Florida’s Flexible Filler Experience

Dr. Natassia Brenkus, The Ohio State University
Motivation

- Cost-effective method of bridge construction

Prestressed Concrete

- Poor grouting practice
- Poor material performance

Durability Issues

Flexible Fillers

- Structural implications
- Reevaluation of current design specifications
Issues with grout

- **Soft Grout**
- **Tendon Corrosion**
- **Tendon Failure**
Post-tensioning Components

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

All tendons unbonded.
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

- Literature review
- Filler injection
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Developed Injection Procedures

- Vacuum assist
- Verified process
Tasks Completed

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

(3) 0.6-in. dia. bonded 270 ksi prestressing strands

at mid-span

at anchorage
Flexural Testing
• 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
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External Tendons – Deviation Points

- Effects of fatigue
- Diabolos
Reduced Beam Testing

- Fretting Fatigue
- Duct Damage
- Anchor Fatigue

18 deg.

11 deg.

Severity of Fretting Fatigue

Slip Amplitude

No Damage  Fretting Fatigue Possible  Fretting Wear
Test Design

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

- **North:** Live End
- **South:** Dead End

- **18 deg.**
- **11 deg.**
Anchorage
Tension Tests

Source: instron.com

6'-0” strand region used for tensile tests
Tension Tests

Source: instron.com

Strand sample

18 degree

11 degree

%GUTS

Control #4

Control #5

1-1

1-2

1-3

1-4

1-5

2-1

2-2

2-3

2-4

2-5

2-6

0%

20%

40%

60%

80%

100%

120%

U of Florida 2-2, Free length

0.000 inches
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
Current Research

- 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

- 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
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