

Replaceable Unbonded Tendons for Post-Tensioned Bridges

FDOT Structures Research Update

August 5, 2015

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FDOT Contract BDV31-977-15

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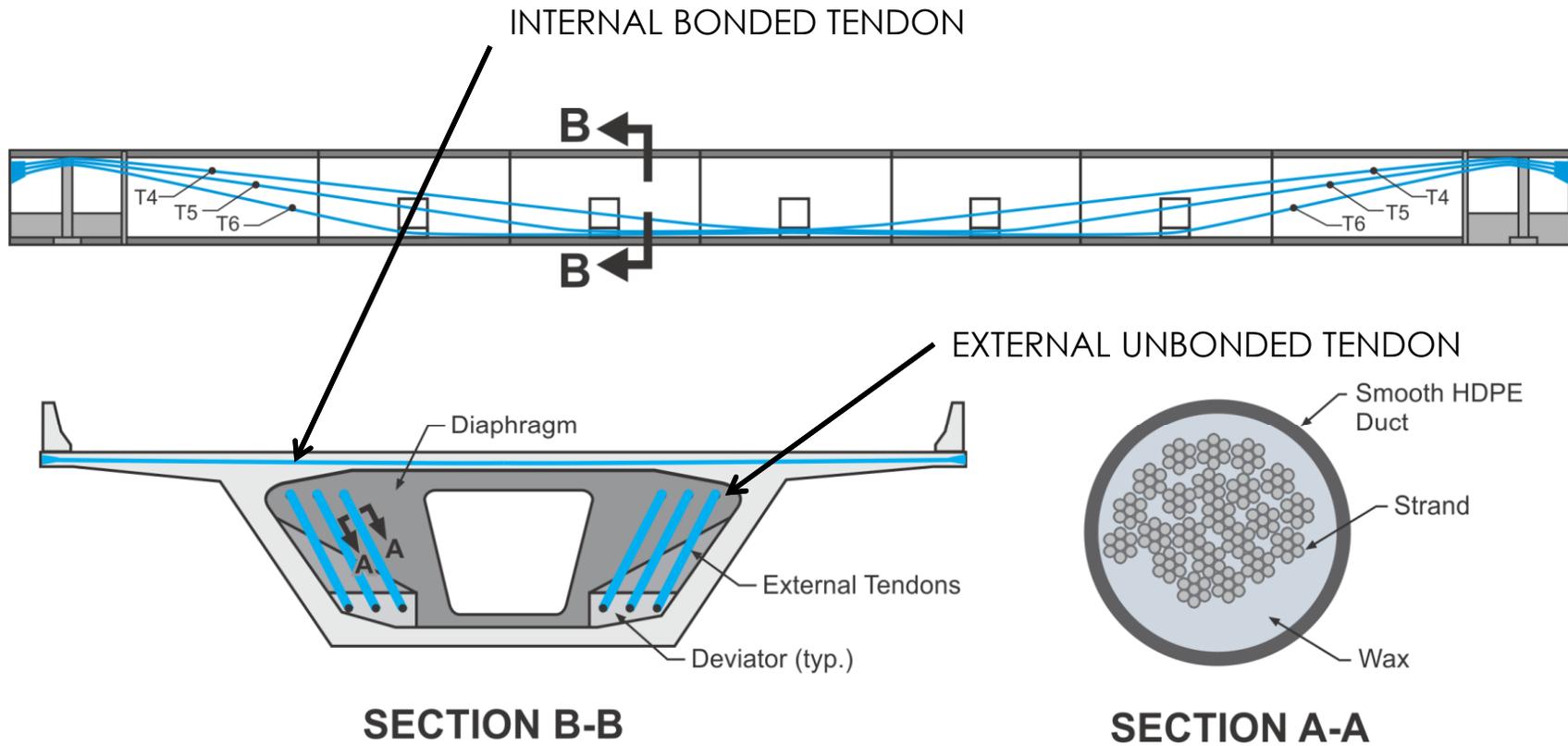
GRA: Natassia Brenkus, A.B.M. Abdullah, Rahul Bhatia



Outline

- ◆ Motivations and scope
- ◆ Testing to date:
 - ✓ (5) 200-ft. mock-up injections
 - ✓ Static testing of full-size beams
- ◆ Future testing

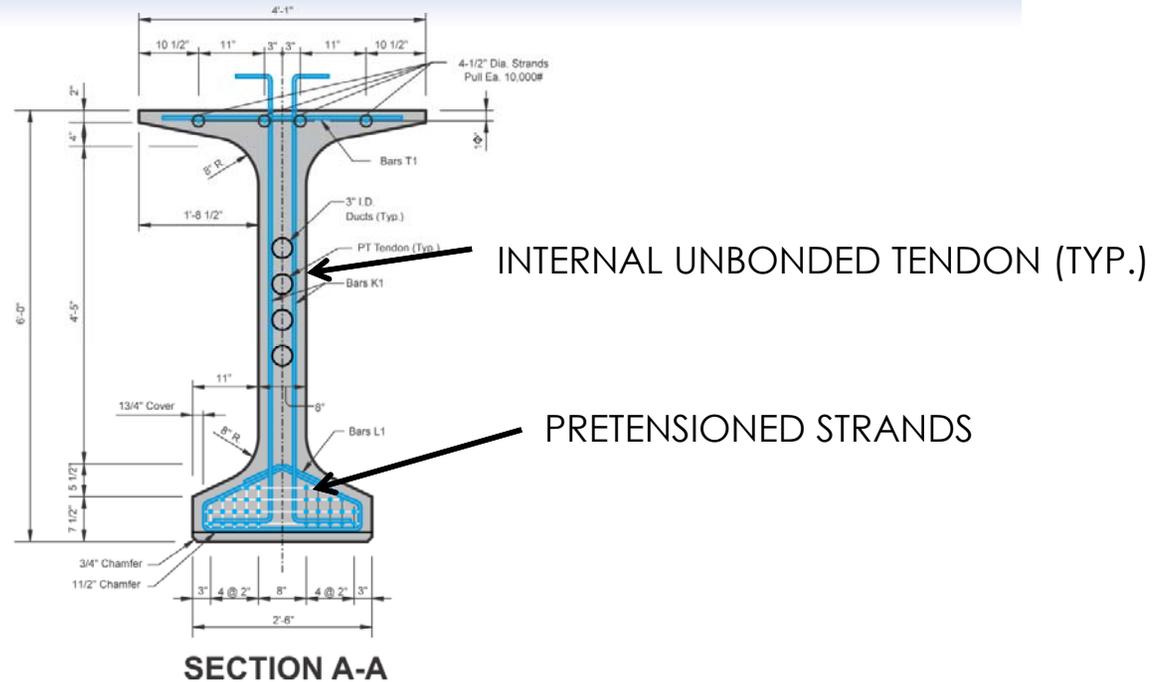
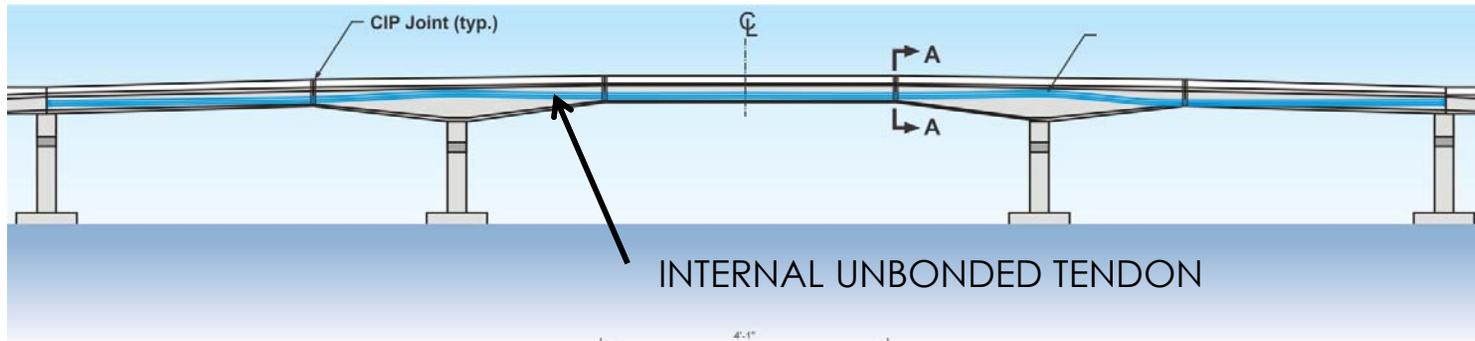
Targeted Applications



**PARSONS
BRINCKERHOFF**

SPAN-BY-SPAN SEGMENTAL BRIDGE

Targeted Applications



**PARSONS
BRINCKERHOFF**

POST-TENSIONED SPLICED GIRDER BRIDGE

Motivations: *Corrosion Protection and Tendon Replaceability*



WAX-INJECTED DUCT



TENDON REMOVAL

Tendons
injected with
flexible fillers



Tendon durability
Easier to replace
Easier to maintain

Filler Materials



Research Objectives

Constructability



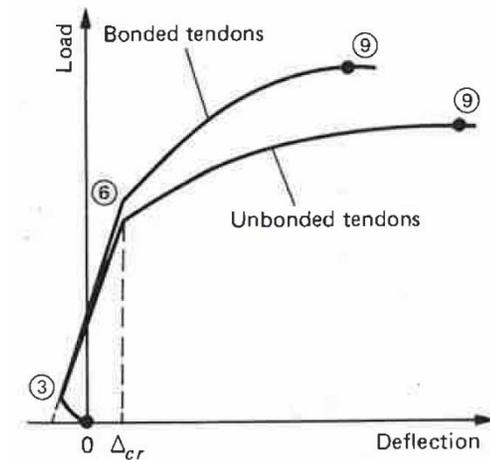
Structural Implications

Bonded vs. unbonded system
Fatigue and fretting (?)

MOCK-UP WAX INJECTION

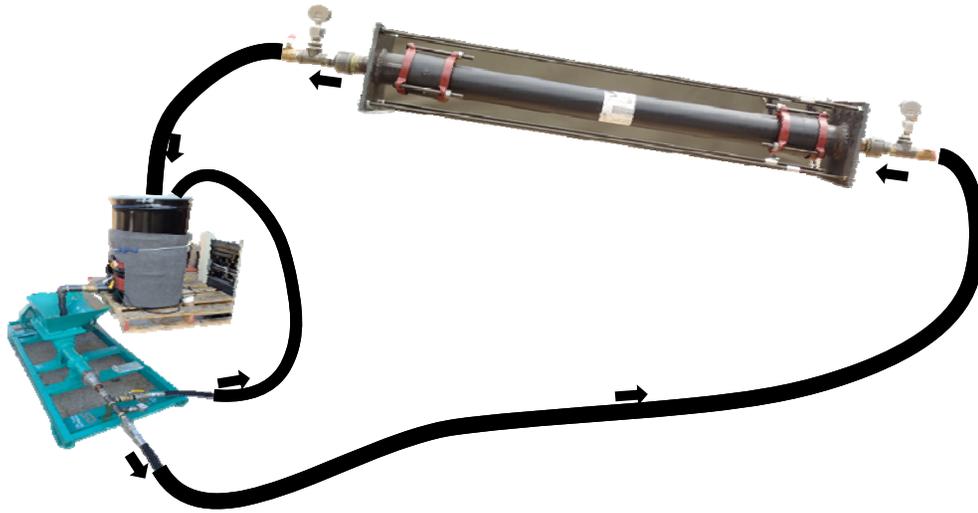
Tendon replaceability

Cut wire detection



Constructability Testing

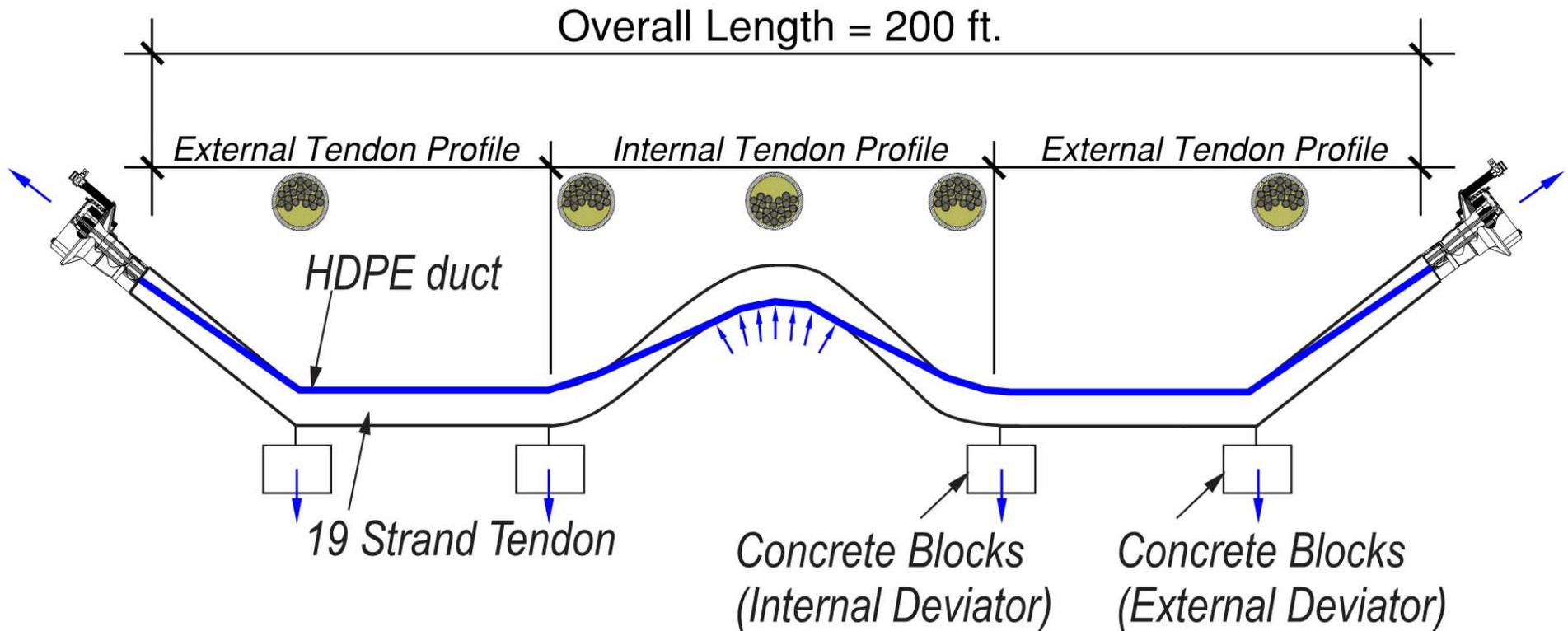
Small Specimen: Component testing



Mock-up: Full-scale injection



Mock-up Injection



- (5) 19 strand tendons @ 200 ft length.
- Light prestressing to achieve profile.
- HDPE with polycarbonate inspection windows.
- Pressure and temperature monitored along length.

Mock-up Injection

- ◆ Several aspects of constructability investigated:
 - ✓ Equipment
 - ✓ Injection port location (anchorage vs. low point)
 - ✓ Speed of injection (3.5 min-15.5 min)



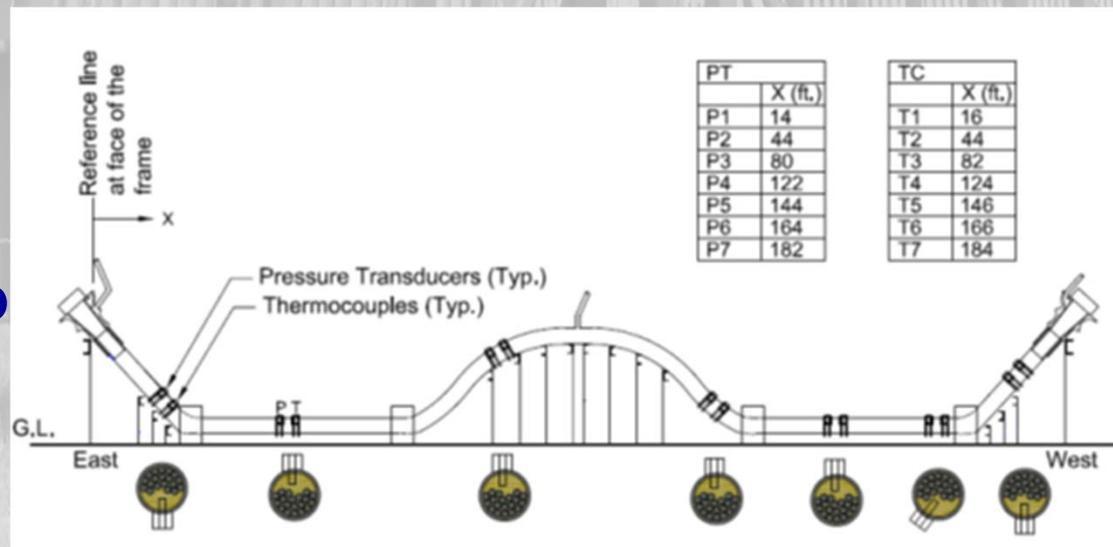
Mock-up Injection

A sample injection

A SAMPLE INJECTION:
VACUUM-ASSISTED END-
TO-END

- ◆ **Materials and Hardware:** Trenton (domestic) with Freyssinet PT
- ◆ **Equipment:** Heated centrifugal pump at inlet/Vacuum pump at outlet
- ◆ **Ambient Temperature:** 70° F
- ◆ **Average Wax Temperature:** 230° F in barrels, at start; 140° F at exit
- ◆ **Injection Duration:** 4 minutes

Pump



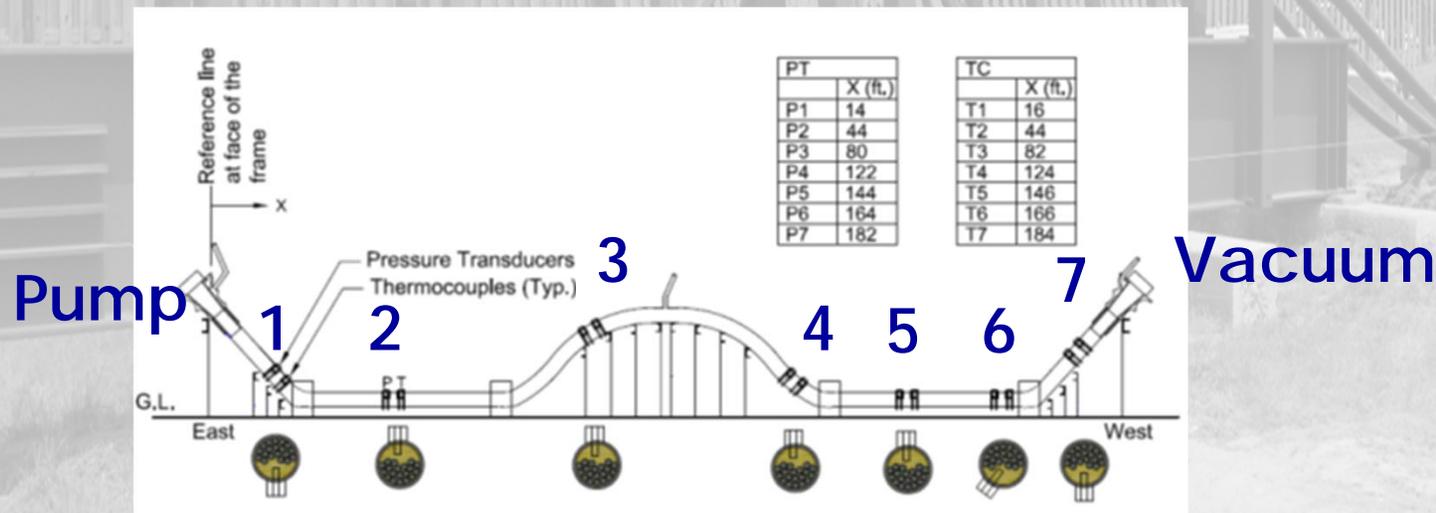
Vacuum

Mock-up Results

A sample injection

A SAMPLE INJECTION:
VACUUM-ASSISTED END-
TO-END

- ◆ Pressure
 - ✓ At start: -14 psi (vacuum)
 - ✓ Locked-in: +50 psi
- ◆ Internal temperature: 130-200 °F
- ◆ Duct surface temperature: 90-150 °F

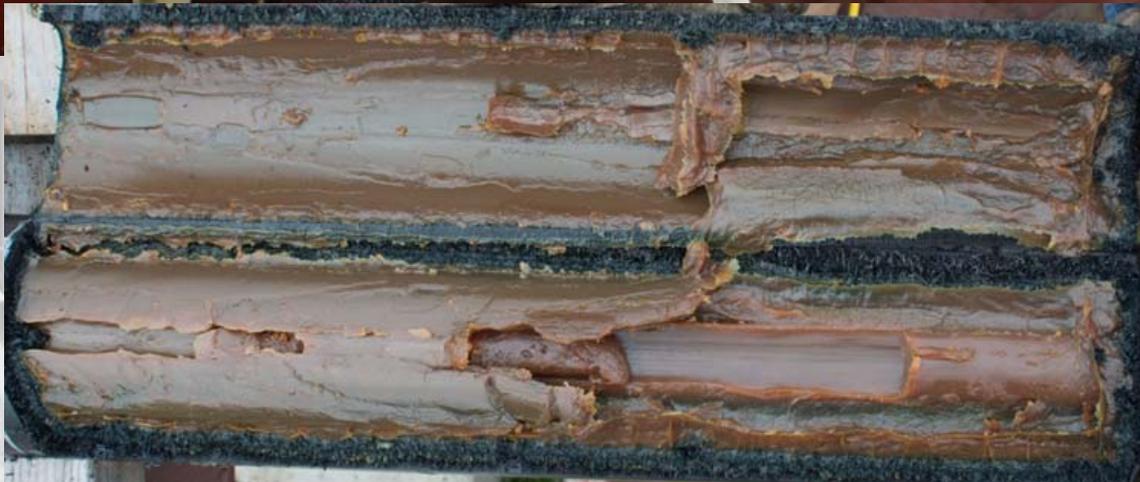


Mock-up Results

A sample injection



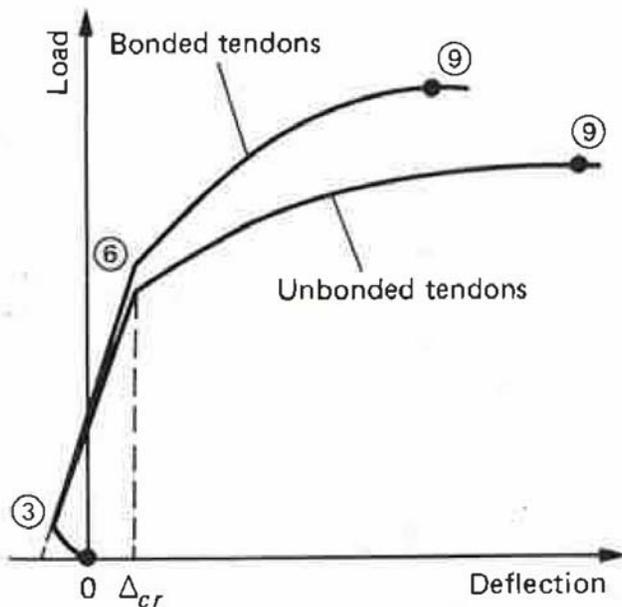
A SAMPLE INJECTION:
VACUUM-ASSISTED END-
TO-END



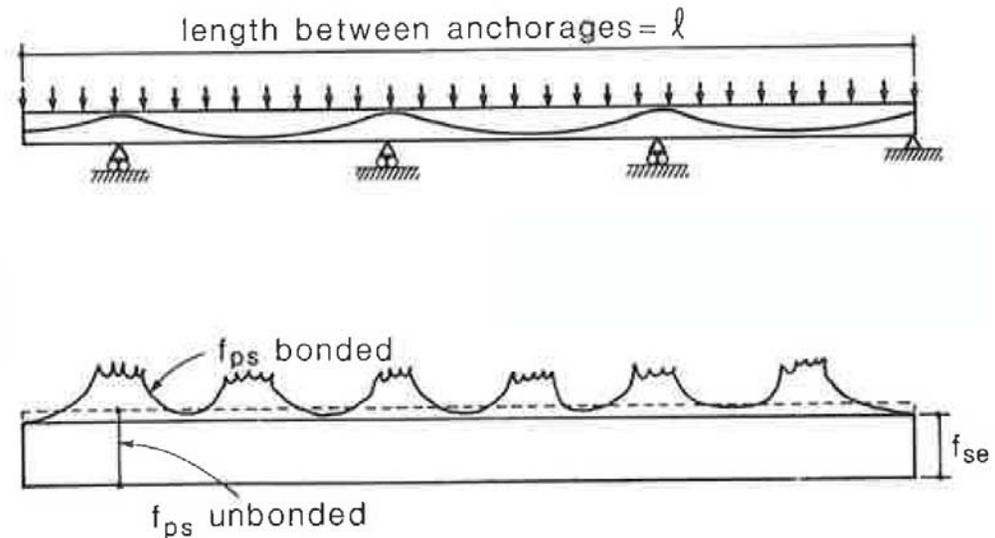
Interim report: [BDV31-977-15](#)
available online

Structural Implications

Comparison of structural behavior:
Bonded (grouted) vs. unbonded (flexible filler) tendons



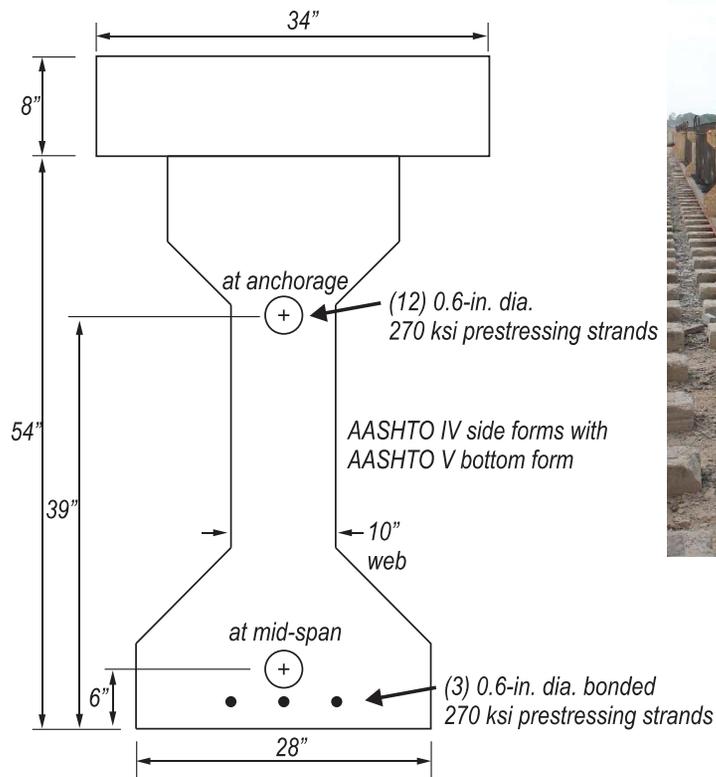
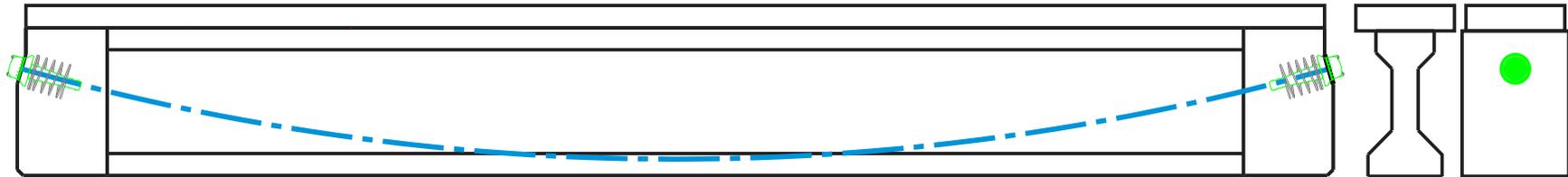
Load vs Deflection



Tendon stresses (f_{ps}) at Ultimate:
Unbonded < bonded at critical sections.

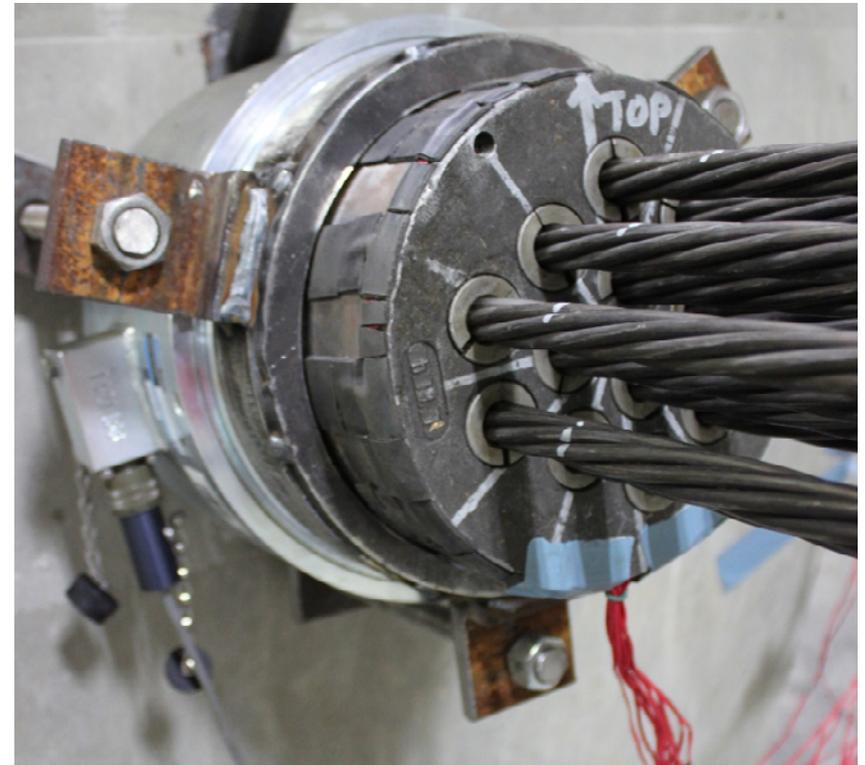
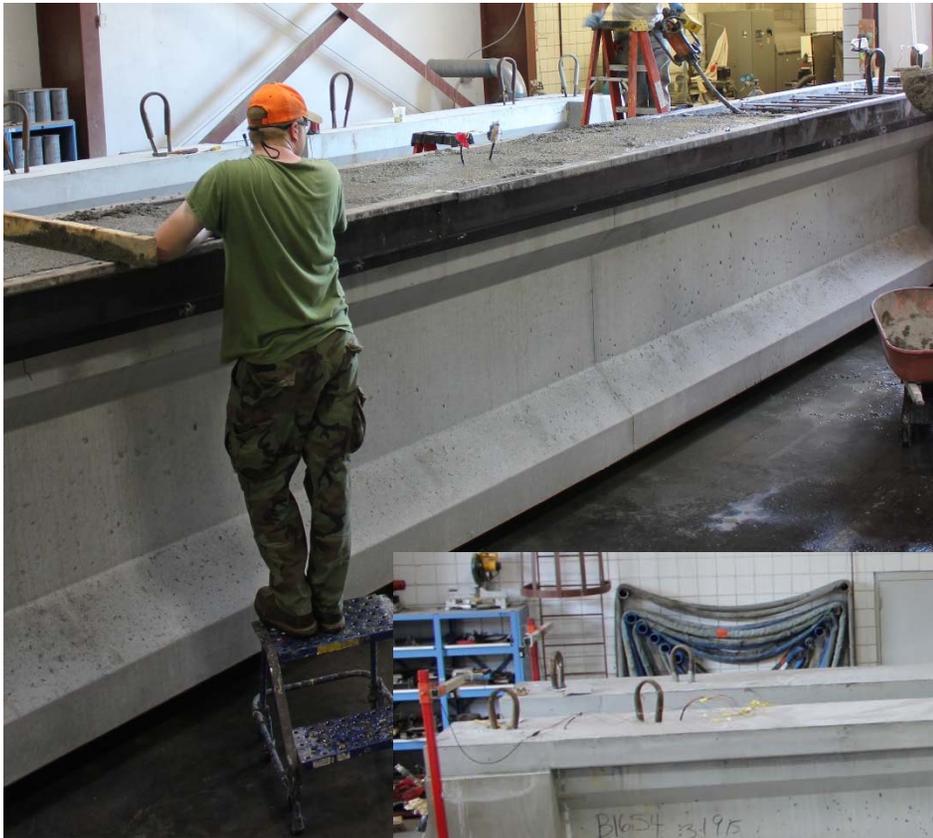
Internal Tendon Specimens: Grouted vs. Unbonded

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

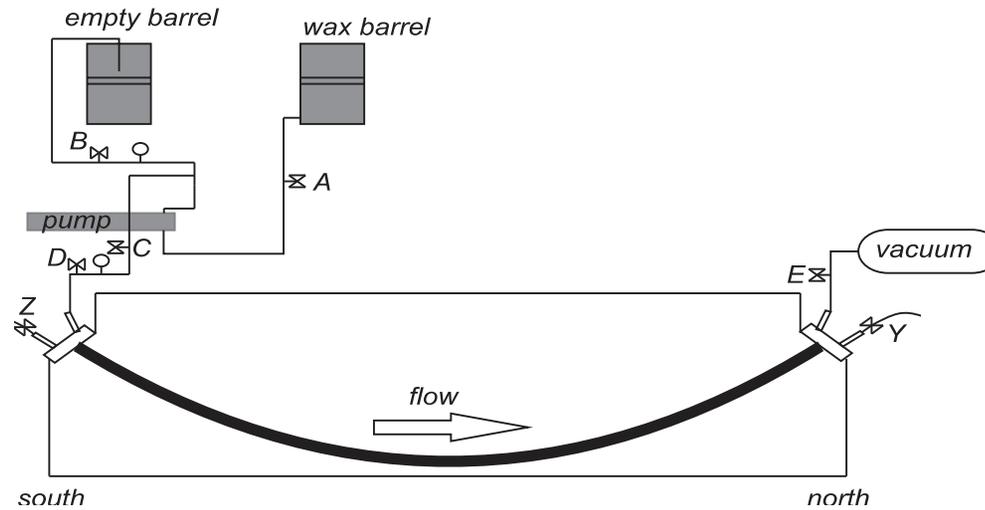


Internal Tendon Specimens: Grouted vs. Unbonded

- ◆ (1) grouted and (1) wax-injected



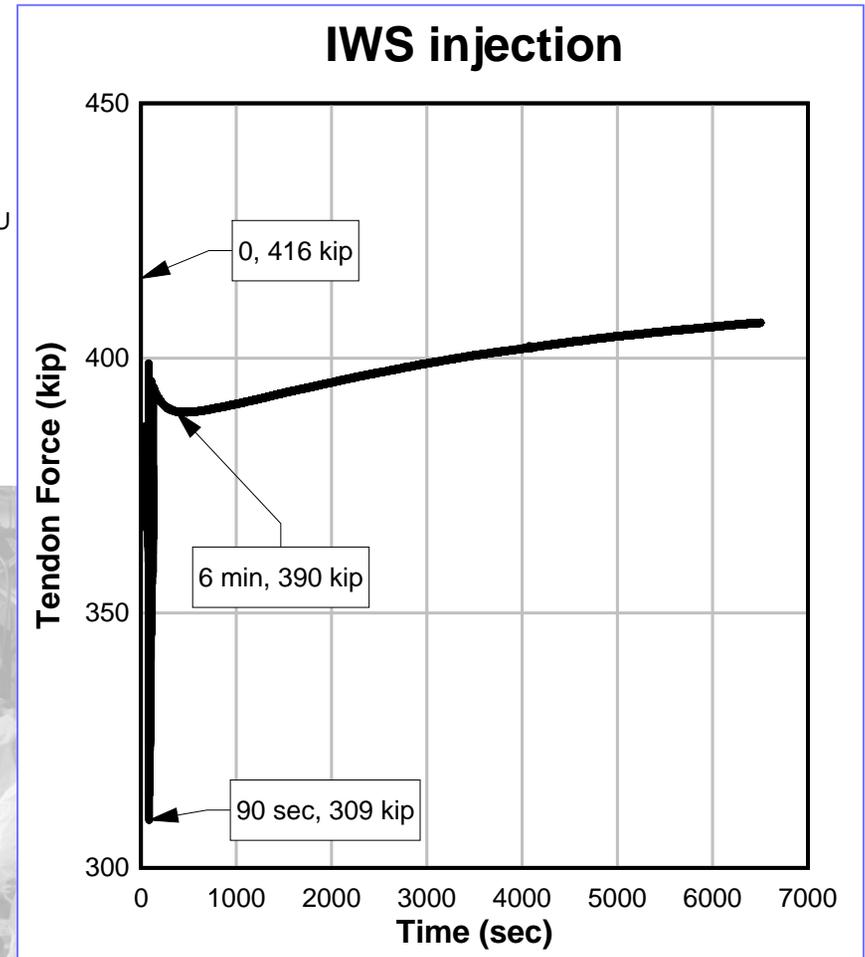
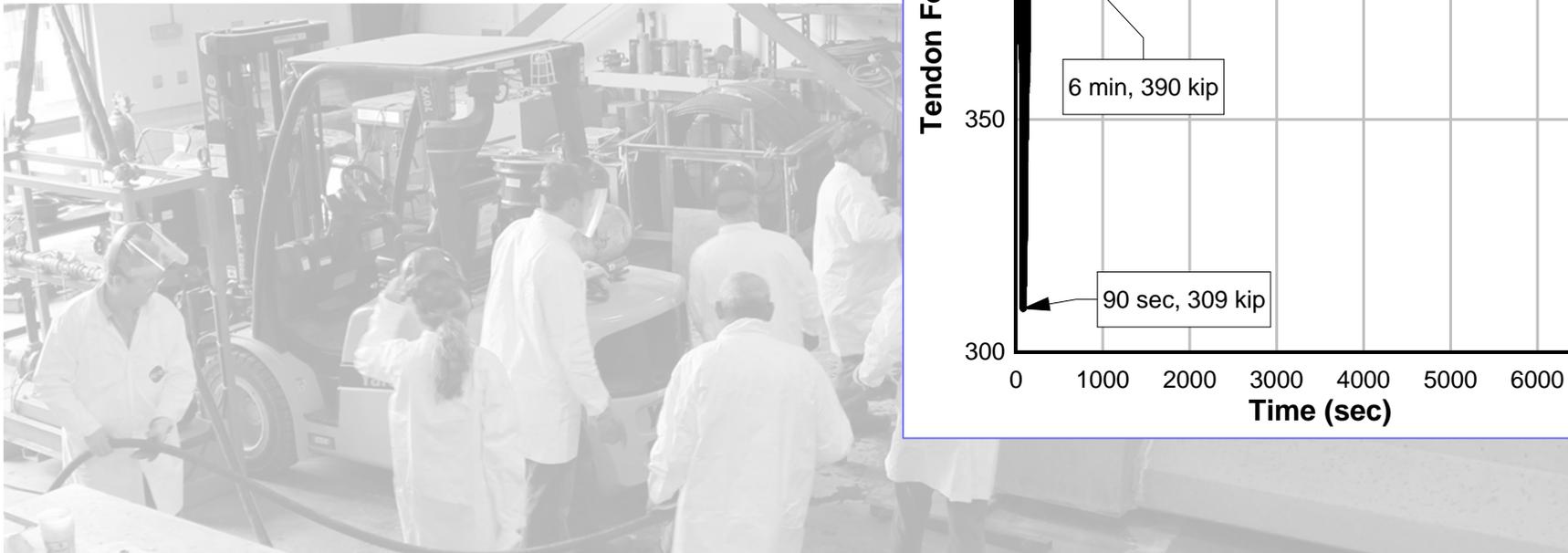
Internal Tendon Specimens: Injection



Wax (barrels): 212 °F
Ambient : 83 °F

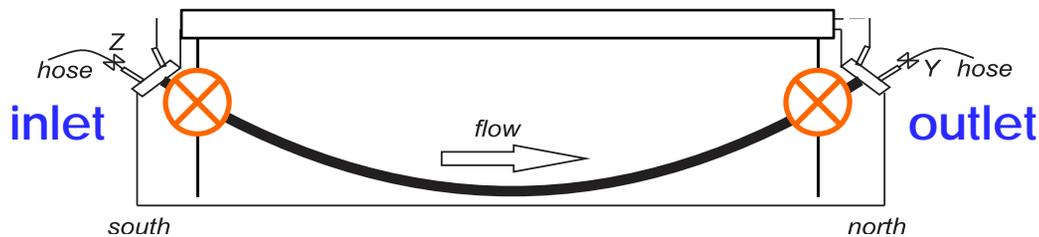
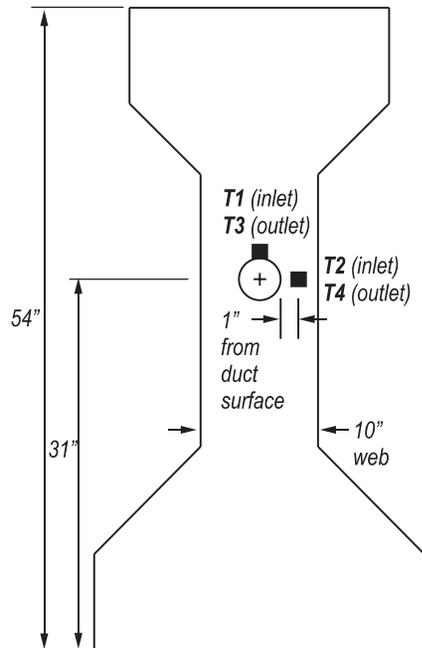
Internal Tendon Specimens: Injection

- ◆ Wax temperature: 212 °F
- ◆ Ambient temperature: 83 °F
- ◆ Force at start of injection: 416 kip or $0.6f_{pu}$
- ◆ Tendon force drop: ≈ 25 kip after 6 min.
- ◆ Approx. 7 hrs. to force recovery

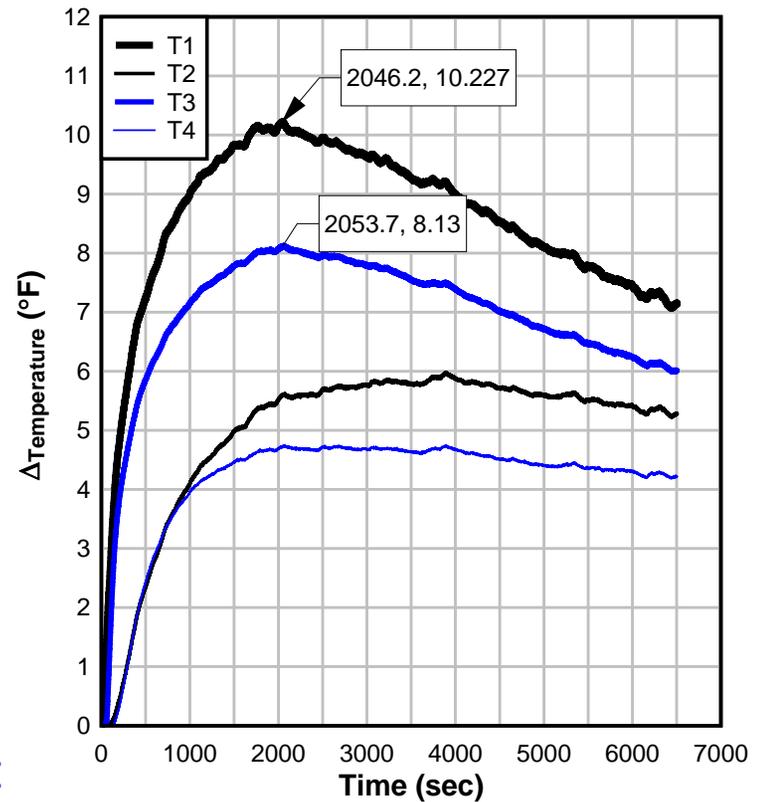


Internal Tendon Specimens: Injection

- ◆ Max. concrete temperature change ≈ 10 deg F

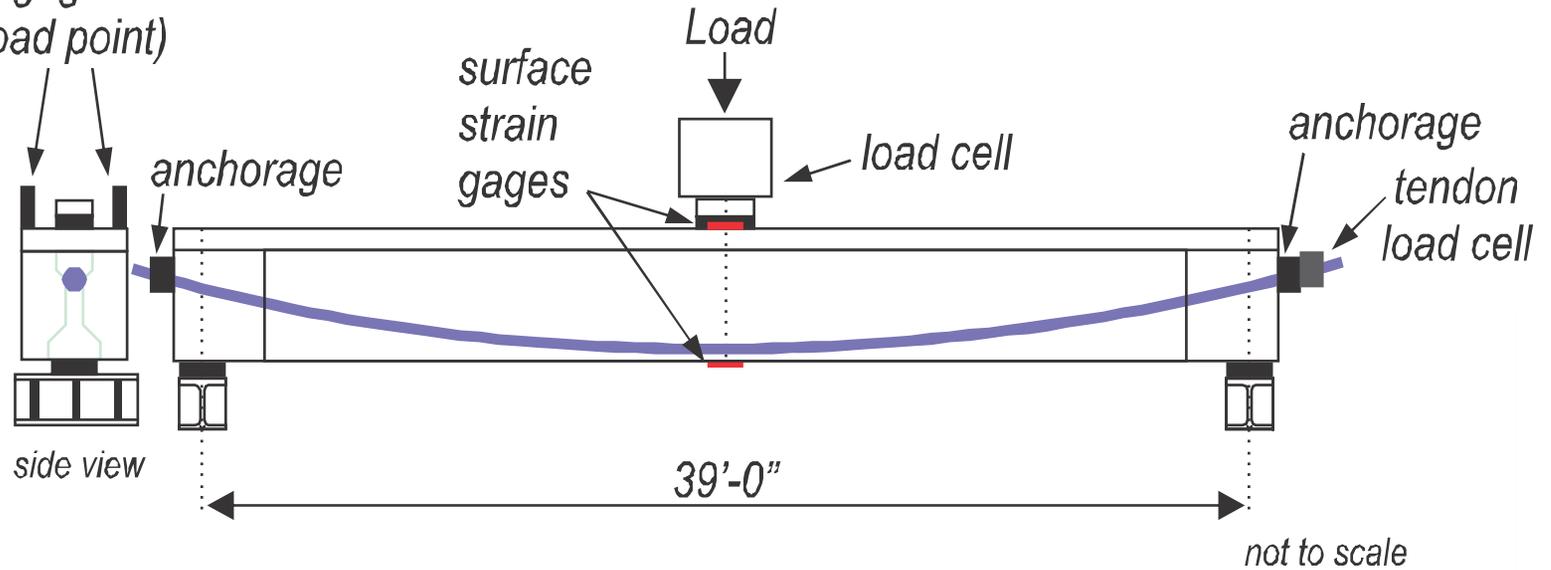


IWS
Concrete Web
Near inlet and near outlet

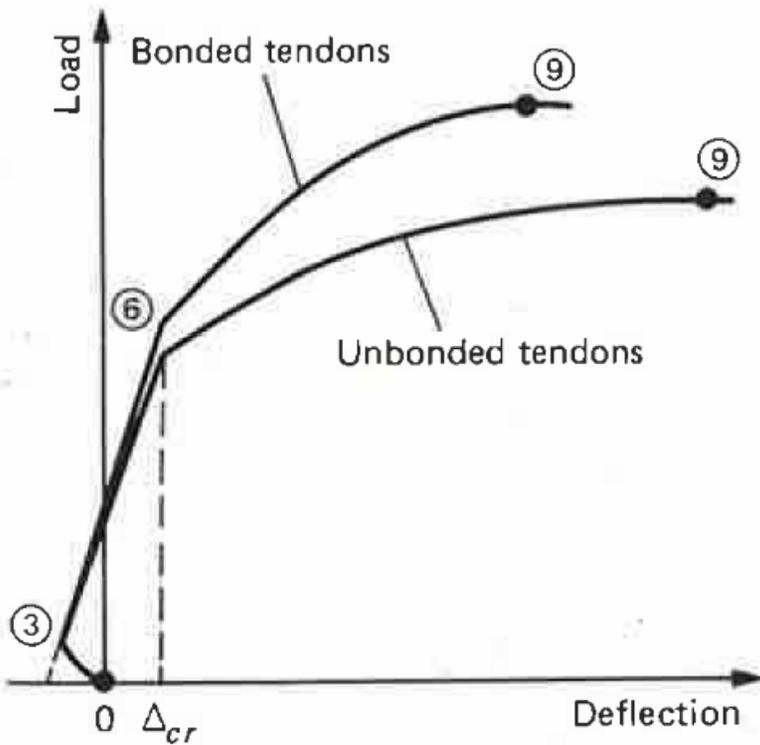


Internal Tendon Specimens: Static Testing

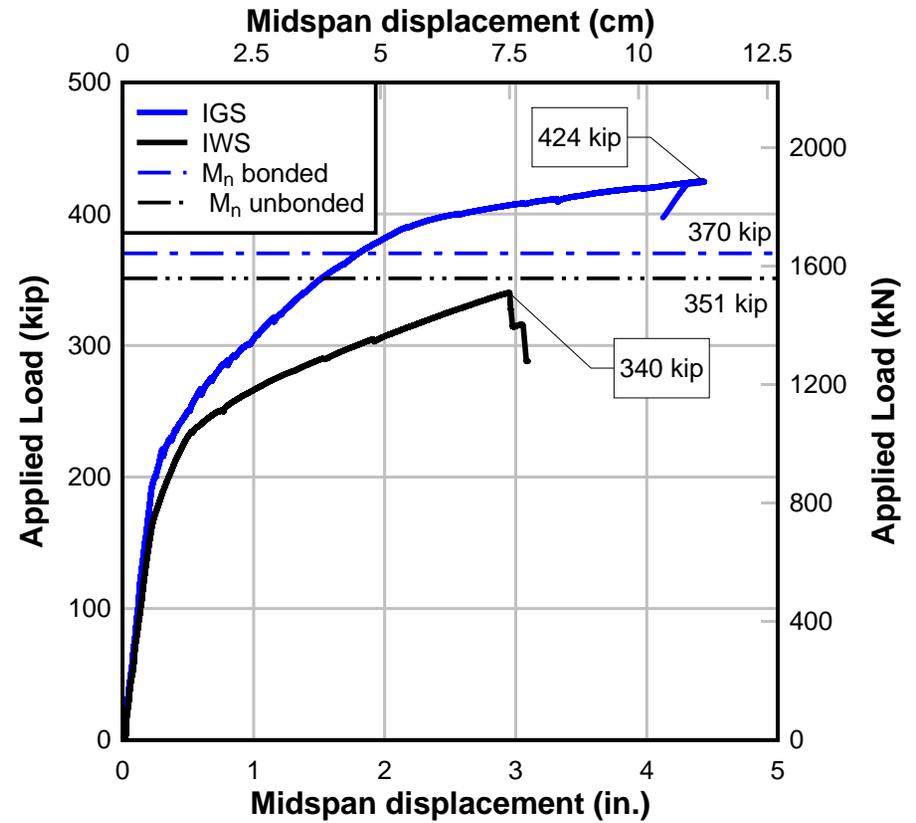
displacement gages
(either side of load point)



Internal Tendon Specimens: Static Testing



IGS vs. IWS



Internal Tendon Specimens: *Static Testing*

- ◆ **IGS:** compression failure of deck at load point
- ◆ vs. **IWS:** rupture of the bonded prestressing steel (deck strain $\gg 0.003$)

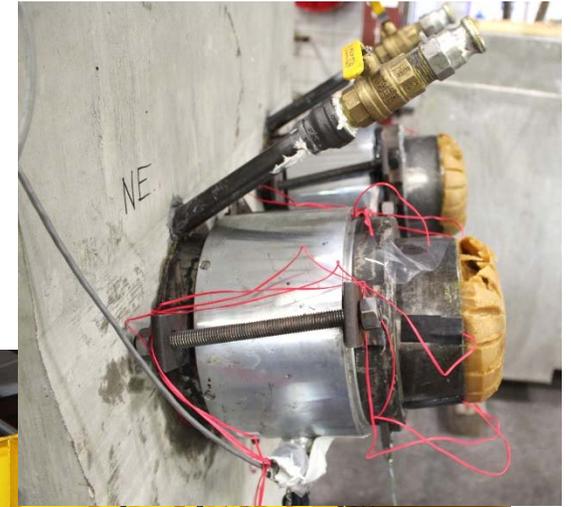


IGS: crushing of the deck at max load



IWS: rupture of bonded prestressing

External Tendons Specimen: Static Testing

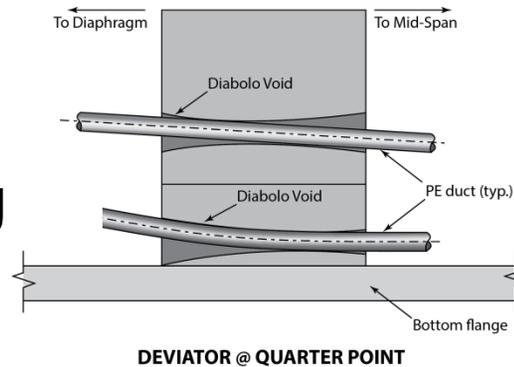


Future Tasks

Fatigue testing

- Full-size beams (under construction):
- (1) specimen with parabolic internal tendon
- (1) specimen with external tendons

Reduced beam testing



Tendon replaceability



Thank you



Co-PIs: Dr. Trey Hamilton and Dr. Jennifer A. Rice

Research Assistants: Natassia Brenkus, Rahul Bhatia, and A.B.M. Abdullah

FDOT Coordinators: Will Potter and Rick Vallier

Special thanks to the Structures Research Center staff