Use of Flexible Filler in Post-Tensioned Bridges

Dr. Natassia Brenkus, The Ohio State University

Gary R. Consolazio & Trey Hamilton, University of Florida
Seaska Pérez-Avilés, University of Florida
Madiha Ammari, The Ohio State University
Motivation

• Cost-effective method of bridge construction

Prestressed Concrete

• Poor grouting practice
• Poor material performance

Durability Issues

• Structural implications
• Reevaluation of current design specifications

Flexible Fillers
Post-tensioning Components

Internal Tendons designed as bonded.
External Tendons designed as unbonded.

All tendons unbonded.

Flexible Filler
Wax/Grease

post-tensioning Components

prestressing steel

duct

case material

Grout
Issues with grout

- Soft Grout
- Tendon Corrosion
- Tendon Failure
Internal and External Tendons

Drop-in Girders
Internal Tendons

Segmental Box Girders
External Tendons
Research Status - Final Report Complete

- Literature review
- Filler injection
- Structural testing
  - Flexural strength
  - Fatigue at deviator and anchorage
- Wire break detection
Tasks Completed

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Developed Injection Procedures

✓ Vacuum assist recommended
✓ No venting
✓ Verified process
Developed Injection Procedures

✓ ASBI Flexible Filler Certification
✓ Offered 3 years, including field demo
Tasks Completed

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Structural Testing Internal and External Tendons

- **Drop-in Girders Internal Tendons**
- **Segmental Box Girders External Tendons**

(3) Internal Tendon Specimens
(2) External Tendon Specimens
Test Specimens

- (12) 0.6-in. dia.
- 270 ksi prestressing strands
- AASHTO IV side forms with AASHTO V bottom form
- 10" web
- (3) 0.6-in. dia. bonded
- 170 ksi prestressing strands
• Bonded Tendons

**Article 5.6.3.1.1**

- For rectangular or flanged sections subjected to flexure about one axis where the approximate stress distribution specified in Article 5.6.2.2 is used and for which $f_{pe}$ is not less than 0.5 $f_{pu}$, the average stress in prestressing steel, $f_{ps}$, may be taken as:

$$f_{ps} = f_{pu} \left[ 1 - k \left( \frac{c}{d_p} \right) \right]$$

• Unbonded Tendons

**Article 5.6.3.1.2**

- For rectangular or flanged sections subjected to flexure about one axis and for biaxial flexure with axial load as specified in Article 5.6.4.5, where the approximate stress distribution specified in Article 5.6.2.2 is used, the average stress in unbonded prestressing steel may be taken as:

$$f_{ps} = f_{pe} + 900 \left( \frac{d_p - c}{l_e} \right)$$

• Mixed Reinforcement Conditions

**Article 5.6.3.1.3**

- 5.6.3.1.3A – Detailed Analysis
- 5.6.3.1.3B – Simplified Analysis
Comparison with AASHTO-LRFD

- Using LRFD 5.7.3.1.3b simplified analysis for elements with bonded and unbonded tendons
Research Status

- Literature review
- Filler injection
- Structural testing
- Flexural strength ✓
- Fatigue at deviator and anchorage ✓
- Wire break detection
External Tendons – Deviation Points

- Effects of fatigue
- Diabolos
Reduced Beam Testing

18 deg.

Fretting fatigue
Duct damage

Anchor fatigue

11 deg.

Severity of Fretting Fatigue

No Damage
Fretting Fatigue Possible
Fretting Wear

Slip Amplitude

The Ohio State University
College of Engineering
Post-cycling evaluation

- Visual inspection of HDPE sections in diabolo
- Visual inspection of prestressing strand at wedges
- Ultimate tension tests of individual prestressing strands with diabolo in gage length
Anchorage

Wedge “bite” marks
Tension Tests

Source: instron.com
Tension Tests

Source: instron.com

Strand sample

18 degree

11 degree
Channel 5 segmental bridge

Tendon force difference at deviator
Outcomes and Implementation

- Injection procedures
- Developed heat transfer model for use in evaluating maximum length of tendon to inject
- Developed and delivered flexible filler training for engineers, contractors, and owners
- Evaluated AASHTO LRFD provisions for flexural design
- Evaluated fatigue resistance
- Evaluated diabolo geometry
- Developed prestressing strand breakage detection algorithm
Field Implementation

- Wekiva Parkway – Section 6
- Cast-in-place segmental
- Flexible filler used for external tendons and internal bottom continuity tendons
Field Implementation

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- Cast-in-place segmental
- Flexible filler used for external tendons and internal bottom continuity tendons
Field Implementation

- First continuity tendons injected
- (3) 650 gallon internally-heated tanks
- Monitored flow and qty injected.

- Initial feedback from the field
- Vacuum-assist learning curve
Current Research - **Flexural Capacity of Concrete Elements with Unbonded/Bonded Prestressing**

- Develop design guidelines and analysis procedures for bridge members with unbonded tendons with particular focus on a combination of unbonded tendons and bonded prestress and/or mild reinforcement.
Phases of Project (BDV31-977-93)

- Development of analytical modeling procedures
- Preliminary analytical study
- Experimental testing
- Integration of experimental and analytical data
- Development of design and analysis guidelines
Contact Information

◆ Dr. Natassia Brenkus, The Ohio State University
  ◆ Brenkus.4@osu.edu / 614-688-3184

◆ Dr. Trey Hamilton, University of Florida
  ◆ hrh@ce.ufl.edu / 352-294-7797
  ◆ Dr. Gary Consolazio, University of Florida
  ◆ grc@ufl.edu / 352-294-7796
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FDOT

Trenton Anticorrosion Materials

Sanchem, Inc.
Working with trusted brands since 1913

Sonneborn
Pilgrim

Schwager Davis Inc

Civetea
Test Design

- Modeled fatigue test after ETAG-013
- Minimum stress range of 11.6 ksi
- Maximum load of 65% of tensile element characteristic strength