2016 VIRGINIA CONCRETE CONFERENCE

FDOT CHANGING POST-TENSIONING AND SEGMENTAL CONCRETE BRIDGE PROGRAM

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Presentation Outline

1. Introduction
2. FDOT Revisions to Policy for Post-Tensioned Bridges
3. Specifications, Design Guidelines and Standards
4. Research & Laboratory Tests
5. Implementation

Introduction

Why is FDOT changing the Post-Tensioning Policy?

1999-2003: PT corrosion / durability issues related to bleed water in grout.

- Niles Channel Bridge, Florida Keys
- Mid-Bay Bridge, Destin, FL
- Sunshine Skyway Bridge , Tampa Bay, FL
- Seabreeze Bridge, Daytona Beach, FL

2010-2013: PT corrosion / durability issues related to chloride and sulphate issues in grout and soft grout formation.

- Ringling Bridge, Sarasota, FL
- Wonderwood Bridge, Jacksonville, FL
- I – 4 / Crosstown Connector, Tampa, FL (issue found during construction)
- I-95 / I-295 Interchange , Jacksonville, FL

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Introduction

Soft / Chalky grout (2001)

Wet / soft grout (2011)

Corroded tendon (2011)

INTRODUCTION

Timeline of FDOT's Development of Flexible Filler Policy

- March 2012 FDOT's Invitation to Innovation – An Initiative to Explore New or Existing Technology Not Addressed in FDOT Policy
- May 2012 Research Project Began on Replaceable PT Tendons
- July 2012 Report on Un-bonded Tendon System Practices in Europe
- Dec. 2012 Parametric Study of Un-bonded Post-Tensioning System
- Oct. 2013 Site Visit to Observe Flexible Filler Injection in France
- Jan. 2014 FDOT Executive Committee Presentation
- April 2014 Revisions to Policy for Post-Tensioning Tendons
- Jan. 2015 Updated on Revisions to Policy for Post-Tensioning Tendons
- May 2015 Design and Construction Specifications
- Jan. 2016 Meeting with ASBI and PTI for development of Flexible Filler Injection Certification Training

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FDOT Revisions in Policy for Post-Tensioned Bridges

There are three Structures Design Bulletins (Policy Changing) Published:

1. Structures Design Bulletin 14-06 dated on April 30, 2014
2. Structures Design Bulletin 15-01 dated on January 28, 2015
3. Structures Design Bulletin 15-03 dated on May 20, 2015

Significant Items in the Revised Policy:

1. Adoption of flexible filler material (wax) as post-tensioning tendon corrosion protection in certain types of tendons, such as continuity tendons, hammer head pier tendons, straddle beam tendons, C piers tendons, draped tendons in I girders and U beams.
2. All external tendons shall be injected with flexible filler.
3. Grouted tendons are still implemented to certain types of tendons, such as horizontal tendons in the deck, cantilever tendons, straight tendons in U beams and PT bars.
4. Tendons with flexible filler material shall be designed as un-bonded and fully replaceable.
5. Diabolo forms in deviators and diaphragms are permitted.

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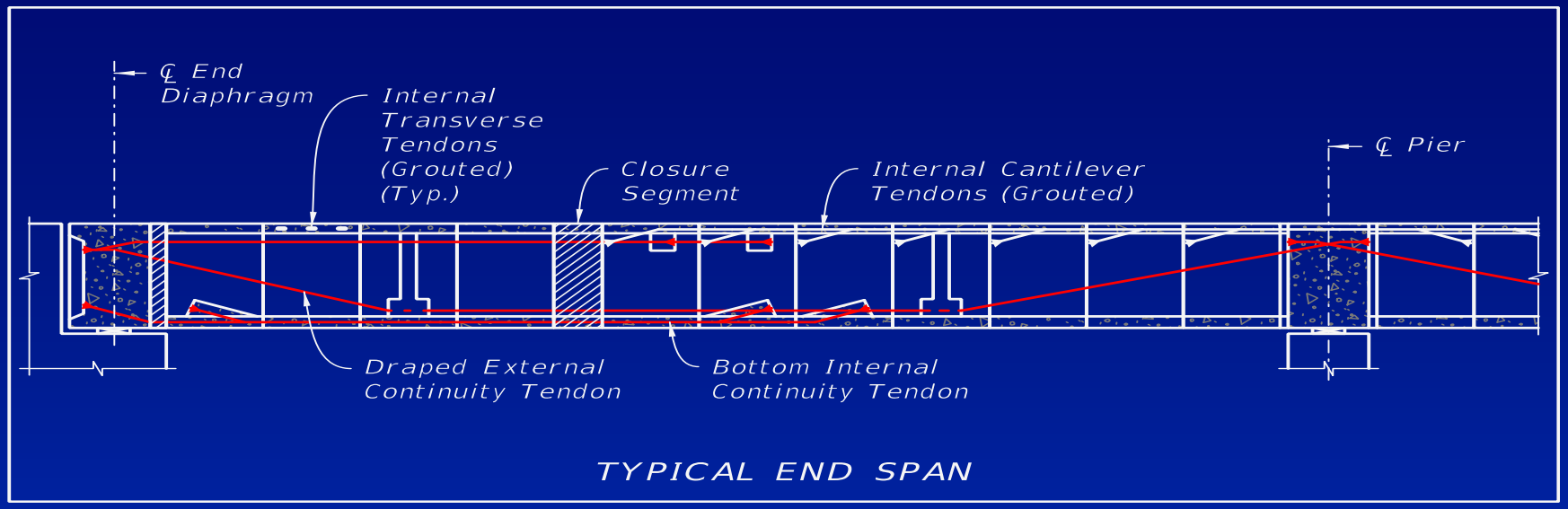
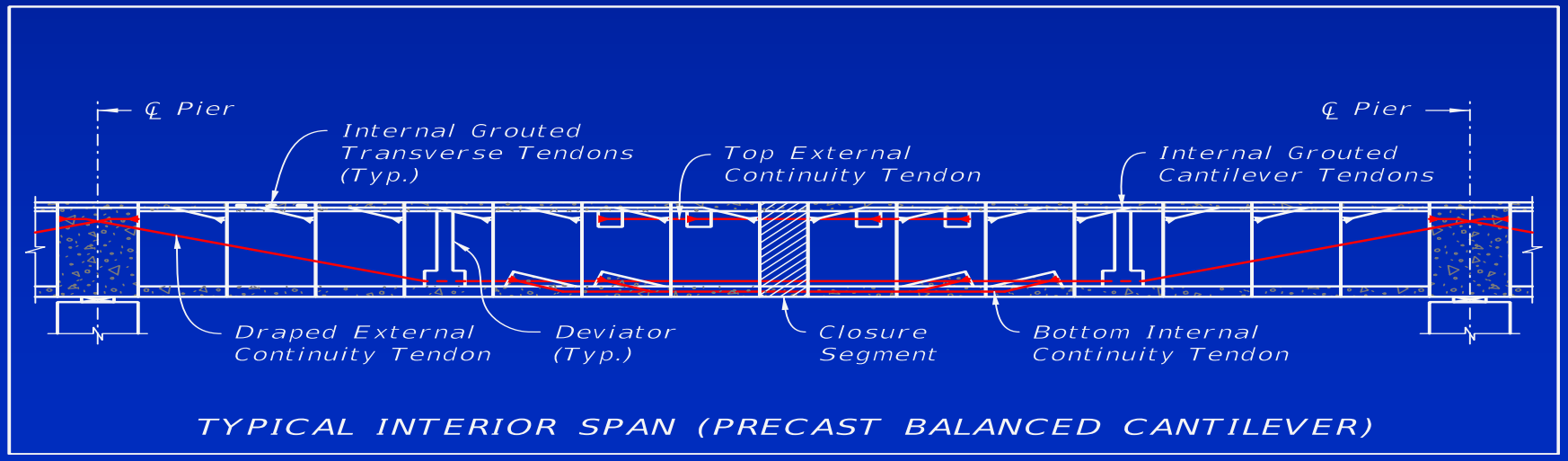
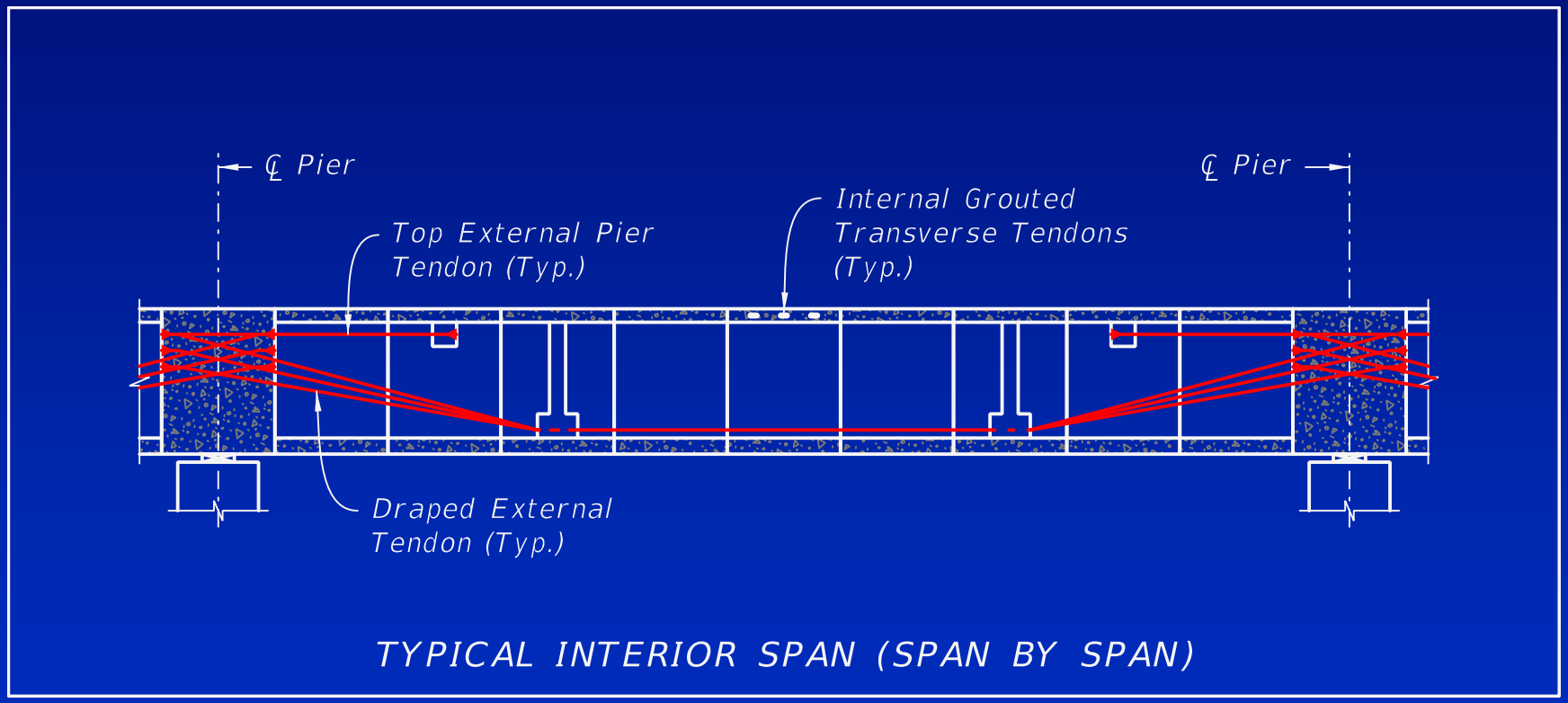
Example of Tendons with Flexible Filler





Note: Tendons in red are filled with flexible filler

Example of Tendons with Flexible Filler



Example of Tendons with Flexible Filler

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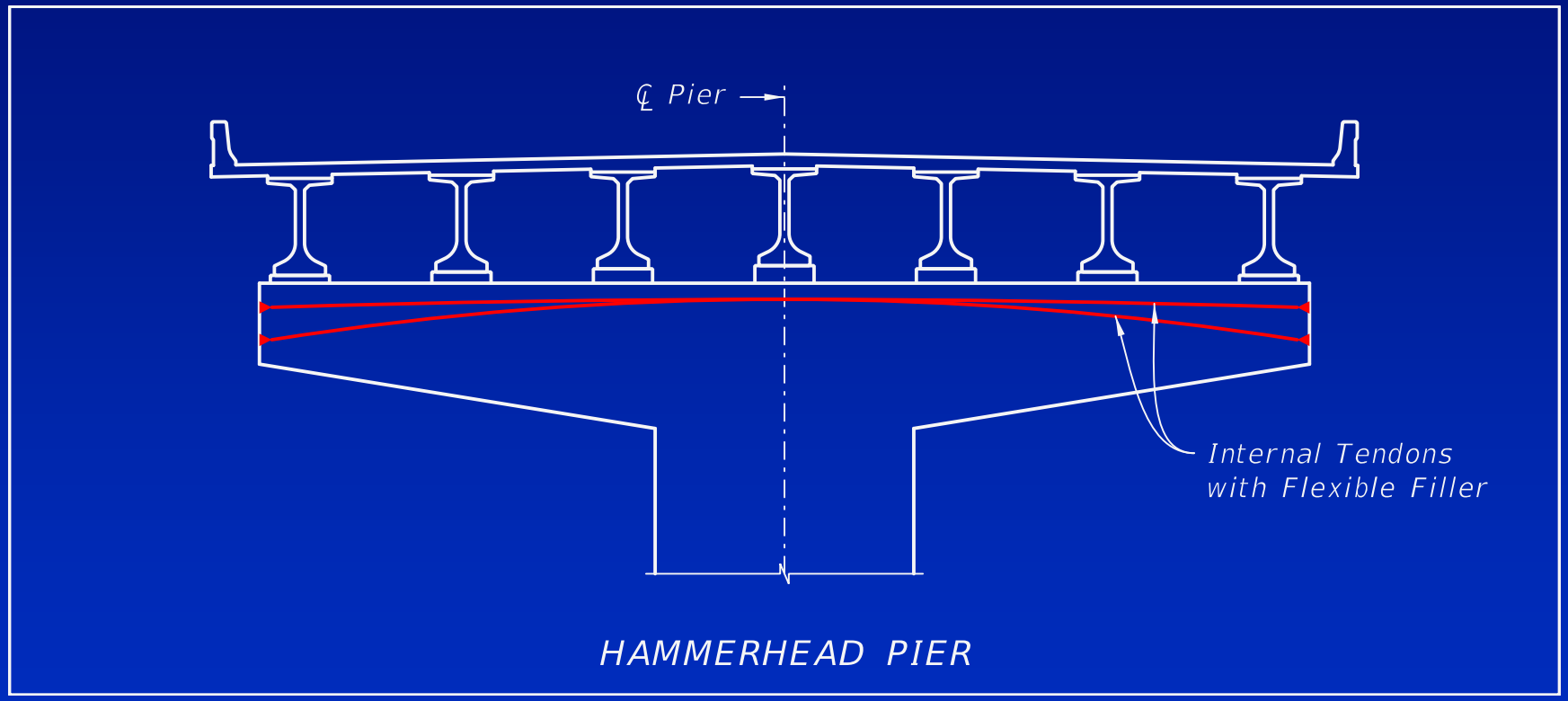
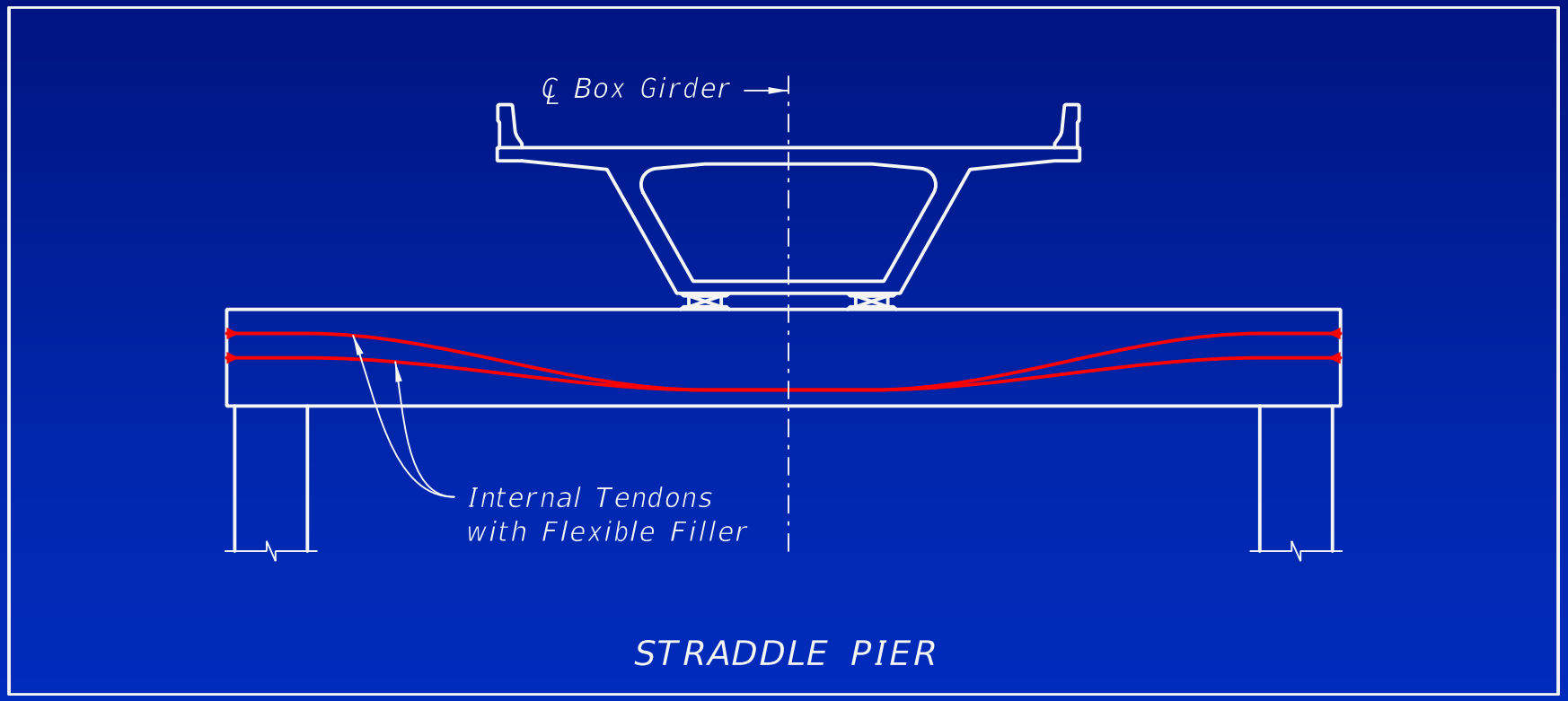
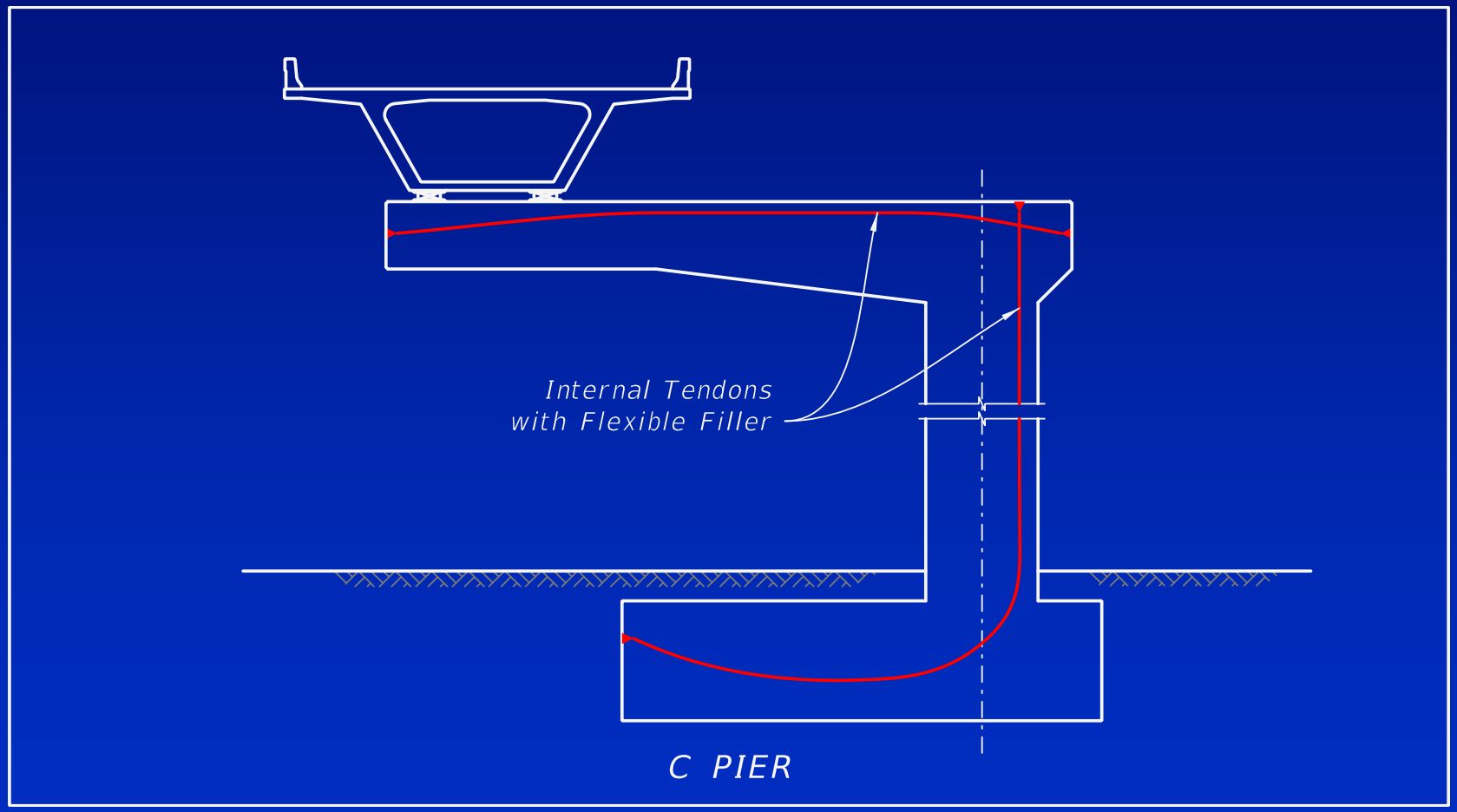


Example of Tendons with Flexible Filler



Example of Tendons with Flexible Filler



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Specifications, Design Guidelines and Standards

Revisions to FDOT Documents:

1. **Structures Manual (Vol. 1 & Vol. 2)**
2. **Design Standards (Index Nos. 21801, 21802 and 21803)**
3. **Standard Specifications:**

- **Section 105 Contractor Quality Control**
- **Section 452 Precast Segmental Bridge Construction**
- **Section 462 Post-Tensioning**
- **Section 938 Filler Material for Post-Tensioned Structures**
- **Section 960 Post-Tensioning Components**

The above documents can be downloaded from the link below:

http://www.dot.state.fl.us

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Research Projects

Analytical and Field Research Study

1. Un-Bonded Tendon System Practices for Bridges in Europe – July 2, 2012.
2. Parametric Study of un-bonded PT System – Nov. 9, 2012.
3. FDOT Scan Tour In France – Oct. 16, 2013.
4. Review of AASHTO LRFD Bridge Design Specifications and ACI-318 Un-Bonded PT Provisions for FDOT Implementation – Nov. 17, 2015.

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Research Projects (Cont')

Laboratory Research Study

Replaceable Un-bonded Tendons for Post-Tensioned Bridges

FDOT Contract Nos. BDV31-977-15 & BDK977-71

1. Five full-scale mock-up injections with different flexible fillers and PT systems (complete)
2. Beam structural Test Specimens (on-going)

Interim Research Report Available at:

http://www.dot.state.fl.us/structures/structuresresearchcenter/ActiveResearch.shtm

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Research Projects - Summary

Objectives: To learn the behavior of flexible filler material properties, construction and cost impact, including structural behavior in order to develop specifications, design guidelines and standards for implementation.

Mock-up for flexible filler injection (5 mock-up specimens)

1. The target injection rate range was 50-80 ft/min. Average injection rates for each mockup were 21.5, 49, 62, 75, and 100 ft/min.
2. Injection rates and venting procedures were varied among the five mockups, primarily in an effort to determine the most suitable approach.
3. In spite of the variation of procedures, strands in each of the specimens were well-coated with filler material.

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Research Projects – Summary (Cont')

Mock-up for flexible filler injection (5 mock-up specimens) (Cont')

4. The first two tendons injected contained a void at the top of the duct cross section in the parabolic portion of the mockup, which were the result of intentional venting procedures and not the PT system or individual filler products used. Vacuum assist circumvents the need for venting and burping.
5. At the completion of these mockup tests, no cause to restrict use of any of the PT systems or filler products was found.

Structural Test on bonded vs un-bonded (on going)

1. Static Tests – Four Specimens (Internal Bonded, Internal Unbonded (2), External).
2. Fatigue Test – One Specimen (External).
3. Fretting and Wedge Fatigue Tests – 3 Reduced Scale Specimens.

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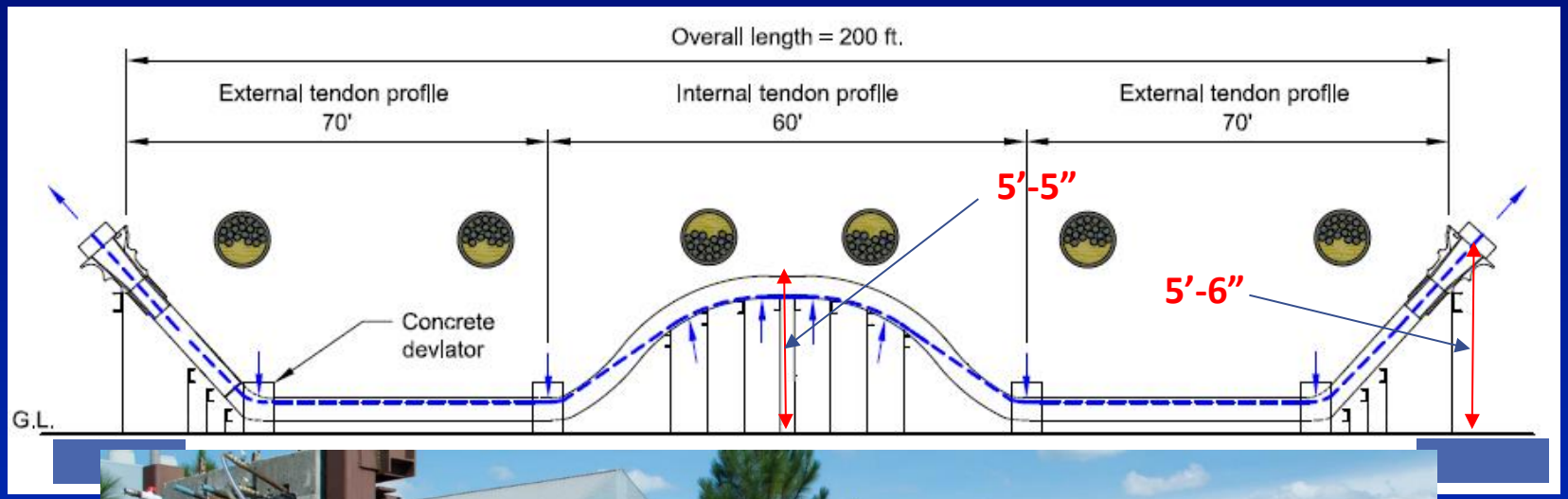
Mock-up injections: An investigation of constructability



Tendon installation

Post-tensioning anchor

Strands tensioned with monostrand jack

Gravity deviators

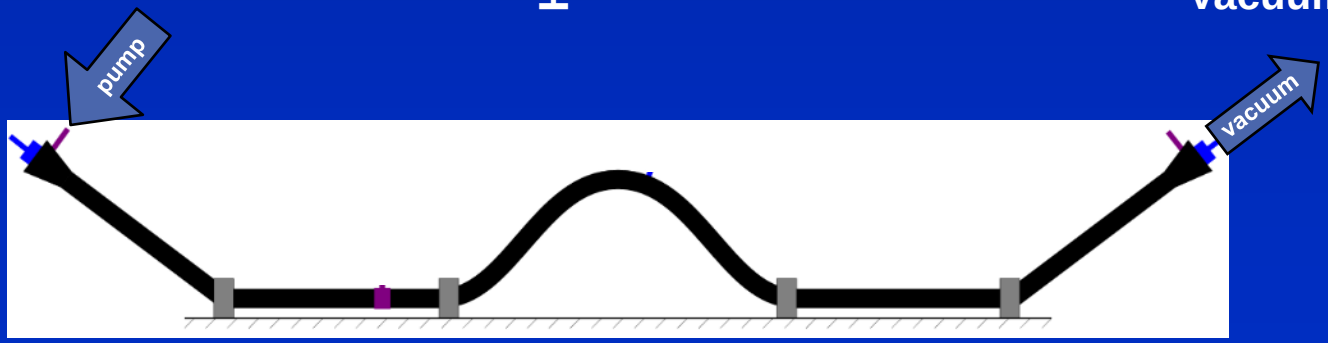
Mock-up injections

- Average wax temperature: **230° F** in barrels, at start; **140° F** at exit
- Injection duration: 4 minutes

Heated in drums

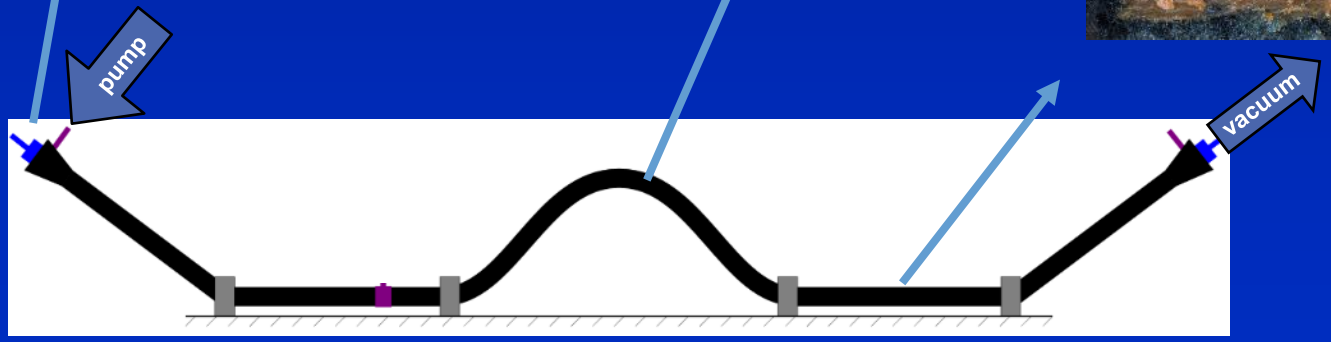
Heated centrifugal pump and barrels

Vacuum pump



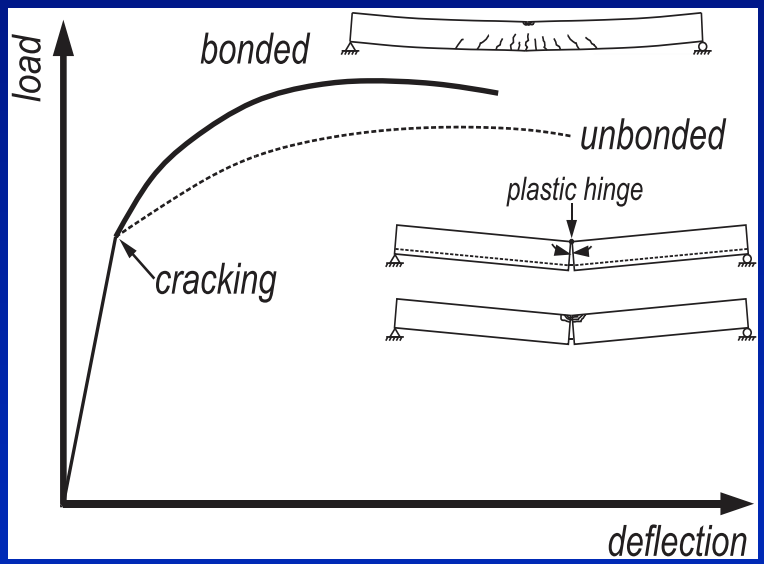
Post-injection inspection

Strands well-coated with filler material

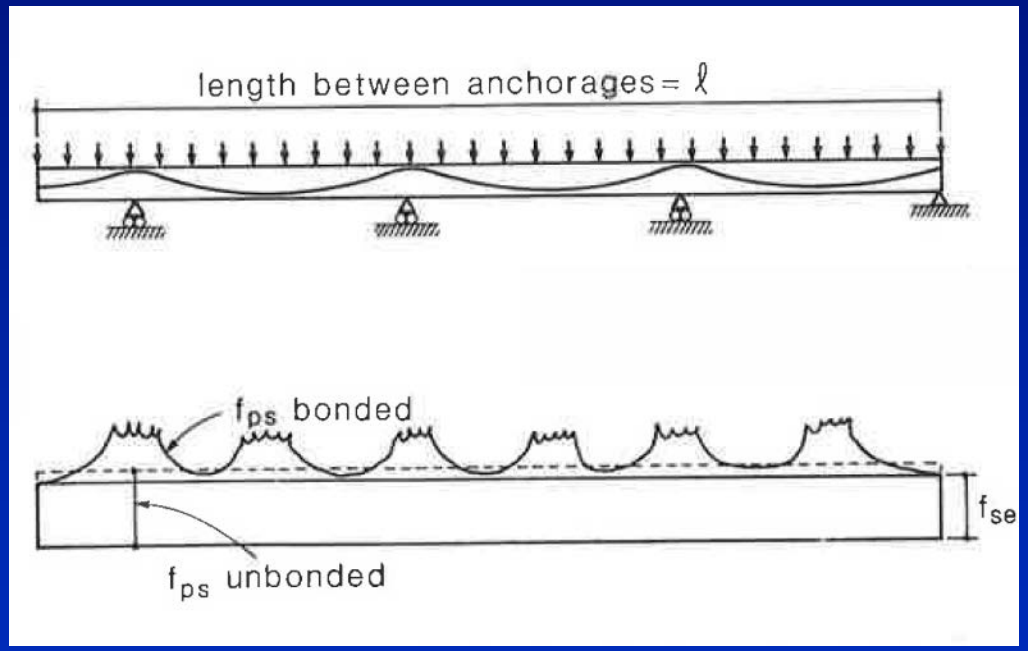


Structural Implications

Bonded (grouted) vs. unbonded (flexible filler) tendons



Load vs. Deflection

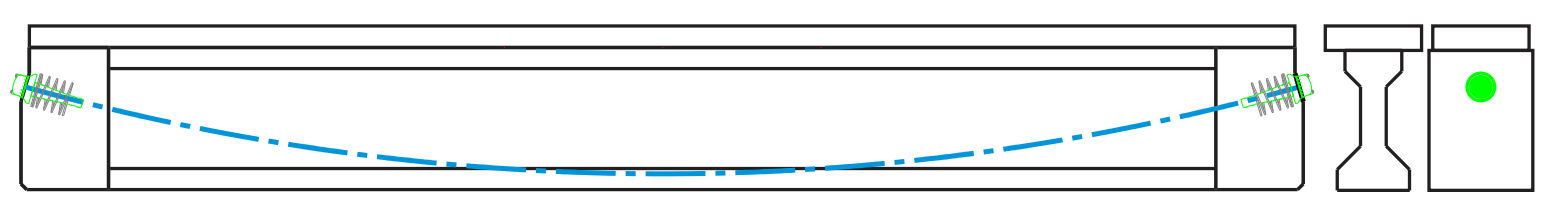


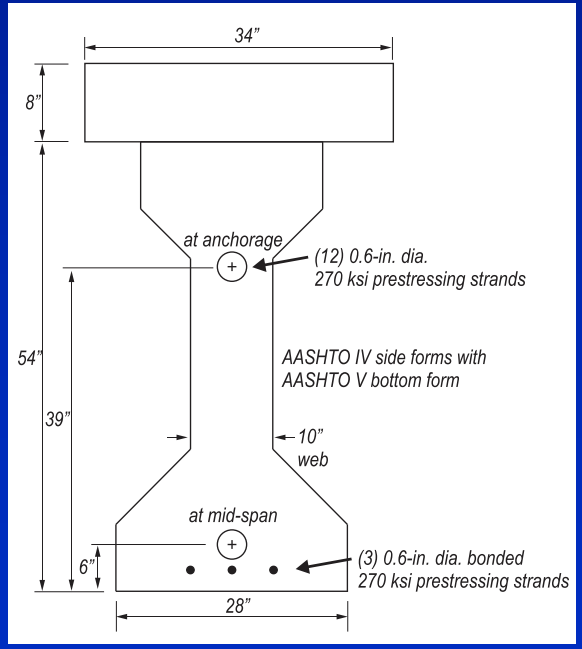
Tendon stress (f_{ps}) at ultimate:

unbonded < bonded at critical sections.

Structural Testing - Internal Tendon Specimens - Grouted vs. Unbonded

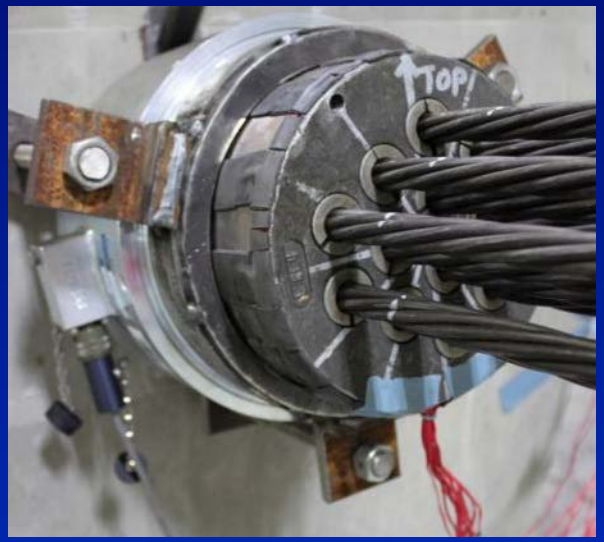
- 40-ft hybrid AASHTO IV-V with 8-in. deck



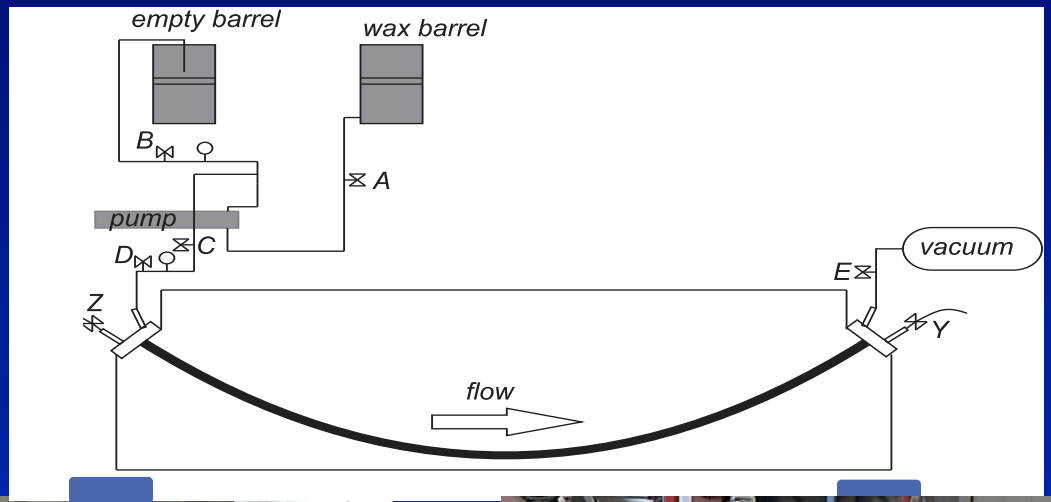


Internal Tendon Specimens

(1) grouted and (2) injected with flexible filler



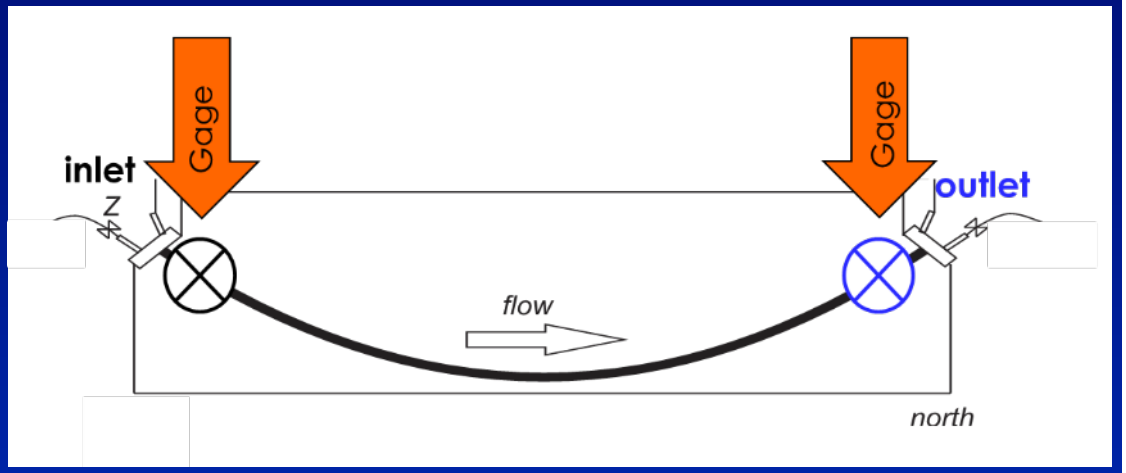
Internal Tendon Specimens - Injection

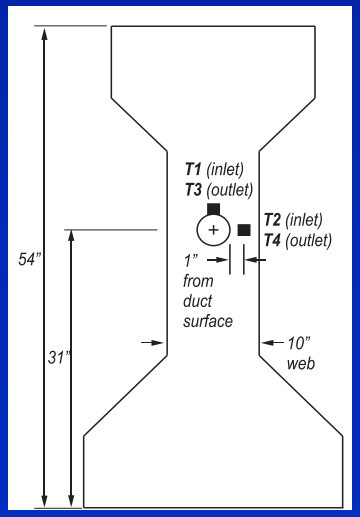


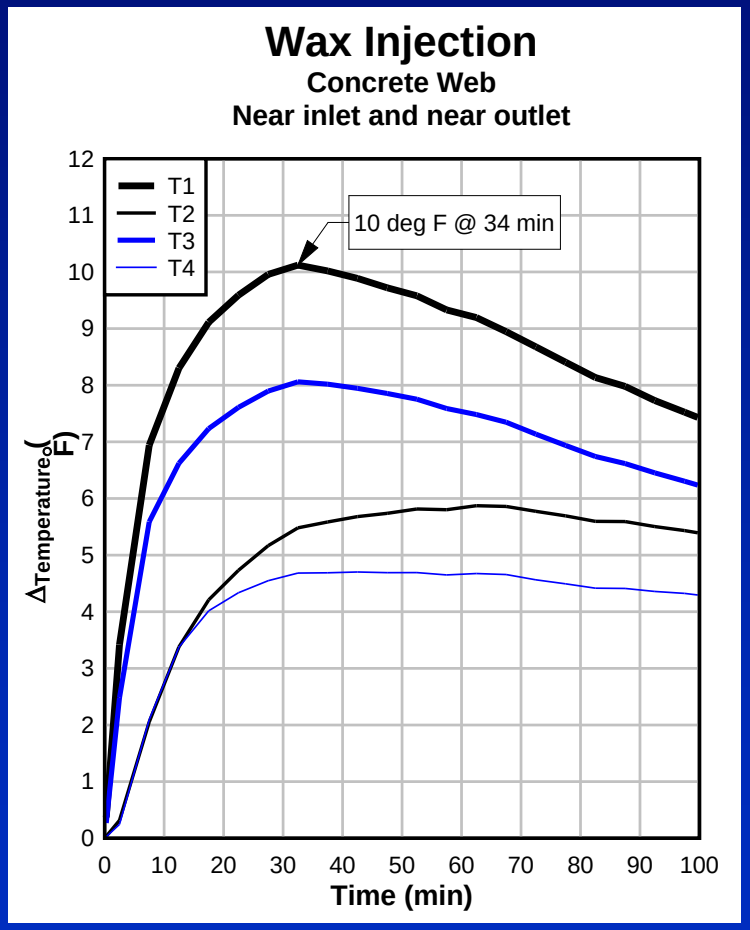
Wax (barrels): 212 ºF

Ambient : 83 ºF

Internal Tendon Specimens-Injection

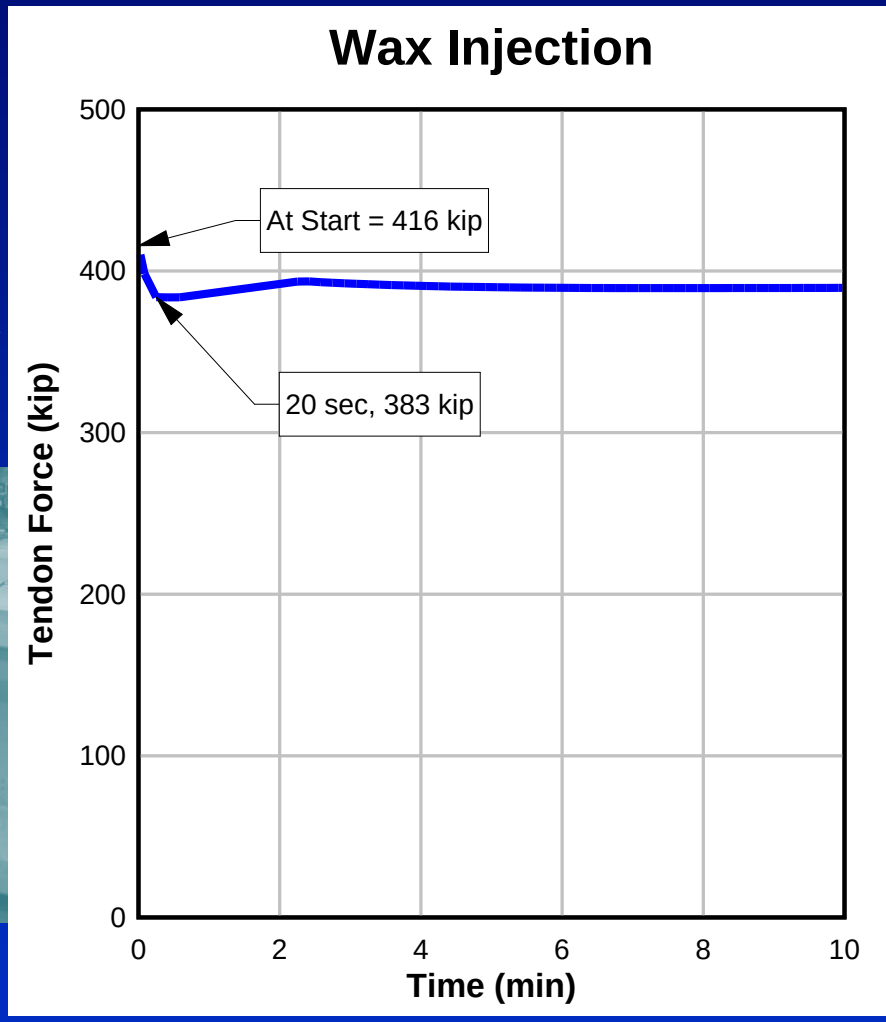




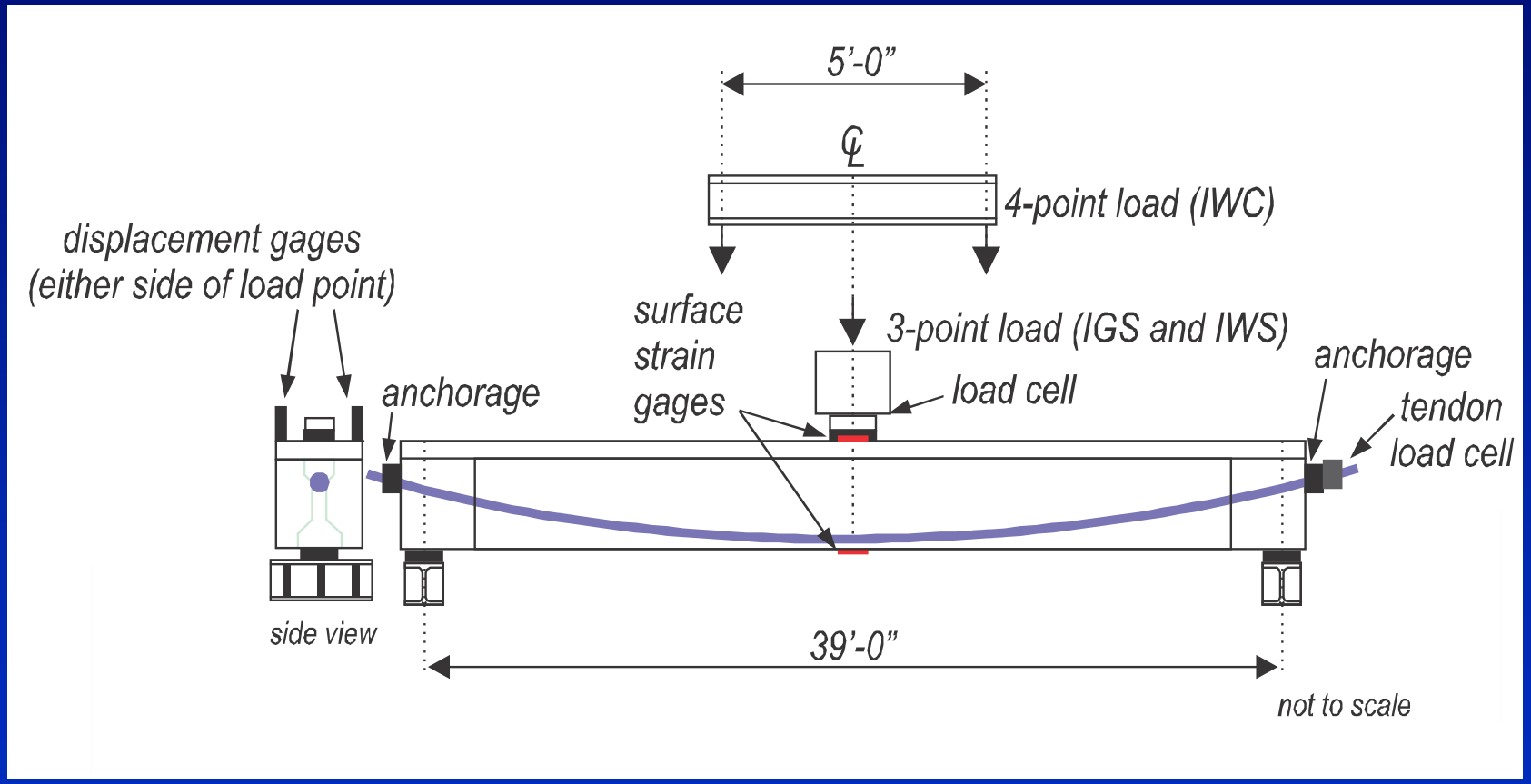


Internal Tendon Specimens - Injection

- Wax temperature: 212°F
- Ambient temperature: 83°F
- Force at start of injection: 416 kip or $0.6f_{pu}$
- Approx. 7 hrs. to full force recovery

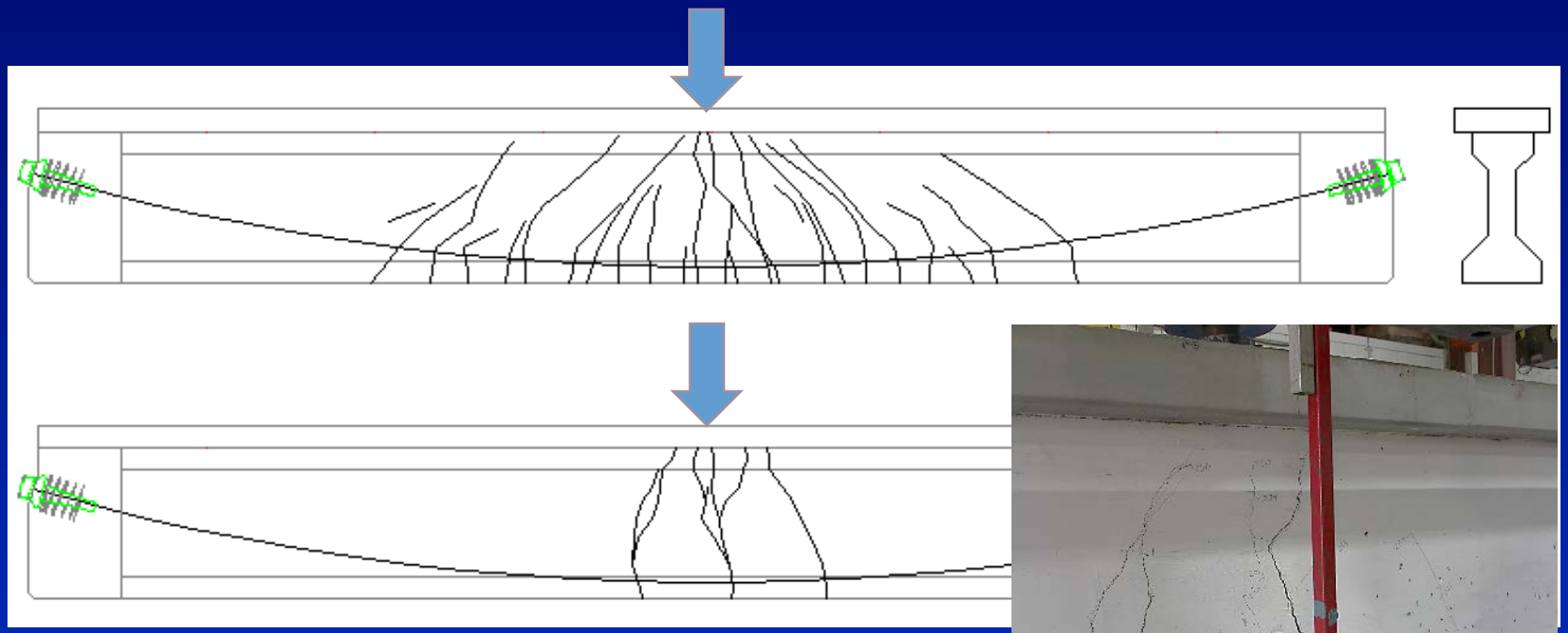


Internal Tendon Specimens-Flexural Behavior



Internal Tendon Specimens -Behavior

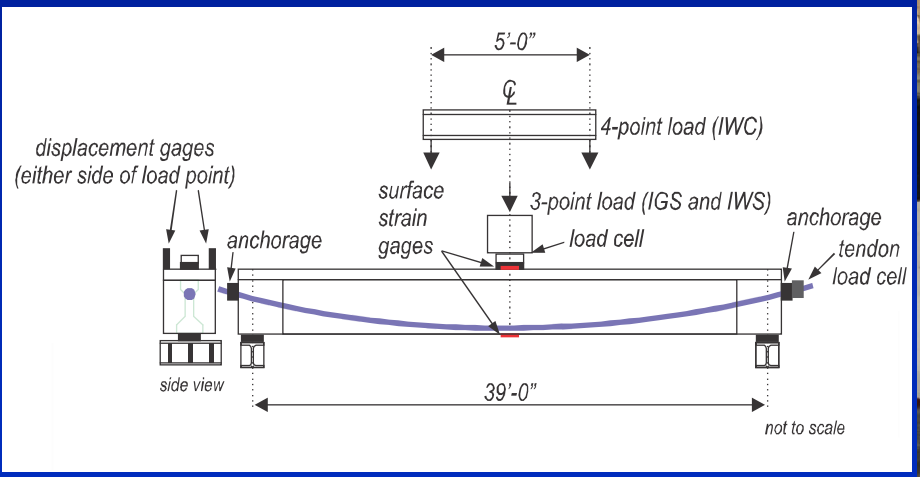
Grouted



Flexible Filler

Internal Tendon Specimens-Ultimate

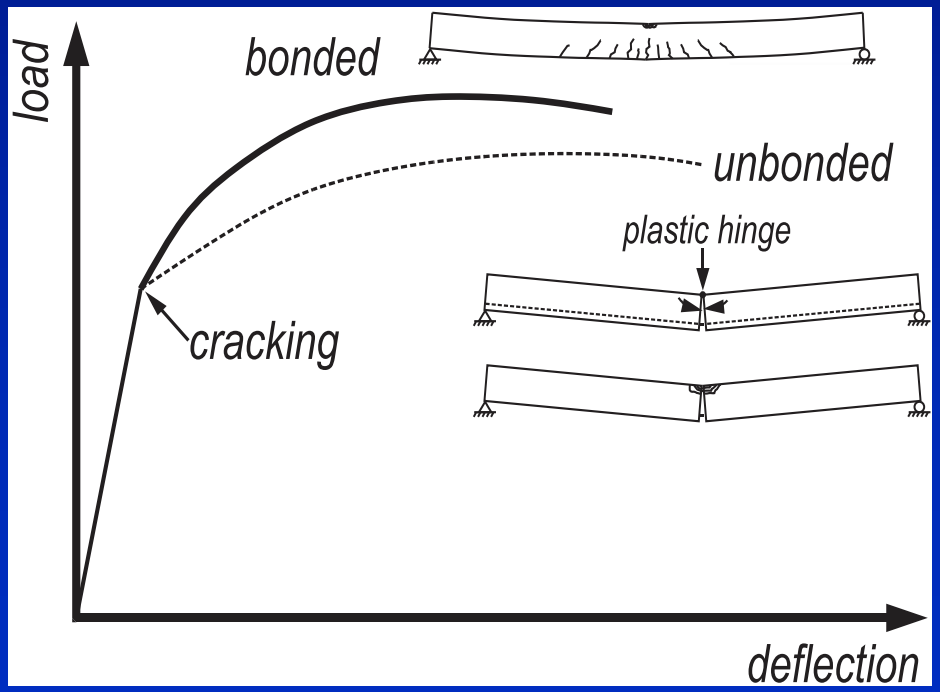
- **Bonded** (Grouted): compression failure of deck at load point
- vs. **Unbonded** (Flexible Filler): rupture of the bonded prestressing steel, followed by compression failure of the deck.

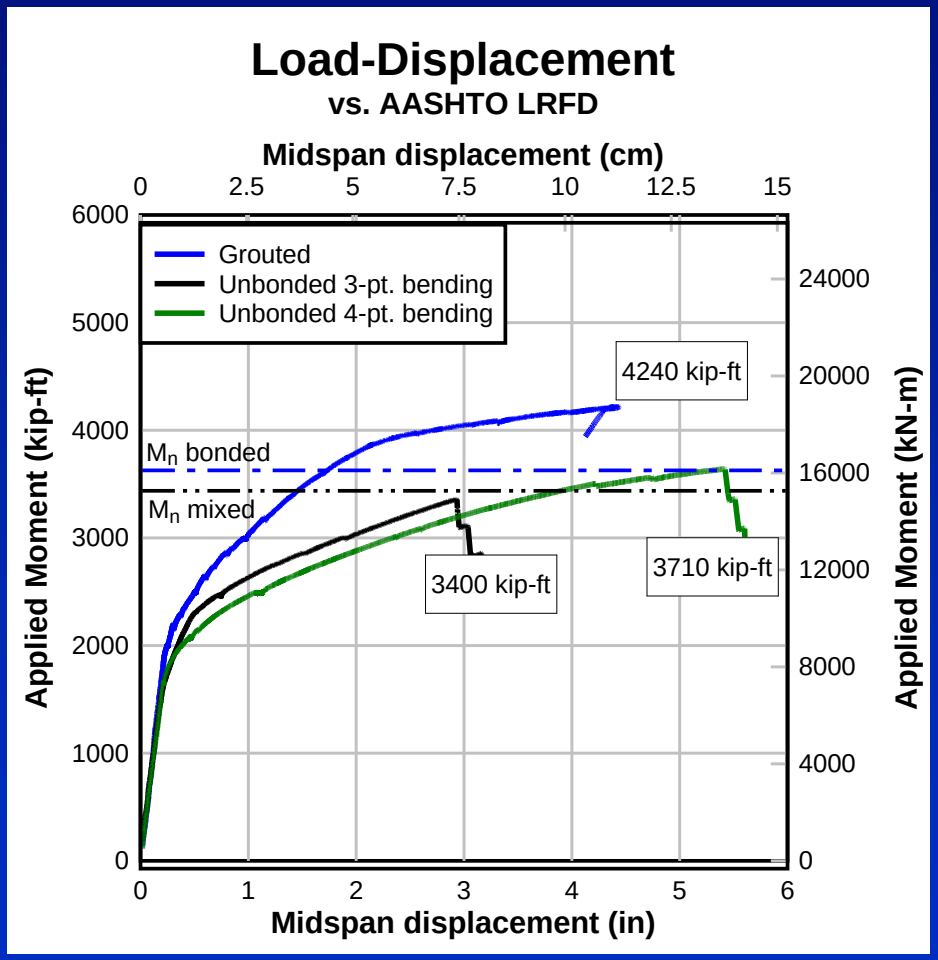


Bonded: crushing of the deck

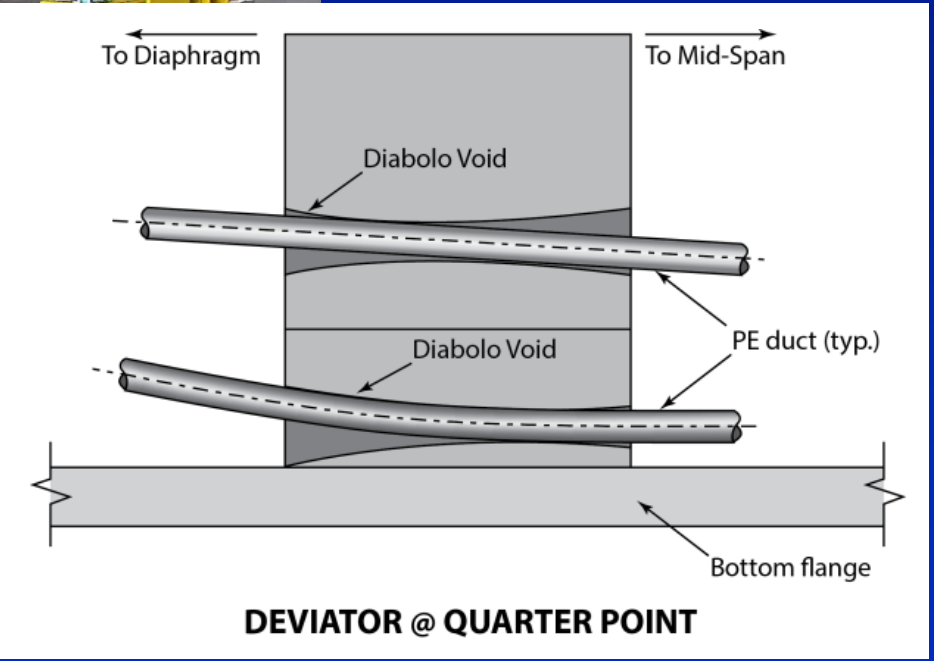
Unbonded: Rupture of bonded prestressing

Internal Tendon Specimens Theoretical Behavior vs. Test Data





External Tendons – Deviation Points



- Effects of fatigue
- Diabolo deviators

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1. Flexible Filler Approved Product List (APL): Three products have been approved.

   - CIRINJECT CP (CIVETEA, France)
   - FILL-FLEX **100, 200** (The Trenton Corp., USA)

2. Upcoming Flexible Filler Injection Training

   - 1/26/2016: FDOT and ASBI/PTI met in Tallahassee to discuss a joint training course for Flexible Filler Injection.
   - Target Audience: installers, CE&I and FDOT personnel.
   - Tentative schedule for the 1st class will be at the end of April 2017

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Implementation (Cont')

3. Application to Actual Projects (Construction phase in 2017)

The following projects (some are being advertised) potentially will use un-bonded PT tendons:

- Pensacola Bay Bridge Replacement
- I-95 / I-295 North Interchange in Jacksonville
- Wekiva Parkway (Section 6)
- SR-836/I-395 in Miami
- Wonderwood Bridge Repair
- Gateway Expressway in Tampa Bay
- I-95 at I- 10 Interchange Operational Improvement (Fuller Warren Widening) in Jacksonville

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Implementation

Construction Cost Impact

1. Post Tensioning Pay Item Cost

   15% to 25% above similar grouted systems

2. Superstructure Cost

   0.5 % to 2.5% higher than a similar grouted system

3. Total Project Cost

   Less than 1% increase compared to a grouted system

Acknowledgements

We would like to acknowledge the following institutions and private industry firms for their participation in supporting FDOT research on flexible filler.

1. University of Florida
2. FDOT Structures Research Lab
3. FDOT State Materials Office
4. Dura-Stress
5. Freyssinet
6. VSL
7. DSI
8. WSP-Parsons Brinckerhoff
9. Trenton
10. Pilgrim
11. Civitea
12. Sonneborn
13. Schwager Davis, Inc.
14. Sanchem, Inc
15. August Gahringer Duisburg

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THANK YOU

Any Questions?