PT Grouting and Corrosion Issues in Florida

Jeff Pouliotte
FDOT State Structures Maintenance Engineer
History

• In 2000 FDOT had several Tendon Failures due to Premature Corrosion in Segmental Bridges
  – Mid-Bay Bridge in the Florida Pan Handle
  – Niles Channel in the Florida Keys
  – Other bridges displayed corrosion and/or voids, which required repair

• Cause of problems was primarily determined to be the poor performance of sand-cement grout inside the tendon ducts
  – Soft Grout that didn’t set-up
  – Grout Segregation
  – Voids
  – Recharge due to water infiltration into duct and anchorage voids
History

- FDOT adopted improved grouting materials and developed new construction practices:
  - Thixotropic Grout
  - Improved duct and tendon protection details
  - Improved anchorage details and protection
  - Improved material testing requirements
  - Improved grouting procedures
  - Improved construction and design specifications
  - Requirement for preapproved PT systems, includes all components (such as: dated prepackaged grouts)
  - PT Grout Training requirement for Contractors and Inspectors
  - Qualification for Grouting & PT technicians (two levels)
New Problems

• 2010 FDOT discovered catastrophic failure in 2 tendons on an 8 year old Segmental Bridge with Thixotropic Grout
  - Voids in Grout
  - Segregation in Grout
  - PT Corrosion
  - Duct systems that were not air tight
  - Grout that has unacceptable final condition (pasty or powdery)

• Repairs needed:
  - 17 external tendons have been identified for replacement
  - Over 500 voids in external tendons have been identified for re-grouting or epoxy repair
8 year old Segmental Bridge
External Tendon Failure
External Tendon Failure
External Tendon Failure
New Problems

• The problems with this bridge spurred a new round of field inspections and repairs in Florida

• Then in October 2011 the Sika Corp. informed FDOT that several bridges built with Sika Grout may have high chloride content (which is currently being investigated)
New Problems, continued...

- In March and May 2012 FDOT discovered two more segmental bridges built in 2010 and 2004 with soft grout in the internal and some external tendons.
- In April 2012 FDOT discovered a post-tensioned girder bridge built in 2003, with soft grout in the internal tendons of a PT spliced girder drop-in span.
- The galvanized ducts of the PT spliced girder bridge exhibited heavy corrosion and loss of galvanizing on the PT ducts.
- Investigation of these bridges is on-going.
Grout Investigation

• Historically the 4 approved thixotropic grouts on FDOT Qualified Products List (QPL) were:
  
  - Masterflow 1205
  - Masterflow 1341
  - Euclid Euco PTX
  - Sika 300PT

• A recent FDOT Specification change reduced the threshold level for chlorides in grout from 0.08% of cementious to 0.4 lbs/cy (≈ 0.01% of cementious)
Grout Investigation

• As a result of specification change, it was decided that the previously referenced thixotropic grouts would still be approved for projects let before January 1, 2012

• Masterflow recently received FDOT QPL approval for the following grouts under the new specification, for projects let after January 1, 2012:
  
  - Masterflow 1205
  - Masterflow 1341
Grout Investigation

• Potentially affected bridge types:
  - Precast Segmental and Cast-in-Place PT Boxes
  - PT Spliced Girder Superstructures
  - Vertically post-tensioned Substructures
  - PT Straddle Bents and Pier Caps
  - Post-tensioned precast prestressed flat slab superstructures
  - Tendon Types Affected:
    i. Grouted External PT Tendons
    ii. Grouted Internal PT Tendons

• 70+ Bridges constructed since 2001 using Thixotropic Grout have been scheduled for further investigation and possible repairs
Grout Investigation

• FDOT is currently constructing 4 segmental bridges and 12 segmental ramps, and investigation of PT ducts at some locations showed:
  - Voids in Grout
  - Segregation in Grout
  - Soft Grout that didn’t set-up

• FDOT State Materials Office (SMO) has plans to field grout tendons using FDOT’s approved QPL grouts

• The tendons will then be disassembled and analyzed to determine if and why these problems occur
Grout Investigation

• During a field investigation of a current construction project, Masterflow 1341 grout displayed voids and soft grout in 2 tendon caps

• Euclid Euco PTX grout developed entrapped/entrained air and soft grout during laboratory tests performed at the SMO at temperatures between 90° F to 93° F

• In the field Euclid Euco PTX grout was observed to develop air bubbles at 90° F

Note: FDOT Specifications require grout temperatures not to exceed 90° F
Grout Investigation

• Sika 300PT grout:
  - Sika 300PT grout met the old FDOT Material Specification requirements
  - All 4 FDOT Bridges with PT grout problems were constructed using Sika grout
  - Historically Sika grout has been used more than any other thixotropic grout on PT bridge construction projects in Florida
  - Sika is approximately 25% less expensive than Euclid or Masterflow grouts
Grout Investigation

• Sika 300PT grout:

  - During FDOT laboratory tests, grout was observed to begin setting up at 90° F

  - Field conditions observed on FDOT bridges where Sika 300PT grout was used:

    1) Soft Grout (4 bridges)
    2) Voids (1 bridge)
    3) Segregation (3 bridges)
    4) PT or Galvanized Duct Corrosion (2 bridges)
Grout Investigation

• Sika 300PT grout, continued...

  - During an inclined bleed test (not a current FDOT Specification requirement) performed by the FDOT SMO, the grout was observed to segregate if improperly mixed

  - During field investigation of corroded tendons, segregated grout was found to have high sulfate concentration
Grout Investigation

- Sika 300PT grout, continued...
  - FDOT believes that the high sulfate concentration promotes PT corrosion
  - Corrosion due to high chloride content has not yet been observed on FDOT bridges
Colloidal Grout Plant (Mixer and Pump)
Inclined Bleed Tests using Clear PVC Ducts
Grout Investigation

• Sika 300PT grout, continued...

  - During tests performed at the FDOT SMO, solid particles were observed in the colloidal mixer after mixing

  - During the inclined bleed test performed by the SMO, higher moisture contents were observed for Sika 300PT than for other grouts on the FDOT QPL
Moisture content results for Sika 300PT grout at maximum water content
Grout Investigation

- Sika 300PT grout, continued...

    - During Grout Fluidity tests at the upper limit of the manufacturer’s allowable water content, Sika 300PT did not perform consistently within the 10 second requirement in the modified flow cone efflux test as the temperature increased.

Note: Many of the laboratory test findings shown in this Presentation are Preliminary, pending the release of the final FDOT Report.
Grout Investigation

- In June 1, 2012 FDOT met with the Sika Corporation to discuss issues with Sika 300PT
- During the meeting, it was discussed that Sika 300PT had been shipped with bag weights 10% lighter than specified to FDOT construction projects
- On June 18, 2012, Sika agreed not to sell Sika 300PT for any current FDOT project, until Sika fully addresses FDOT’s concerns and FDOT completes the on-going PT investigation
- It is our understanding that Sika intends to reformulate their grout to meet the new FDOT chloride threshold
- Euclid has recently submitted Euclid Euco PTX for approval on FDOT’s QPL
Grout Investigation in Perspective

• How much of the grout problems stated herein can be attributed to the following:
  - Materials?
  - Mixing?
  - Installation?

• How many bridges with PT components constructed using thixotropic grout have grout related problems?

• How many bridges with grout related problems were constructed in full accordance with Specifications?
PT Inspection Problems

• There are no thorough comprehensive reliable methods to inspect the condition of post-tensioning steel and grout

• External Tendons can be sounded for voids, drilled, inspected and re-grouted

• Internal Tendons and Anchorages can be drilled, inspected and re-grouted

• Only Main Magnetic Flux has been identified by FHWA as a reliable NDT Method for External Tendons

• FDOT has seen Magnetic Flux Leakage work in a laboratory demonstration, and FDOT is planning to test the effectiveness of Magnetic Flux Leakage in the field
Sounding External Tendon with Hammer
Royal Park Bridge
Access for Sounding not always easy
Magnetic Main Flux Method Magnetizer
Magnetic Main Flux Method Set-up
Duct Coupler Removal for Inspection
On-going PT Inspection Research

- Florida International University is performing a literature research for FDOT to identify existing NDT and NDT that are promising for further development ($150,000)

- NCHRP 2012-F-09 “Improved Corrosion Inspection Techniques for ducted strands for cable stayed, and post tensioned concrete bridges” ($750,000)

- Will these efforts produce economical reliable NDT methods that are capable of adequately investigating the condition of both internal and external tendons, and anchorages?
Future

• This is a national problem that requires national attention

• Development of more inspectable and/or replaceable PT details are needed (Design Responsibility):
  – Greased Ungrouted Tendons (for easy replacement)
  – Electrically Isolated Tendons (to monitor for PT corrosion)
  – Use of Cathodic Protection for tendons needs to be investigated
  – More rigorous grout acceptance testing, more durable grout systems, and improved grout installation procedures
  – Etc.

• Further pooled fund research may be needed for the further development and implementation of promising NDT technologies (Bridge Preservation Responsibility)
Questions?

Jeff Pouliotte  
Florida Department of Transportation  
850-410-5691  
Jeffrey.pouliotte@dot.state.fl.us