FDOT TRANSPORTATION SYMPOSIUM

Structures Research Update

Christina Freeman

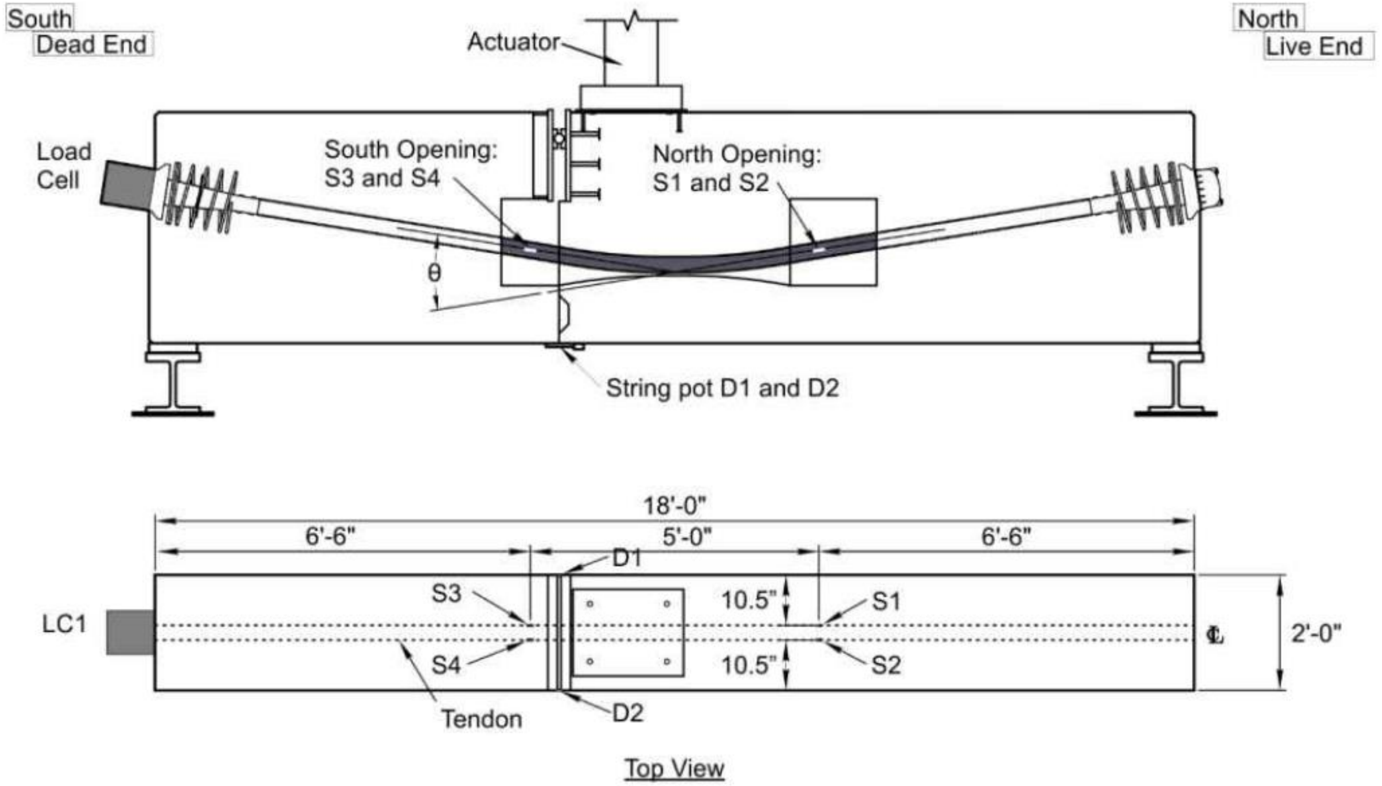
Structures Research Center

- Large Scale Structures Research
  - In-House
  - University/Consultant
- Bridge Load Testing/Rating and Monitoring

Diabolo Deviator Simulation with Flexible Filler

As Part of the Research Project: *Replaceable Unbonded Tendons for Post-Tensioned Bridges*

Test Beam



Source: Hamilton et al. *Replaceable Unbonded Tendons for Post-Tensioned Bridges*. UF, 2017.

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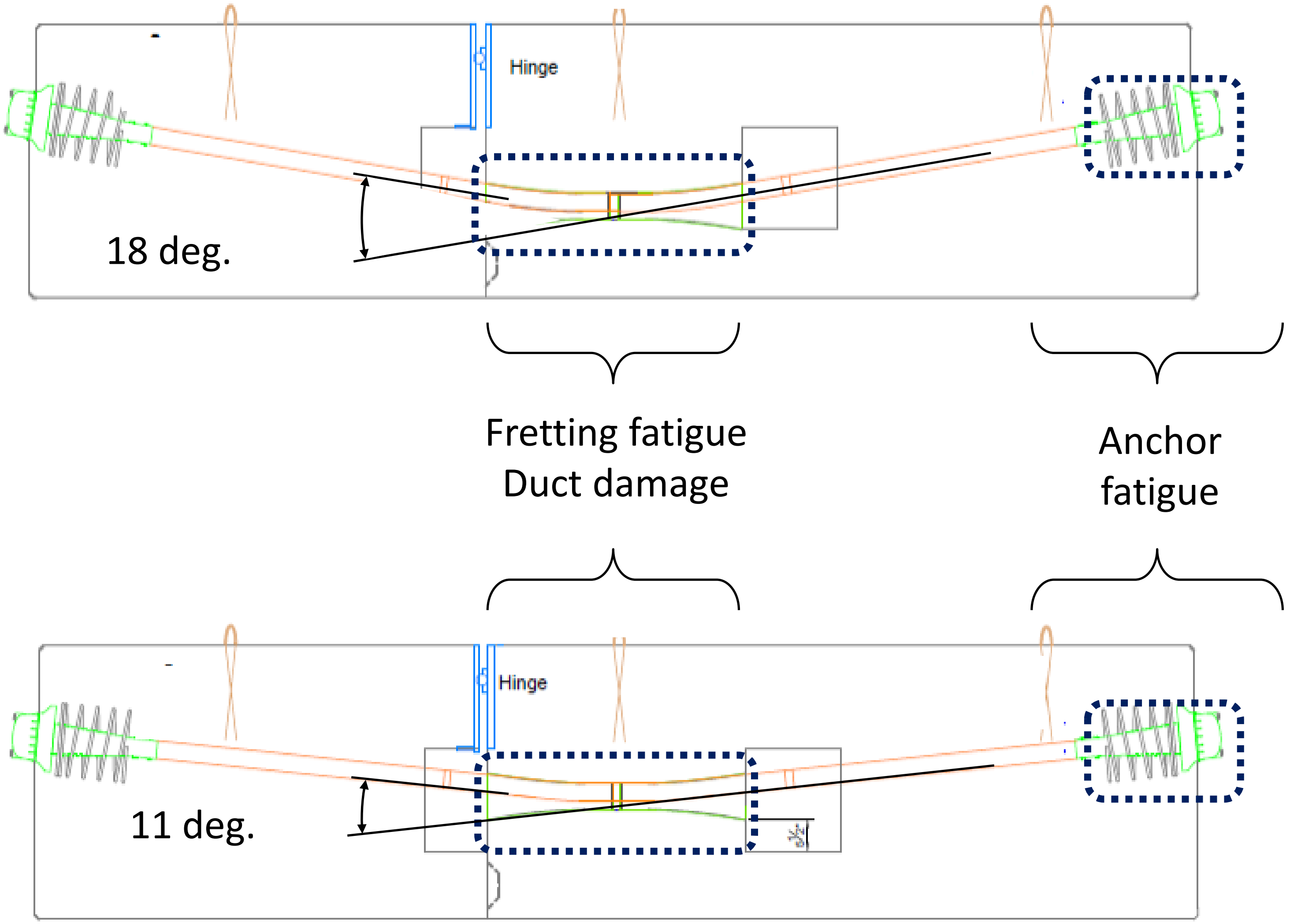
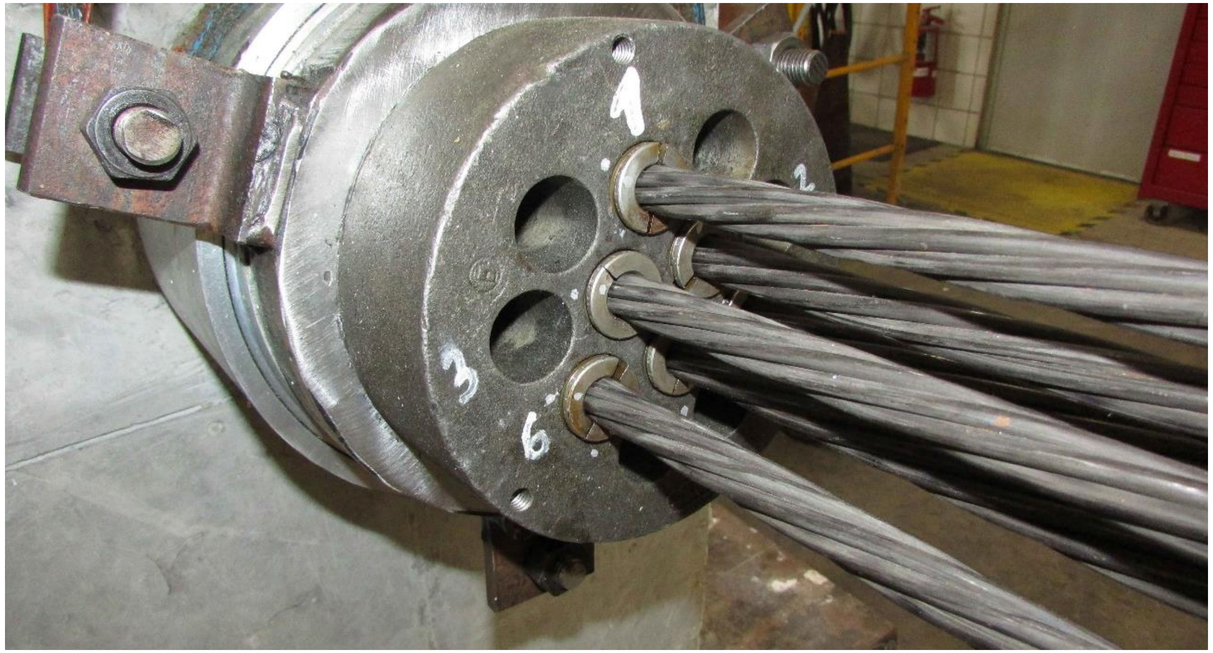
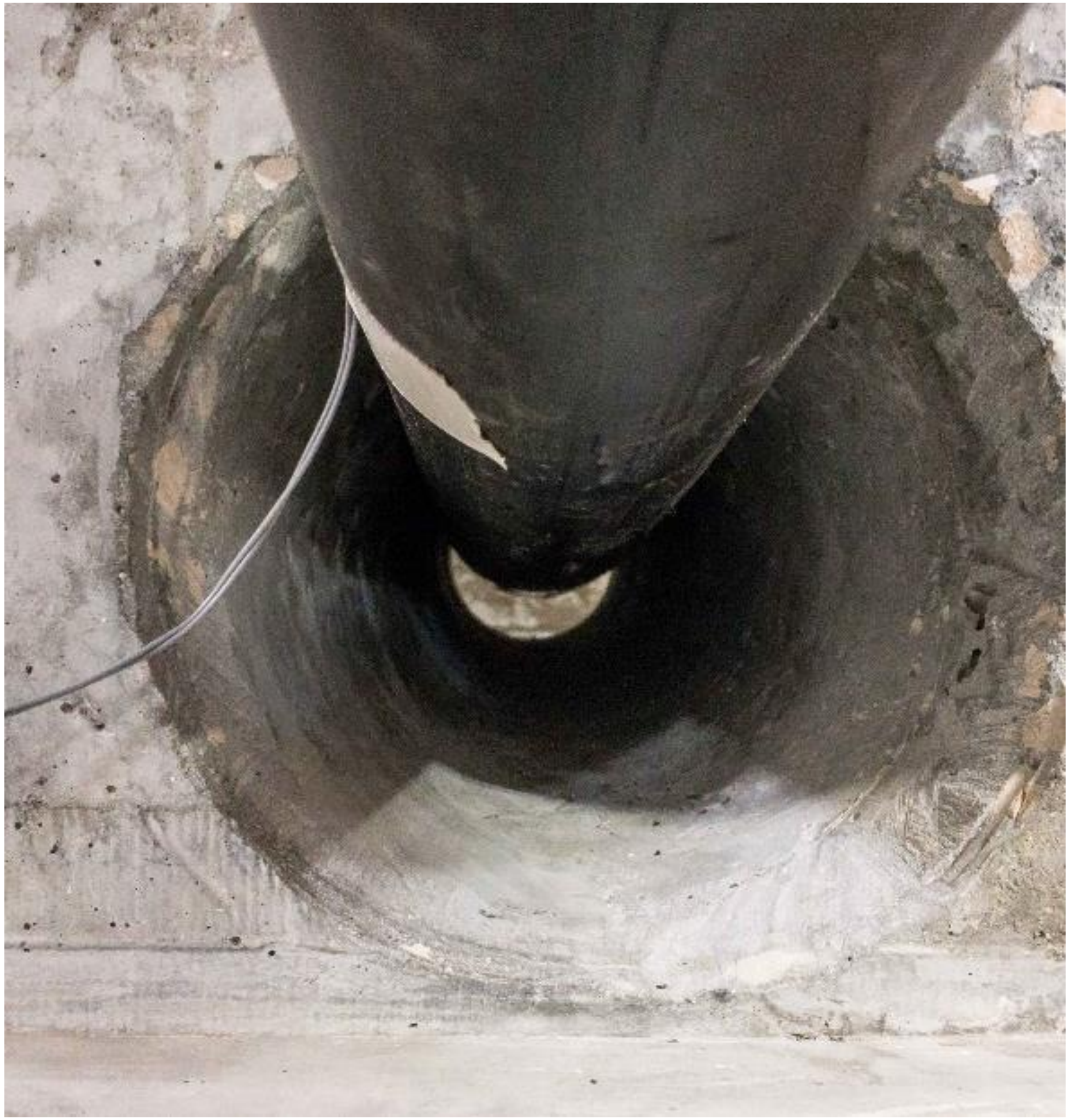
ETAG 013 Fatigue Test



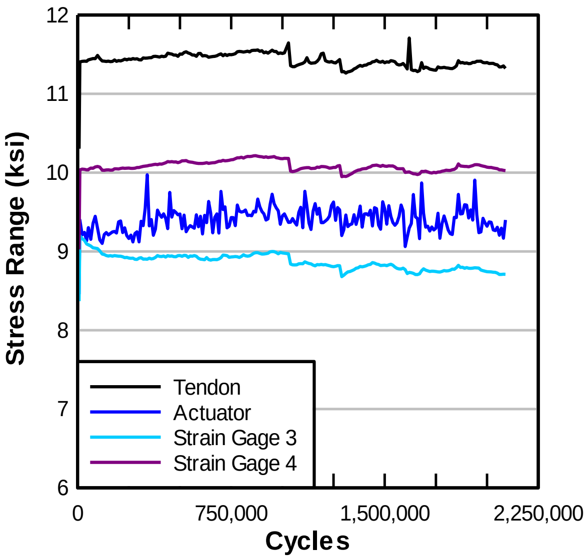
Source: Hamilton et al. *Replaceable Unbonded Tendons for Post-Tensioned Bridges Presentation*. UF, 2017.

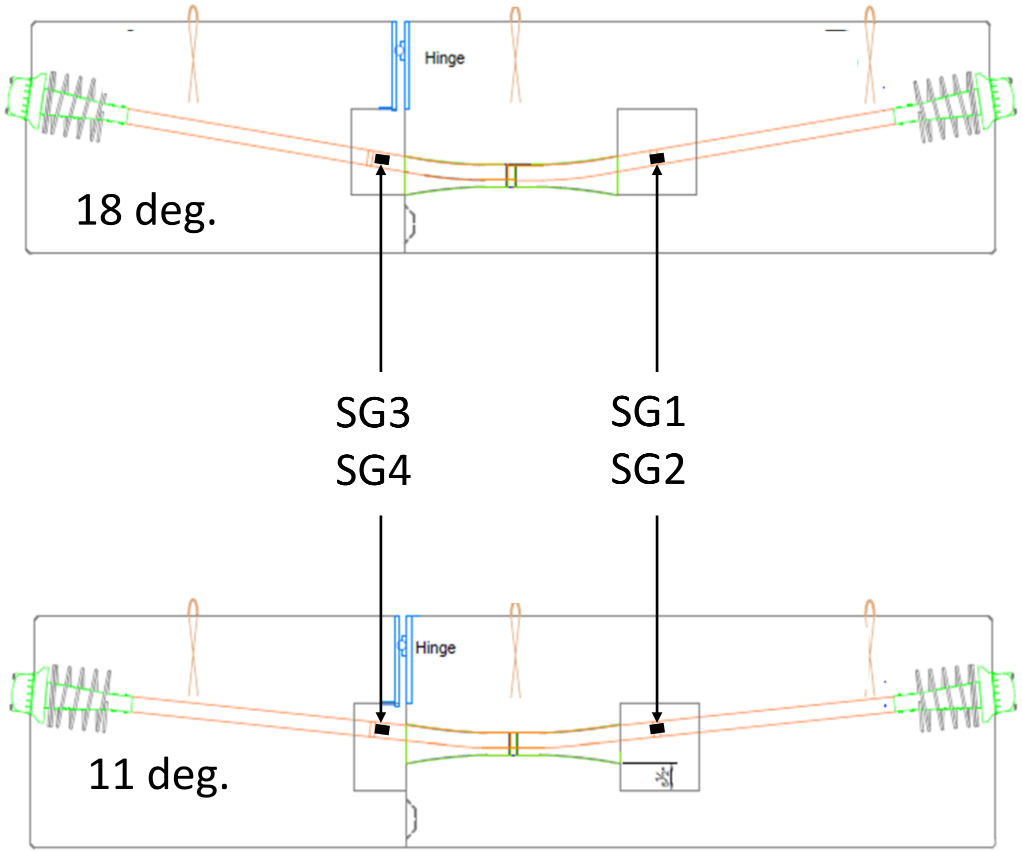


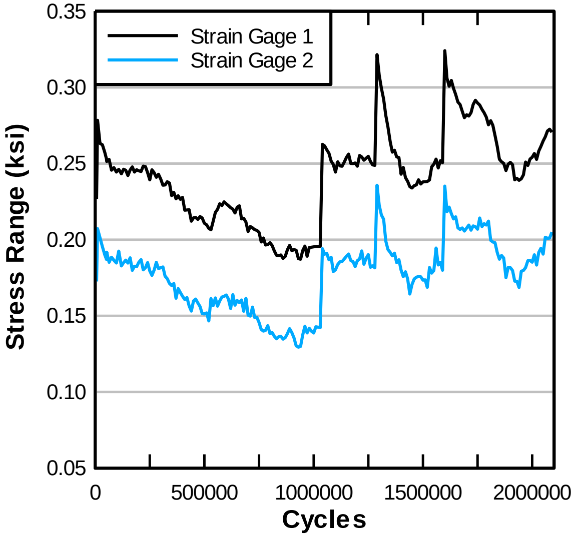


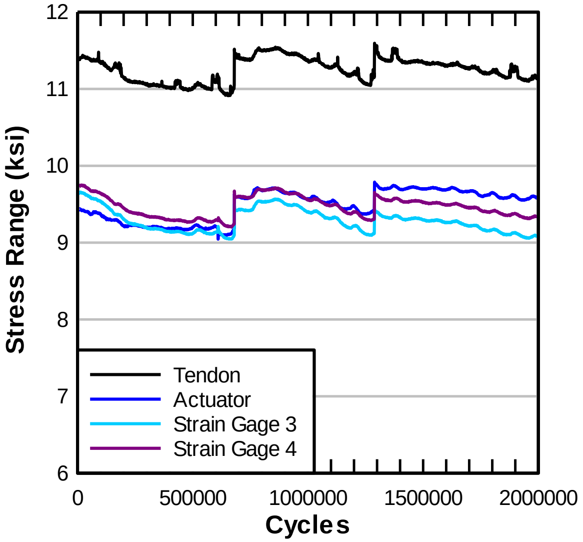
Source: Hamilton et al. *Replaceable Unbonded Tendons for Post-Tensioned Bridges Presentation*. UF, 2017.

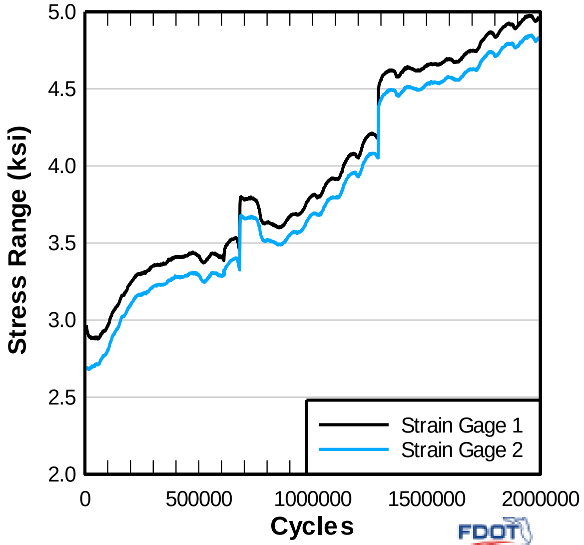
Test Results





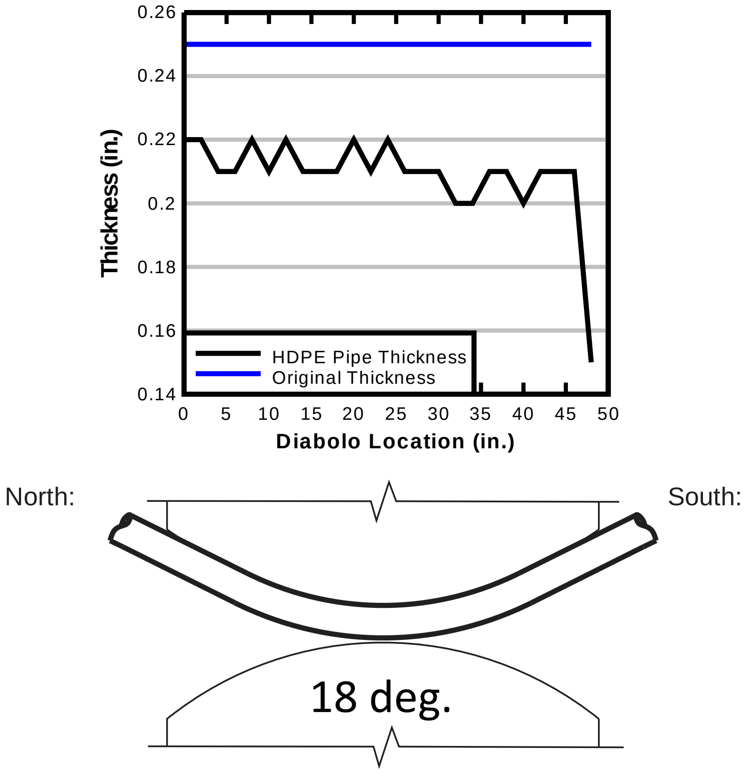


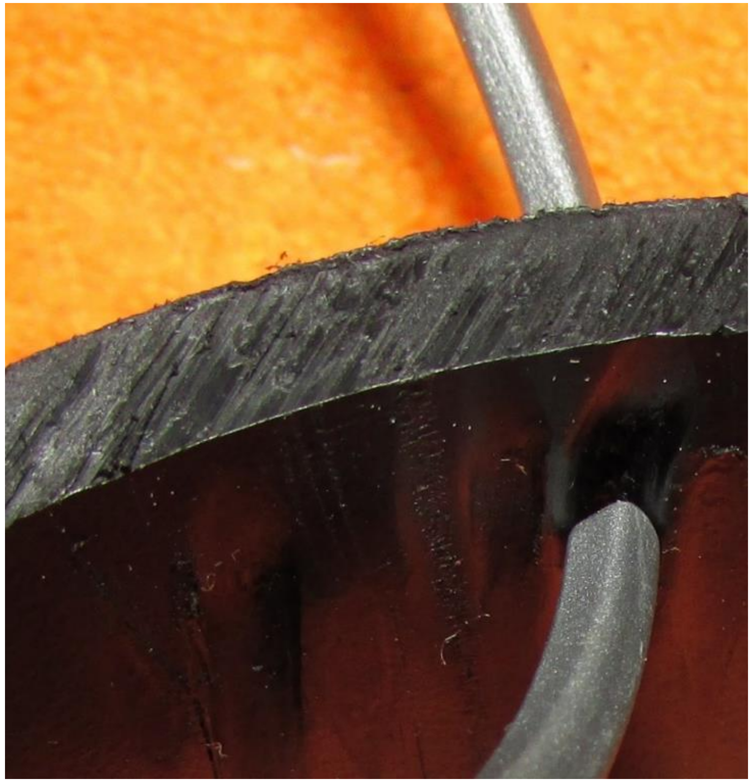


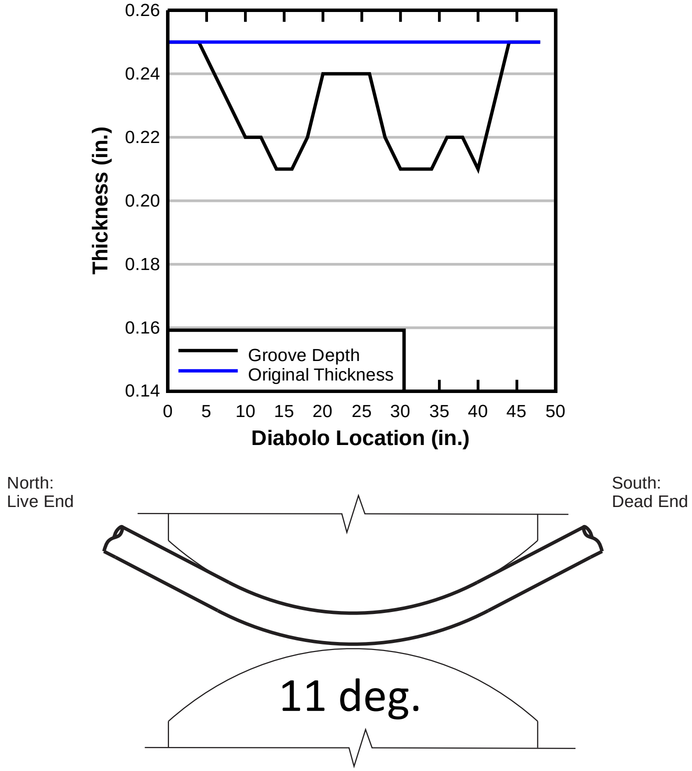


Source: Hamilton et al. *Replaceable Unbonded Tendons for Post-Tensioned Bridges Presentation*. UF, 2017.

Dissection: HDPE Thickness

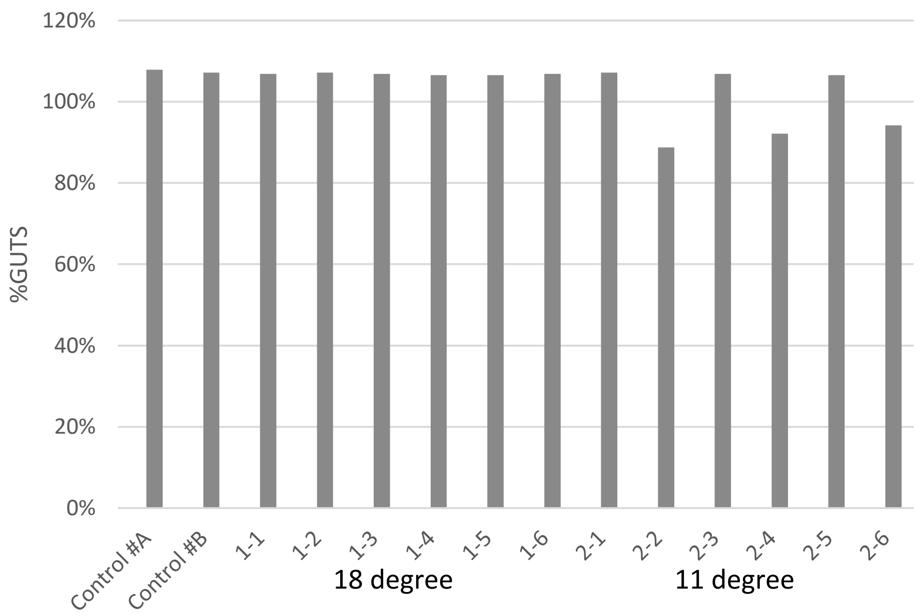


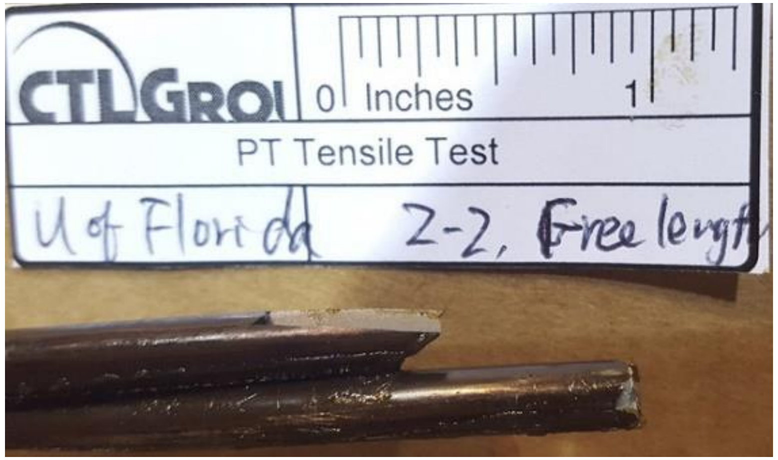




Source: Hamilton et al. *Replaceable Unbonded Tendons for Post-Tensioned Bridges Presentation*. UF, 2017.

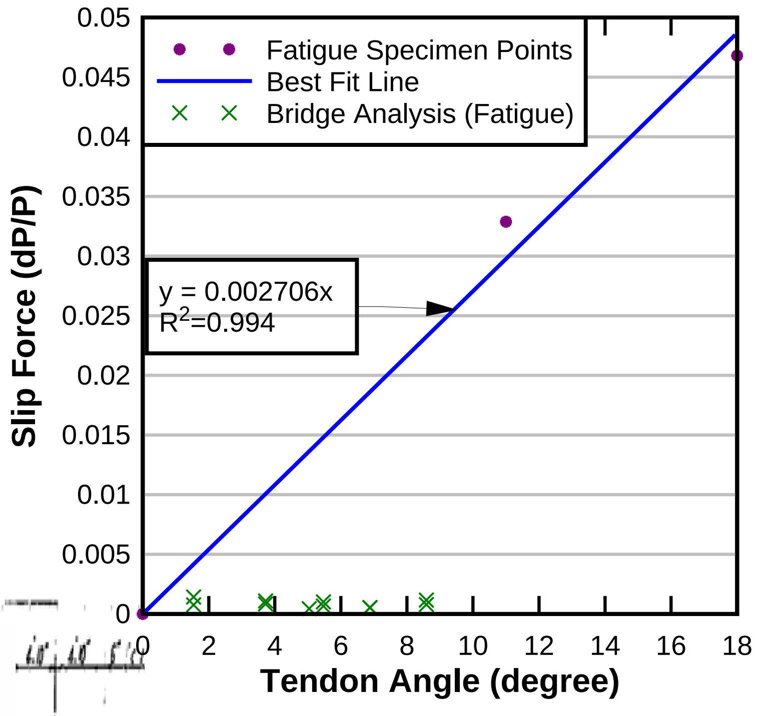
Post-testing Strand Test

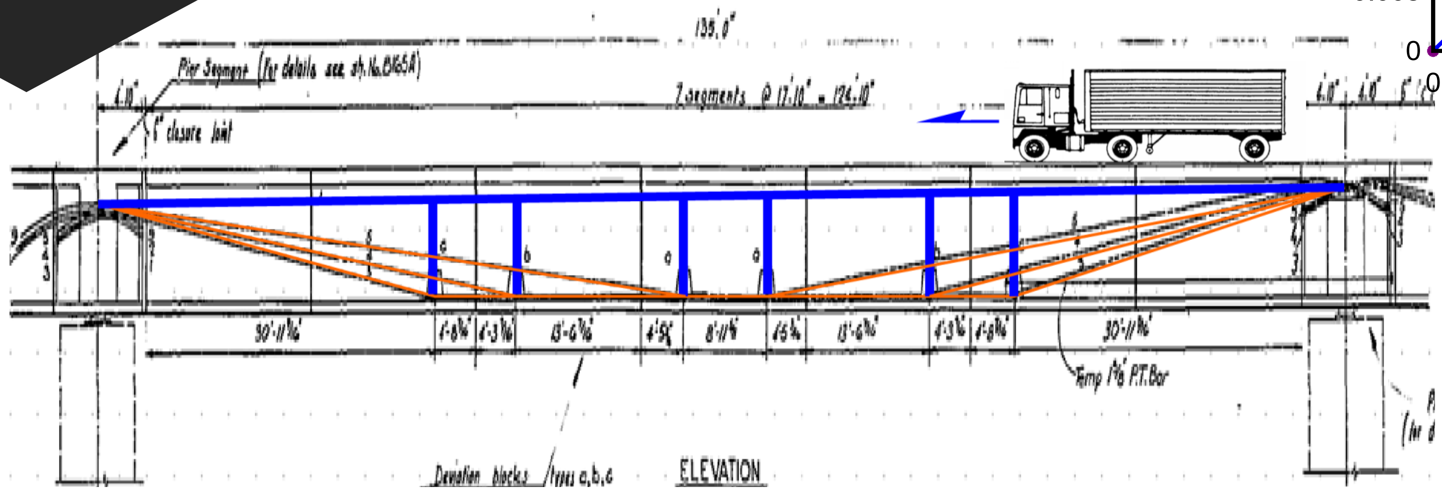


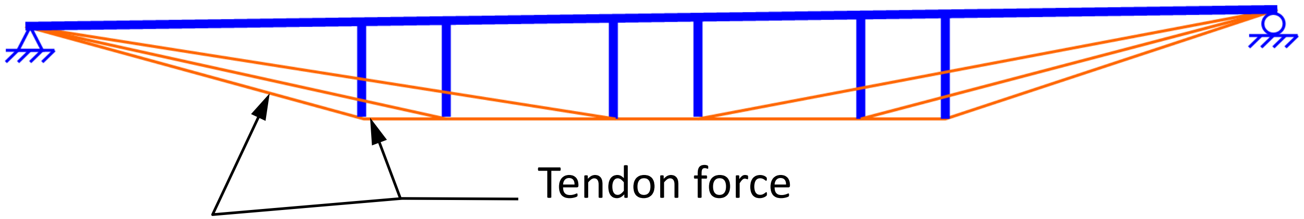


Source: Hamilton et al. *Replaceable Unbonded Tendons for Post-Tensioned Bridges Presentation*. UF, 2017.

Comparison to Prototype Bridge







Source: Hamilton et al. *Replaceable Unbonded Tendons for Post-Tensioned Bridges Presentation*. UF, 2017.

Techniques to Remove Defective Grout

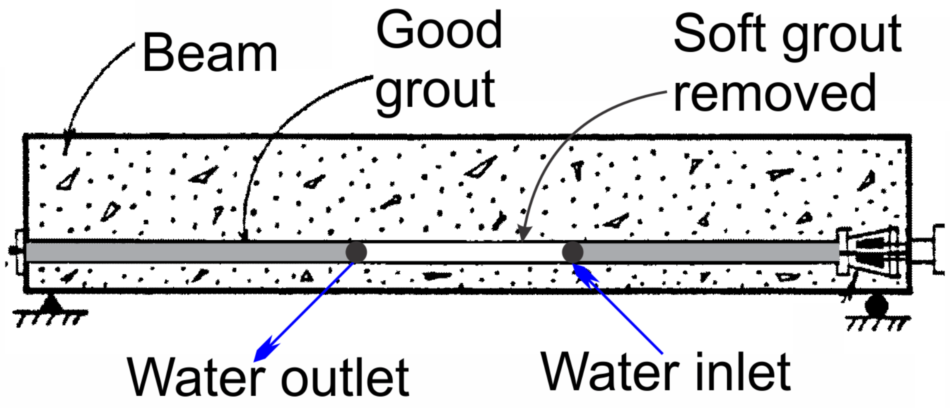
Wonderwood Bridge

Source: TranSystems "Summary of Findings for Bridge No. 720677" 2012.

Two Treatment Methods

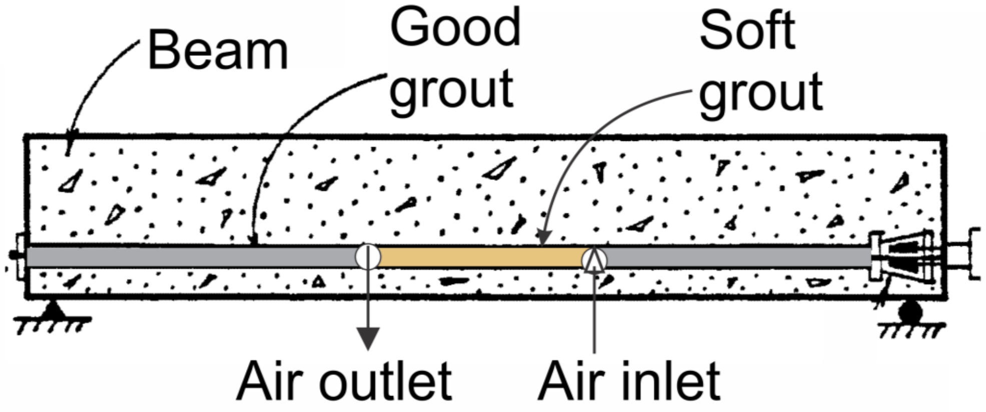
Hydrodemolition

- Remove and replace soft grout



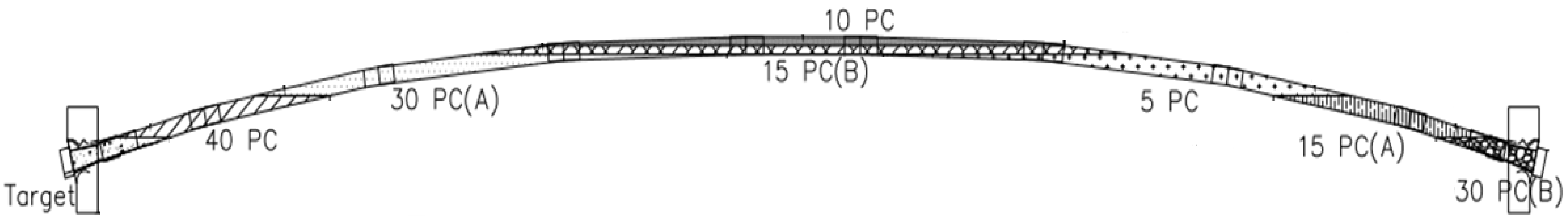
Drying

- Remediate soft grout and leave in place



Source: Hamilton et al. *Evaluation of Techniques for Removal of Defective Grout from Post-Tensioning Tendons Presentation*. UF, 2017.

Hydrodemolition Test Setup



Source: Hamilton et al. *Evaluation of Techniques for Removal of Defective Grout from Post-Tensioning Tendons Presentation*. UF, 2017.

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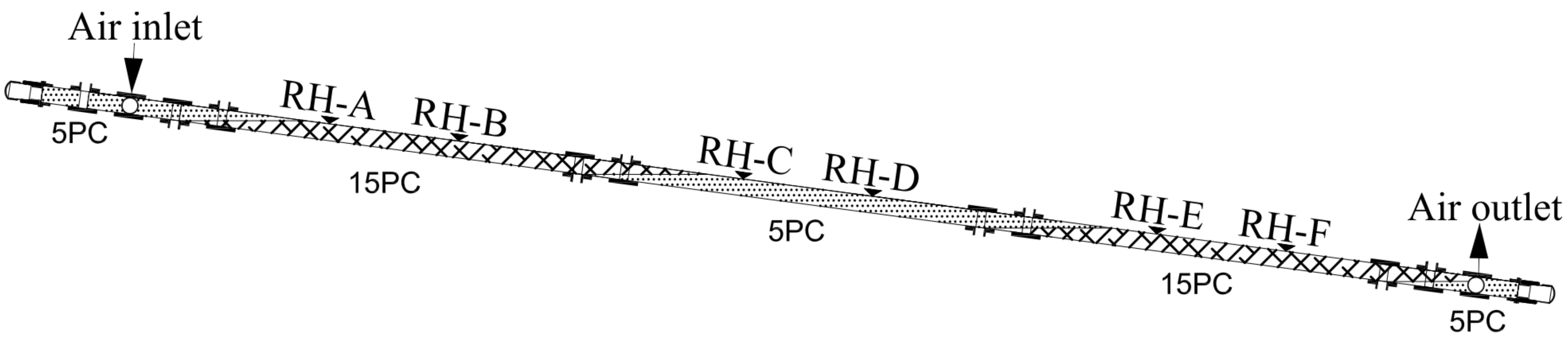
Hydrodemolition Trial

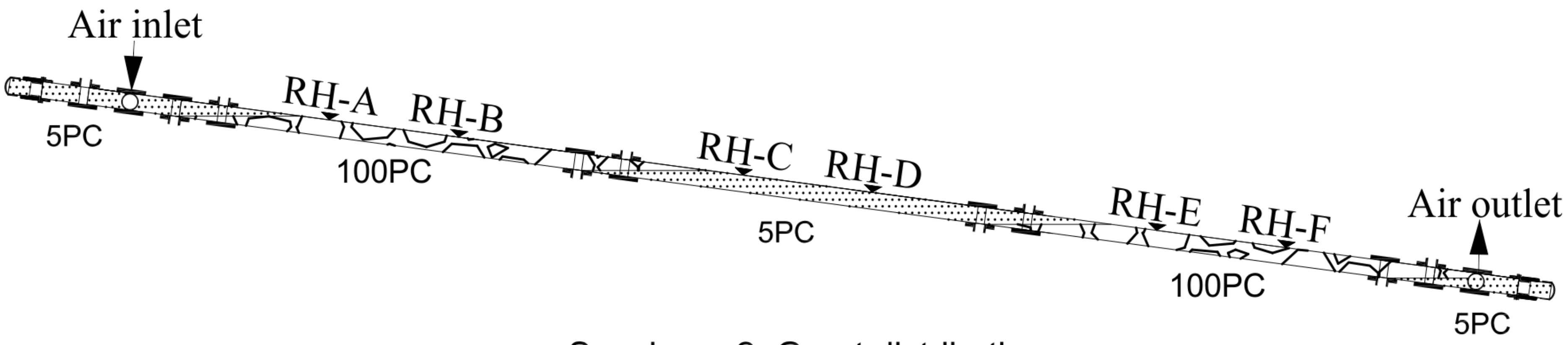
Source: Hamilton et al. *Evaluation of Techniques for Removal of Defective Grout from Post-Tensioning Tendons Presentation*. UF, 2017.

Hydrodemolition Dissection

Drying Trial Setup



Specimen 1: Grout distribution



Specimen 2: Grout distribution

Drying Trial

Source: Hamilton et al. *Evaluation of Techniques for Removal of Defective Grout from Post-Tensioning Tendons Presentation*. UF, 2017.

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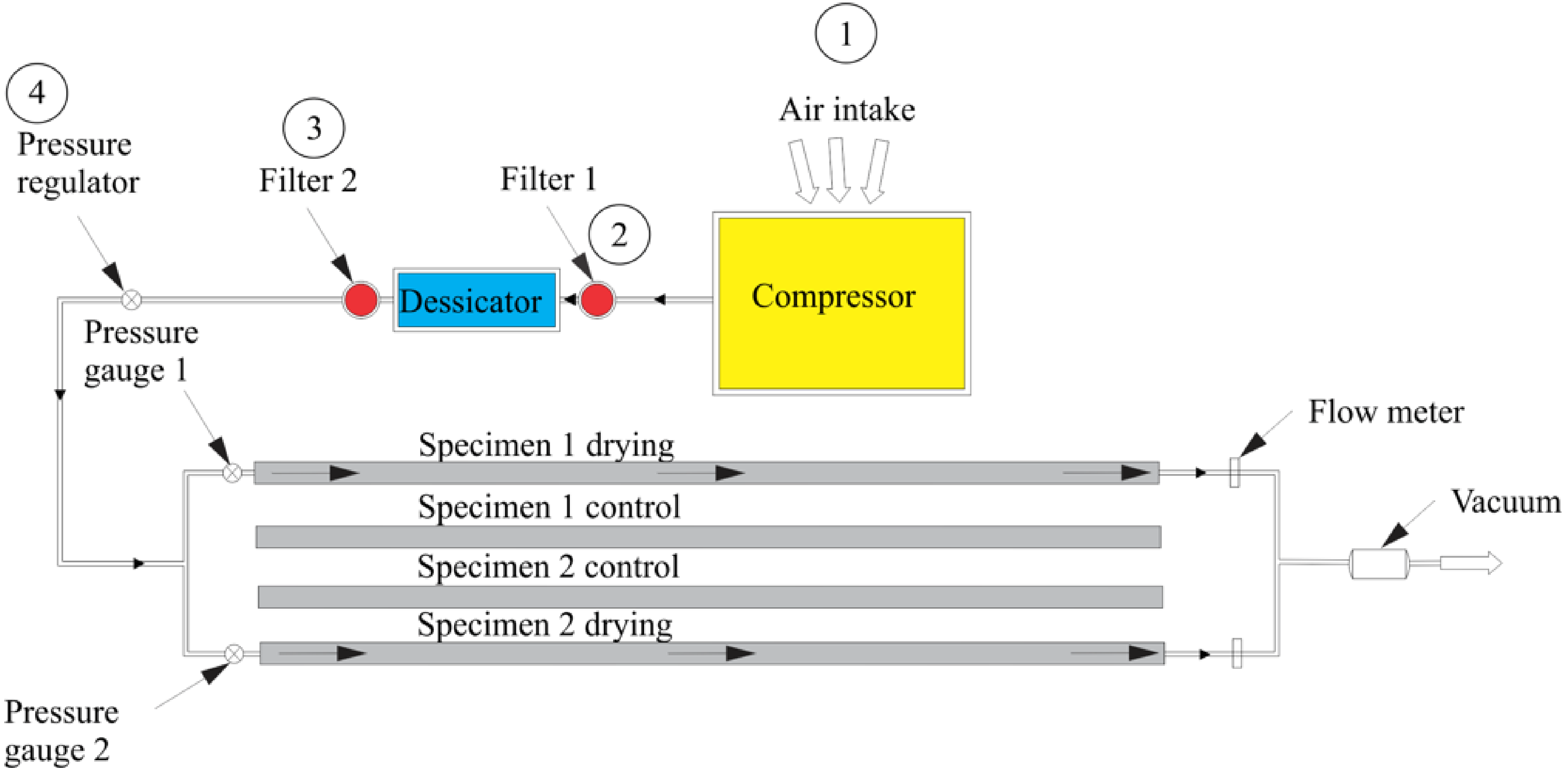
Drying Trial



Source: Hamilton et al. *Evaluation of Techniques for Removal of Defective Grout from Post-Tensioning Tendons Presentation*. UF, 2017.

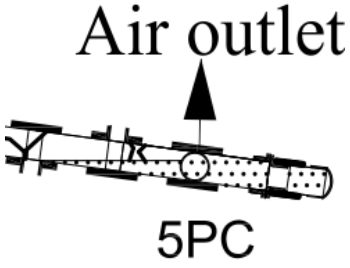
Measurement

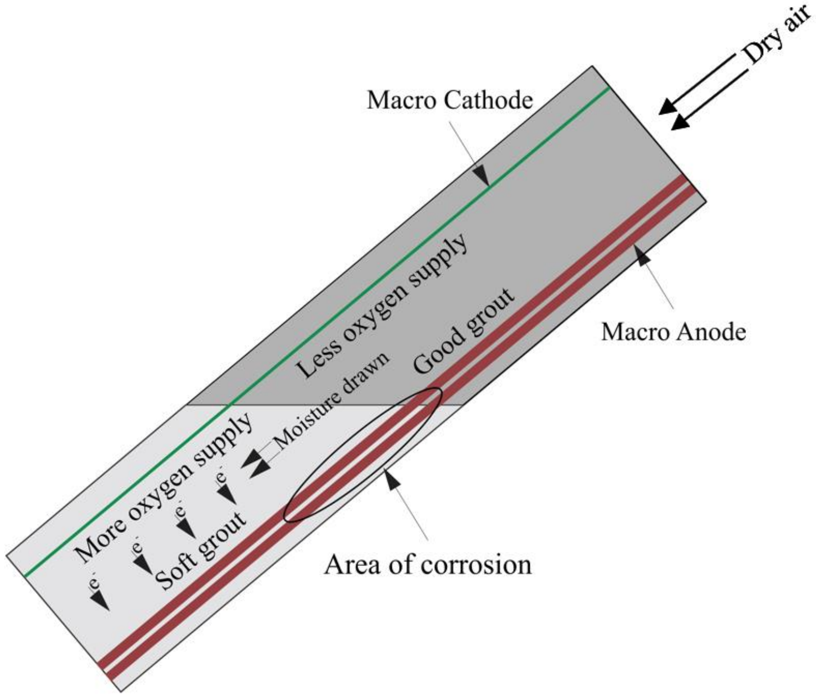
Source: Hamilton et al. *Evaluation of Techniques for Removal of Defective Grout from Post-Tensioning Tendons Presentation*. UF, 2017.

Findings

- Negligible moisture content in soft grout of drying specimen
- Reduced moisture content in good grout of drying specimen
- Inefficient moisture removal beyond outlet
- Corrosion during drying

Source: Hamilton et al. *Evaluation of Techniques for Removal of Defective Grout from Post-Tensioning Tendons Presentation*. UF, 2017.

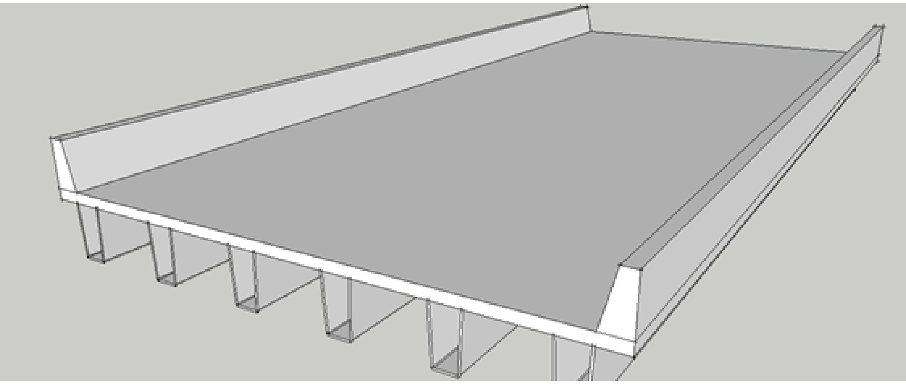




Wonderwood Bridge

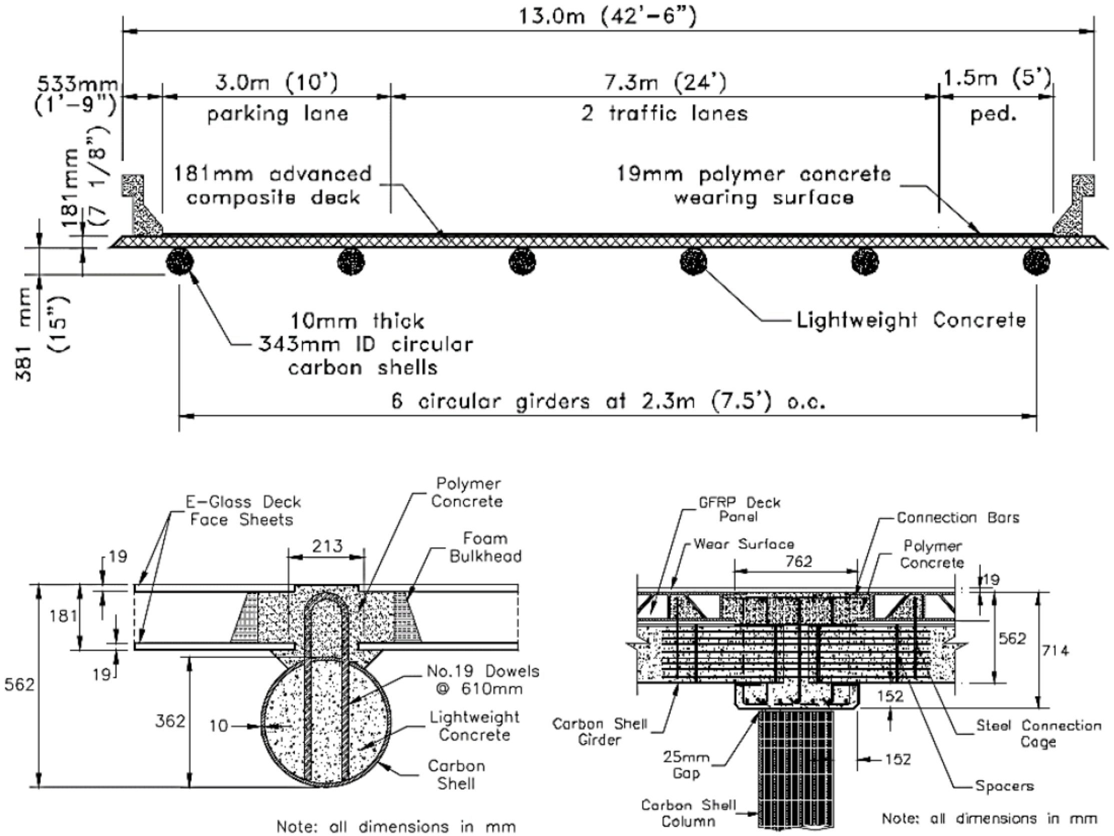
FDOT TRANSPORTATION SYMPOSIUM

Bridge Girder Alternatives for Extremely Aggressive Environments



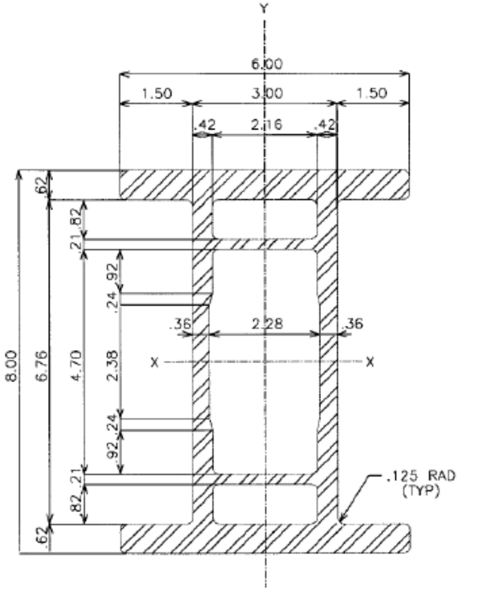
Hybrid FRP/Concrete-filled U-Girder

Source: Brown et al. *Bridge Girder Alternatives for Extremely Aggressive Environments,* Embry-Riddle, 2018.



Hybrid FRP/Concrete-filled Tube

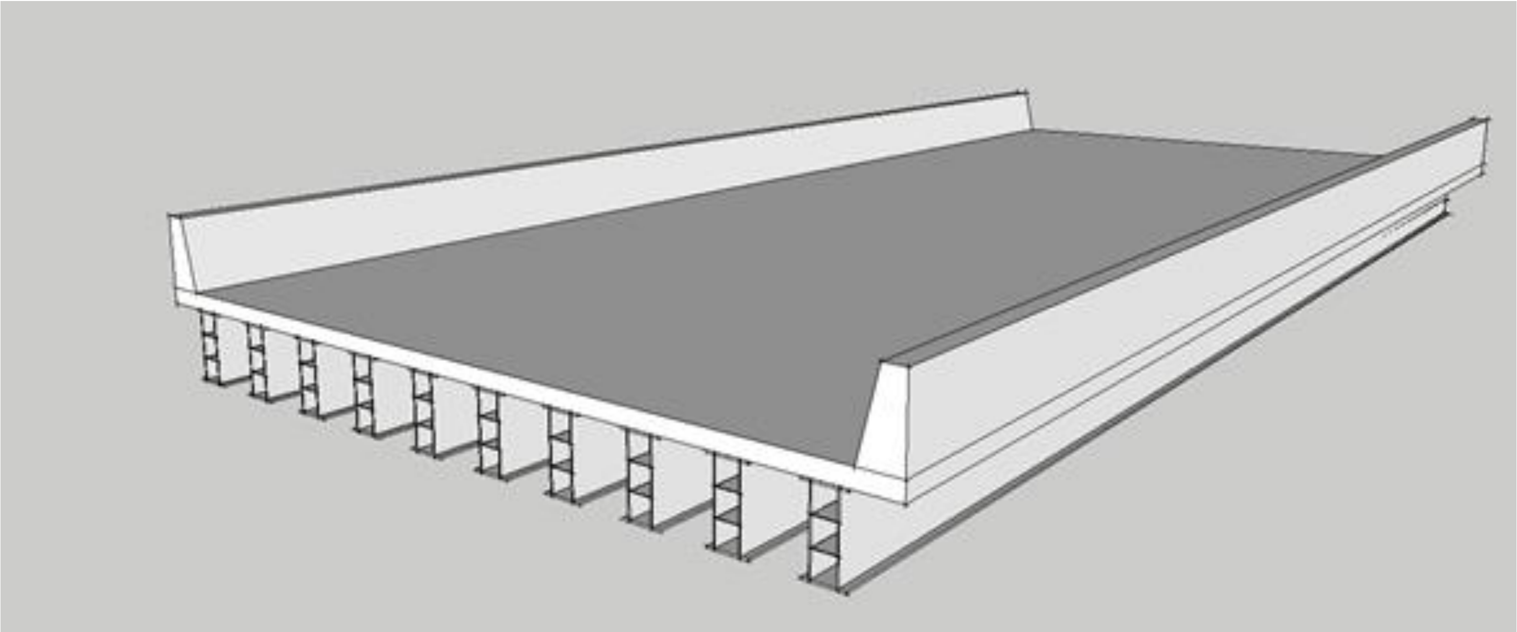
Source: Brown et al. *Bridge Girder Alternatives for Extremely Aggressive Environments*, Embry-Riddle, 2018.

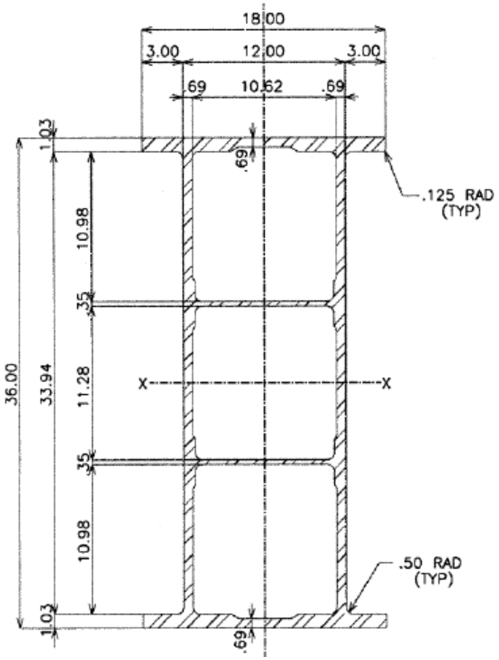


(A)

NOMINAL SECTION PROPERTIES

- I_{xx} = 129 in^4
- S_{xx} = 32.2 in^3
- r_{xx} = 3.07 in
- A = 13.7 in^2
- $A_{2\ webs}$ = 5.36 in^2
- $A_{2\ flanges}$ = 7.44 in^2
- I_{yy} = 31.8 in^4
- S_{yy} = 10.6 in^3
- r_{yy} = 1.52 in
- Weight = 11.2 lbs/lf





NOMINAL SECTION PROPERTIES

- I_{xx} = 15291 in^4
- S_{xx} = 849 in^3
- r_{xx} = 12.9 in
- A = 91.2 in^2
- $A_{2\ webs}$ = 50.1 in^2
- $A_{2\ flanges}$ = 34.0 in^2
- I_{yy} = 2626 in^4
- S_{yy} = 292 in^3
- r_{yy} = 5.37 in
- Weight = 70 lbs/lf

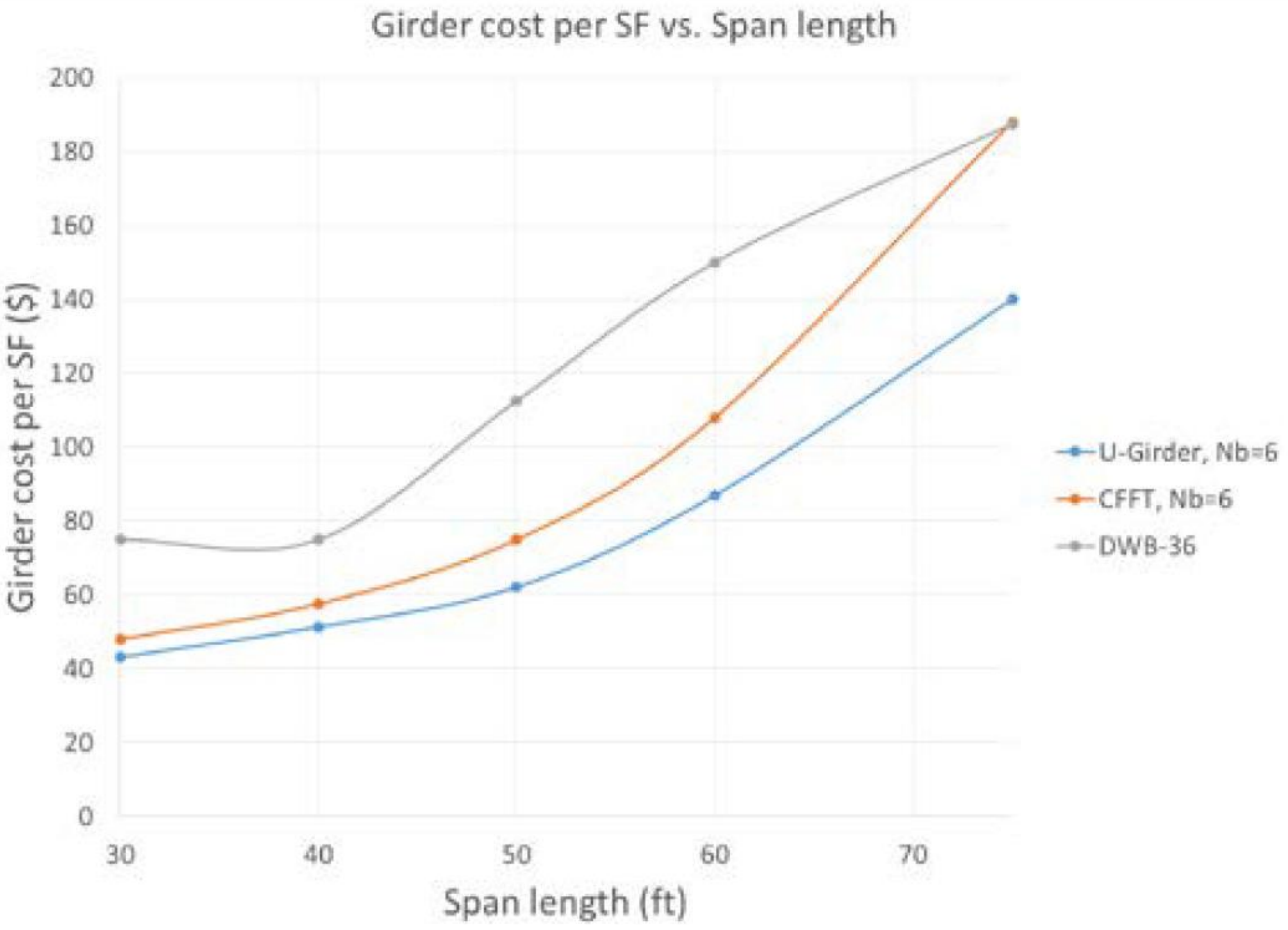
Pultruded Double Web I-Beam

Source: Brown et al. *Bridge Girder Alternatives for Extremely Aggressive Environments*, Embry-Riddle, 2018.

Conceptual Design

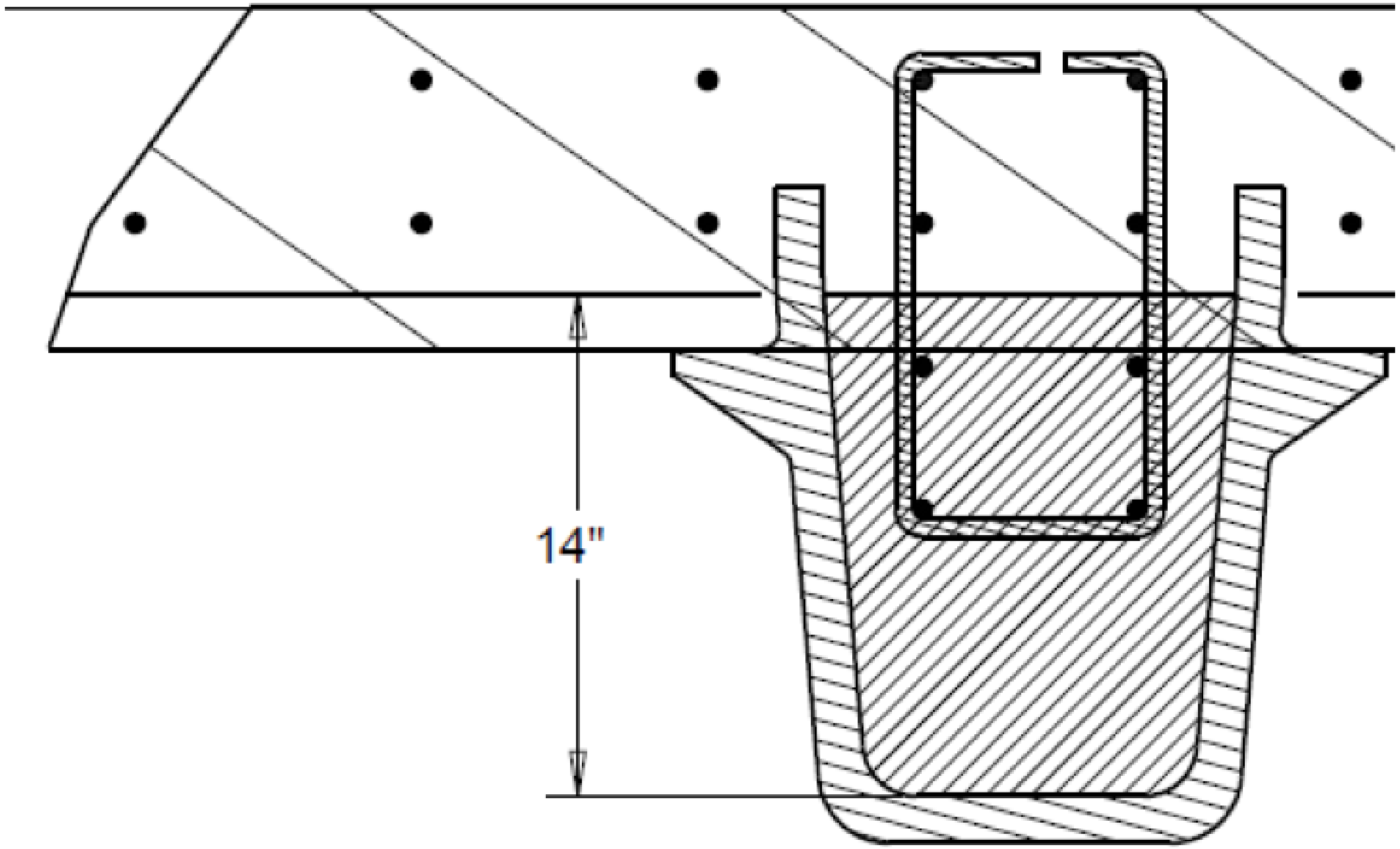
- 32 ft clear roadway width
- 8 in thick cast-in-place RC deck
- Simply supported span lengths: 30’, 40’, 50’, 60’ & 75’
- Variable girder spacing (N_b = 5 through N_b = 12)

Source: Brown et al. *Bridge Girder Alternatives for Extremely Aggressive Environments,* Embry-Riddle, 2018.



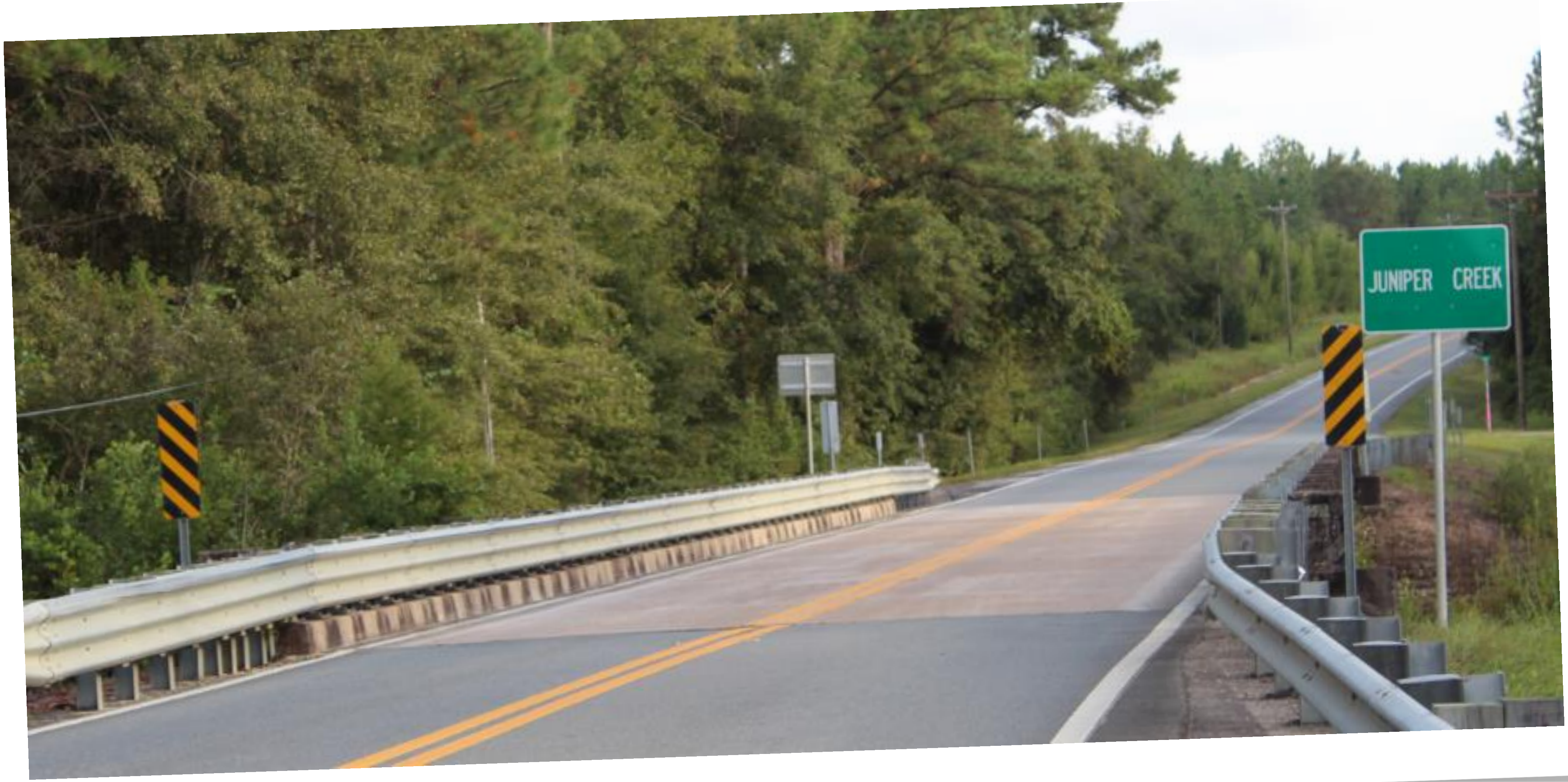
Source: Brown et al. *Bridge Girder Alternatives for Extremely Aggressive Environments,* Embry-Riddle, 2018.

Hybrid Concrete-Filled FRP U-Girder



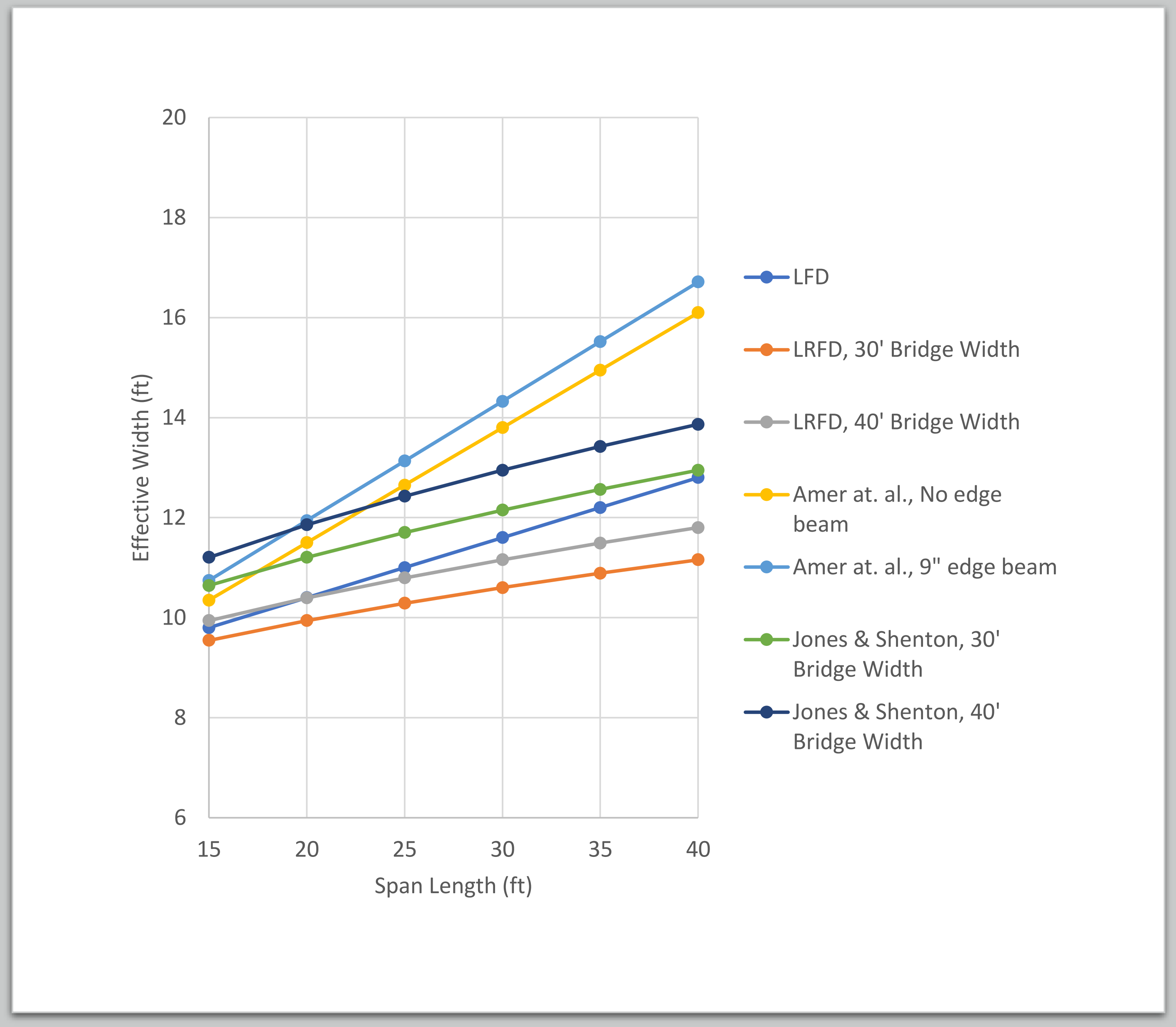
Source: Brown et al. *Bridge Girder Alternatives for Extremely Aggressive Environments,* Embry-Riddle, 2018.

Load Ratings for FDOT Flat Slab Bridges


JUNIPER CREEK

Past Work

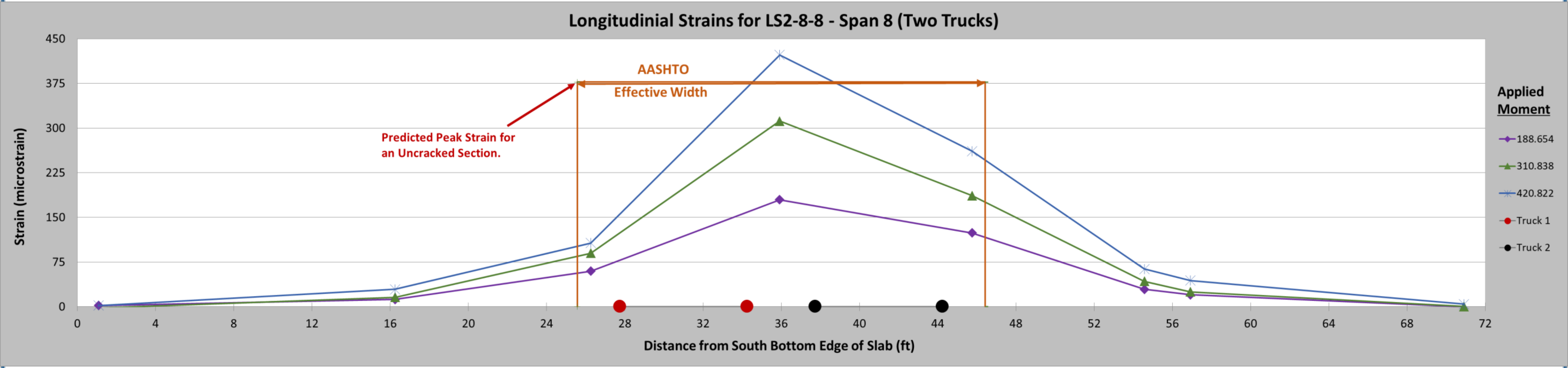
- Contribution from Parapet
- Various Simple Equations for Distribution:
  - AASHTO LRFD Bridge Design Specifications (based on NCHRP Project 12-26)
  - AASHTO Standard Specifications
  - Amer and Arockiasamy Equations
  - University of Delaware Center for Innovative Bridge Engineering

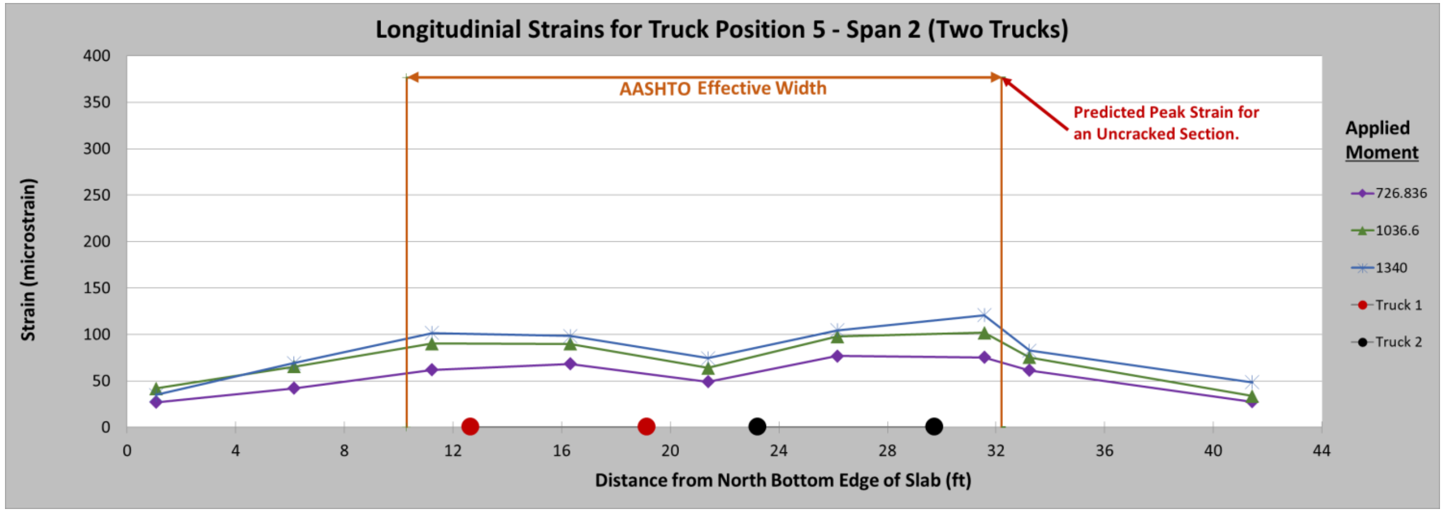


Bridge Testing

Test Result Comparison to AASHTO





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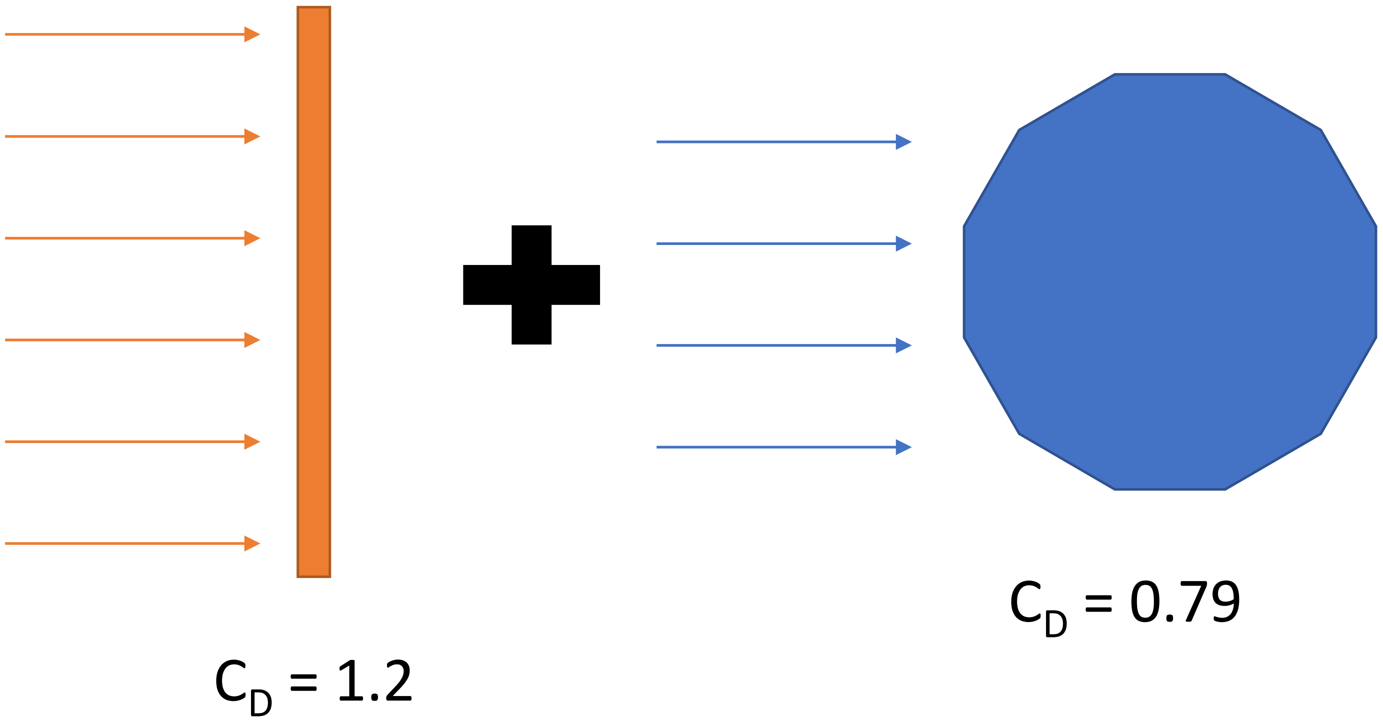
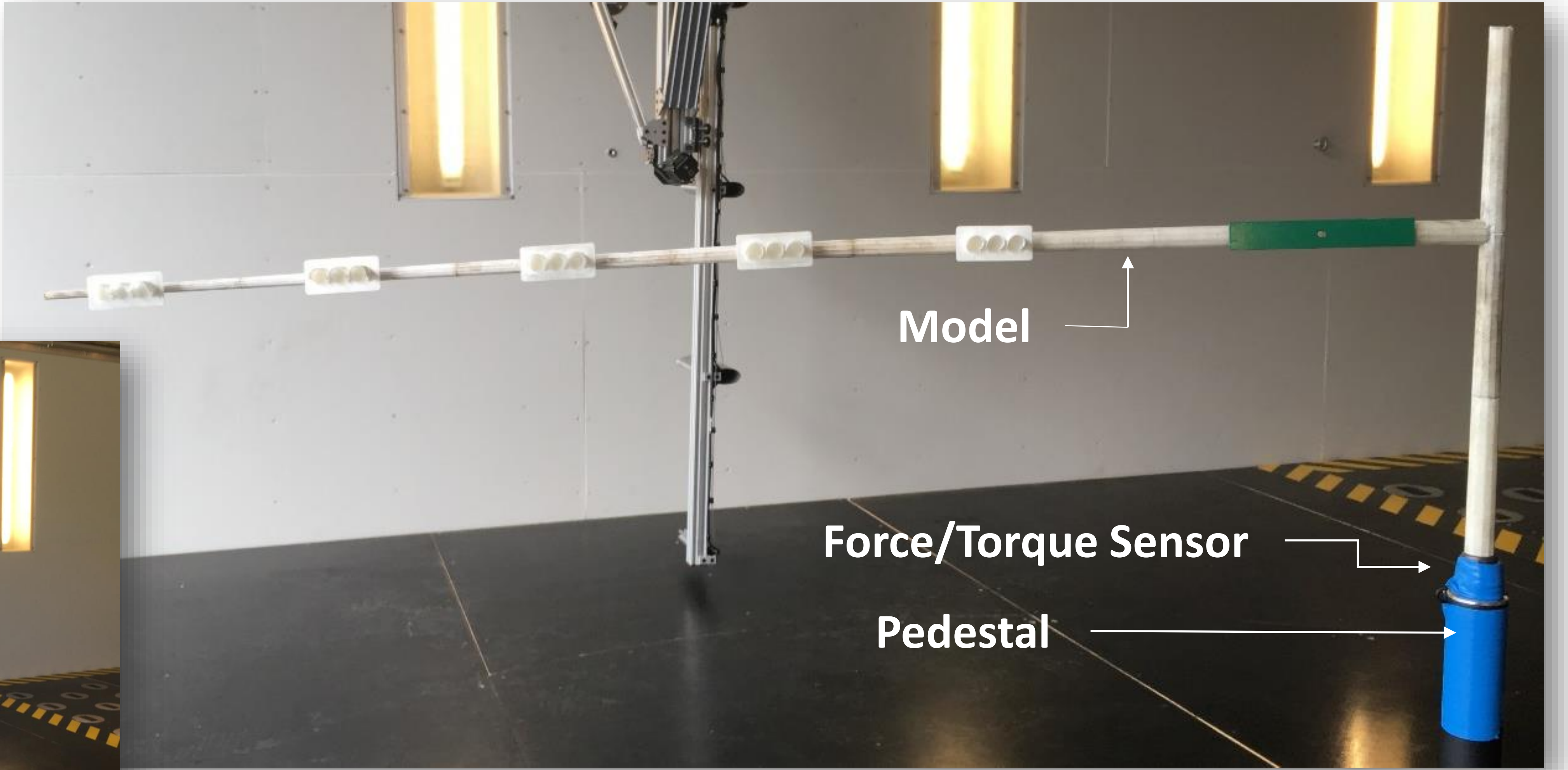
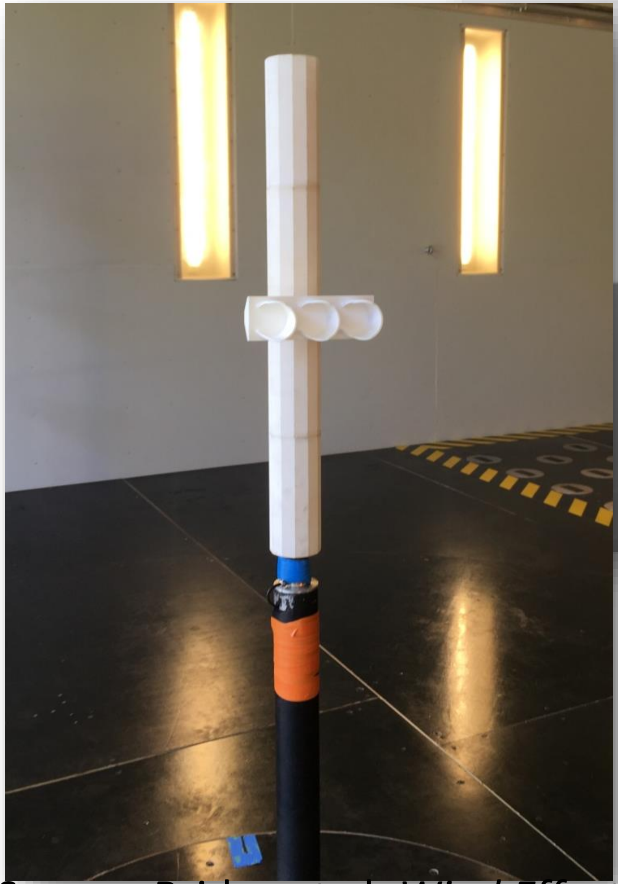
Wind Effects on Mast Arms

Drag Coefficient



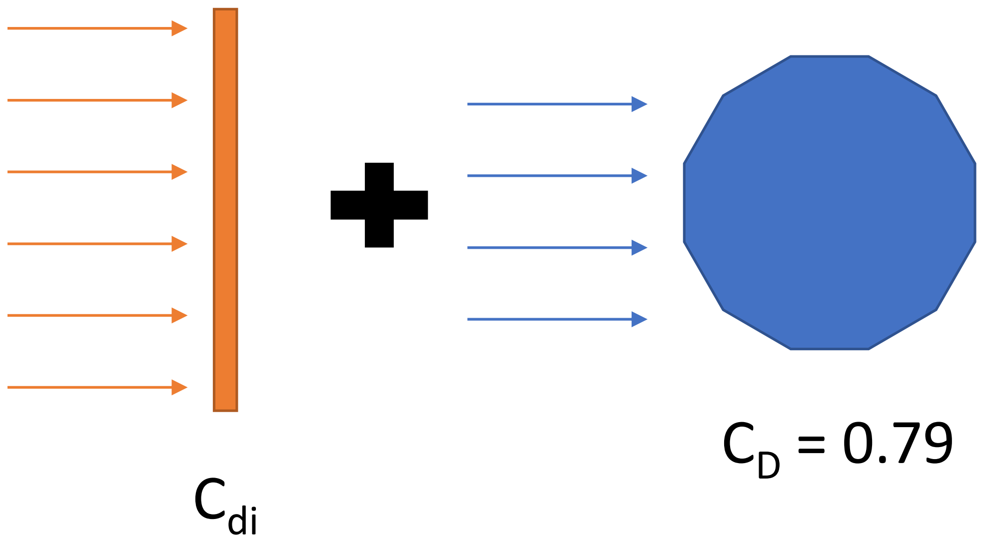
Source: Bridge et al. *Wind Effects on Mast Arms Presentation,* UF, 2018.

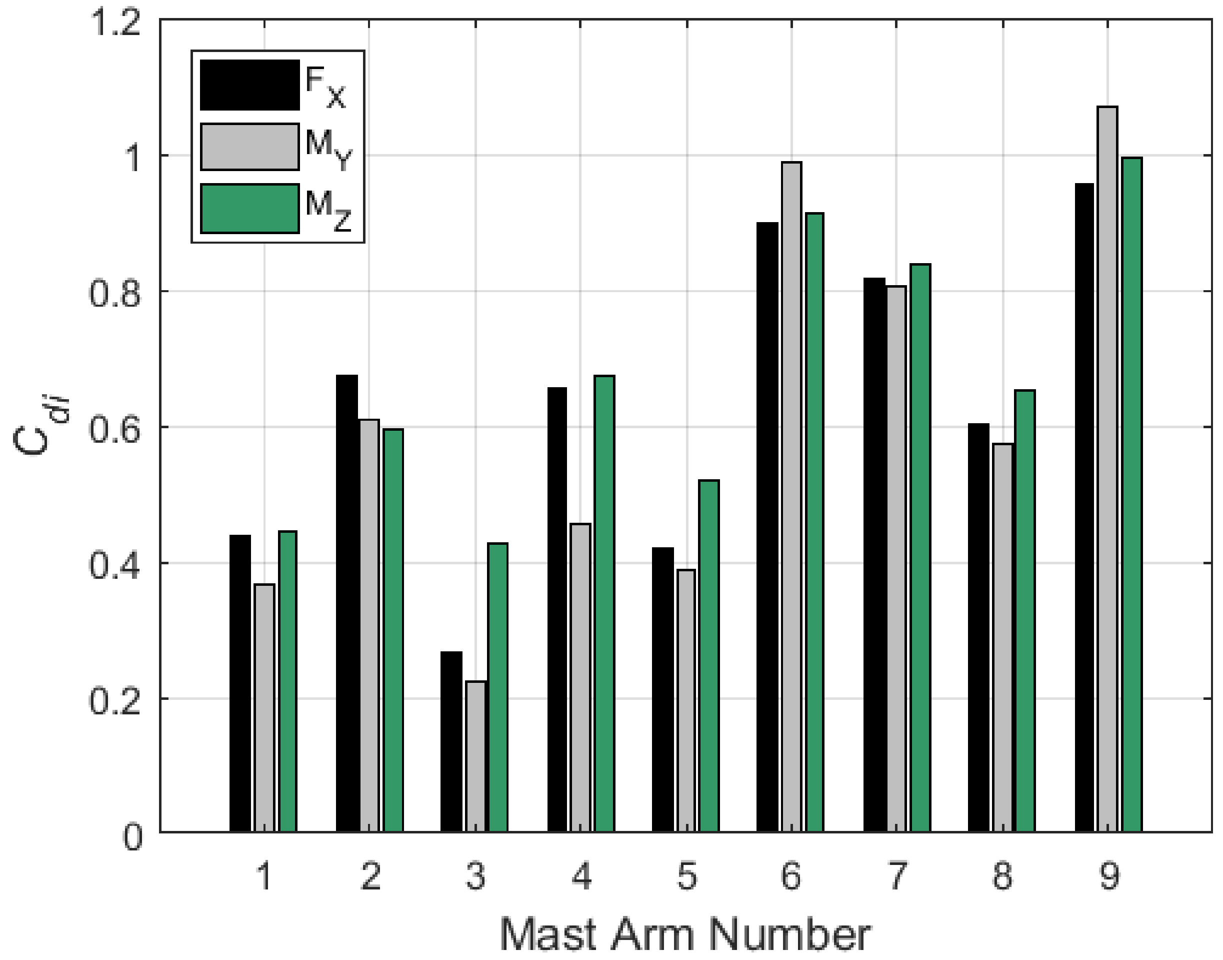




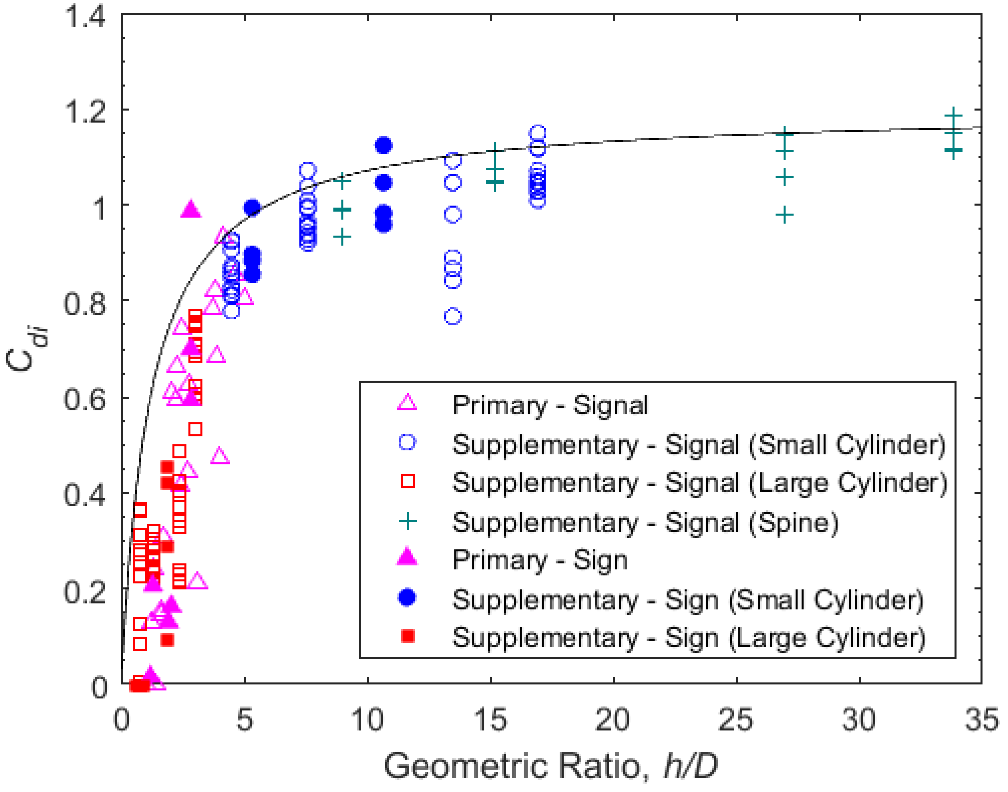
Source: Bridge et al. *Wind Effects on Mast Arms Presentation*, UF, 2018.

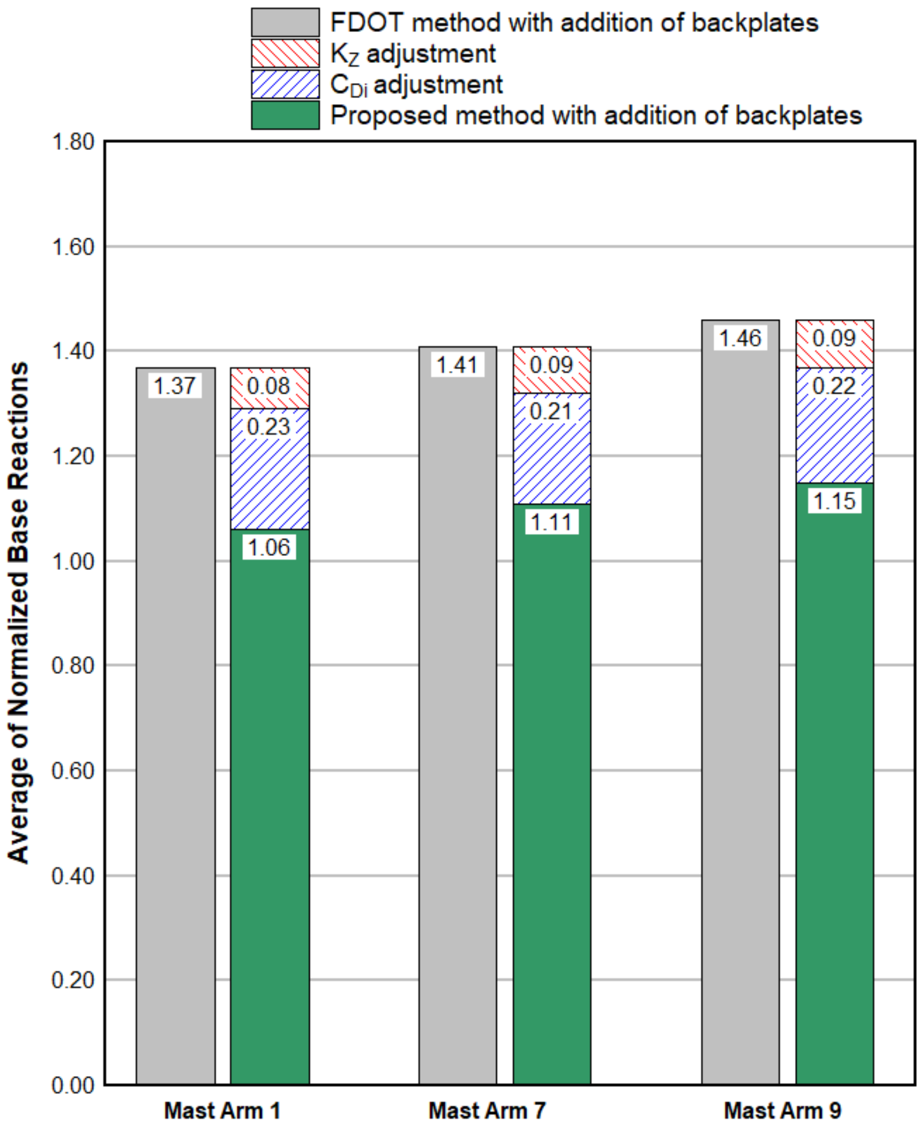
Revised Drag Coefficient





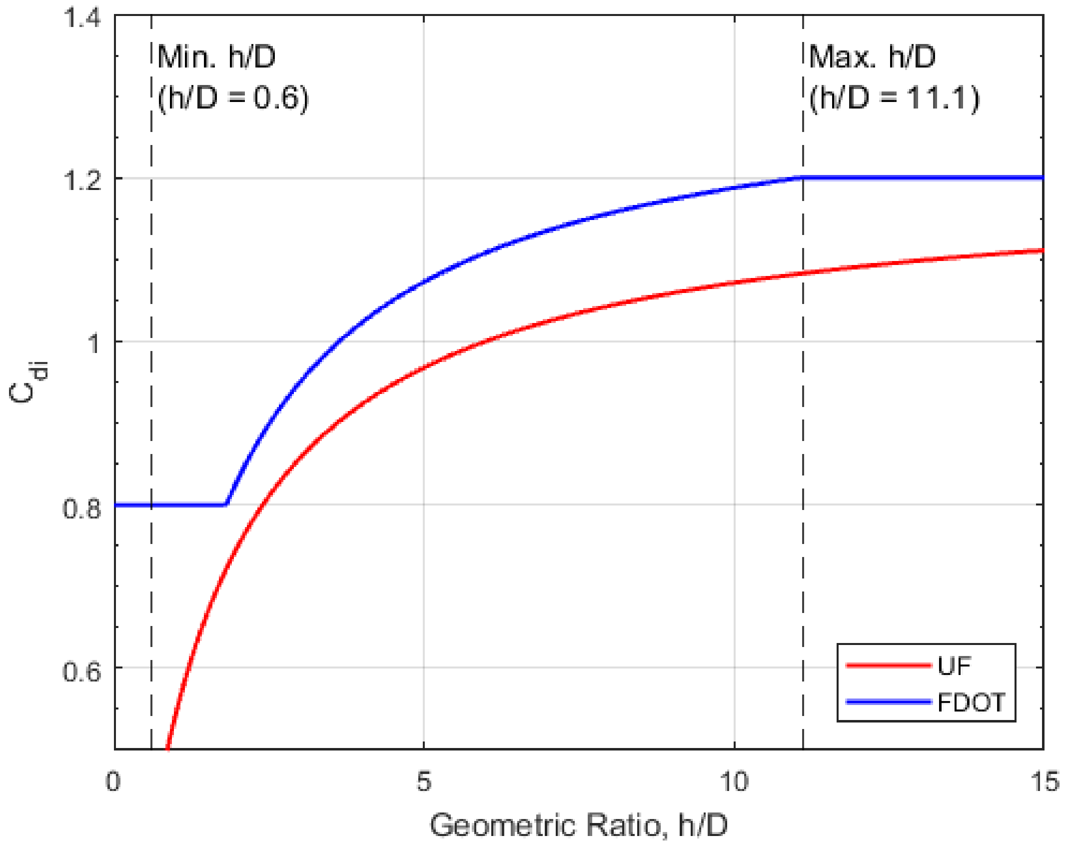
Source: Bridge et al. *Wind Effects on Mast Arms Presentation*, UF, 2018.





Source: Bridge et al. *Wind Effects on Mast Arms Presentation,* UF, 2018.

FDOT Proposed Implementation

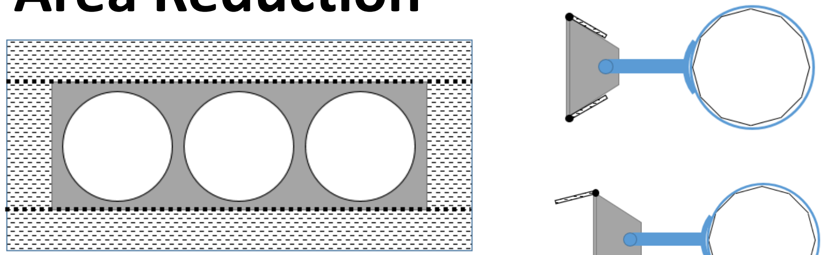


$$C_{di} = \begin{cases} 0.8 & \text{for } \; h/D \le 1.82 \\ \dfrac{1.2(1.33)\left(h/D\right)^2}{1.2\left(h/D\right)^2 + 1.44\left(h/D\right)} & \text{for } \; 1.82 < h/D < 11.1 \\ 1.2 & \text{for } \; h/D \ge 11.1 \end{cases}$$

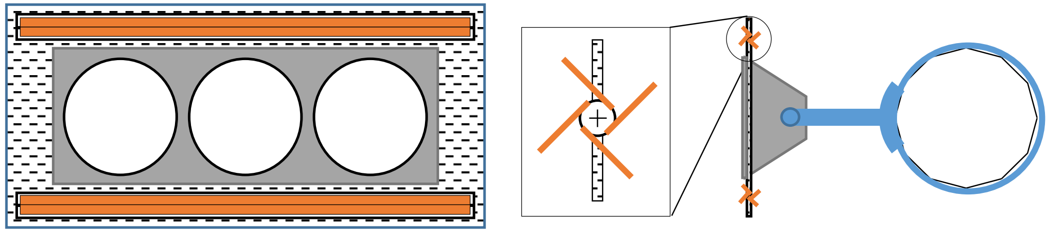
Source: Bridge et al. *Wind Effects on Mast Arms Presentation,* UF, 2018.

Hardware Modification Concepts

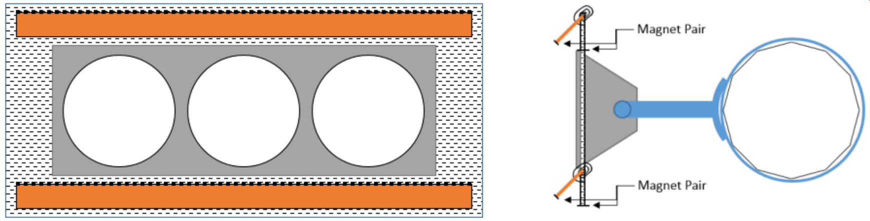
Area Reduction



Foldable Back Plates

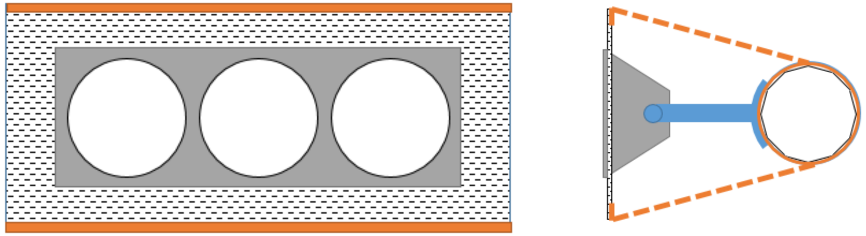


Pinwheel

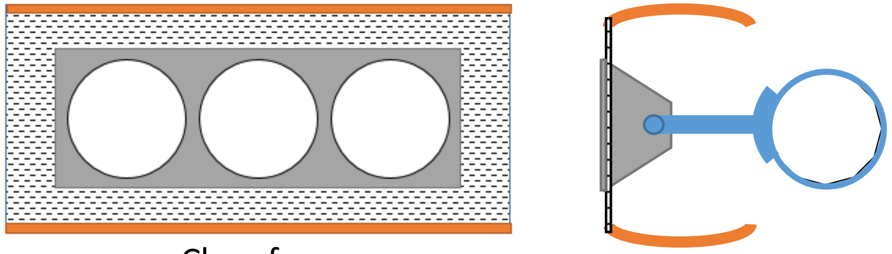


Magnetized Foldable Back Plates

Flow Modification

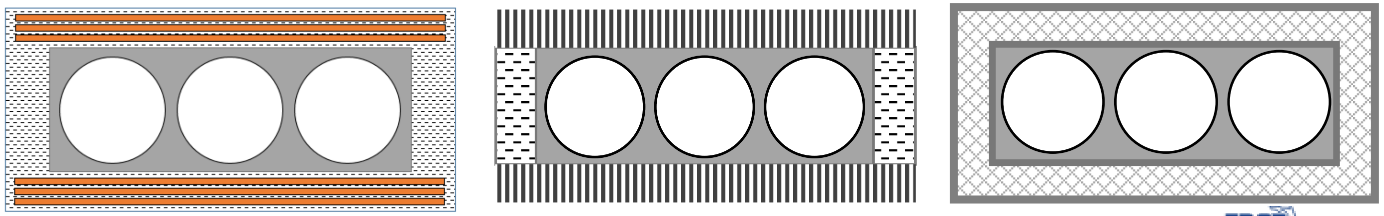


Offset Cover

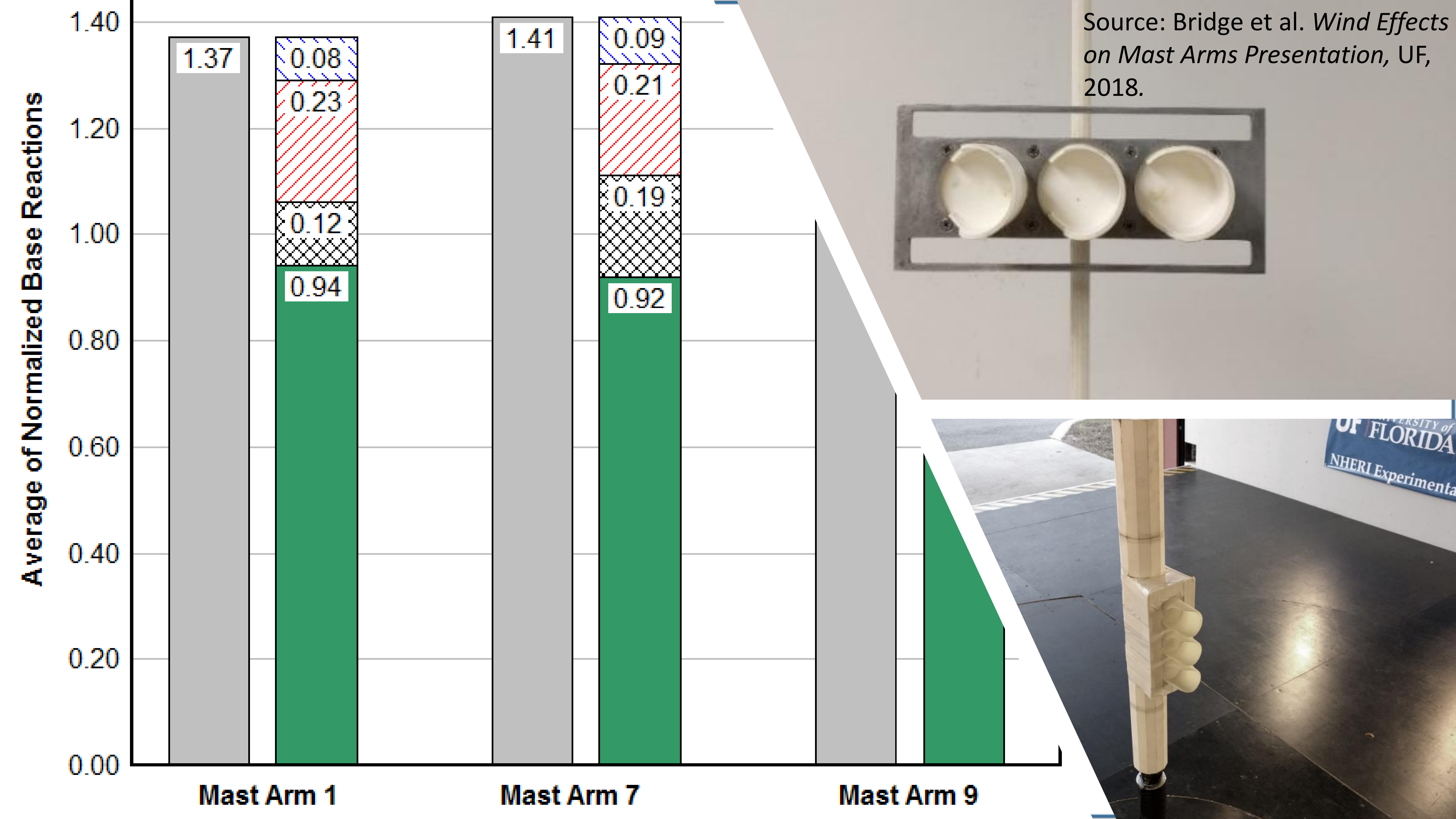


Chamfer

Flexible/Permeable



Source: Bridge et al. *Wind Effects on Mast Arms Presentation*, UF, 2018.

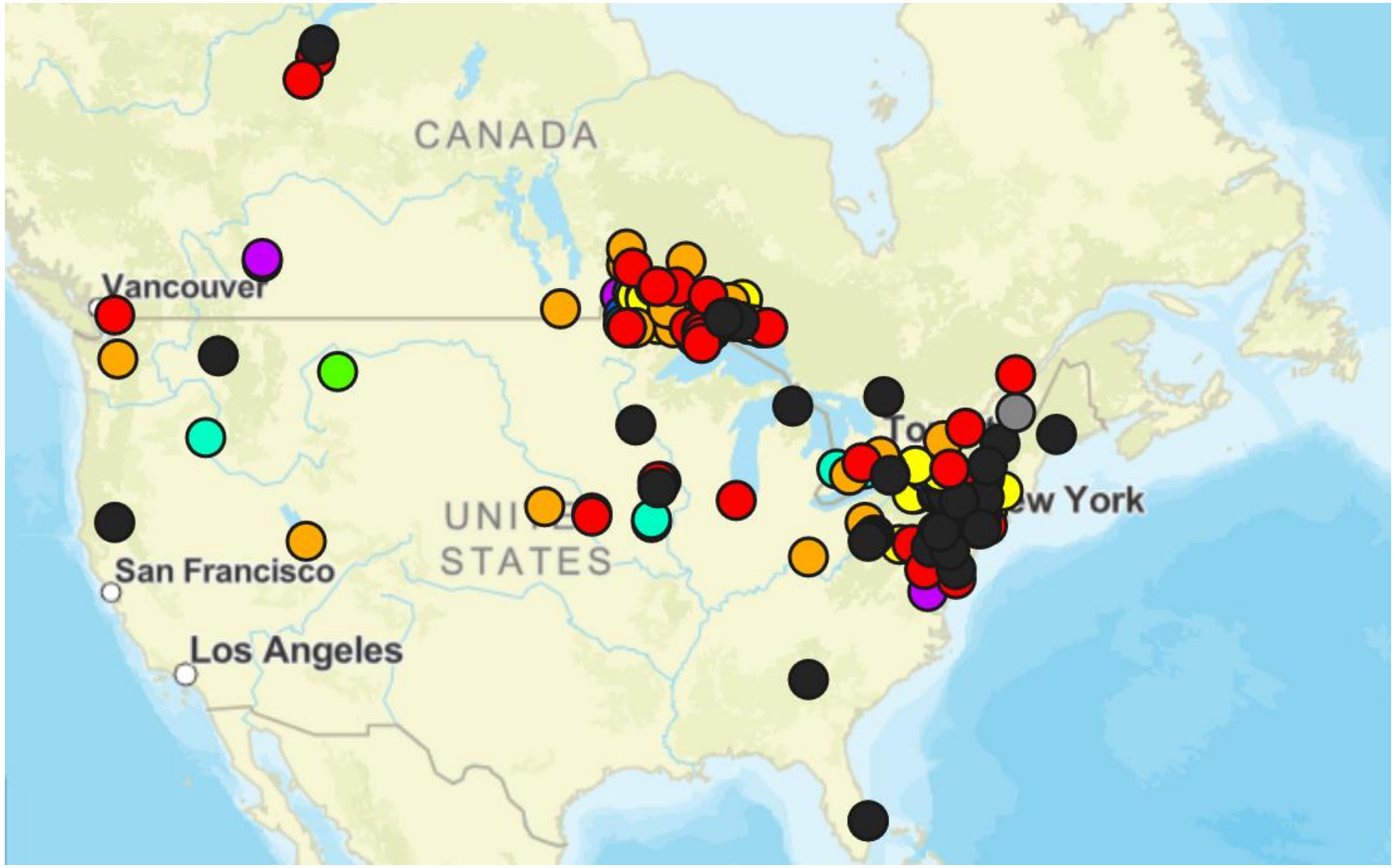

Source: Bridge et al. *Wind Effects on Mast Arms Presentation,* UF, 2018.
Average of Normalized Base Reactions
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1.37
0.08
0.23
0.12
0.94
1.41
0.09
0.21
0.19
0.92
Mast Arm 1
Mast Arm 7
Mast Arm 9
FLORIDA
NHERI Experimenta

Ultra-High Performance Concrete

UHPC Material Properties

- Fiber Reinforced (2%)
- Portland Cement Product
- Water to cementitious ratio < 0.25
- Compressive Strength > 21.7 ksi
- Tensile Strength > 0.72 ksi
- Enhanced Durability

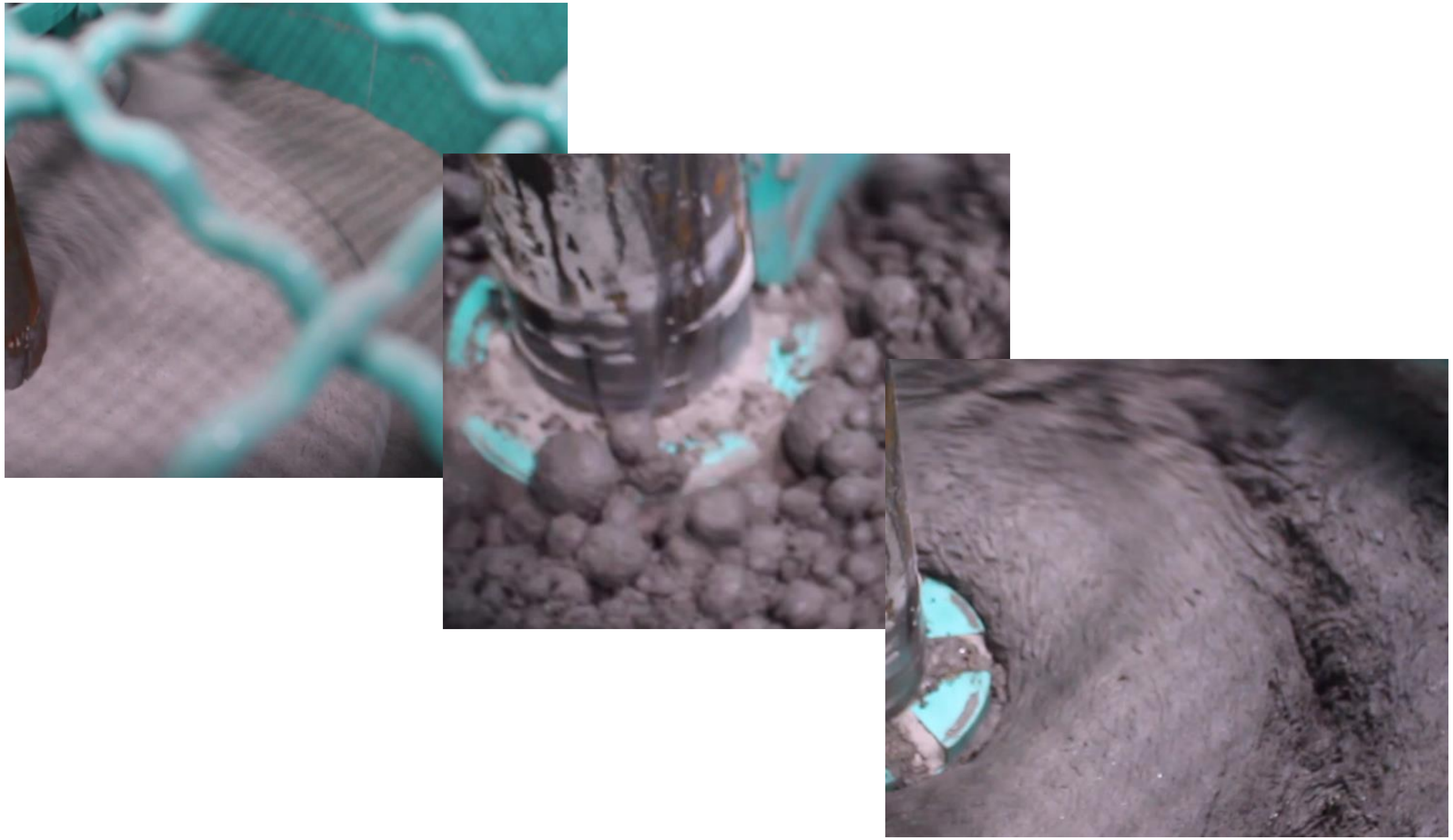
UHPC Connection Use

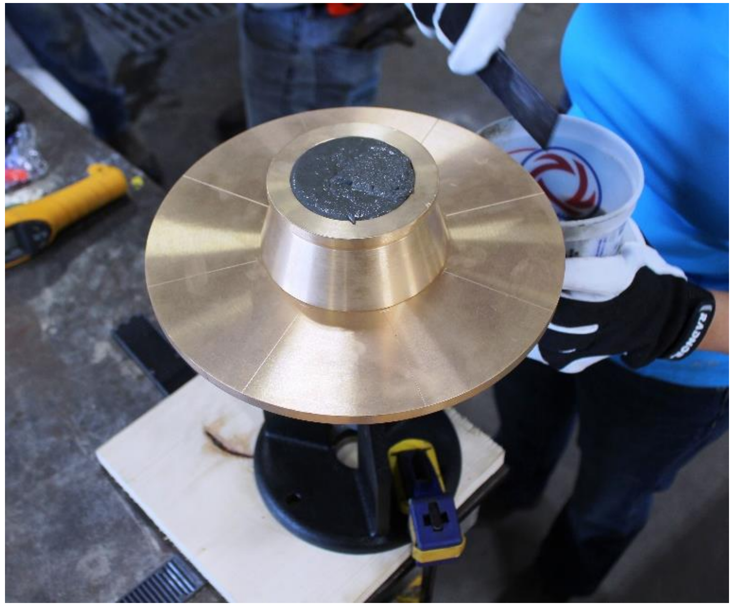


Source: www.fhwa.dot.gov

Mixing

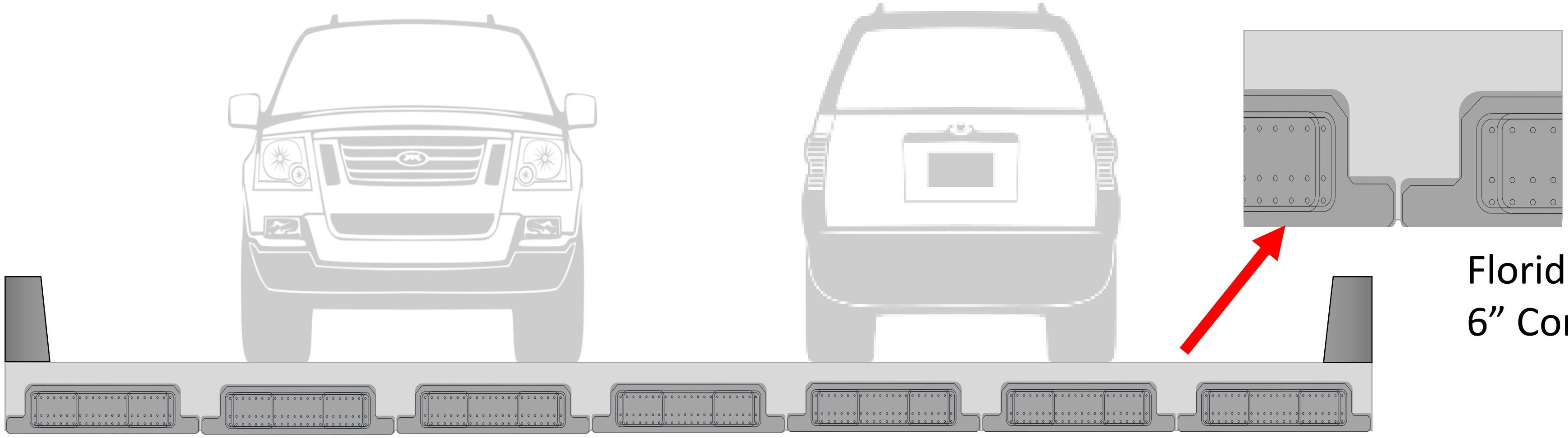
Mixing





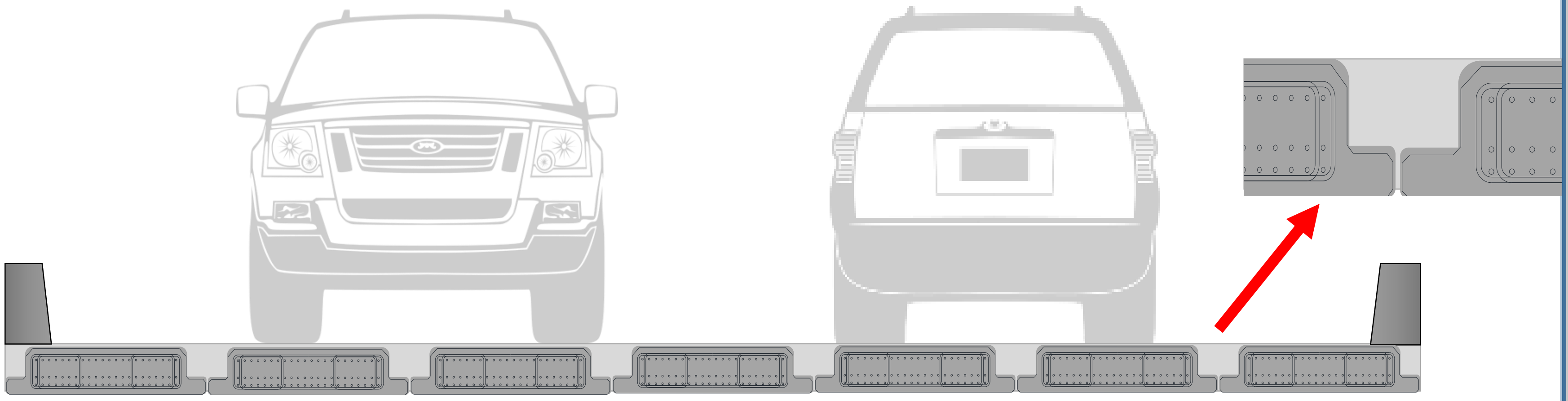
Testing and Placement

Florida Slab Beam (FSB) with Ultra-High Performance Concrete (UHPC) Joint Connections



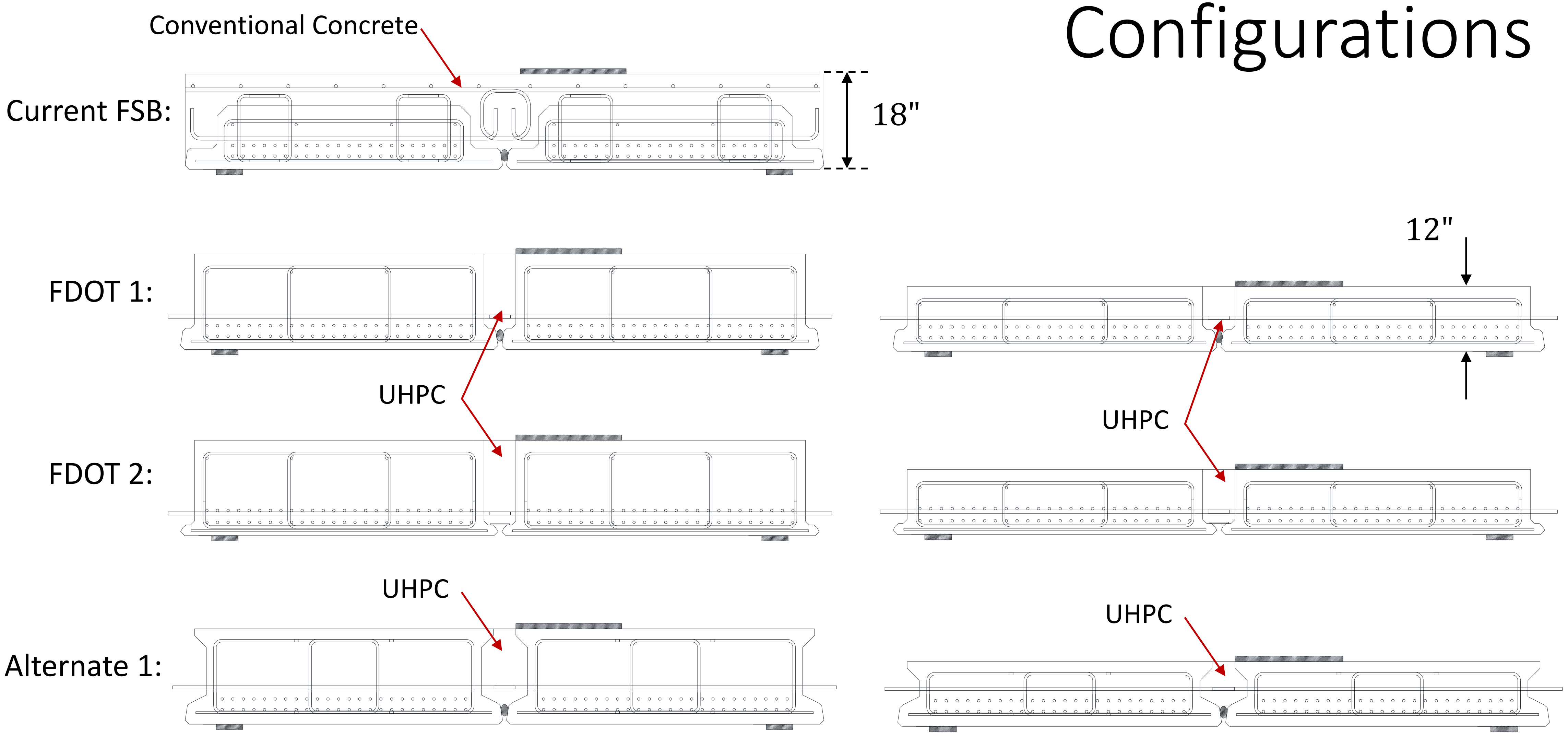
Florida Slab Beam with
6” Concrete Deck

Florida Slab Beam with
UHPC Closure Pour



Source: Garber & Chitty Presentation, SRUT 2017

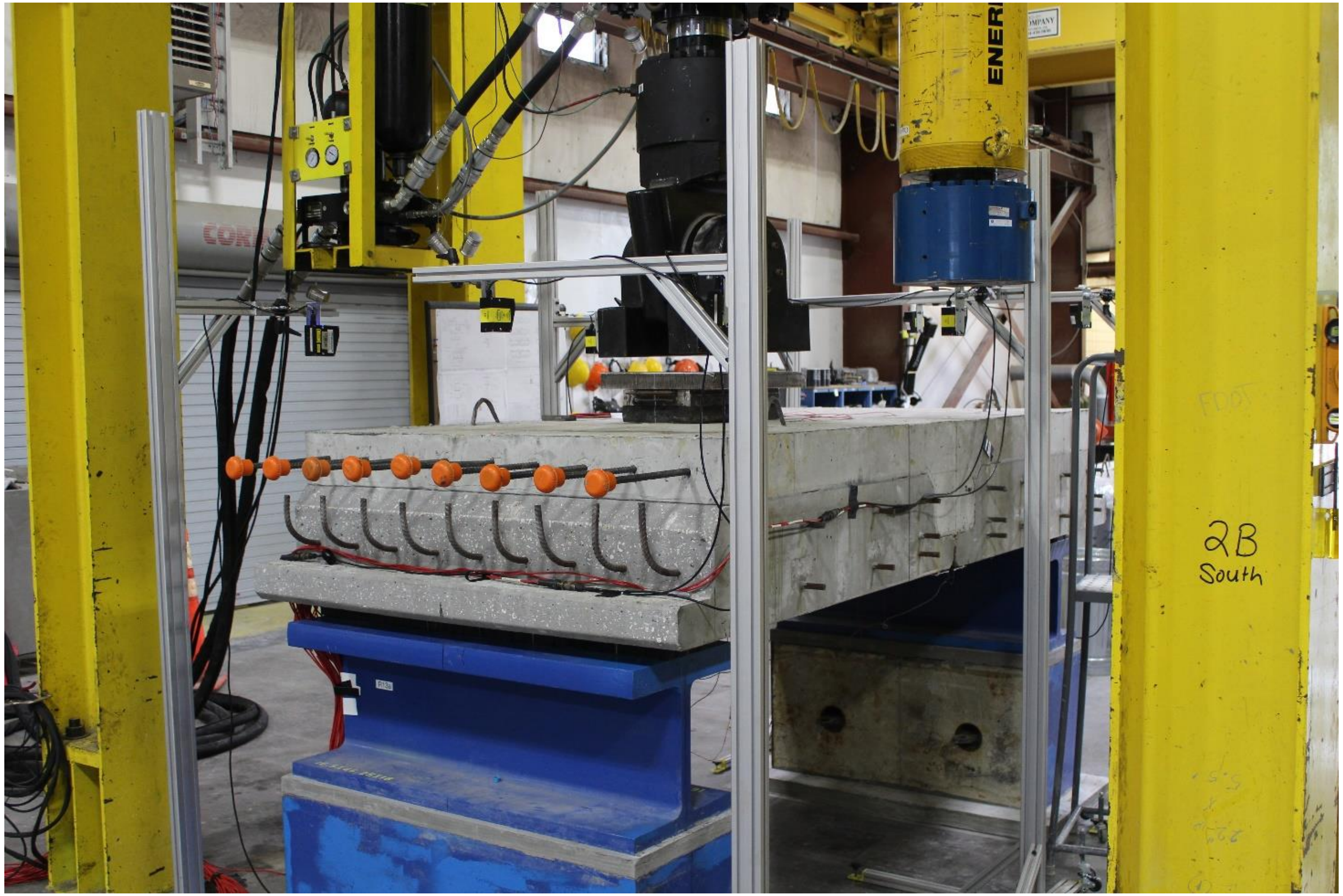
Various Configurations



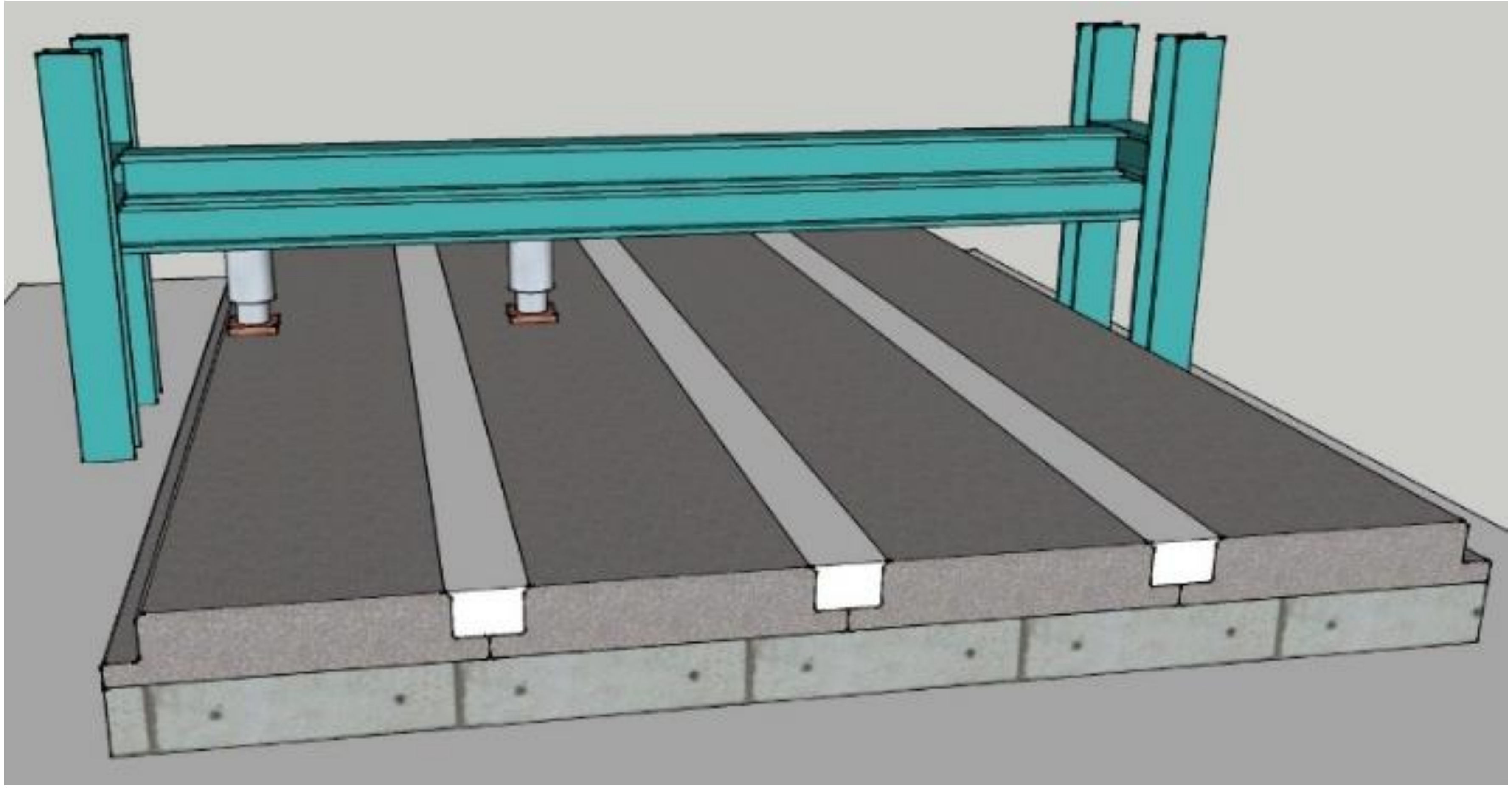
Source: Garber & Chitty Presentation, SRUT 2017

Test Specimen Casting

Control Specimen Test

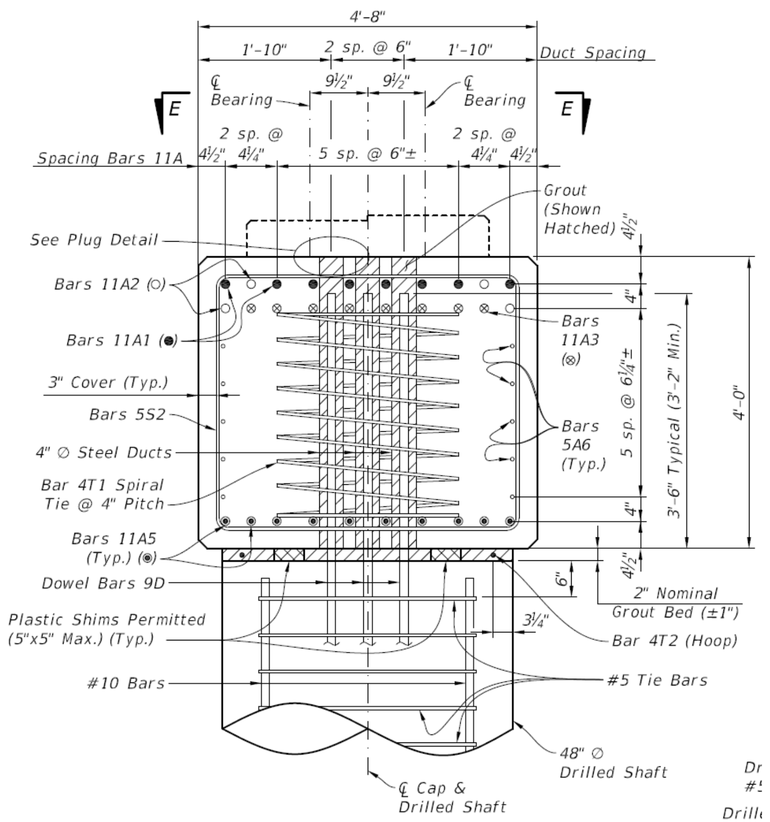


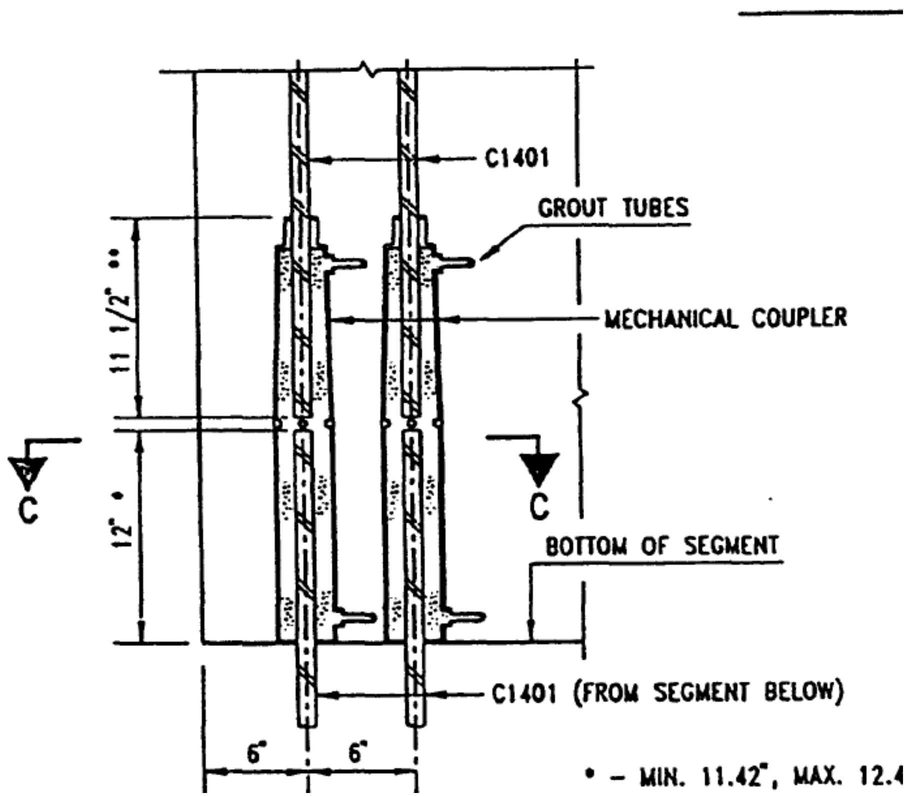
Large Scale Testing



Source: Garber & Chitty Presentation, SRUT 2017

Ultra-High Performance Concrete (UHPC) Large Bar Splice

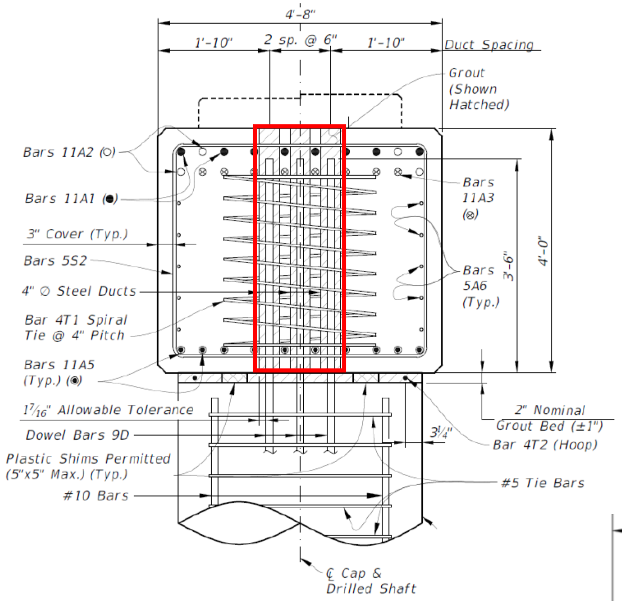


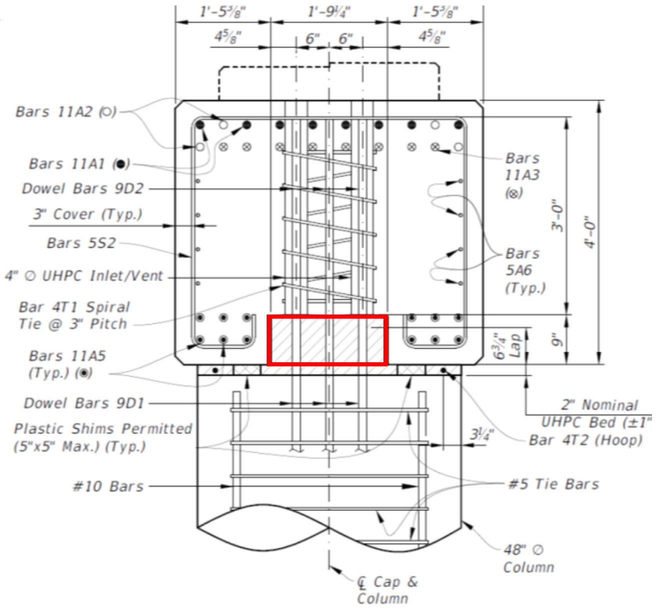


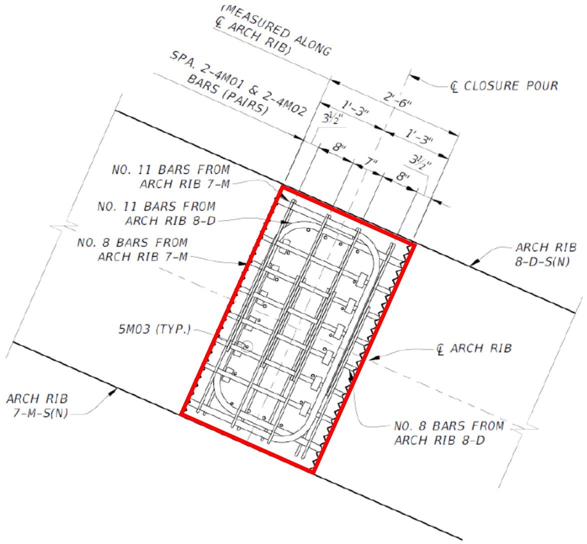
Substructure Accelerated Construction

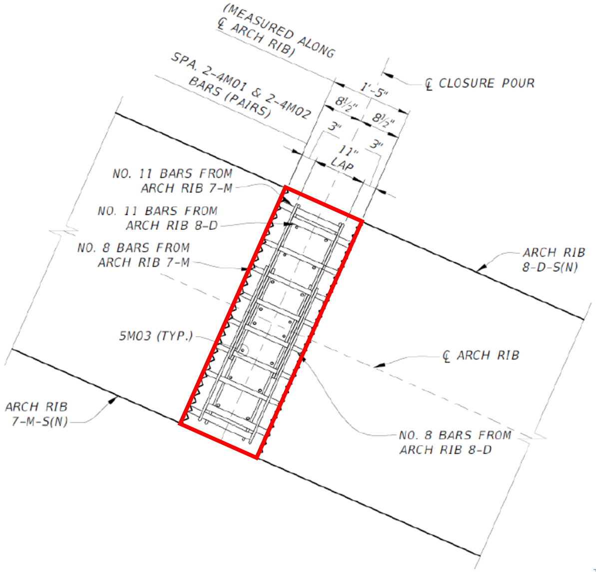
Source: Edison Bridge Plans, US 90 Over Little River Bridge Plans

UHPC Large Bar Splice Connections

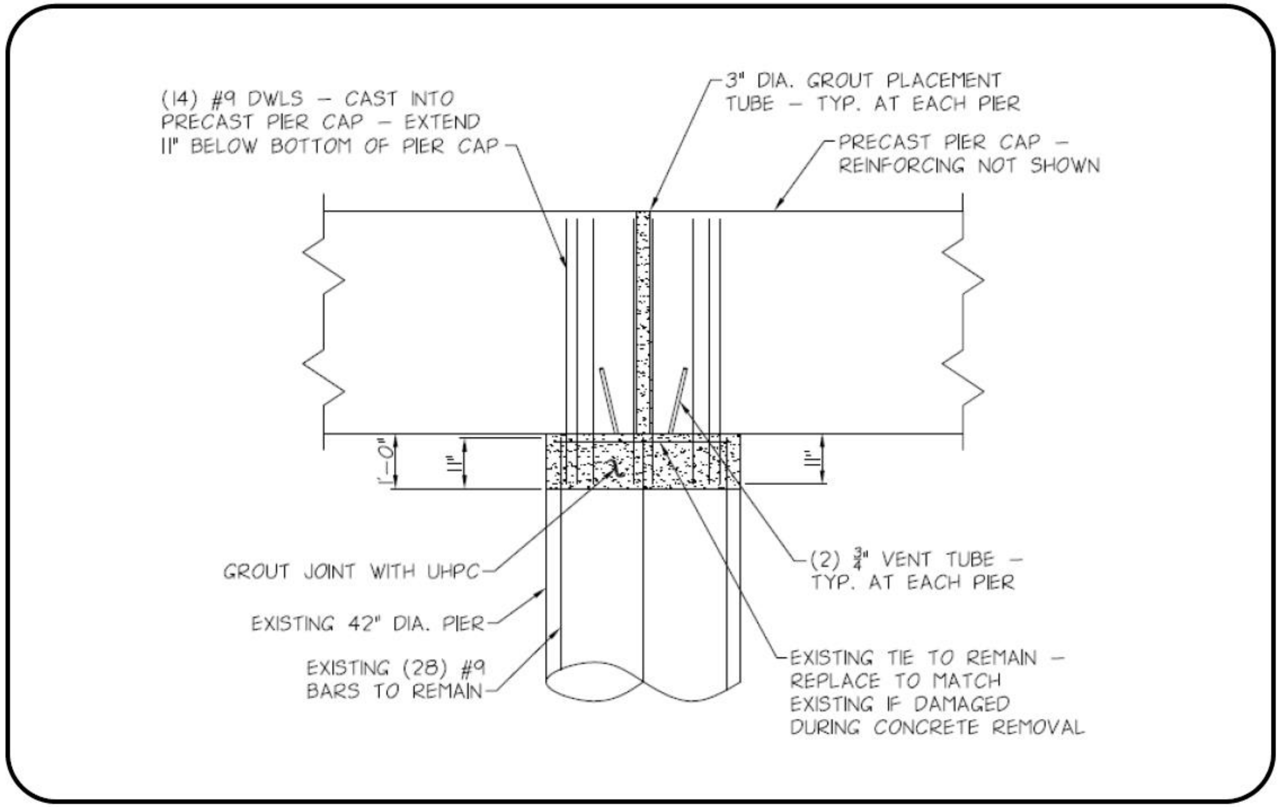






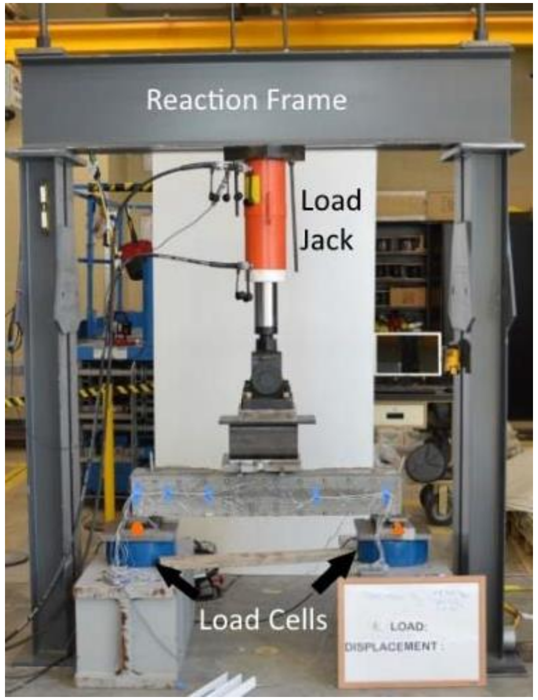


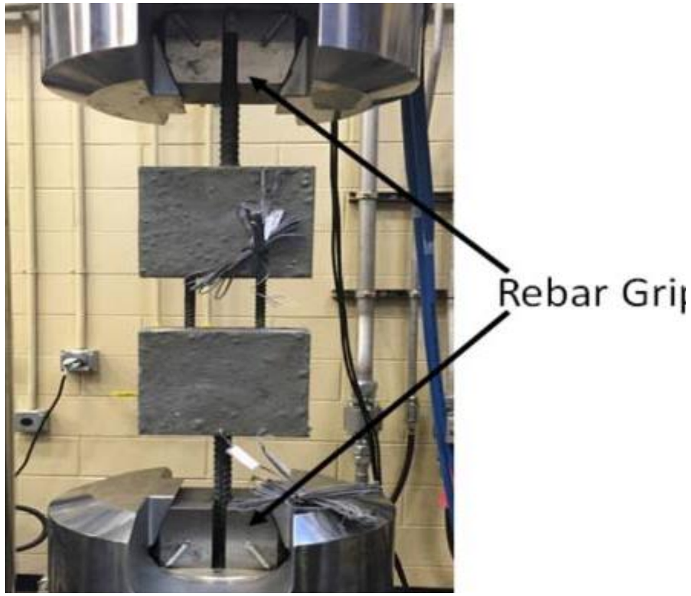
UHPC Substructure Connection

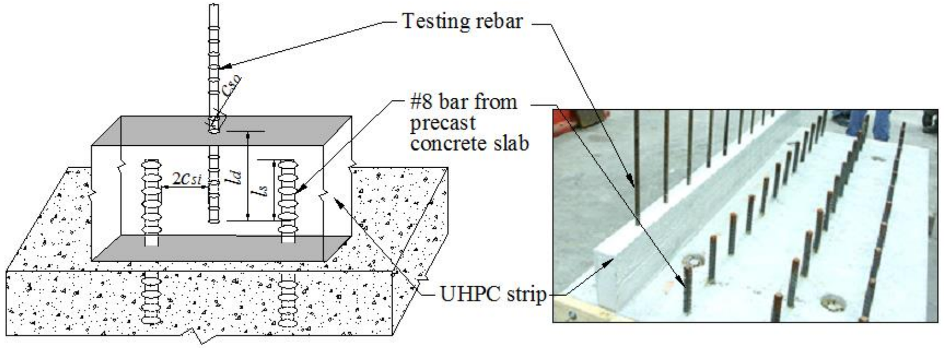


Hooper Road over US 17C in Union, New York

Source: UHPC Connections for ABC presentation by Graybeal



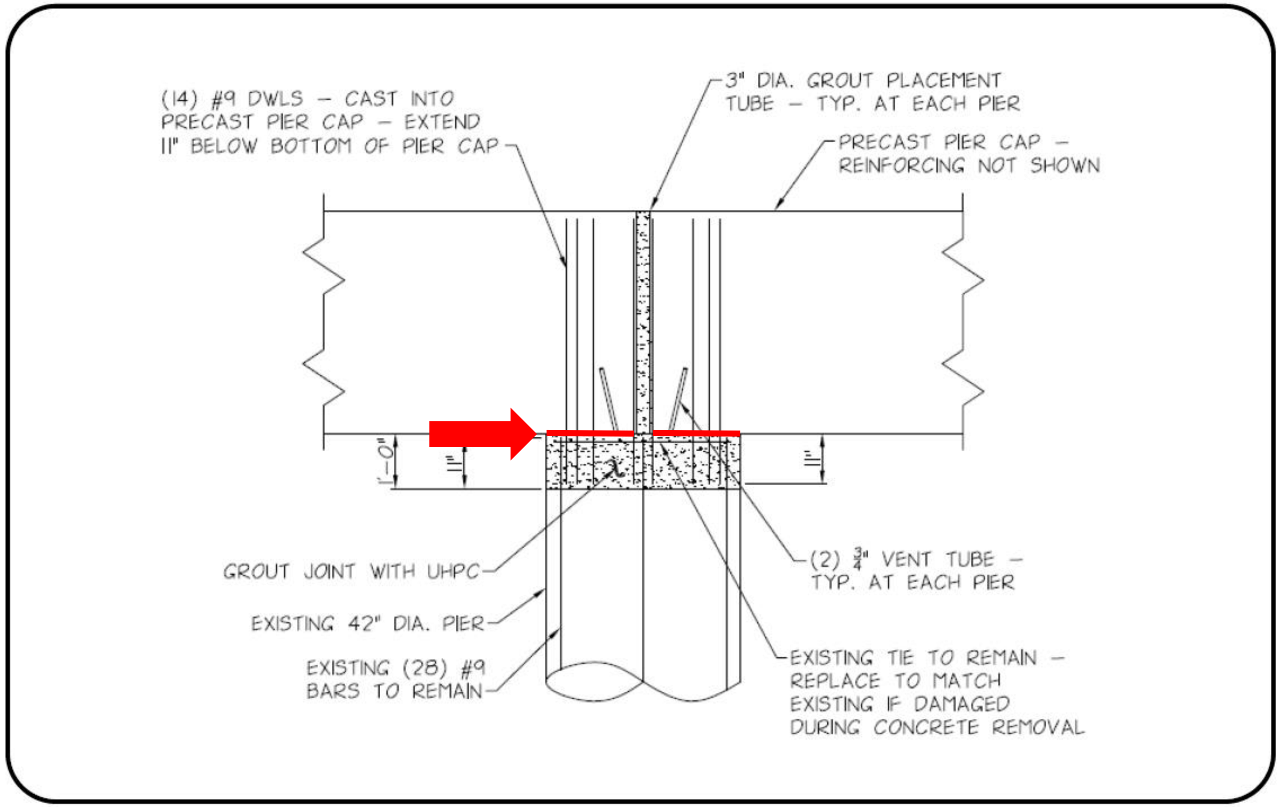




Previous Splice Testing

Source: FHWA-HRT-14-090, Development length of reinforcing bars in UHPC: An experimental and analytical investigation by Ronanki, Valentim and Aaleti

Blind Casting



Hooper Road over US 17C in Union, New York

Source: UHPC Connections for ABC presentation by Graybeal

UHPC Large Bar Splice Testing

Upcoming Research

- Macro Synthetic Fiber Reinforcement for Improved Structural Performance of Concrete Bridge Girders
- Shear Friction Capacity of Corrugated Pipe Connection in Precast Footings
- Stainless Steel Strands and Lightweight Concrete for Pretensioned Concrete Girders
- Fiber-Reinforced Concrete Traffic Railings for Impact Loading
- Straight Steel I-girder Bridges with Skew Index Approaching 0.3
- Flexural Capacity of Concrete Elements with Unbonded and Bonded Prestressing
- Shear Behavior of Webs Post-Tensioned with Tendons Containing Flexible Fillers

Questions?

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