Saving Bridge Piers with Carbon Fiber Wrap and Laminate
Saving Bridge Piers with Carbon Fiber Wrap and Laminate
Purpose of the Project

- Overall investment in bridge understanding the use in the 495/90 interchange
- Deck Condition
- Steel Condition (Coatings and Fatigue)
- Lane Use and Traffic Volumes
- Substructure Condition
Project Partners

MassDOT
  Mohammed Nabulsi, P.E. – District 3 Bridge Engineer

Greenman-Pedersen, Inc.
  Bridge design
  Construction inspection

Carbon Wrap Solutions
  Carbon fiber design
  Installation contractor
Existing Condition

- Pier Deterioration
- Reinforcing Steel Deterioration
- Spalling, Cracking, Delamination
Inspection/Evaluation Process

• Existing Records Review
  • Plans, Inspection Reports, Inventory Photographs
• Visual Examination
• Mechanical Sounding
• Chloride Ion Testing
  • Above thresholds for active reinforcing steel corrosion
Carbon Wrap Solution

- Restore Concrete Section
- Strengthen Pier Cap
- Moisture and Chloride Barrier
- Economical
- Visually Appealing
Design Process

- Carbon Wrap Solutions – vendor design
- Designer verification
- Independent of pier reinforcing
- Columns assumed adequate
- No footing modification
Installation

• Concrete removal and patching
• Epoxy based concrete repair
Installation

- Concrete surface preparation
- Bonding compound
Installation

• Laminate
  • Horizontal Pier Face – “top bars”
  • Underside of Pier Cap – “bottom bars”
Installation

• Fabric Wrap
  • Cap – Shear reinforcing
  • Columns – Confinement
    • Not utilized for this project
Installation

• Fabric Wrap
  • Cap – Shear reinforcing
  • Columns – Confinement
    • Not utilized for this project
Installation

• Surface treatment
  • Elastomeric over Carbon Fiber
  • Acrylic paint after deck replacement
Construction Inspection

- Lack of defined industry procedures
- Bond testing
- Mechanical Sounding to identify voids
- GPR Verification of “hollow” sounding area
- Void defect repair – epoxy injection
- Debonding concern
Monitoring Program

- Moisture monitoring
  - Linear polarization readings
  - Six locations in each pier (3 on each pier face)

- Temperature
  - Internal and external

- Dew Point
  - For correlation to humidity

- MassDOT regular inspection cycle (24 months)
Monitoring Program
Monitoring Program - Results

• Moisture monitoring
  • Favorable trend to reduction – hard to verify
  • Existing saturated concrete – 99.9% readings in multiple probes
  • Limited migration of moisture from “wet” to “dry” locations

• Temperature Variations
  • Concrete does react – but much slower than ambient air condition

• Humidity Variations
  • Day to day variations – generally 60% to 75% year round

• Lack of moisture at weep holes
  • For correlation to humidity
Monitoring Program - Results

• Supplemental Visual Inspection

• Lack of moisture at weep holes
  • No significant migration in concrete or new moisture

• Delamination
  • Generally solid
  • Delamination at underside of pier cap – continue to monitor

• Columns
  • Solid – no noticeable hollow sounding area
First Post Freeze Thaw Inspection

• Reflective cracking and rust colored bleeding
• Discontinuous at laminates
• Possible differential thermal expansion of epoxy concrete patch material and original concrete
• Additional fiber wrap of pier caps
• No future cracking
First Post Freeze Thaw Inspection
Conclusions

- Economical Solution
  - $400,000 total pier repair cost with no traffic impacts
  - Compared to multiple million dollar replacement with traffic impacts

- Epoxy concrete performance
  - Difficult to verify due to carbon fiber wrap

- Chloride protection
  - Barrier to road salts

- Possible moisture protection
  - Trapped moisture still diffusing and migrating
  - No new moisture in system
  - Corrosion of reinforcing steel on going – but reduced
Saving Bridge Piers with Carbon Fiber Wrap and Laminate