Multiyear Restoration & Protection of 1969 CIP Post-Tensioned Parking Garage

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AGENDA

- Company Profile
  - THA Consulting, Inc.
  - Vector Corrosion Technologies, Inc.

- Garage History
- 2018 Critical Repair Program
- Multi-Year Restoration Program (2019 - 2024)

- Review Previously Installed Cathodic Protection System
- Discuss steps taken to determine performance for current CP System
- Review solutions for new CP system
- Installation of New Cathodic Protection System
DESIGN, ENGINEERING & MOBILITY CONSULTING FIRM

- Since 1994 - Parking Consultants & Specialists
- Multi-Disciplined Expertise
  - Planning, Design, Operations, & Restoration of Parking Structures
- 1,000 Parking Projects & 500,000 Parking Spaces
- Parking Study & Master Planning
  - Complex Parking Issues
  - Practical Solution strategies
  - Hands on operating experience

ASSESSMENT MANAGEMENT
- Adaptive Re-use
- Condition Appraisal
- Restoration Engineering
- Life Cycle Cost Analysis
- Operational Consulting
- Owner Representation
- Graphics & Wayfinding
- Maintenance Program

ENGINEERING & ARCHITECTURE
- Parking Structure Design
- Mixed-Use Structure Design
- Project Design Management
- Functional Design
- Architectural Design
- Structural Engineering
- Design Build Services
- Sustainable Design
Vector Corrosion Technologies is the leading full-service supplier of technologies and restoration services for concrete and masonry corrosion.

- Experience: 1,000+ projects to control corrosion in structures around the world with innovative solutions.
- Many of these projects have been honored as award-winning projects by the International Concrete Repair Institute.

TECHNOLOGIES & RESTORATION SERVICES
Wilkes University Parking Garage
• Built ~ 1969
• CIP Post-Tensioned Beams and Slabs
• Beams Reinforced w/ Mild Reinforcing + Grouted Post-Tensioned Bars
• Slabs Reinforced w/ Unbonded Post-Tensioning Only; No Mild Reinforcing
• Cathodic Protection System – Zinc Arc Spray ~ 20 Years Old & Required Upgrades
• 7 Tier Garage
• Double Threaded Helix Functional Layout
• Student Parking + WU Police Department
Wilkes University Parking Garage

- 2018 Critical Repair Program
  - PT Induced Shear Failure – Top Tier Ramp Columns
Wilkes University Parking Garage

- 2018 Critical Repair Program
  - PT Induced Shear Failure – Top Tier Ramp Columns
Wilkes University Parking Garage

- 2018 Critical Repair Program
  - PT Induced Shear Failure – Top Tier Ramp Columns
2018 CRITICAL REPAIR PROGRAM

Wilkes University Parking Garage

- 2018 Critical Repair Program
  - PT Induced Shear Failure – Top Tier Ramp Columns
Wilkes University Parking Garage
- Multi-Year Restoration Program (5 Year)
  - Top-Down Approach
  - Critical Structural Repairs Addressed Early
  - Phase 1 (2019)
  - Phase 2 (2021)
  - Phase 3 (2022)
  - Phase 4 (2023)
  - Phase 5 (2024)
  - Goal to extend service life of garage to ~ 2040
Wilkes University Parking Garage

- Each Phase Includes
  - Structural Repairs
    - Concrete
    - Post-Tension
    - At floor / soffits / façade
  - Waterproofing
    - Sealants & Traffic Deck Membrane
  - Cathodic protection upgrades

MULTI-YEAR RESTORATION PROGRAM
MULTI-YEAR RESTORATION PROGRAM

Wilkes University Parking Garage

- Structural Repairs
  - PT Slab Failures at Façade
  - Primary Tendons
  - Broken Strand and/or Anchorage Zone Failure
Wilkes University Parking Garage

- Structural Repairs
  - PT Slab Failures at Façade
  - Primary Tendons
  - Broken Strand and/or Anchorage Zone Failure

MULTI-YEAR RESTORATION PROGRAM
Wilkes University Parking Garage

- Structural Repairs
  - PT Slab Failures at Facade
  - Primary Tendons
  - Broken Strand at Interior – Release of Energy Caused Exterior Spall
  - Not Anchorage Zone Failure
Wilkes University Parking Garage

- Structural Repairs
  - PT Slab Failures at Façade
  - Primary Tendons
  - Finished Condition After Repairs
MULTI-YEAR RESTORATION PROGRAM

Wilkes University Parking Garage

- Structural Repairs
  - PT Slab Failures at Interior Slab
  - Primary Tendons
MULTI-YEAR RESTORATION PROGRAM

Wilkes University Parking Garage
• Structural Repairs
  • PT Slab Failures at Interior Slab
  • Primary Tendons
Wilkes University Parking Garage

- Structural Repairs
  - PT Slab Failures at Interior Slab
  - Primary Tendons
Wilkes University Parking Garage

- Structural Repairs
  - PT Slab Failures at Interior Slab
  - Primary Tendons

MULTI-YEAR RESTORATION PROGRAM

July 2019
Wilkes University Garage
Existing PT Conditions at Construction Joint
Wilkes University Parking Garage

- Structural Repairs
  - PT Slab Failures at Interior Slab
  - Primary Tendons
MULTI-YEAR RESTORATION PROGRAM

Wilkes University Parking Garage

- Structural Repairs
  - PT Slab Failures at Interior Slab
  - Primary Tendons
MULTI-YEAR RESTORATION PROGRAM

Wilkes University Parking Garage

- Structural Repairs
  - PT Slab Failures at Interior Slab
  - Primary Tendons
Wilkes University Parking Garage

- Structural Repairs
  - PT Slab Failures at Interior Slab
  - Shrinkage & Temperature Tendons
MULTI-YEAR RESTORATION PROGRAM

Wilkes University Parking Garage

- Structural Repairs
  - PT Slab Failures at Interior Slab
  - Shrinkage & Temperature Tendons
**MULTI-YEAR RESTORATION PROGRAM**

Wilkes University Parking Garage

- Structural Repairs – PT Girder Repairs
Wilkes University Parking Garage

- Waterproofing
  - Sealants & Traffic
  - Deck Membrane

MULTI-YEAR RESTORATION PROGRAM
MULTI-YEAR RESTORATION PROGRAM

Wilkes University Parking Garage

- Waterproofing
  - Sealants & Traffic Deck Membrane
MULTI-YEAR RESTORATION PROGRAM

Wilkes University Parking Garage

- Waterproofing
  - Sealants & Traffic
  - Deck Membrane
Current Cathodic Protection System
Zinc Arc Spray (ZAS)

- Installed approximately 20 years ago
- CP system is comprised of Zinc Arc Spray (ZAS), which is a surface-applied galvanic CP system
- ZAS will sacrificially corrode to protect the embedded steel from corrosion activity
Spalling around CP System
White Zinc Oxide Film from corrosion of ZAS

Spalled Concrete in the Metalized
Area Showing Corroding Rebar

Corrosion of Post Tension System

VISUAL INSPECTION OF ZAS SYSTEM
INSPECTION OF ZINC ARC SPRAY (ZAS) - CONT....

- PVC boxes that are attached to the ZAS system
- These boxes are test stations which provide the ability to determine if the ZAS is working properly
INSPECTION OF ZINC ARC SPRAY (ZAS) - CONT....

- 20 boxes in total within the garage – 11 were found to be in working condition (failed Reference Electrode)
- NACE criteria of a minimum of 100 mV of cathodic polarization criterion was primarily used for evaluation of the effectiveness of the CP system
- Only 1 out of 11 test panels displayed a polarization shift of at least 100 mV over the 24-hour period
- ZAS is still providing some current, though not sufficient to provide adequate corrosion protection
Replace Current ZAS w/ new ZAS
Targeted Protection using Type 2 Embedded Anode

- Two Stage Anode
- Type 2A Galvanic
OPTION 1 – REPLACE ZINC ARC SYSTEM (ZAS)
• Clean surface with light abrasive blasting
• Achieve sufficient profile which maximizing the amount of cement paste in contact with the zinc coating
• Dry compressed air used to clean any residual dust and blast media
CONSIDERATIONS FOR THIS OPTION

- Have to Clean off existing ZAS system to apply to concrete surface
- Removing system that is still providing some protection
- Economical advantages occur when large areas can be completed at one time
  - Due to phasing of the project (1-2 levels per year) this option looses some its cost effectiveness
OPTION 2 – Targeted Protection using EMBEDDED TYPE 2 ANODES

PRODUCT RANGE

Embedded Type 2A Galvanic Anode

Alkali-activated Galvanic Anode

Self-powered ICCP System

Single wire installation

Self Powered Two Stage Anode

Fully Alkali-Activated
OPTION 1 – SELF POWERED TWO STAGE ANODE

**Stage 1: Electrochemical Treatment (50+ Days)**
- Passive Oxide Film

- Concrete repairs carried out as required
- High charge density delivered
- Alkalinity restored around steel
- Chlorides pushed away from steel surface
- Corrosion mitigated in pits
- Steel passivity is restored
- Stage 1 can be repeated

**Stage 2: Cathodic Prevention (30+ Years)**
- Alkali-activated Zinc Anode

- On-going protective current delivered to steel
- Steel passivity is maintained
- Chloride continues to be repelled
- Alkalinity continues to increase

Structure protected for up to 30+ YEARS

Single Wire Installation

Self-powered ICCP System
CONSIDERATIONS FOR THIS OPTION

Benefits of Two Stage Embedded Anode

- Self Powered ICCP Phase can provide cathodic protection to steel in Phase 1 w/ out the use of outside power
- Due to ICCP Phase, wider spacing compared to galvanic Type 2 Anodes (Less Anodes, install time etc.)
- Potentially provide longer service life if desired due to ICCP Phase protection steel up front – Galvanic Stage does not work nearly as hard

Consideration

- Not just protecting mild Steel
- Existing reinforcing attached to Post Tension system as well
- Risk of Hydrogen Embrittlement
SOLUTION 2 – EMBEDDED TYPE 2A GALVANIC ANODES

• Control on-going corrosion /prevent the initiation of new corrosion
• Type 2A Embedded anodes are alkali-activated and consist of a sacrificial zinc anode core
• Installed into concrete that is mechanically sound but has ongoing corrosion activity
• Once installed, the zinc anode corrodes preferentially to the surrounding steel
INSTALLATION OF TYPE 2 A EMBEDDED ANODE SYSTEM (ANODE LAYOUT MAP)

Descending Ramps

Ascending Ramps
• Example of Initial Layout of Anode Grid
• Does not include rebar or Post Tension Strands
• Use GPR verify locations, ensuring no rebar or PT is in the drill location
• These will be slightly different due to location of existing reinforcing steel and post tension system
• Holes being drilled for installation of Type 2A Embedded Anodes
• Saw cut made between each drilled hole to run header wire
• Connection to the steel made at each end – max of 8-10 anodes
INSTALLATION OF TYPE 2 A EMBEDDED ANODE SYSTEM - CONT...

Two Series Of Anodes  
*Ready to be tied to steel*

Lead Steel Connector

Connection from header wire to steel  
*Example*
INSTALLATION OF TYPE 2A EMBEDDED ANODE SYSTEM - CONT....

• Type 2A Embedded Anodes Grouted in Place
• Traffic Coating then installed over top of the anode system throughout the two levels of the garage
Continuity checks for steel and post tension system were conducted

New Anode system was connected back to existing monitoring boxes from previous system

New reference electrodes were installed so potential measurements could be taken

Two Test Boxes were initially monitored

Installed galvanic system is operating as designed

The two zones presently do not meet NACE criteria for cathodic protection (-100mV Shift), but this will take time to achieve
• Original CP System near end of service life
• New CP System chosen on variety of factors (service life, protection level, project constructability)
• Embedded Type 2A have capability to monitored in future to determine overall performance
• Installation of Cathodic Protection System will occur at each phase
Questions?

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