Testing Effort and Interim Results

Wax Filler in Post-Tensioning Systems

AASHTO Subcommittee on Bridges
April 2015
Presentation Outline

1. Unbonded Post-Tensioning Research

2. Purpose of Research

3. Testing Effort & Preliminary Results
Unbonded Post-Tensioning Research
Research Project BDV31-977-15

Replaceable Unbonded Tendons for Post-Tensioned Bridges – Phase II

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• FDOT Project Managers
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• Co-Principal Investigator
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  — University of Florida

• Task 1 – Mock-up Injection
• Task 2 – Internal Tendon Testing
• Task 3 – External Tendon Testing
• Task 4 – Final Report

• Research Assistants
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Purpose of Research
Conventional Post-Tensioning
Tendon Corrosion in Florida

- Excess Bleed Water
- Grout Voids
- Soft Grout
- Contaminants
France

External Cement-Grouted Tendons

• Difficult to Observe Warning in Detailed Inspections Prior to Failure
• 5 Bridges Suffered External Tendon Failure from 1995 to 2000
• Excess Bleed Water
• Soft Grout

Strand, Water, and White Product on Grout Surface

High-Energy Release After 30% Strands Cut in a Grouted Tendon

Photos Courtesy of IFSTTAR
France

External Tendon Regulations in 2001
• Avoid Sudden Breakage of Tendons
• Easily Replaceable Tendons

Result of 2001 Regulations
• Flexible Filler
• No Reported Tendon Failures Using Flexible Filler
Nuclear Power Industry

Petroleum Wax in Post-Tensioning Applications

• Between 1969 and 2003

• 43 Power Plants

• Located in the USA, Sweden, Spain, Taiwan, Korea, Canada, Japan, England and China

• Periodically Monitored by Scheduled Strand Removal
Design Methodology for Flexible Filler

- Unbonded Tendon Design
- Similar to Grouted External Tendon Design
Prestress Behavior of Local Failure

**Internal Cement Grouted Tendons**
- Tendons
  - Redevelop Prestress

**External Cement Grouted Tendons**
- Strands
  - Redevelop Prestress Within Duct

**Internal and External Waxed Tendons**
- Strand Failure
  - Leads to Incremental Prestress Loss

**Warning Levels**
- Internal Cement Grouted Tendons: Little to No Warning of Failed Tendon
- External Cement Grouted Tendons: Little to No Warning Prior to Tendon Failure
- Internal and External Waxed Tendons: Progressive Warning Before Tendon Failure
Testing Effort & Preliminary Results
Mock-Up Injection

- 200 ft. Long Tendon Profile
- 19-0.6 in. Strands
- 4” (IPS) HDPE Duct
- Heated Wax Injection
- Low Point and Anchor Injection Locations

- Temperature and Pressure Monitoring
- Three Clear Windows (Polycarbonate) for Visual Inspection During Injection
- Short Sections of Duct Removed at Critical Locations After Injection
Flexible Filler Properties

Microcrystalline Wax

- Homogeneous
- Hydrophobic
- Metal Adhesion Properties
Flexible Filler PT System

• Similar to Cementitious Grouted PT Systems

• Tendons are Replaceable
Wax Installation Equipment

- Pumping Equipment
- Gauges, Valves and Injection Fittings
- Wax Heating Equipment
Equipment & Safety Protection

- Protective Clothing
- Face Mask
- Temperature Gauge
- Drill with Paddle Blade
Example Wax Injection Process

1. Heat Wax to 221°F (Spec Range 212-240°F)
2. Pump Wax into Duct at Low Point
3. Vent at High Points
4. Pump Wax between 40 and 70 Feet Per Minute
5. Maximum Injection Pressure of 75 PSI
Venting Operation
Wax Injection Results - Venting
Example Vacuum Assisted Wax Injection

1. Heat Wax to 240°F (Spec Range 212-240°F)
2. Vacuum Duct to 28 in. Mercury
3. Pump Wax End-to-End at 90 Feet Per Minute
4. After Vacuum, Final Lock Off Pressure of 40 PSI
Vacuum Assisted Injection Results
Research Schedule

- **Mock-up Injection**  Ongoing
- **Internal Tendon Testing**  Summer 2015
- **External Tendon Testing**  Summer 2015
- **Final Report**  Early 2016

**Note:** Strength, Fatigue, and Replace-ability Testing will be Performed during the Internal and External Tendon Tests for Waxed Systems.
Questions?

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