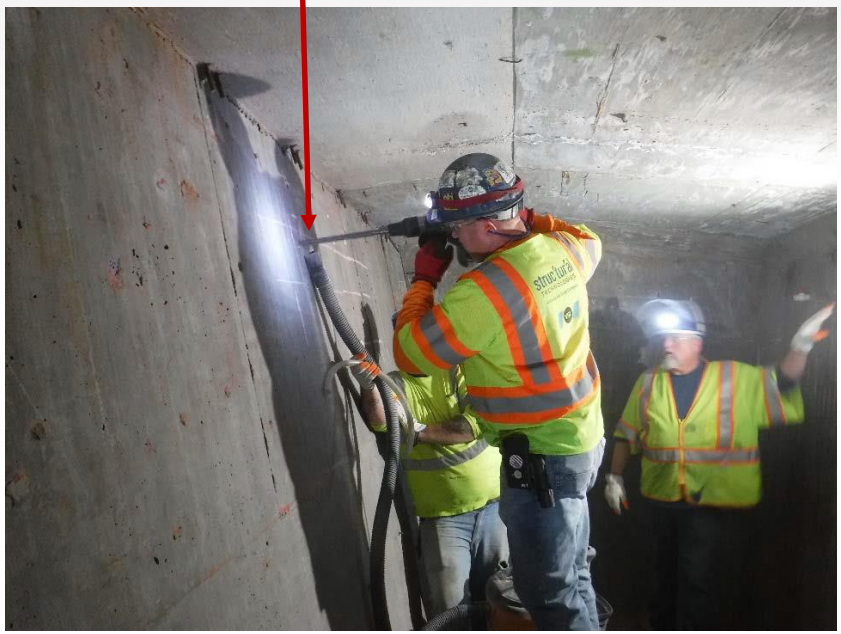


GPR Layout and Borescope Testing

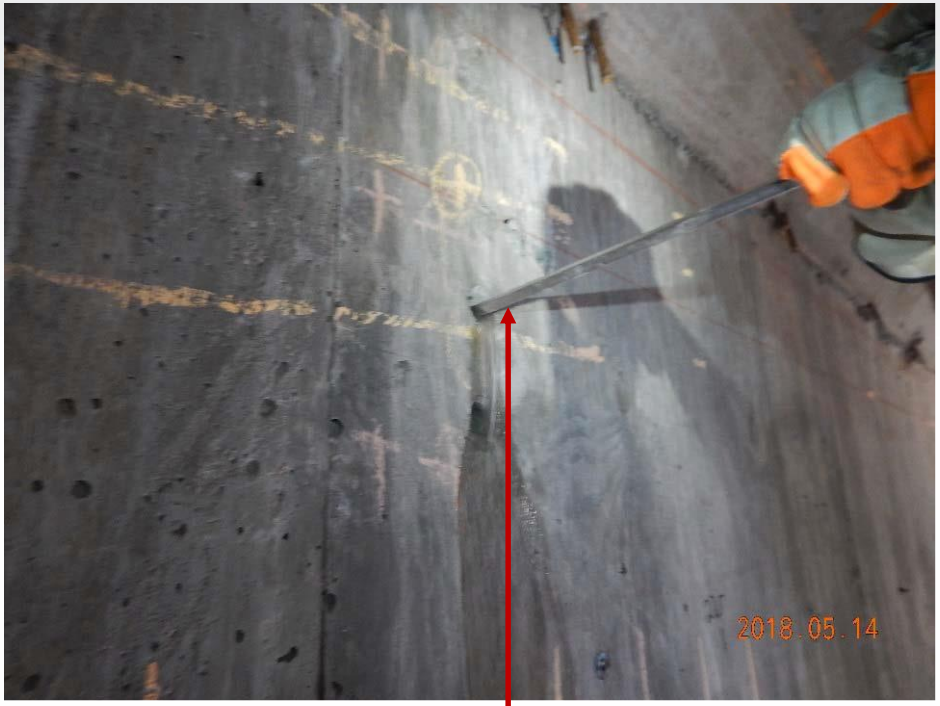
GPR located reinforcement steel

GPR located tendon duct

Drilling borescope test location



Borescope Testing Procedures



Driving screwdriver into top of duct

Inserting borescope camera line into test location

Borescope Test Locations

Looking into borescope test location at duct full of grout.

Looking into borescope test location, void at top of duct

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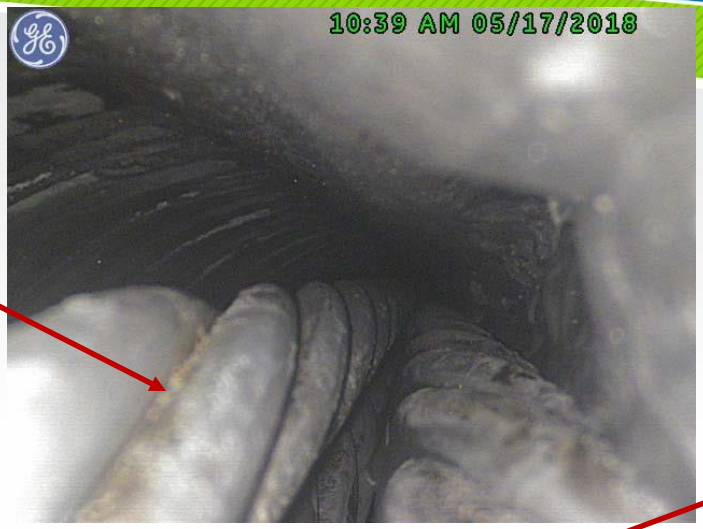
PTS Interiors of Duct Voids-3 Span



Light corrosion

Note grout at top of duct

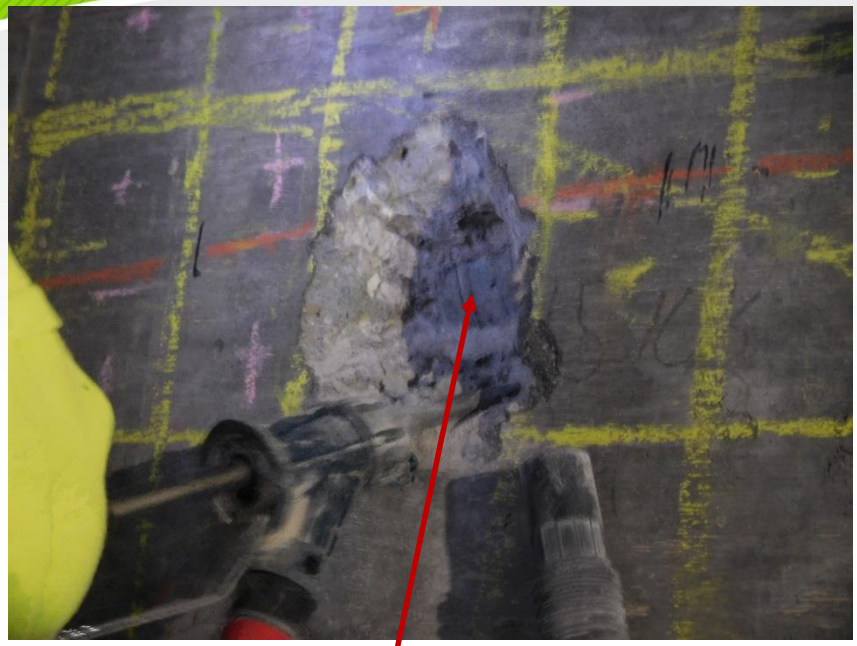
Repair of Borescope Test Locations

Repairing borescope test location where duct is full of grout

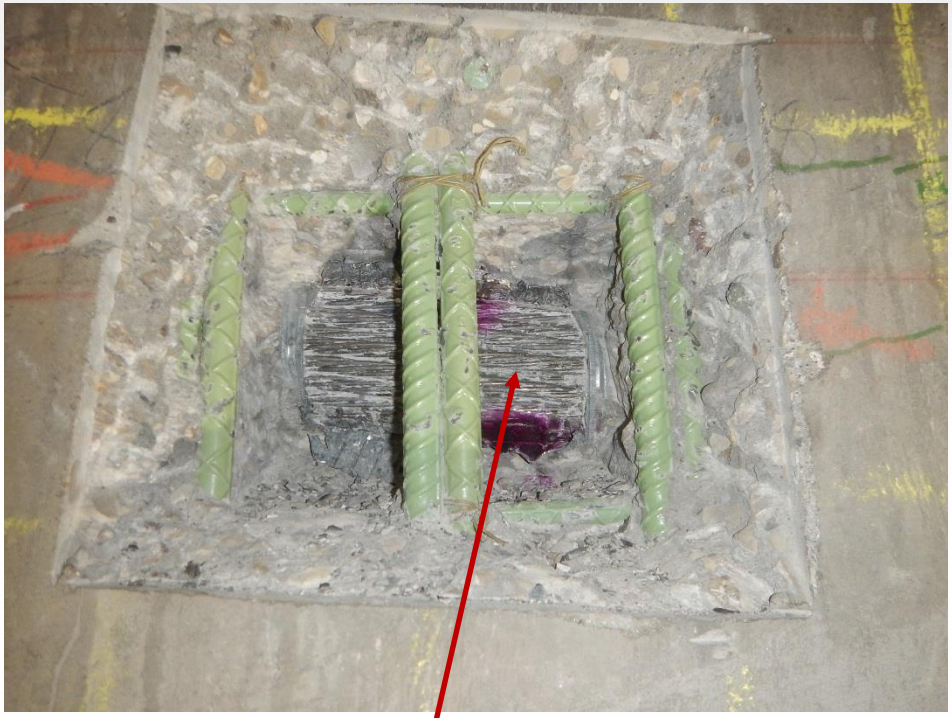
1/2 inch PVC pipe and valve for void locations

Borescope test location repaired

Corrosion Rate and Grout Sampling

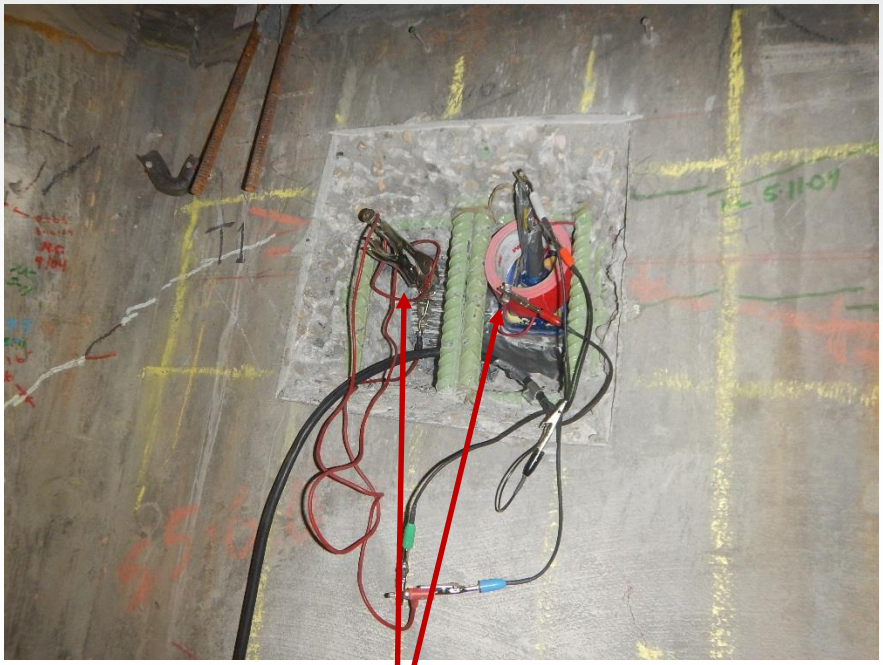


Chipping concrete to access tendon duct in web wall



Exposed tendon strand bundle for corrosion rate testing and grout sampling

Corrosion Rate and Grout Sampling



Typical corrosion rate set up, connecting directly to the tendon bundle

Typical grout sampling from the exposed tendon duct. Note void at top of duct

Repair of Corrosion Rate Test Locations

Repair of corrosion rate test location. Duct has been epoxied back into original location

Finished repair of corrosion rate test location

Form in place for corrosion rate test location repair pour back

PTS Interiors of Duct Voids-5 Span

Void at highpoint with exposed tendon strands

Void at highpoint with moisture corroding the duct interior

PTS Interiors of Duct Voids-5 Span

Light corrosion of strand wire at void, indicates moisture in void

Maximum height level during pumping operation

Current grout level

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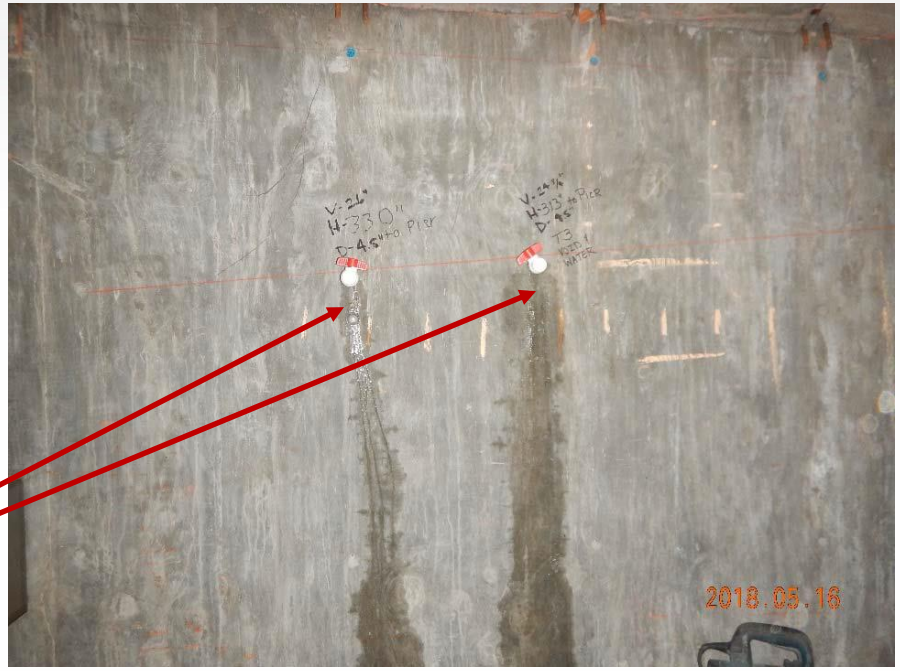
Water Draining from Void at Borescope Test Location



Water draining from 3 separate locations along Tendon 3

Water Draining from Void at Borescope Test Location

Summary of Conditions and Testing of 3 Span PTS Bridge

- Initial cracks/lower strength concrete
- Chloride content 0.013%, sulfate content less than 3%.
- Grout high pH, moisture below 25%, low grout corrosion rates.
- 20 of 36 (56%) locations had voids. Void depths ranged from 0.25” to 2.0”.
- Voids; Strands above grout/light corrosion steel strands-duct interiors/moisture entering voids.
- Highpoint voids are only a few inches below the top of deck
- Advantageous conditions of bridge
  - Structure is 18 years old/ corrosion has just initiated**.**
  - Existing grout is of good quality, should protect the embedded steel strands.

Summary of Conditions and Testing of 5 Span PTS Bridge

- Five span bridge summary is similar to the 3 span bridge except for the following:
  - 16/78 (20%) locations had voids. Void depths ranged from 0.125 inches to 4.0 inches.
  - One void had 5 gallons of water. Concrete cracks/additional moisture?

Recommendations are Similar for the 3 Span and 5 Span Structures

- Concrete bridges crack with age/to prevent corrosion of the PTS we recommend:
  - Most water comes from the deck, interval application of flood coat will help.
  - Remedial grouting of voids per current ASBI and PTI specifications.
  - No further borescope testing required if remedial grouting is performed.
  - Perform corrosion rate analysis and grout analysis every 10 years to check for carbonation reaction.
  - Web shear cracks should be monitored for growth.
  - Perform baseline survey to check for future sags and deflections of the box girders.

HAM-71-0111L over 3rd St & Broadway PTS Pier Cap 2

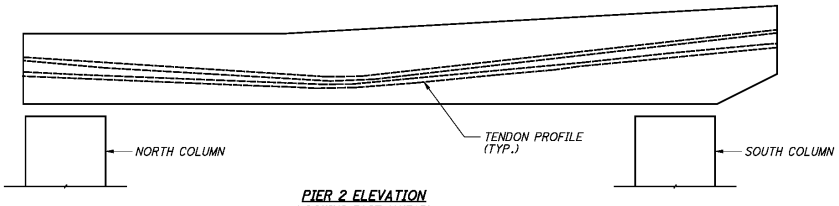
East side, north half, note cracks up to 0.036 inches wide

West side, north half, note cracks

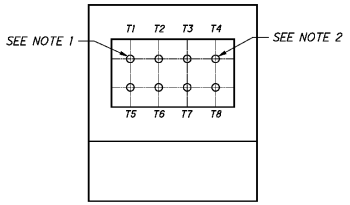
Blockout at south end of PTS Pier Cap 2. Note rough patch and shrinkage cracks

HAM-71-0111L over 3rd St & Broadway PTS Pier Cap 2-Elevation View

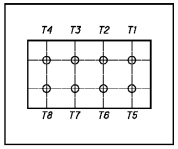
Pier Cap 2 Detail Drawing



PIER 2 ELEVATION
LOOKING EAST (AHEAD)



SOUTH END OF CAP



NORTH END OF CAP

NOTES:

1. 1/4" VOID WITH EXPOSED AND MODERATLY CORRODED STRAND WEDGES AND TAILS. TOP 1/3 OF ANCHOR HEAD HAS SOFT GROUT. GROUT VENT PIPE IS EMPTY.
2. 1/8" VOID THROUGH GROUT PORT. UNABLE TO REACH TENDON DUCT. ANCHOR PLATE EXHIBITS MOISTURE AND CORROSION.

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Engineers ■ Architects ■ Planners

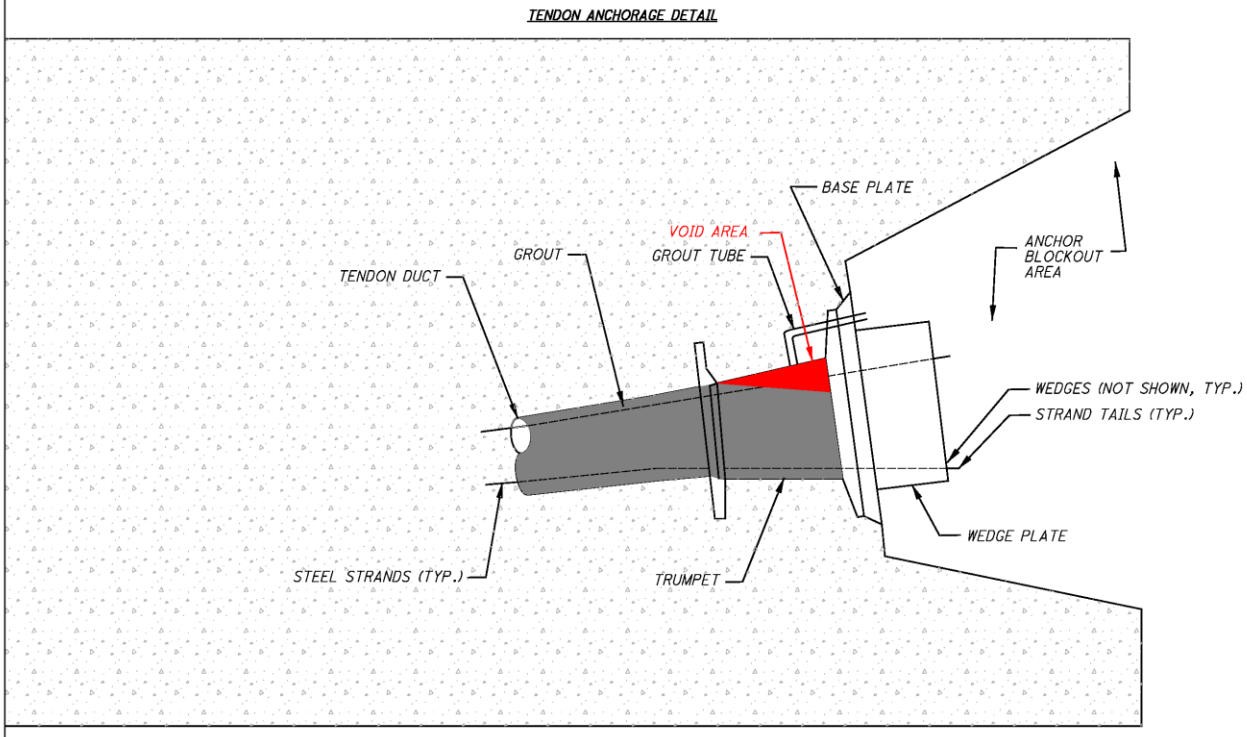
DESIGNED DEM
DRAWN MJK/AAA
CHECKED EMC
REVISED

HAM-71-0111L
PIER 2

01/02

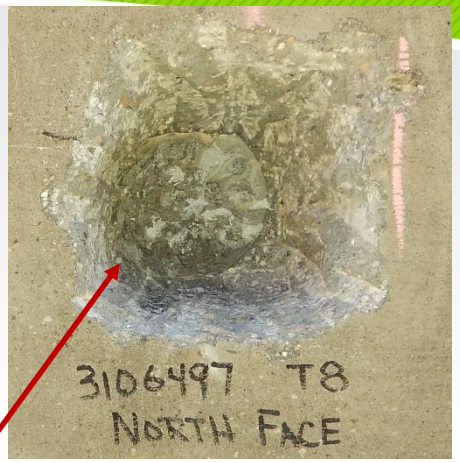
HAM-71-0111L over 3rd St & Broadway PTS Pier Cap 2-Elevation View-Typical Elevation View of Blockout and Anchor Assembly

Pier Cap 2 Detail Drawing



North End-Tendon 8 Anchor Head Assembly Exposed

Blockout at north end of pier cap



Completely exposed Tendon 8 exterior anchor assembly

Chipping operation exposing Tendon 8 anchor assembly

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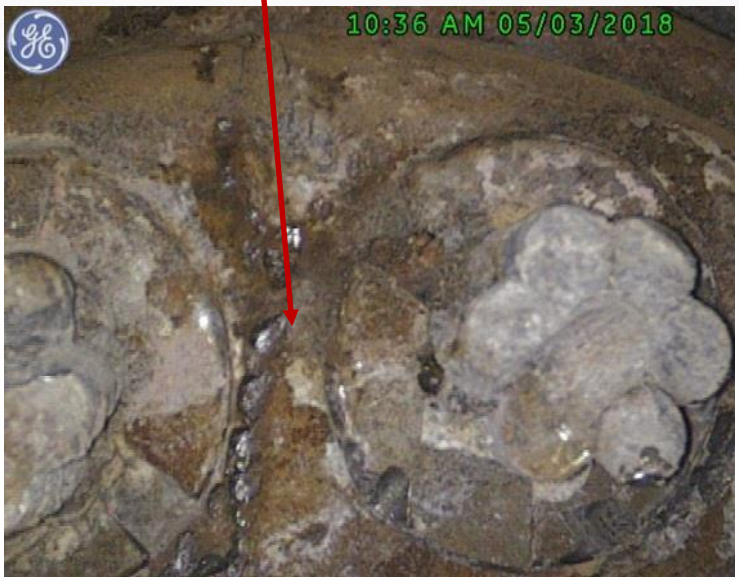
South End-Tendon 1 Anchor Head Assembly Exposed

Exposed anchor assembly, empty grout vent and moisture

Chipping operation to the anchor assembly, note moisture

Exposed anchor assembly, note corrosion



South End-Tendon 4 Anchor Head Assembly Exposed

Note moisture at interior of blockout

Note corrosion of anchor assembly, empty grout tube and moisture

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South End-Tendon 1 Anchor Head Assembly Empty Grout Vent

Entrance to empty grout vent and corrosion at vent interior

1/4 inch void between trumpet and grout vent

South End-Tendon 4 Anchor Head Assembly Empty Grout Vent

Entrance to empty grout vent and corrosion at vent interior

1/8 inch void between trumpet and grout vent

Summary of Conditions and Testing of PTS Pier Cap 2

- Regular concrete was used in block outs creating shrinkage cracks/water enters the anchor assemblies
- 2 of 4 anchor assemblies exhibited moderate to heavy corrosion.
- 2 of 4 grout vents were empty/vents exhibited heavy corrosion/voids in the trumpet areas.
- Moisture may be accessing into the anchor trumpet and tendon strands.
- 4 of 16 locations were tested/failure rate of 50%. 8 locations potentially at risk of corrosion.
- Pier Cap 3 and Pier Cap 4 of HAM-50-2142R/may have corrosive conditions.
- Cracks at the north end of P2 have not grown since being created around construction.
- Grout quality was good/similar to 3 span and 5 span bridges

Recommendations for PTS Pier Caps 2 & 3 of HAM-71-0111L and PTS Pier Cap 4 of HAM-50-2142R

- Pier Caps 2,3 and 4/replace concrete block outs with non-shrink and urethane clearcoat.
- The heads of the anchor assemblies should be cleaned of all corrosion
- All voids in the anchor trumpets and grout vents should be filled with an approved pre-packaged grout
- All anchor head assemblies should have an approved plastic cap installed over them and vacuum grouted with an approved pre-packaged grout
- ASBI and PTI guidelines should be the controlling specifications for all PTS rehabilitation
- The cracks at the north end of PTS Pier Cap 2 should be cleaned and epoxy injected to protect the PTS

Recent Past and Future Construction of PTS Bridges

- Most of the PTS bridges built before 2003, inspected and tested by our team have been well constructed but were lacking in the quality of grouting of the tendon ducts. This is important since the grout surrounding the steel tendons is usually it's last line of defense against moisture and contaminates.
- Since 2003 ASBI, PTI and other stakeholders have made vast improvements in the requirements of grouting materials and grout installation procedures.
- Moving forward from 2003, any PTS bridge built with these requirements should perform satisfactory with minimal maintenance for decades.

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Questions ?

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Thank you!

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