Development of UHPC Joint Detail for Florida Slab Beam Bridge

April 9, 2018

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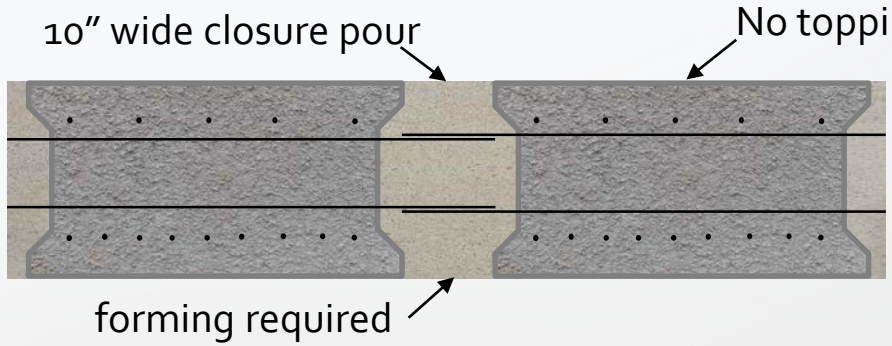
Project Manager: Christina Freeman, PE
GRA: Francisco Chitty Gozalo, MS

Outline

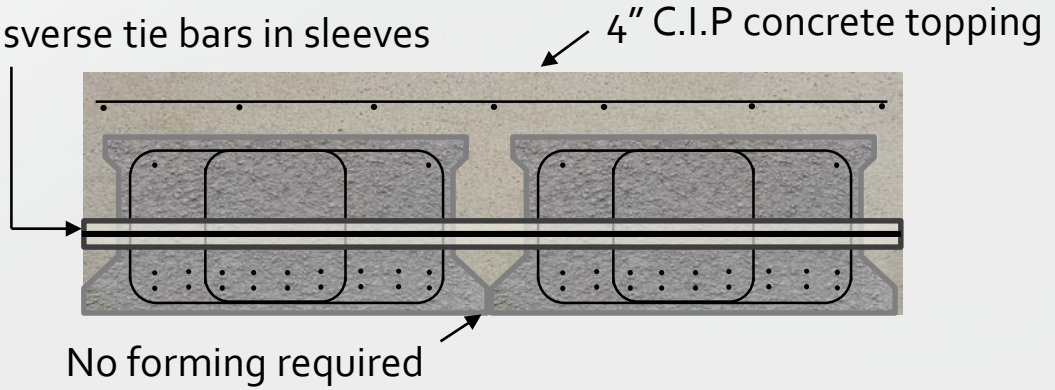
- Background
  - Slab Beam Superstructures
  - Florida Slab Beam (FSB)
  - Current FSB Superstructure System
  - Ultra-High Performance Concrete (UHPC)
- Objectives
- Joint Development
- Experimental Program
- Summary of Results
- Update of Current Research

Background – Florida Slab Beam Superstructures

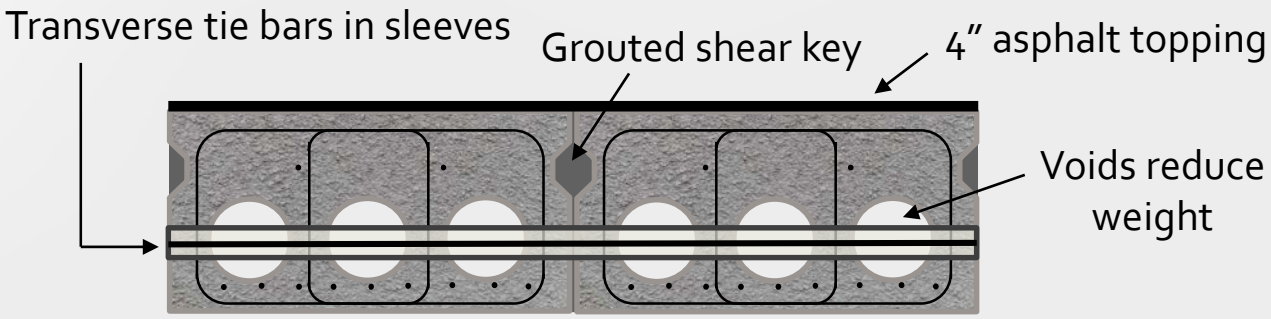
History



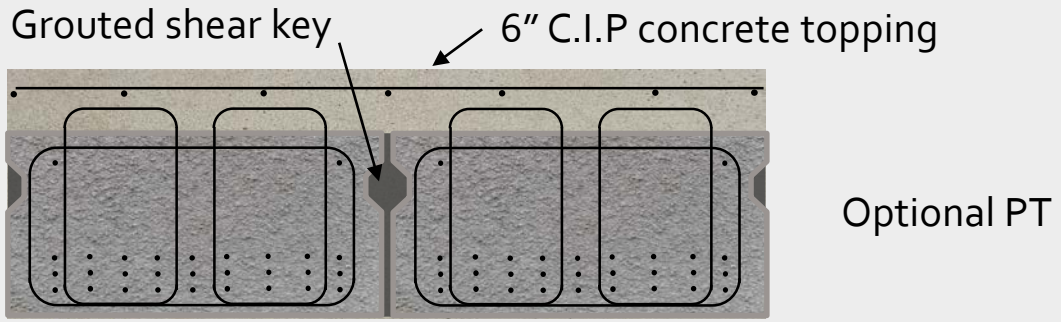
Prestressed Rectangular Slab Units (1955)



Prestressed Keyed Slab Units (1958)



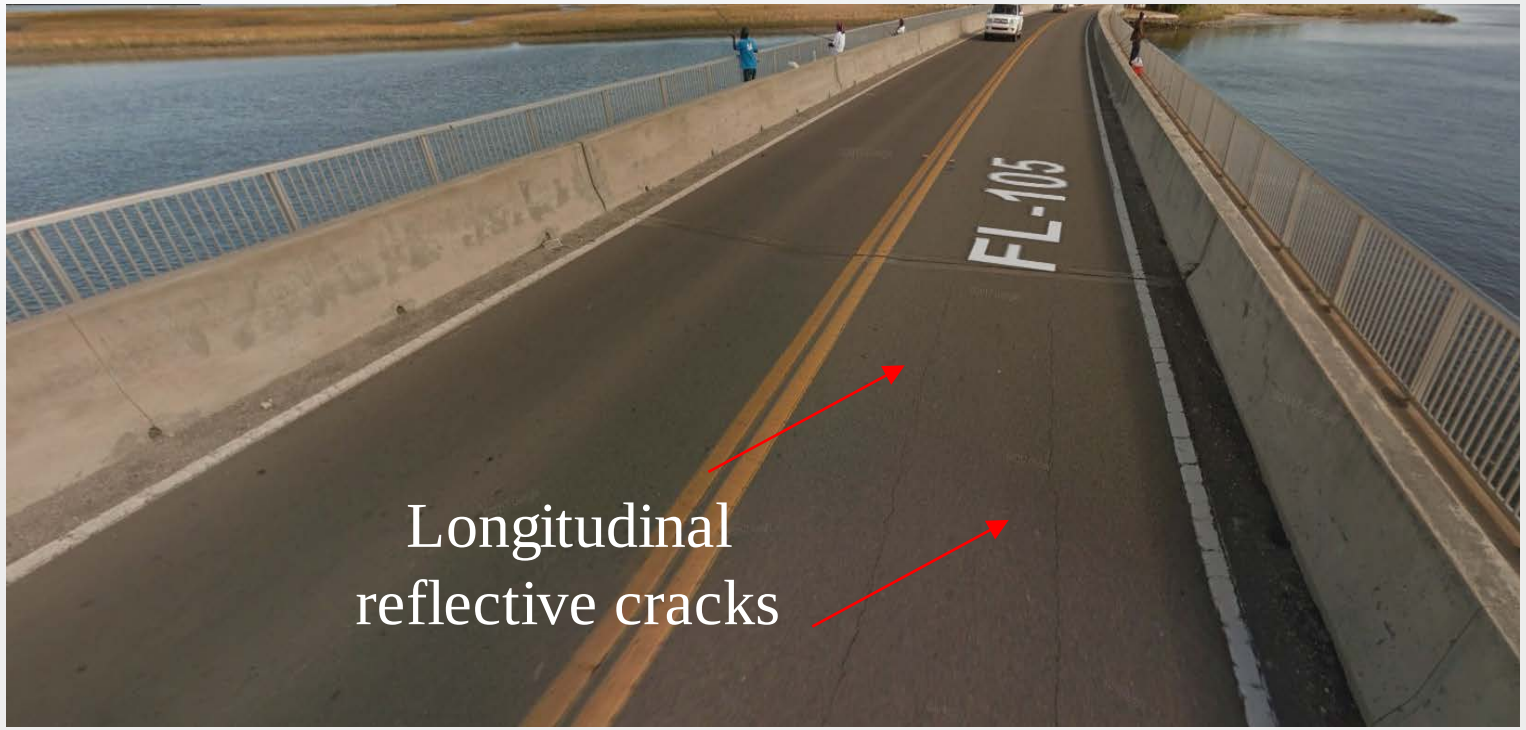
Prestressed Voided Slab Units - Sonovoids (1959)



Prestressed Slab Unit - PSU (2008)

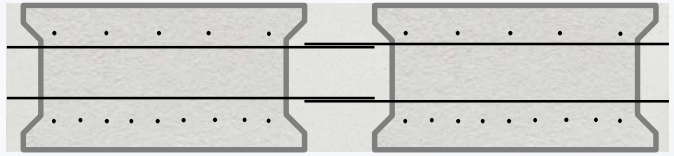
Background – Florida Slab Beam Superstructures

Performance

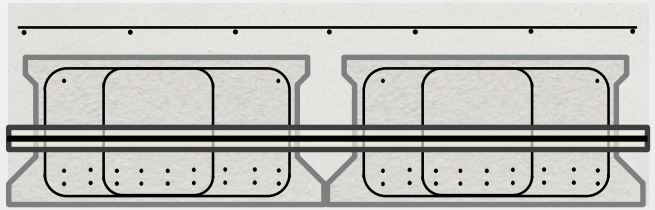


Bridge over Browns Creek (Jan 2017)
Jacksonville, FL 32226
30°25'02.9"N 81°31'52.7"W

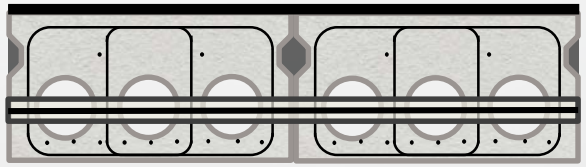
Background – Florida Slab Beam Superstructures



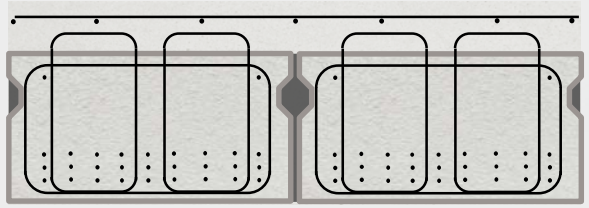
Prestressed Rectangular Slab Units (1955)



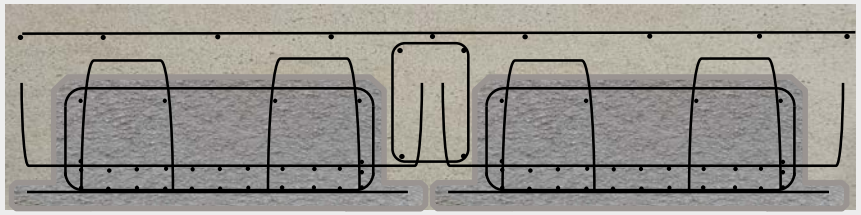
Prestressed Keyed Slab Units (1958)



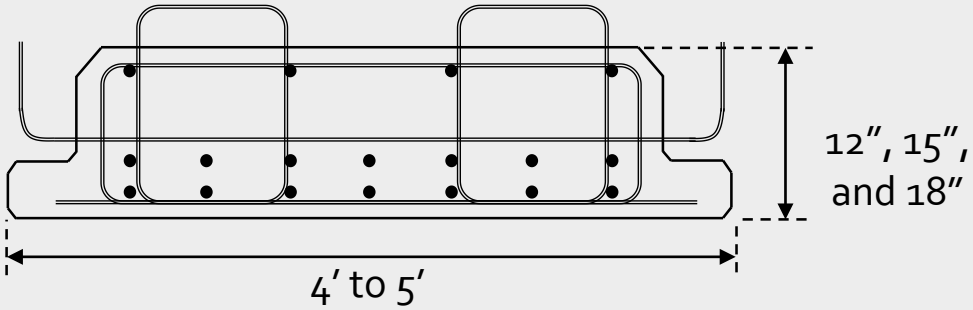
Prestressed Voided Slab Units - Sonovoids (1959)



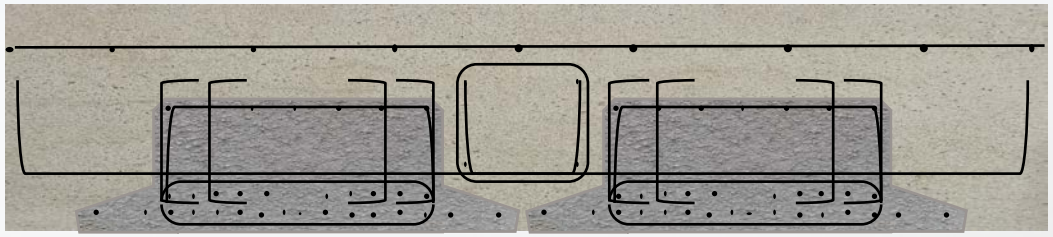
Prestressed Slab Unit - PSU (2008)



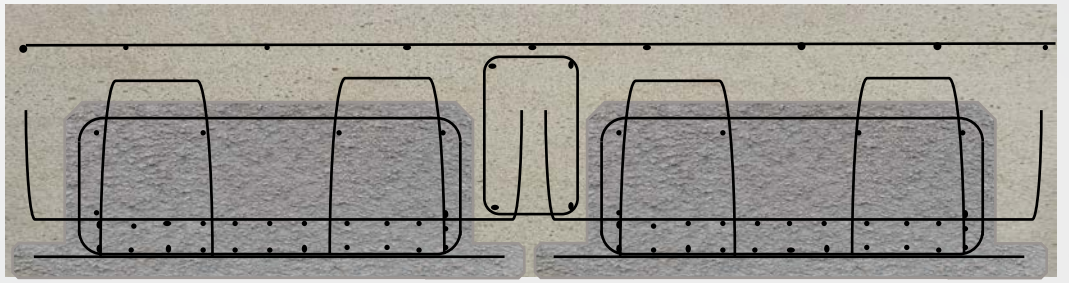
Florida Slab Beam – FSB (2015)



Background – Current FSB System

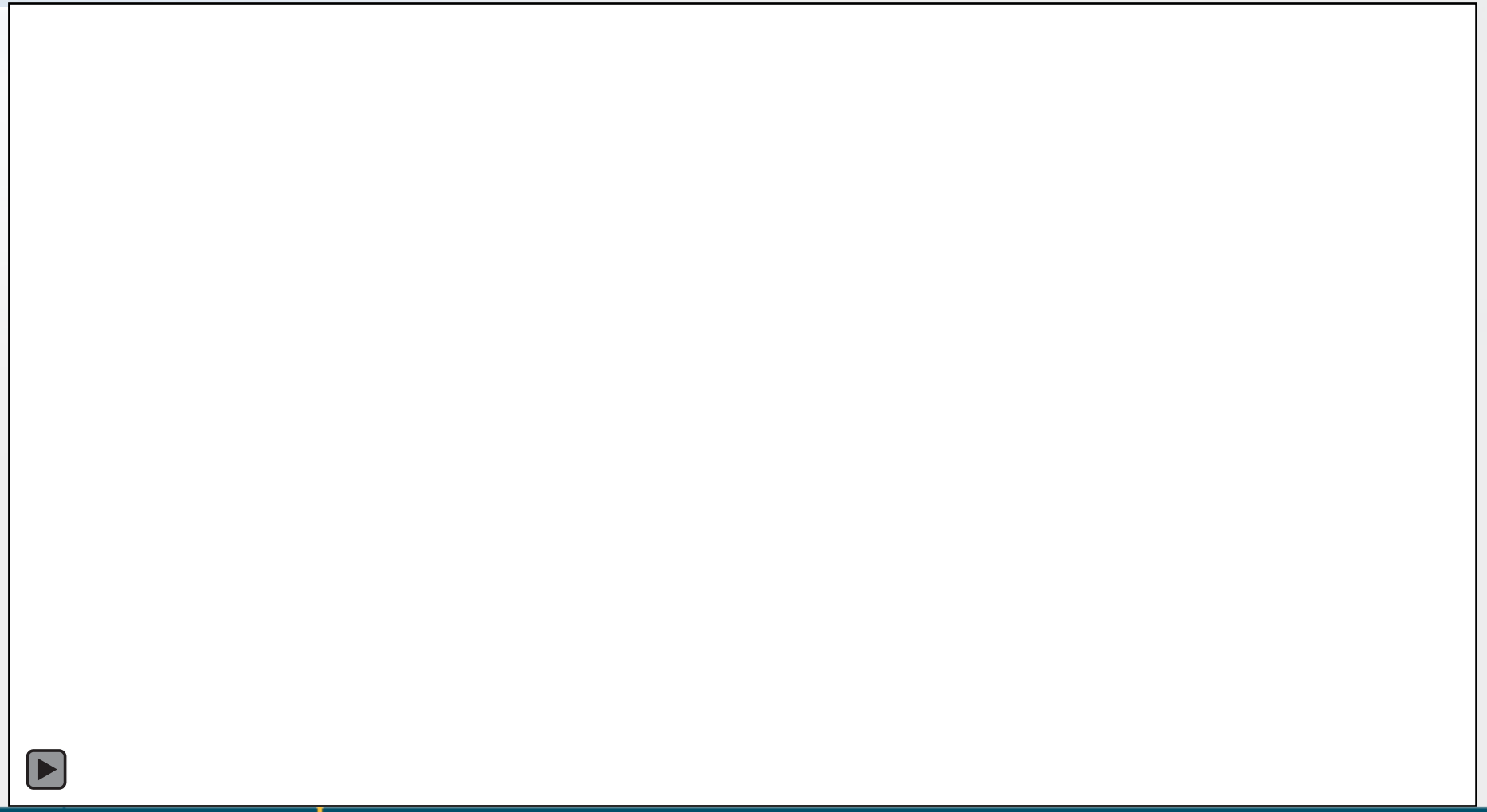


Precast Composite Slab Span System – PCSS (2005)



Florida Slab Beam – FSB (2015)

Background – Current FSB Superstructure Construction

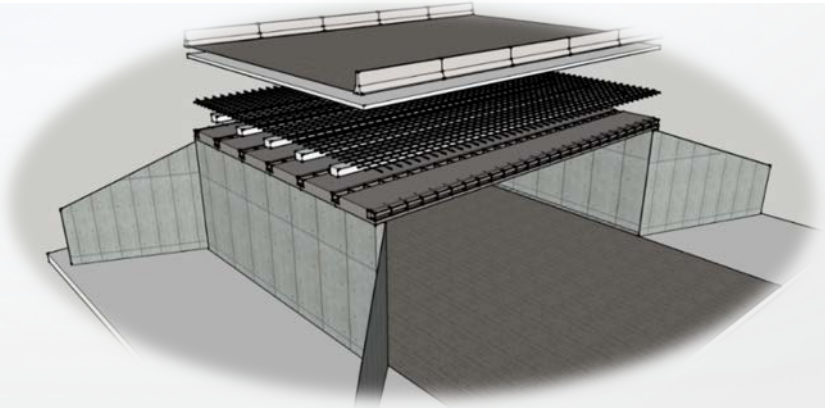


Background – UHPC

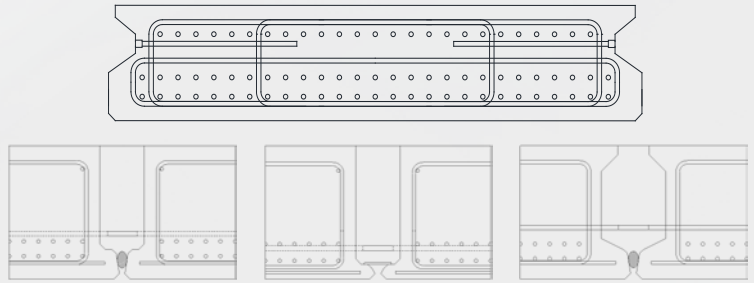
Property	Range	
Compressive Strength	20 to 30 ksi	140 to 200 MPa
Tensile Cracking Strength	0.9 to 1.5 ksi	6 to 10 MPa
Modulus of Elasticity	6,000 to 10,000 ksi	40 to 70 GPa

Source: https://www.fhwa.dot.gov/research/resources/uhpc/

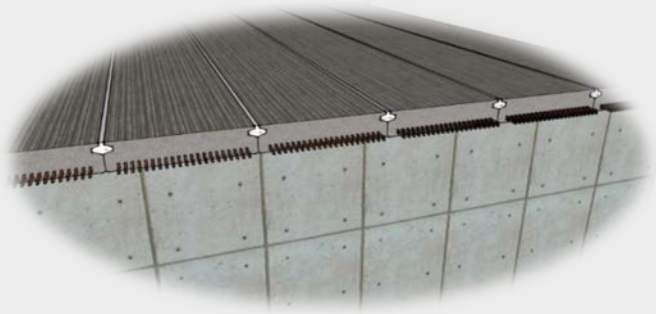
Objectives



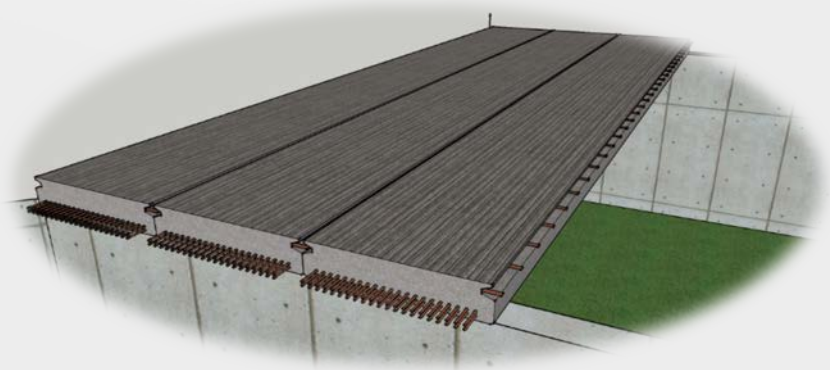
Current FSB System



Modification to FSB and Joint Region



Use of UHPC in Longitudinal Joints

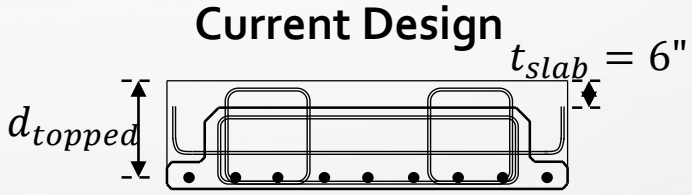


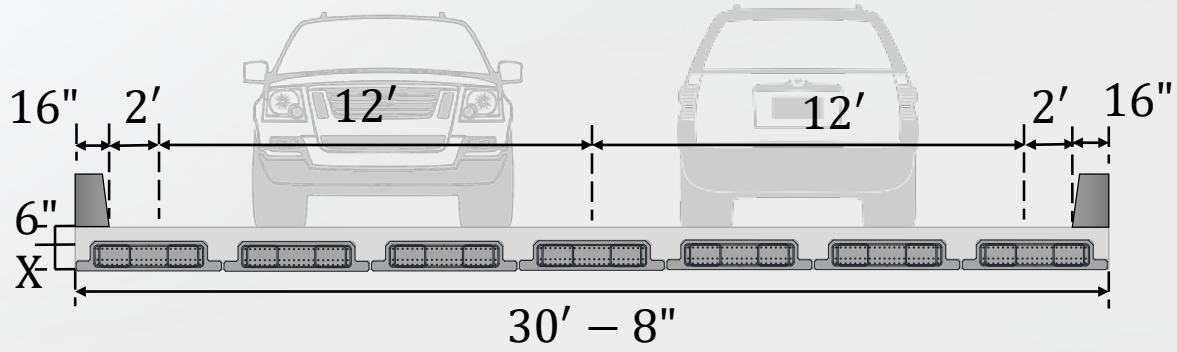
New Accelerated Construction Method

Joint Development

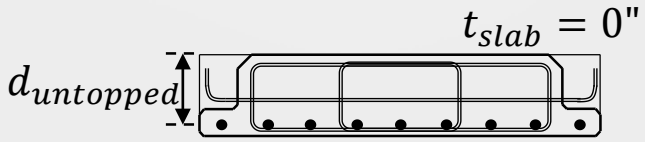
Feasible Span Lengths

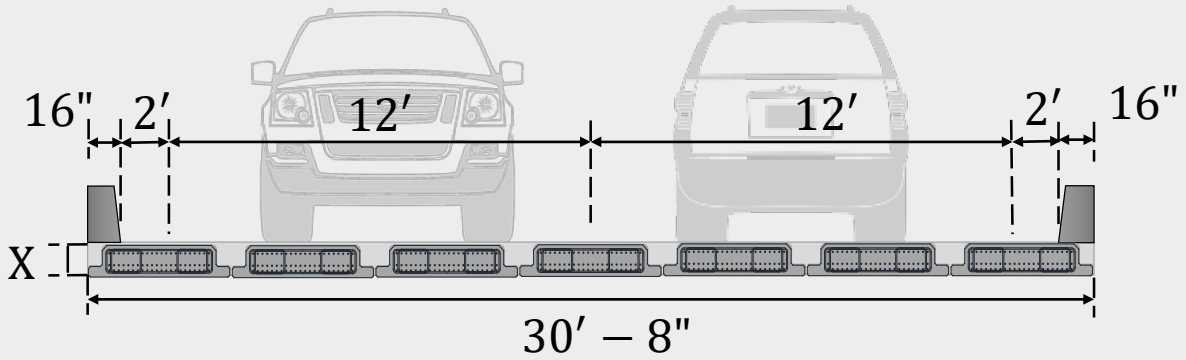
Current Design





Modified for ABC

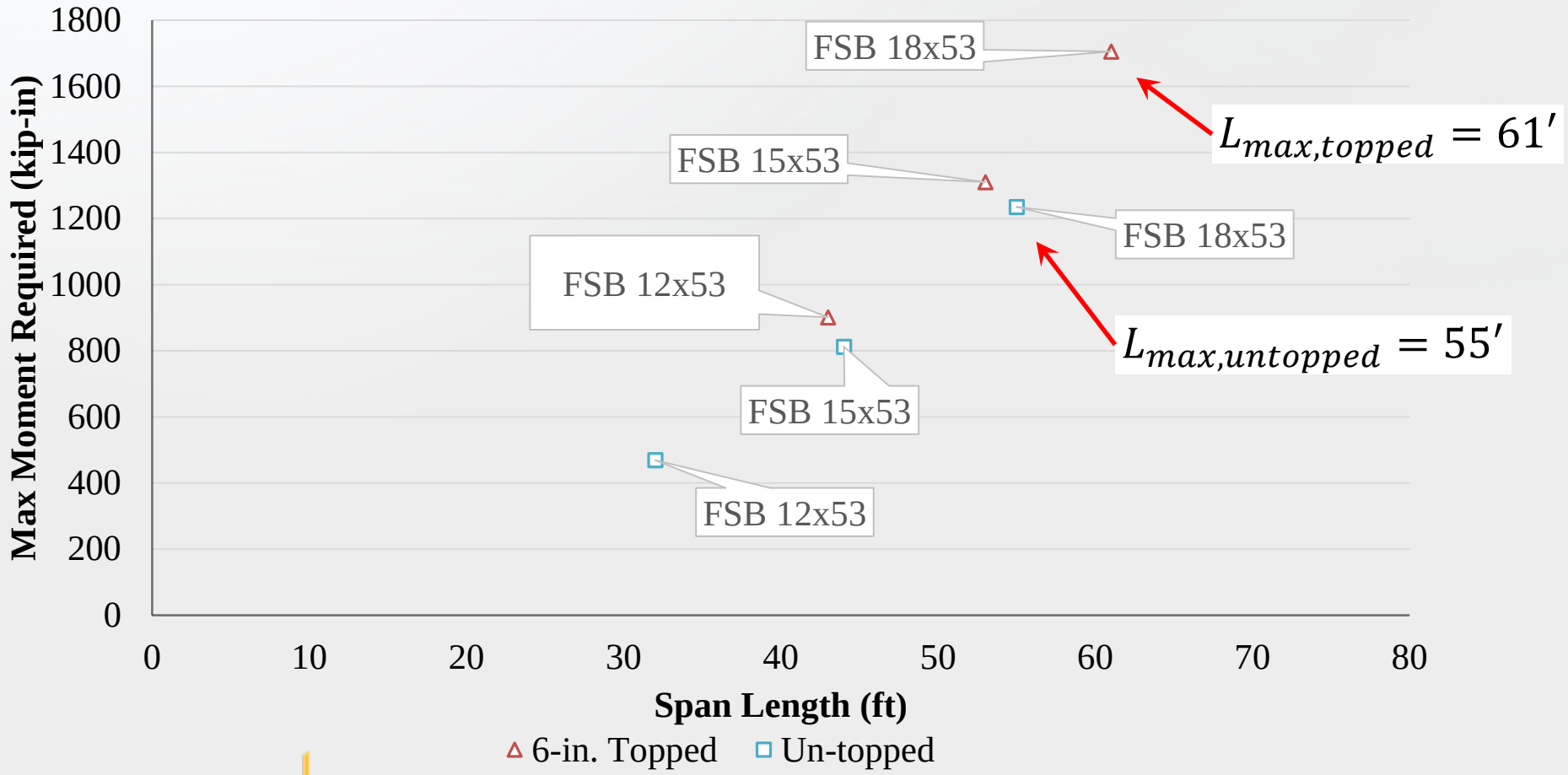




Using FDOT Design MathCAD Program

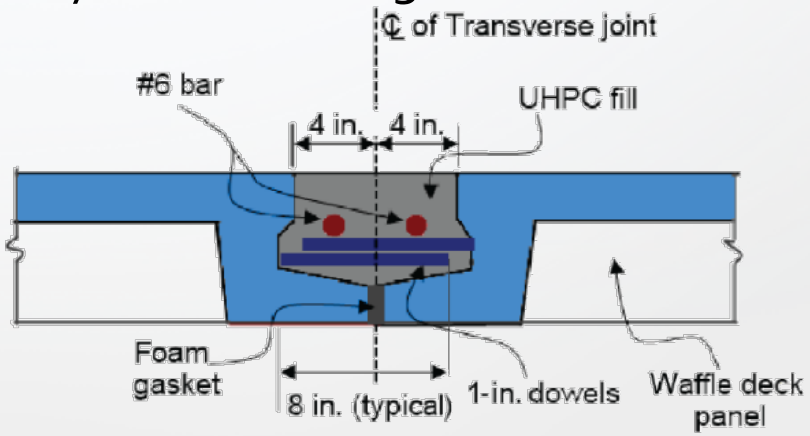
Joint Development

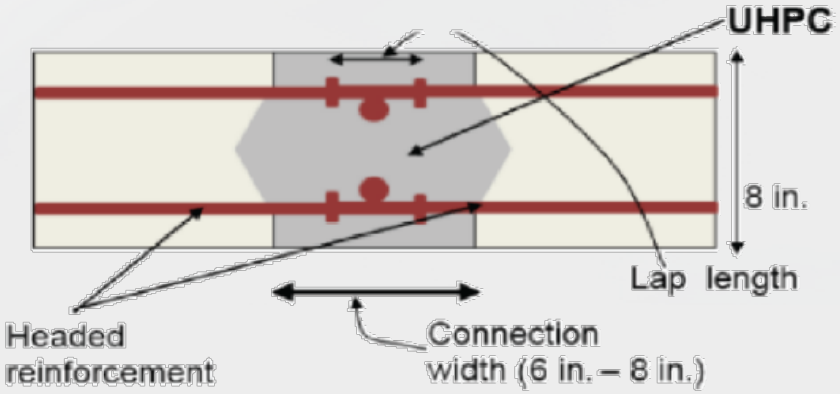
Feasible Span Lengths

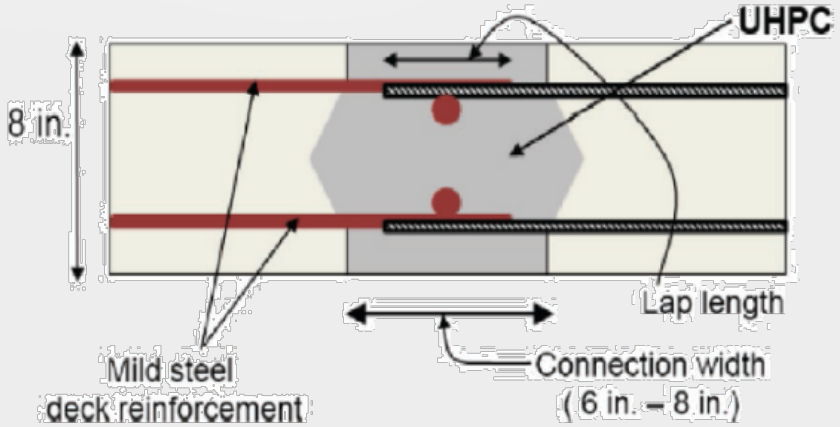


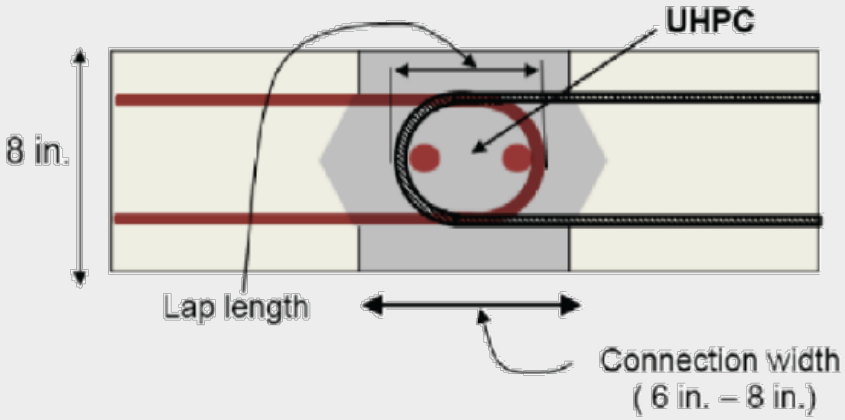
Joint Development

Previously Used/Investigated Details









(Aeleti and Sritharan, 2014)

Joint Development

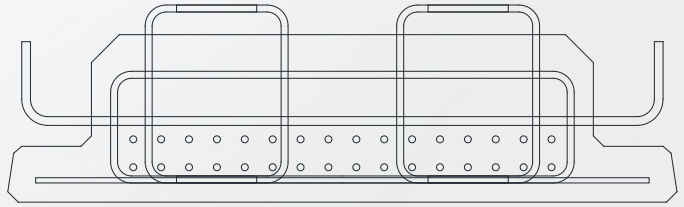
Previously Used/Investigated Details

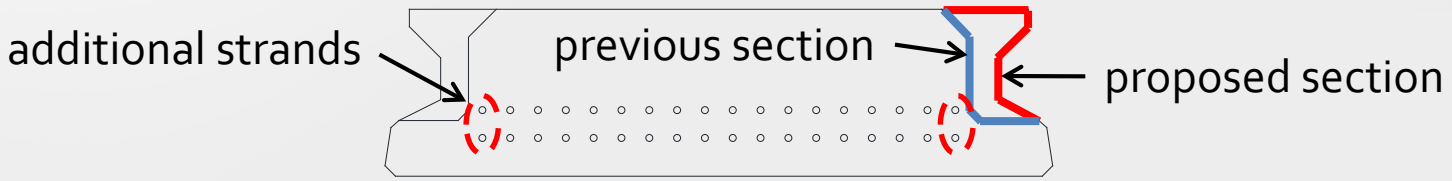
(Graybeal - FHWA)

Joint Development

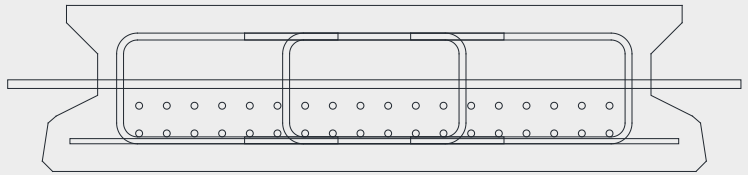
Option 1 – Box Beam Joint Integration

Original FSB Section:





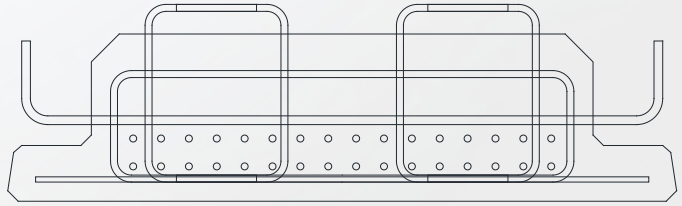
Modified FSB Section (Alternate 1):

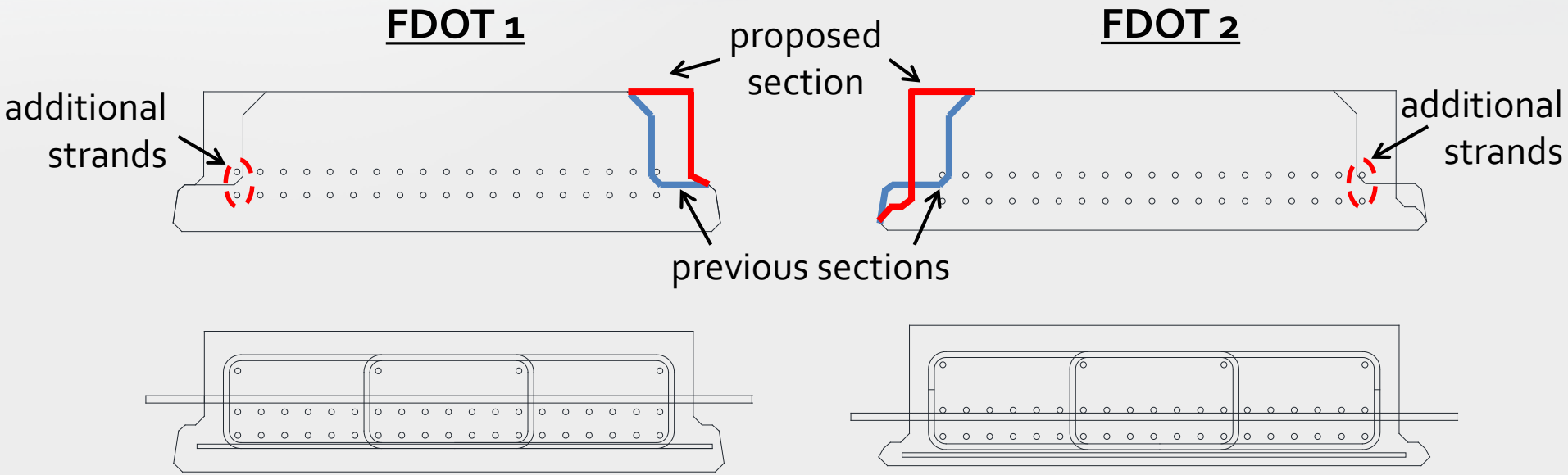


Joint Development

Option 2 – FDOT Proposed Joints

Original FSB Section:

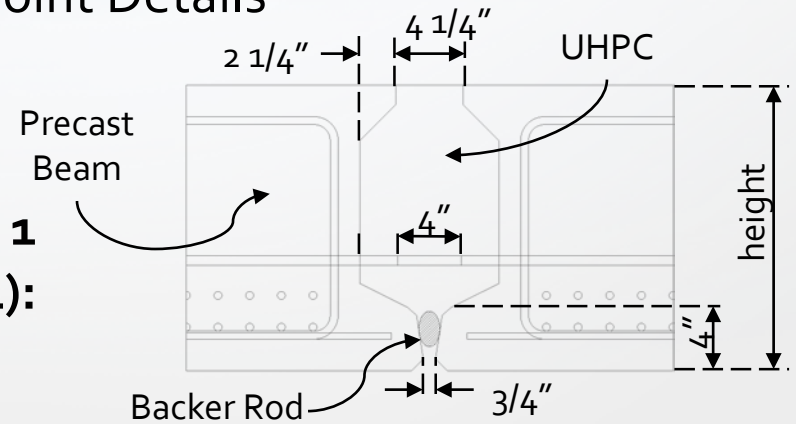




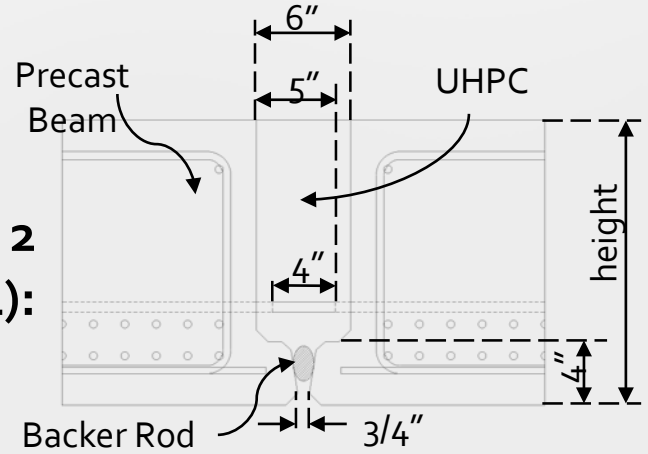
Joint Development

Final Joint Details

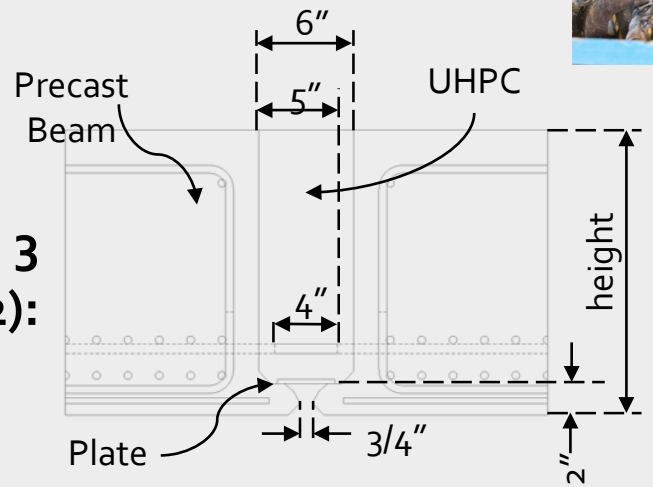
Option 1 (Alternate 1):



Option 2 (FDOT 1):



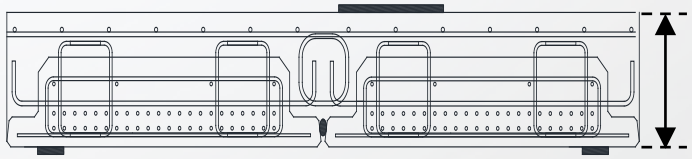
Option 3 (FDOT 2):



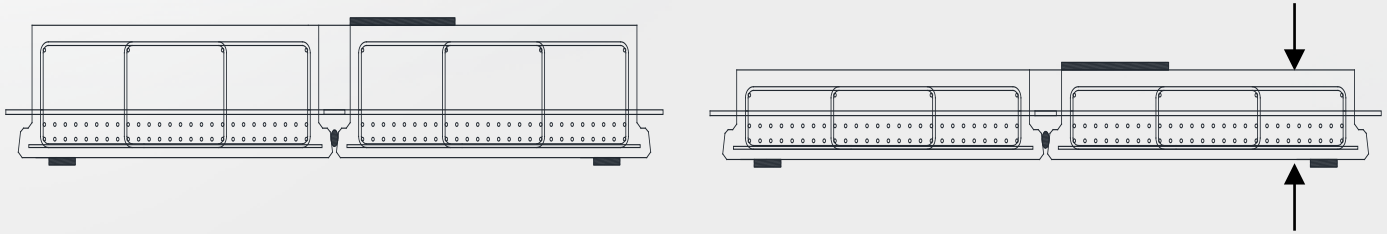
Experimental Program

Preliminary Test Specimens

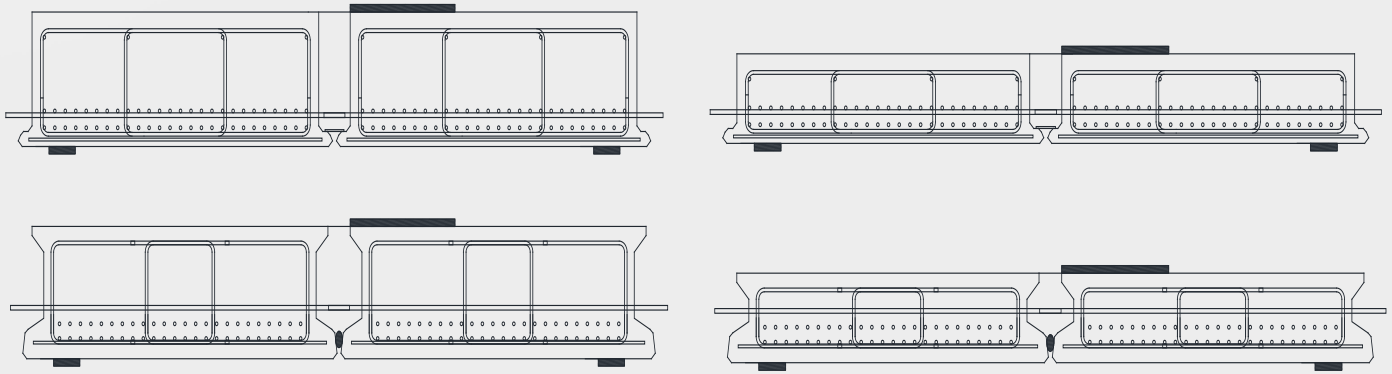
Current FSB:



FDOT 1:

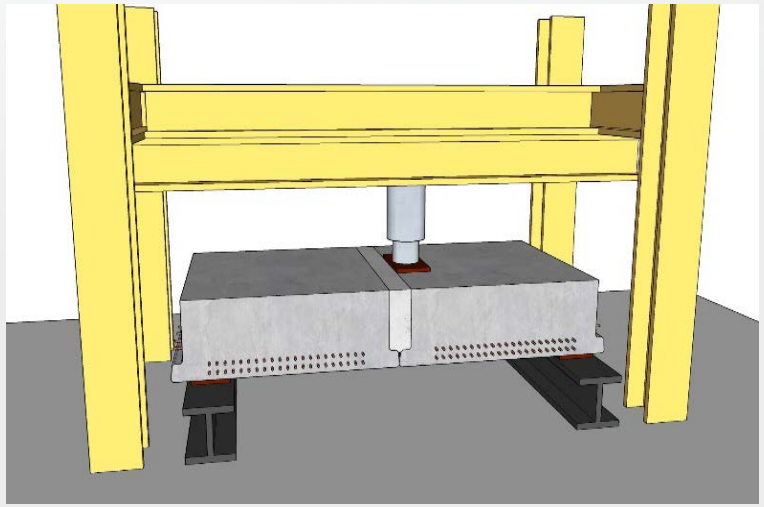


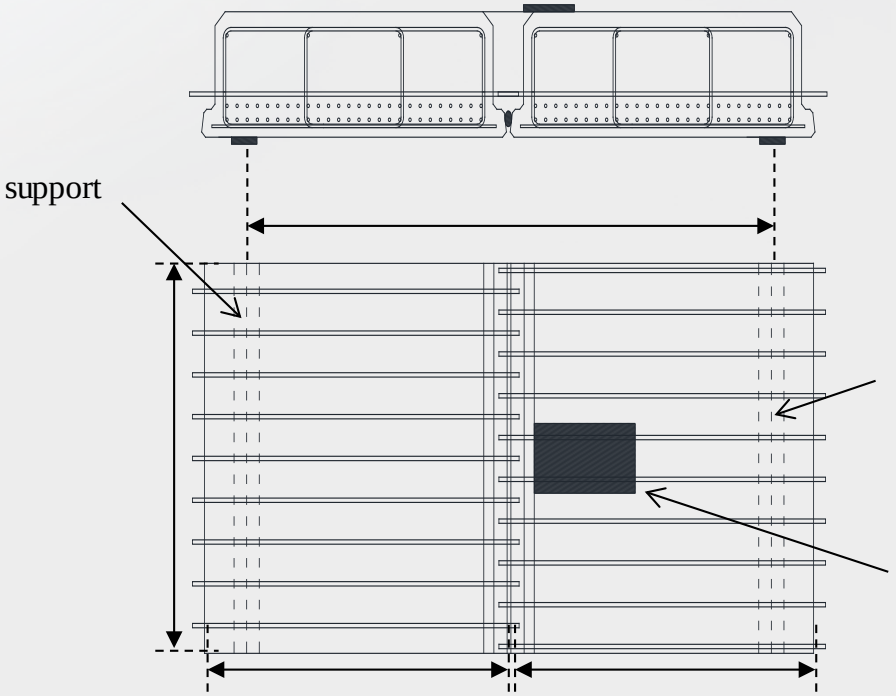
FDOT 2:



Experimental Program

Test Set-Up



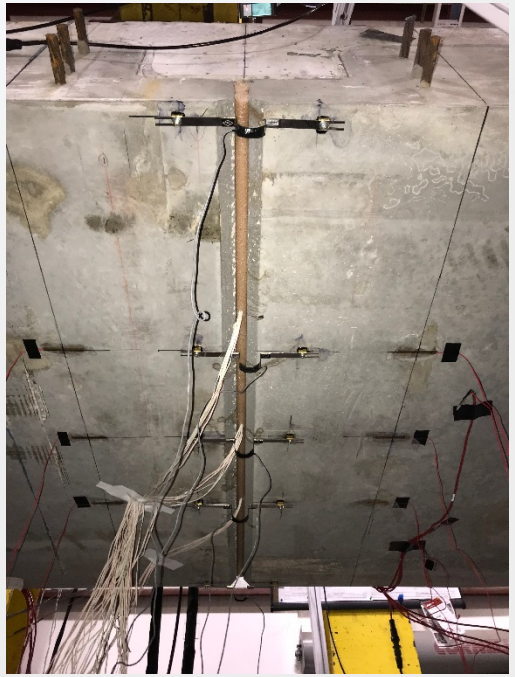


Wheel Path: AASHTO LRFD Bridge Design Specifications (Section 3.6.1.4)

Experimental Program

Experimental Testing – Current FSB

Side View

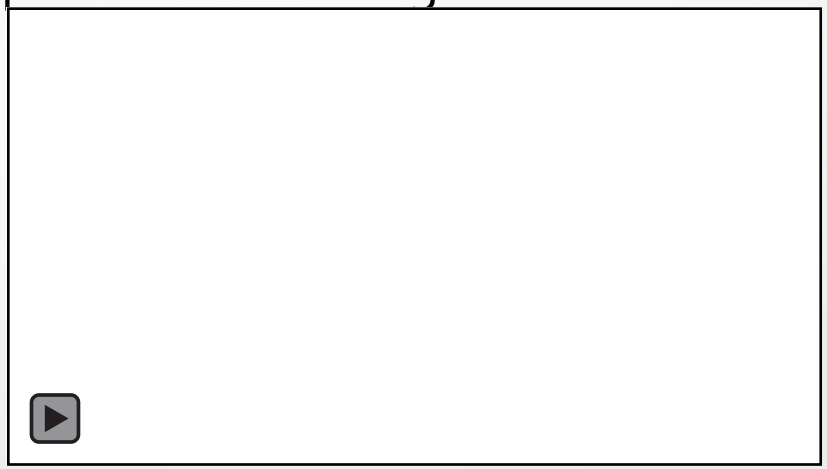


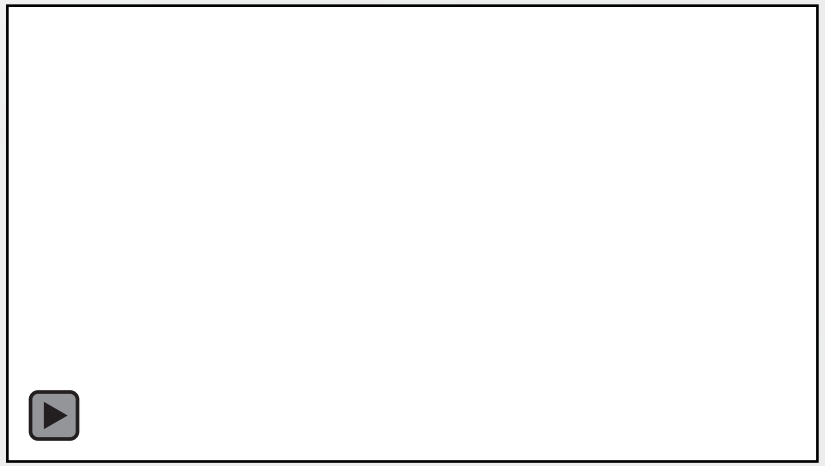
Bottom View

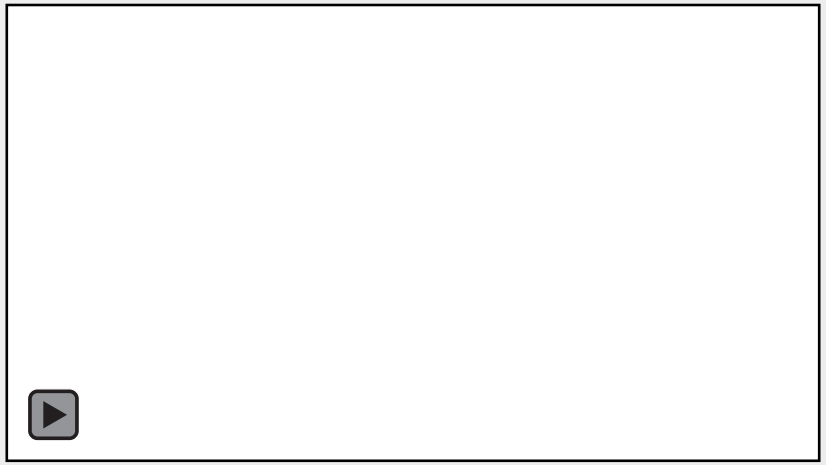
Top View

Experimental Program

Experimental Testing

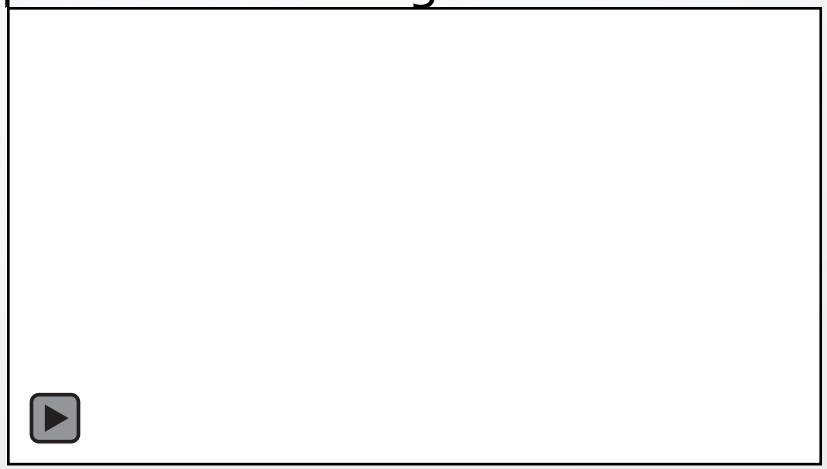


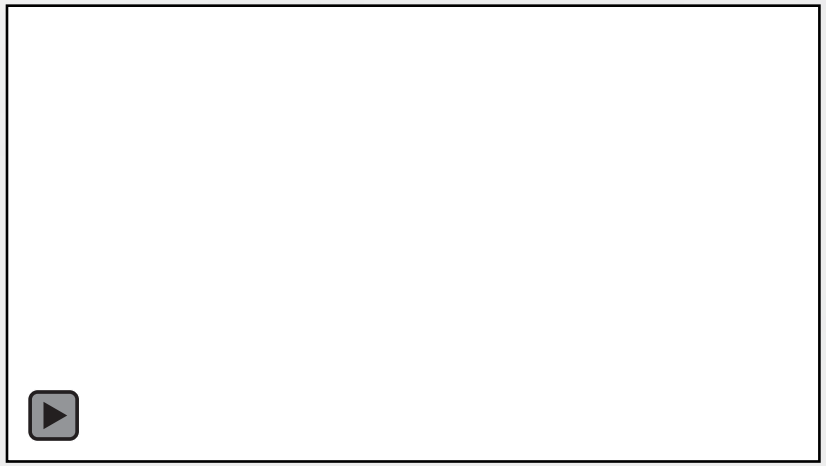


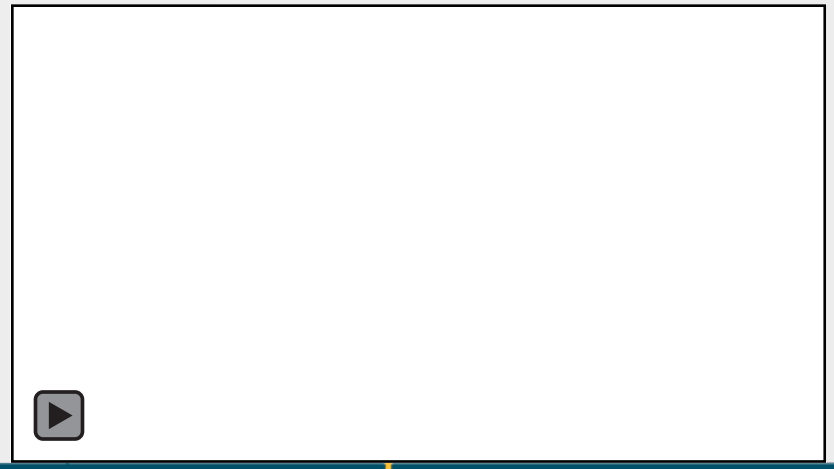


Experimental Program

Experimental Testing







Analysis of Results

Numerical and Experimental Modeling

Specimens	Max. Force [kips]		Δ @ Max. Force [in]	
	Software Analyses	Experimental Test	Software Analyses	Experimental Test
Control FSB	153.25	63.42	-0.477	-1.44
18F1	149.84	149.86	-0.374	-0.80
18F2	169.36	170.21	-0.220	-0.91
18A1	135.95	154.39	-0.185	-1.76
12F1	68.87	69.98	-0.278	-1.32
12F2	91.90	98.10	-0.210	-2.00
12A1	49.32	61.04	-0.423	-1.25

Analysis of Results

Numerical and Experimental Modeling

Specimens	Max. Force [kips]		Δ @ Max. Force [in]	
	Software Analyses	Experimental Test	Software Analyses	Experimental Test
Control FSB	153.25	63.42	-0.477	-1.44
18F1	149.84	149.86	-0.374	-0.80
18F2				91
18A1				76
12F1				32
12F2	91.90	98.10	-0.210	-2.00
12A1	49.32	61.04	-0.423	-1.25

Development failure occurred before yield (discussed later)

Analysis of Results

Numerical and Experimental Modeling

Specimens	Max. Force [kips]		Δ @ Max. Force [in]	
	Software Analyses	Experimental Test	Software Analyses	Experimental Test
Control FSB	153.25	63.42	-0.477	-1.44
18F1	149.84	149.86	-0.374	-0.80
18F2	169.36	170.21	-0.220	-0.91
18A1	135.95	154.39	-0.185	-1.76
12F1	68.87	60.08	-0.278	-1.23
12F2				
12A1				

Modified 18" Joints with UHPC performed well compared to Control FSB

Analysis of Results

Numerical and Experimental Modeling

Specimens	Max. Force [kips]		Δ @ Max. Force [in]	
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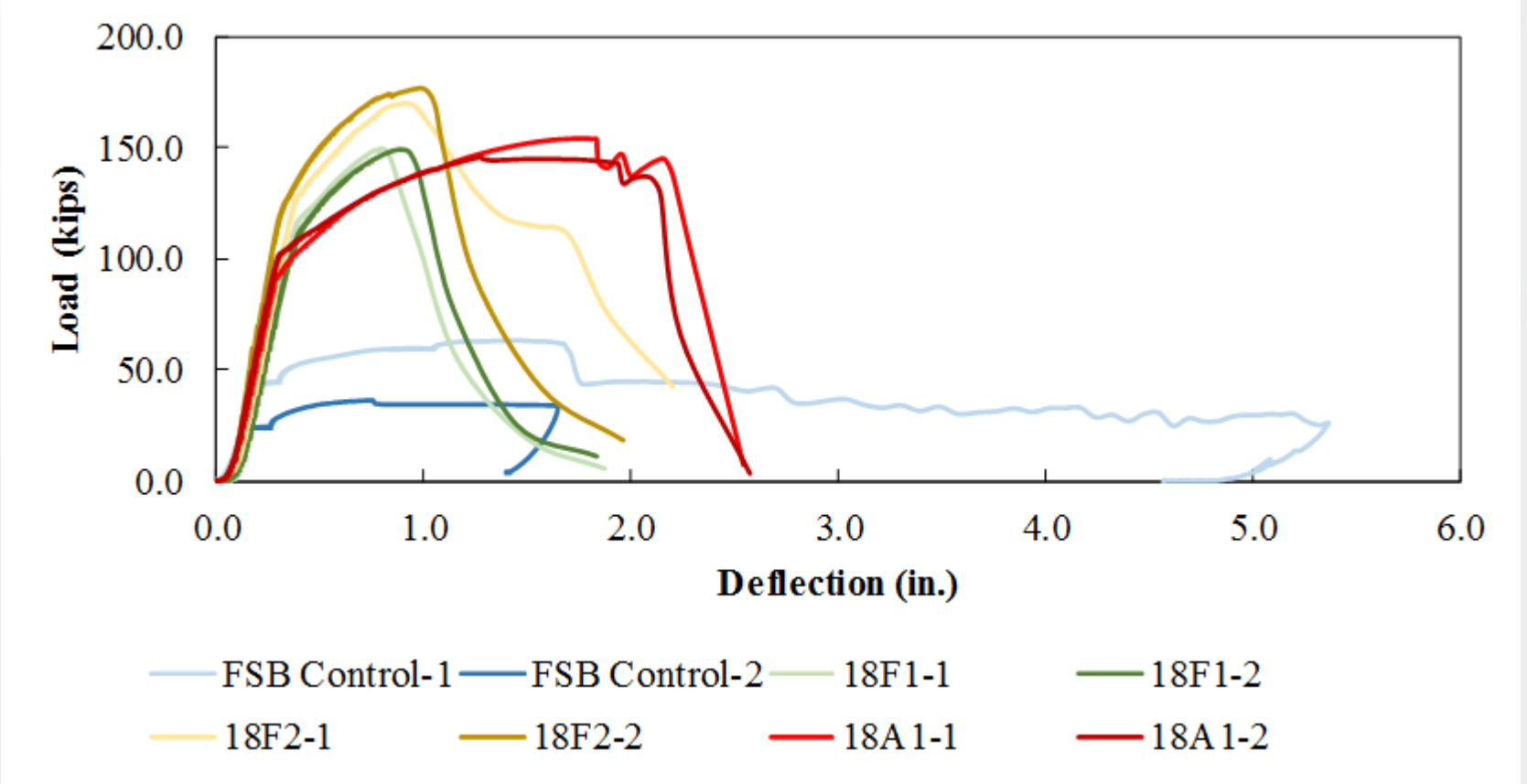
12F1	68.87	69.98	-0.278	-1.32
12F2	91.90	98.10	-0.210	-2.00
12A1	49.32	61.04	-0.423	-1.25

Difference in lever arm of steel is more significant in 12-inch deep specimens

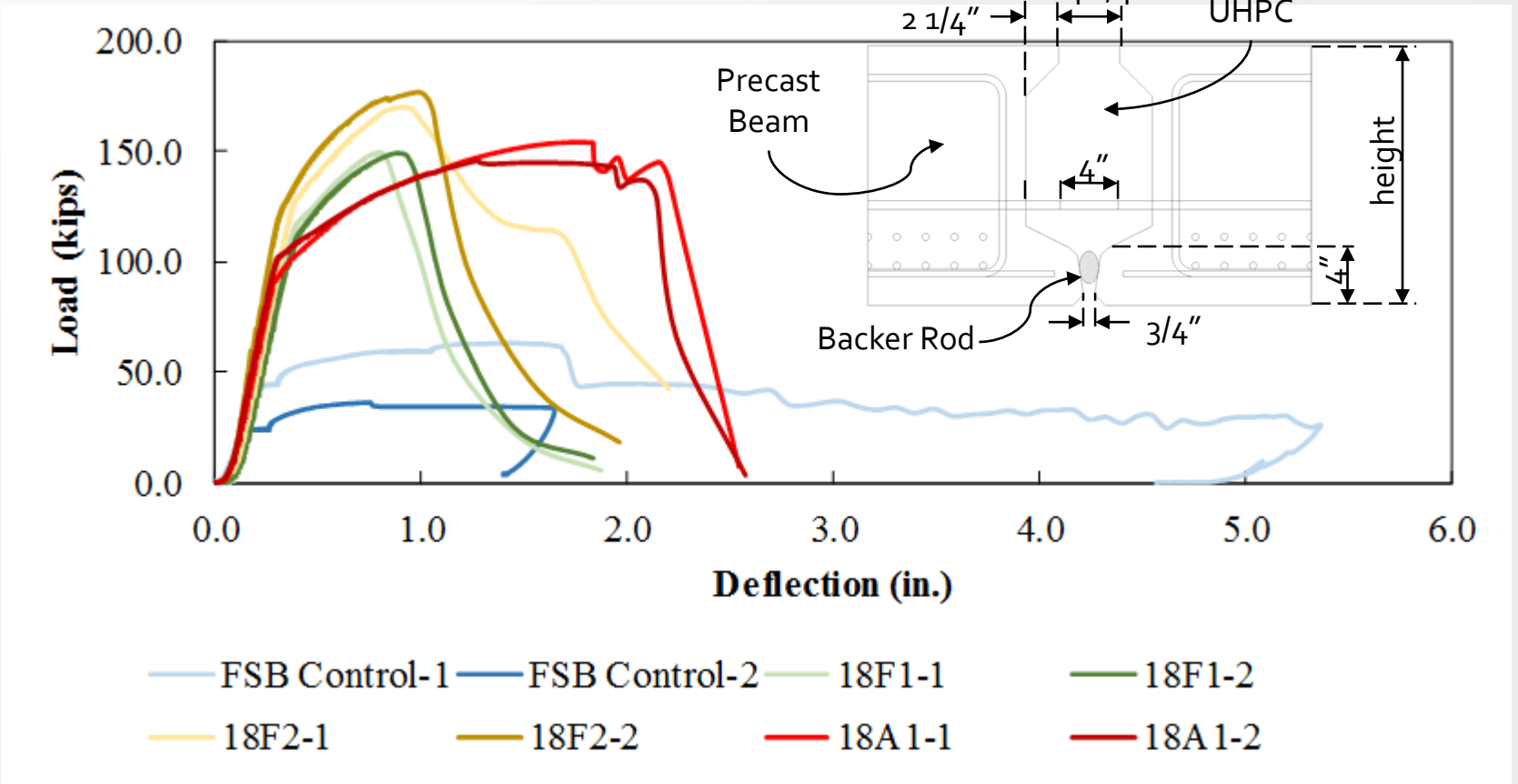
Analysis of Results

Experimental Models – 18" Specimens



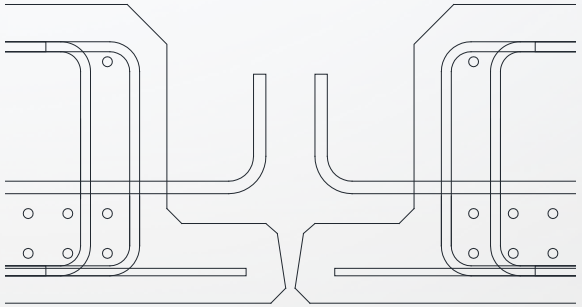
Analysis of Results

Experimental Models – 18″ Specimens



Preliminary Recommendations

Experimental Testing – Current FSB



Original Joint Design

Observed faulty bar bend in FSB Control joint

Original FSB joint delivered

Ensure proper bend detail during construction

Preliminary Recommendations

Experimental Testing – Joint Surface Exposure

Exposed Aggregate Finish

Set-Retarding Agent

(Graybeal - FHWA)

VS

Sand-Blasted

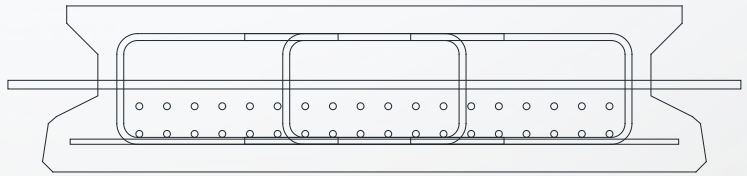
(Current Research)

Debonding between UHPC and precast concrete

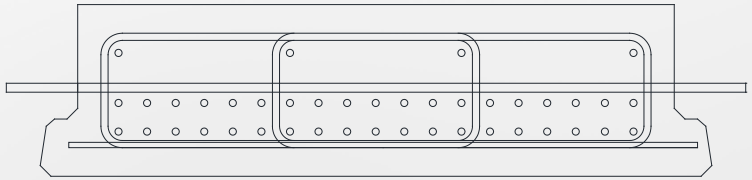
Ensure ¼" roughened surface

Preliminary Conclusions

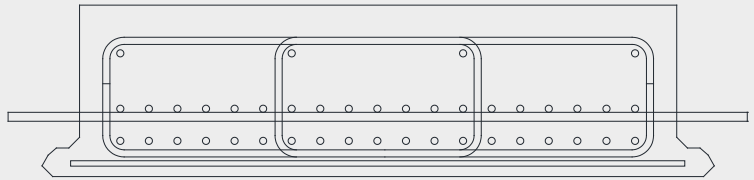
Joint Strength



P_{max} = 154.40 kips

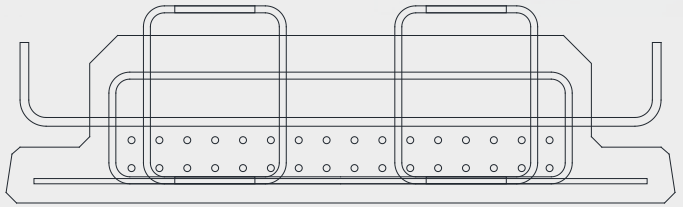


P_{max} = 149.90 kips



P_{max} = 170.20 kips

$\geq$



P_{max} = 153.25 kips*

(P_{max} = 63.42 kips**)

*from numerical model

**from experimental testing

Acknowledgments

- Advisor
  - Dr. David Garber
- Project Manager
  - Christina Freeman
- Instrumentation and Testing
  - Brandon Winter
- Fabrication & Test Setup
  - Paul Tighe
  - Ben Allen
  - David Allen
  - Miguel Ramirez

Thank You

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