Brightline Trains Florida:

Rail Structure Innovation & Construction over 235 Miles of New Railroad

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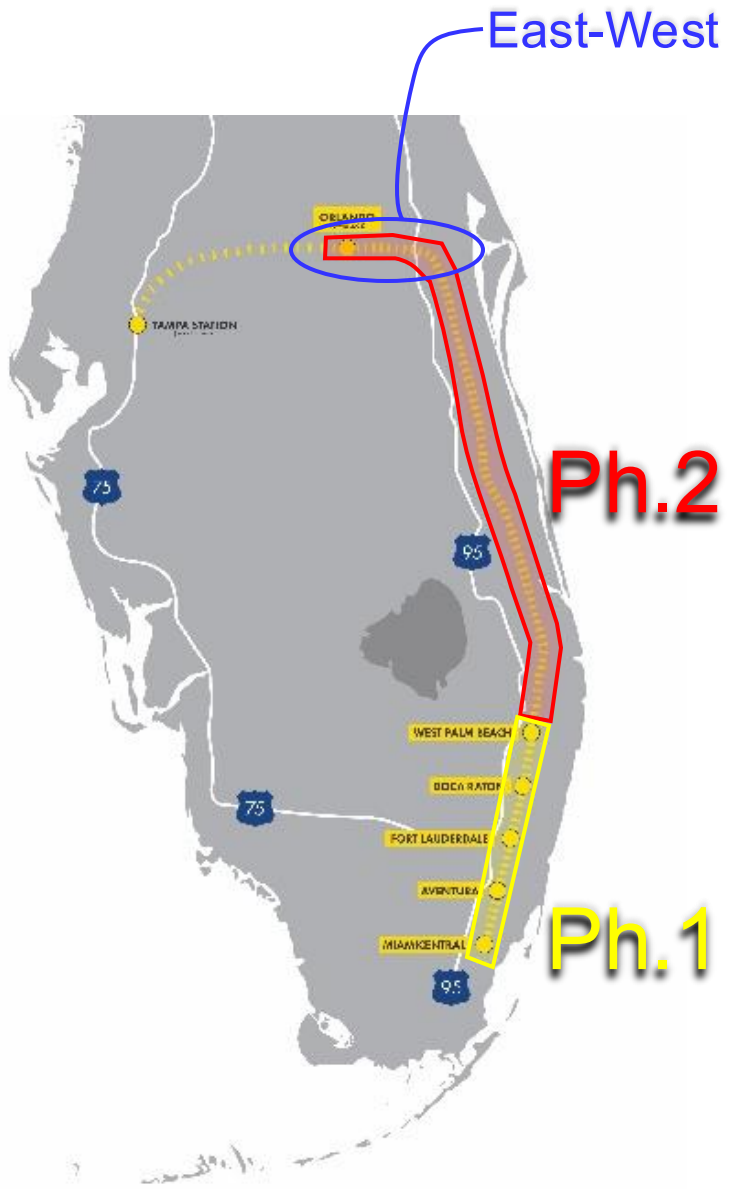
brightline HNTB

Agenda

- Program Overview
- Project Design Criteria
- Application of Structure Types
- Prestressed Concrete Deck Beams
- Construction Constraints
- Bascule Bridges
- Summary and Conclusions
- Acknowledgements
- Questions

Program Overview

- $6B Construction
- 103 Structures
- North-South Corridor Shared with Freight (195 Miles)
- East-West Corridor Greenfield (40 Miles)
- 5 Major Stakeholders
  - Brightline
  - Florida East Coast Railway (FECR)
  - Greater Orlando Aviation Authority (GOAA)
  - Florida DOT (FDOT)
  - Central Florida Expressway Authority (CFX)
- HNTB served as PM, CM, EOR, Extension of Staff



Project Design Criteria

- AREMA Manual for Railway Engineering (MRE) supplemented with
  - Eurocode
  - ACI, AASHTO, FDOT

- Maximum Design Speeds
  - Freight – 70mph, no freight allowed on East-West corridor
  - Passenger:

Segment	MAS	MDS[1]
Miami to W. Palm Beach	79 mph	-
W. Palm Beach to Cocoa	110 mph	135 mph
Cocoa to Orlando.	125 mph	150 mph

Project Design Criteria

- Live Load
  - Passenger-only Territory: Brightline Intercity Trains and Cooper E-60 for Maint. Trains
  - Shared Territory: Cooper E-80 freight loads

- Longitudinal Load
  - Freight – AREMA Chapters 8 & 15
  - Passenger – EuroCode 6.5.3

Braking forces BR (kips) = 1.37 kip/ft * L ≤ 1350 kips,
where L is the lesser of expansion length or 1000ft

Traction forces TR (kips) = 2.26 kip/ft * L ≤ 225 kips,
where L is the lesser of expansion length or 100ft

Project Design Criteria

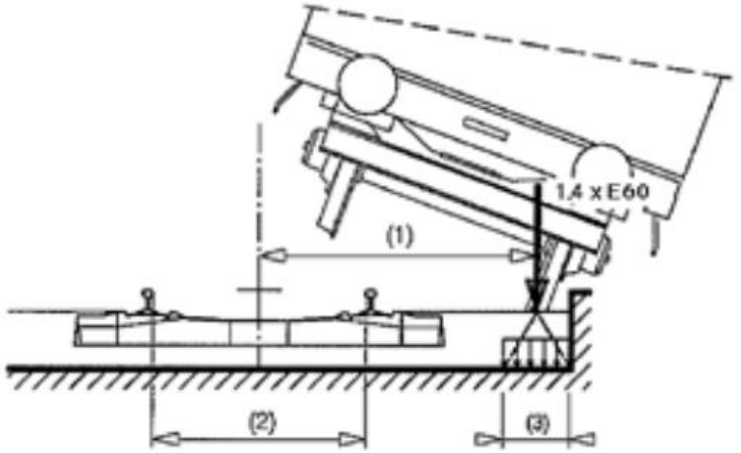
- Vertical Deflection
  - AREMA L/640
  - Passenger Comfort – vertical vehicle acceleration limited to 3.28 ft/sec^2
  - Track Maintenance – Brightline Intercity Train L/1500, L/2250, or L/2600
    (for MAS 79mph, 110mph and 125mph)

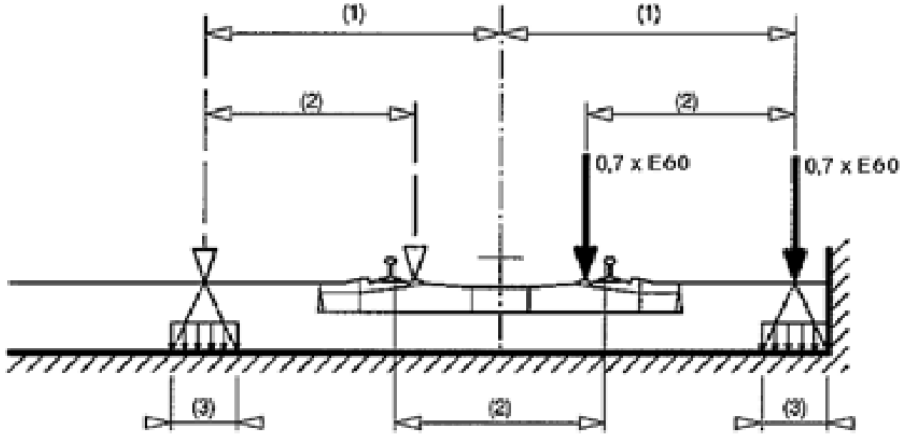
- Live Load Dynamic Effects
  - Passenger Traffic > 90 mph – Resonance check using Eurocode High Speed Load Model (HSLM)
    - Exempt from Dynamic Analysis if Natural Frequency falls between given limits

Project Design Criteria

- Derailment Loads
  - Vertical – EuroCode 6.7
  - Horizontal – ACI 358-3.5.2

- Approach Slabs for MAS > 90 mph
  - AREMA Ch.8 – 2.1.7





Application of Structure Types

- Summary:
  - Std. RR Concrete Box Beam: 20
  - Std. Flat Concrete Slab: 11
  - Steel Deck Plate Girder: 5
  - Steel Through-Girder: 3
  - Concrete FIB w/Deck: 20
  - Rehabilitations: 4
  - Concrete Box Culverts 10
  - Concrete Trenches: 3
  - Concrete Arch Underpass: 1
  - **Jacked Box Underpass: 2**
  - **Concrete Deck Beam (w/UHPC): 21**
  - **Moveable/Bascule: 3**

➔ 103 Transportation Structures

Application of Structure Types

- Standard Concrete Box Beams
  - Very limited vertical clearance
  - Threading a needle of conflicts
    - Airport Guideway Transit
    - Airport Baggage Tug roadway
    - Critical FAA communication lines
  - Easy to handle, quick to install

Application of Structure Types

- Concrete Flat Slabs, Rolled Steel Beams
  - Short span bridges crossing canals and natural gas transmission lines
  - Skewed, with low vertical clearances

Application of Structure Types

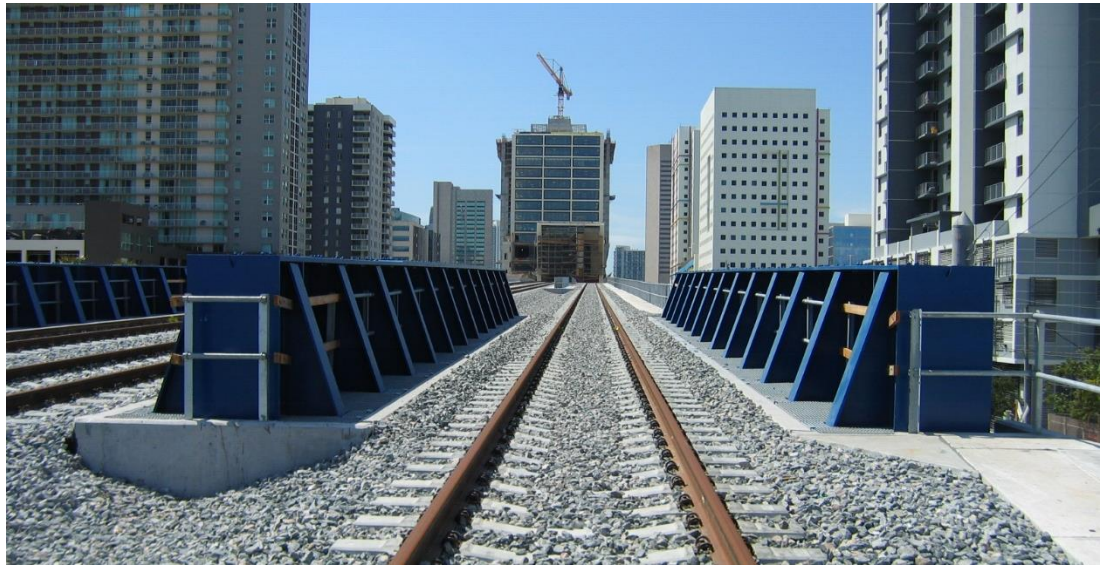
- Concrete I-Beams
  - Less maintenance in congested areas
  - CIP concrete decks
  - Used primarily in the aerial stations
  - Mix of direct fixation and ballast deck

Application of Structure Types

- Steel Deck Plate Girders
  - Longer spans (max. 163 feet)
  - Require concrete decks
  - Ramp bridges with straddle piers

Application of Structure

- Steel Through Girders
  - Increase overhead for low clearance sites
  - Urban streets and boat channels



Application of Structure Types

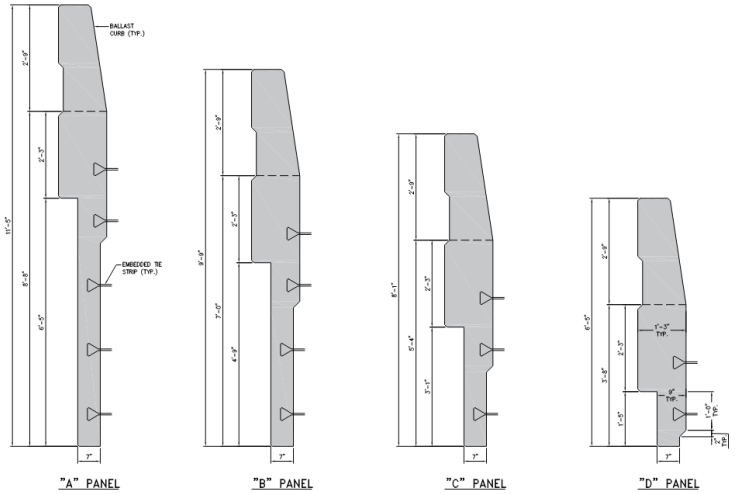
- Steel Through Girders – Crane Creek
  - Frequently hit by trucks
  - USCG required more vert. clearance

Application of Structure Types

- Concrete Trenches
  - Trenches built below water table to allow trains under airfield taxiways
  - Micropile supports near Taxiway footings

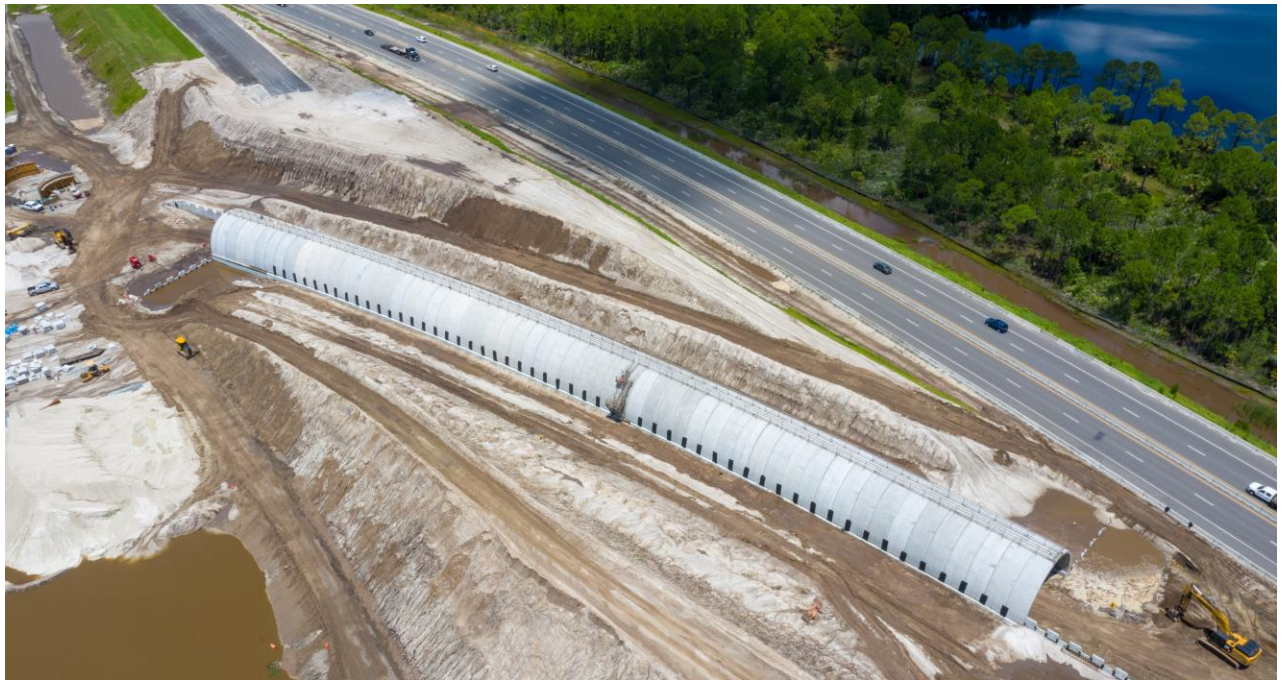
Application of Structure Types

- Retaining Walls
  - T-Walls used in freight corridor
  - MSE walls used in passenger-only corridor
    - Design includes load transfer from end bent piles
  - Full-height panels (“piano walls”)
    - Cost-effective for long linear stretches of low-height walls (8’ – 10’)



Application of Structure Types

- Concrete Arch Underpass
  - SR 528 Underpass has unique geometry
  - Complete rebuild of SR 528 above tracks
  - Precast arch panels
  - Fill conveyor over expressway traffic



Application of Structure Types

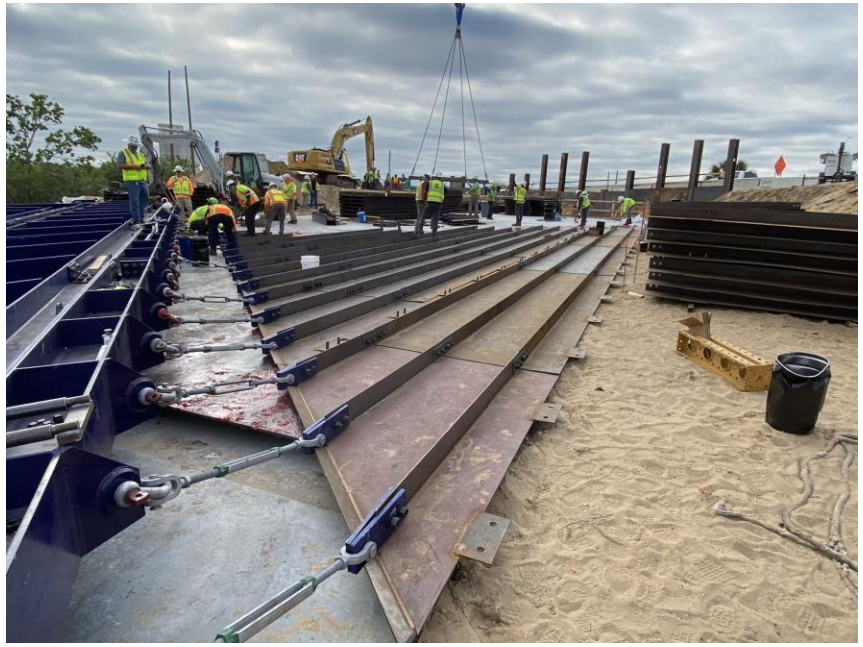
- Jacked Box Underpass – Goldenrod Rd
  - Italian technology, only 2nd Time used in USA
  - 12 million pounds of thrust

Application of Structure Types

- Jacked Box Underpass – SR528
  - 1st time in USA jacked under traffic
  - Skewed alignment

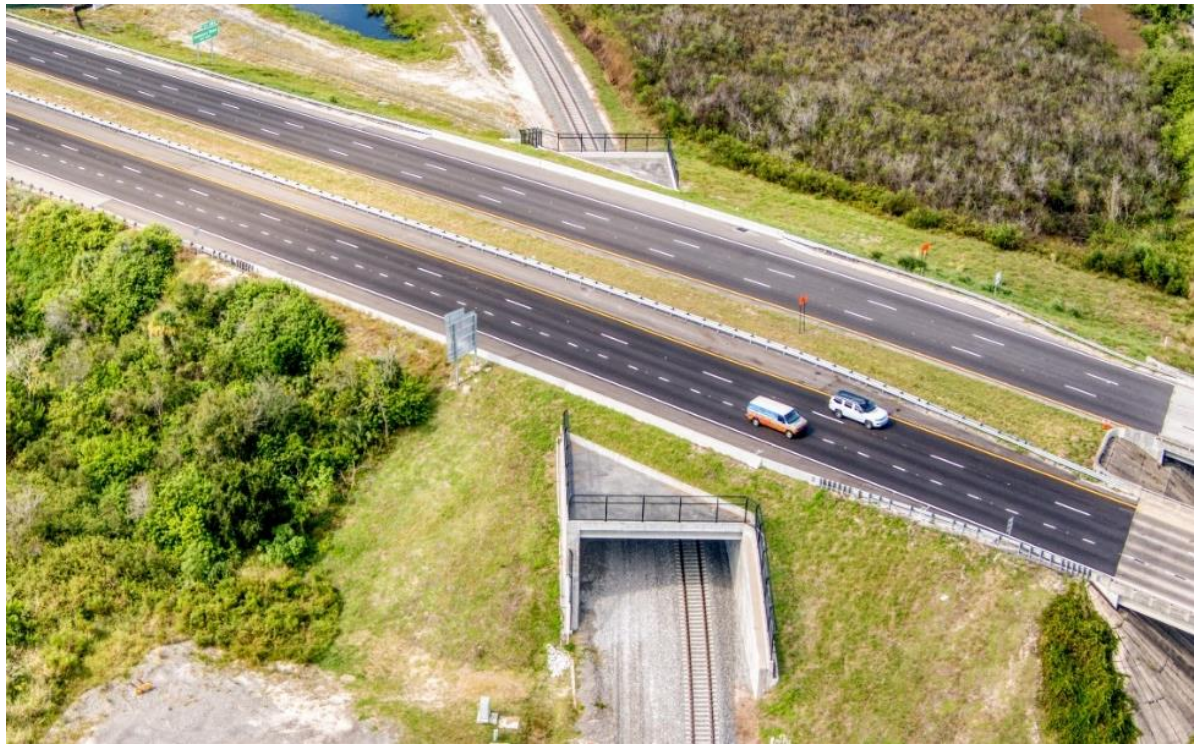
Application of Structure Types

- Jacked Box Underpass – SR528
  - Temporary pavement placed on greased plate
  - Cars drive atop moving box



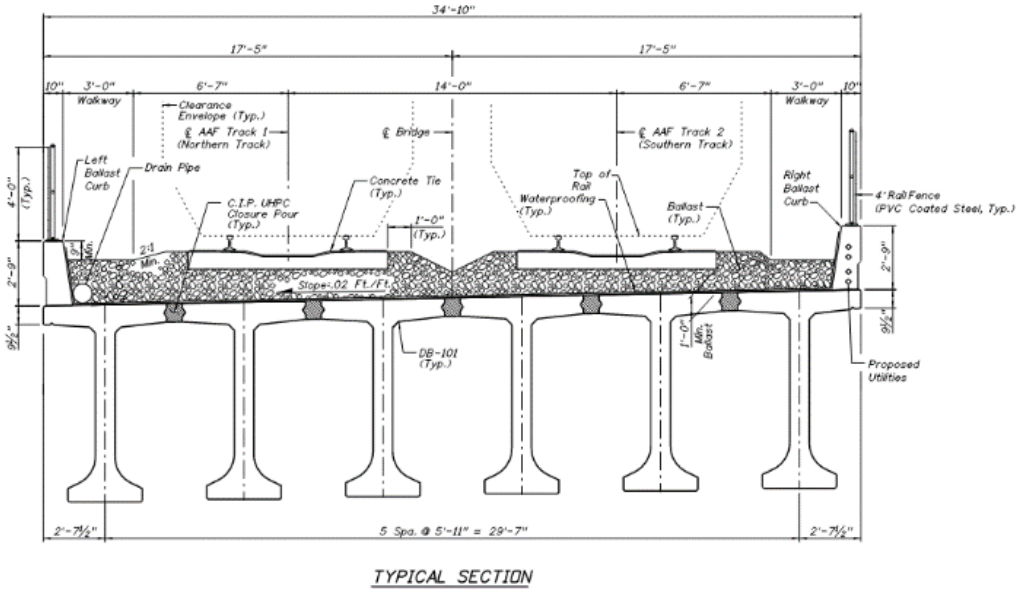
Application of Structure Types

- Jacked Box Underpasses
  - Eliminated months of roadway impacts



Prestressed Concrete Deck Beams

- FIRST EVER use on freight or passenger rail
- Ultra High-Performance Concrete (UHPC)
- No concrete decks required

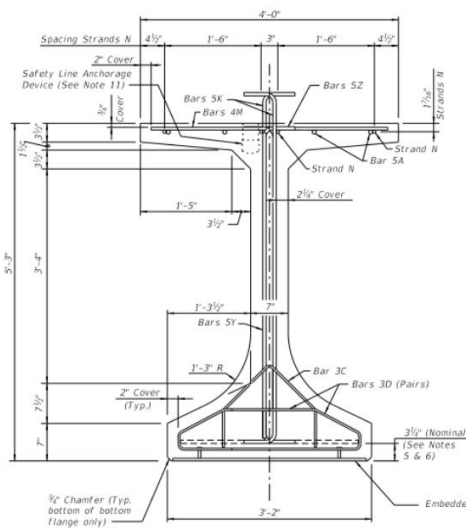


TYPICAL SECTION

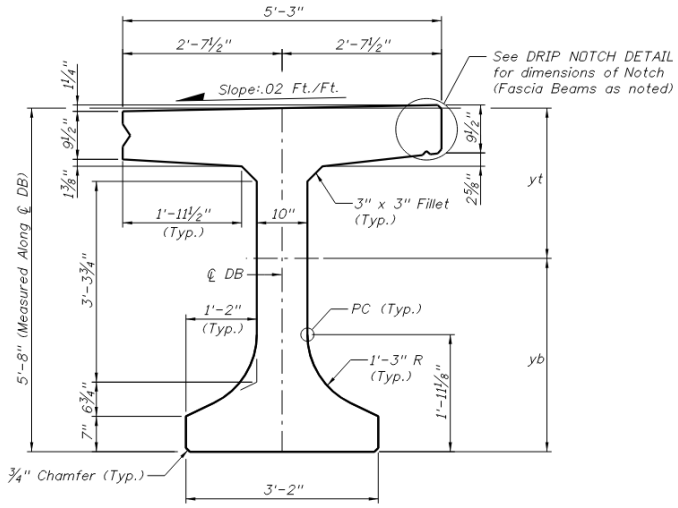
- Contractor-requested bridge type
- Fastest construction for a long span (40 to 108 feet max.)

Prestressed Concrete Deck Beams

- Modification of FDOT Standard
- DB-68, DB-84 (Freight), and DB-101
- Bottom Flange Similar to FIB
- Local precasters



FIB-63

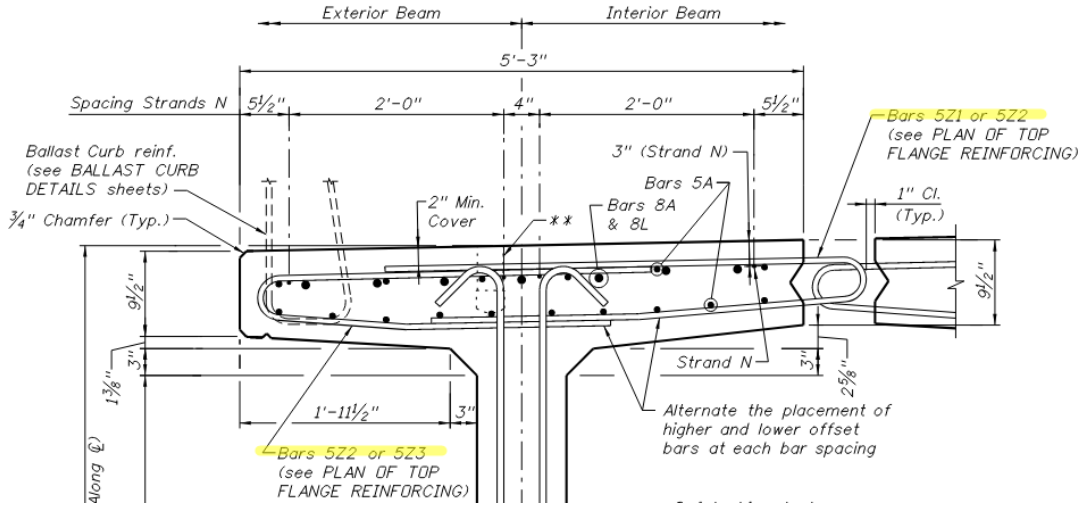


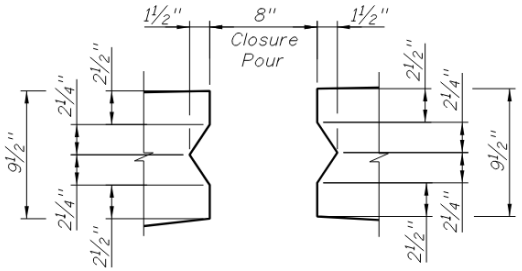
DECKED BEAM (DB-68)

Property	FIB-63	DB-68
Beam Weight (Kips/Ft.)	1.04	1.64
Area (in^2)	995.6	1,571.5
Perimeter (in)	260.6	295.4
Ixx (in^4)	530,313	950,795
Iyy (in^4)	81,842	259,379
yt (in)	35.0	29.3
yb(in)	28.0	38.7

Prestressed Concrete Deck Beams

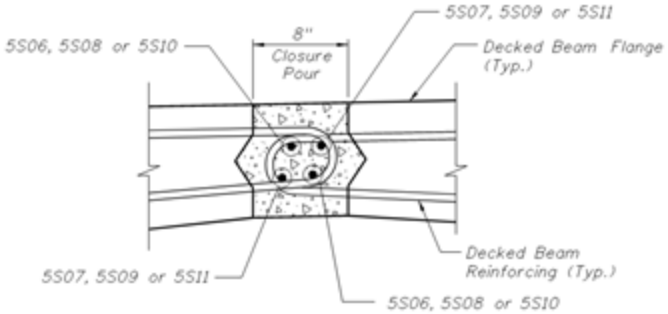
- UHPC Closure Pours
  - 24ksi UHPC (Steelike)
  - 2 x #5 bar bundles
  - Splice length < 7-inches
  - Standard Splice > 30-inches
- FHWA-HRT-14-084 Specified
- FHWA-HRT-19-011 Available





FLANGE EDGE DETAIL

(Omit Key on outside edge of fascia beams)



SECTION A-A

TECHNOTE

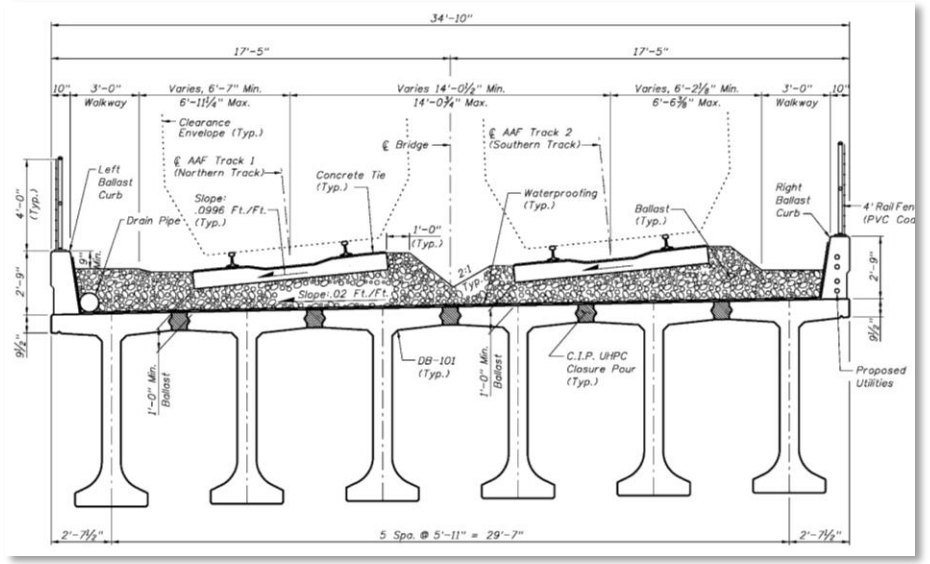
Design and Construction of Field-Cast UHPC Connections

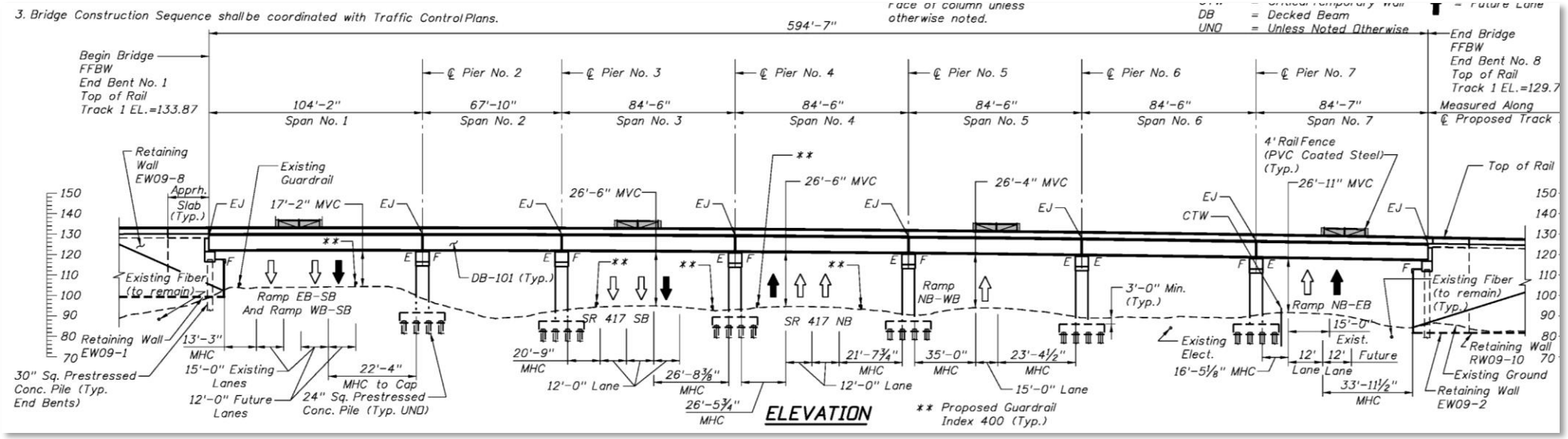
FHWA Publication No: FHWA-HRT-14-084

FHWA Contact: Ben Graybeal, HRDI-40, 202-493-3122, benjamin.graybeal@dot.gov

Prestressed Concrete Deck Beams

- Brightline over SR-417 (East – West Corridor)
  - Passenger Only
  - Max Load Cooper E-60
  - 594-ft long (max span 104 feet)





Prestressed Concrete Deck Beams

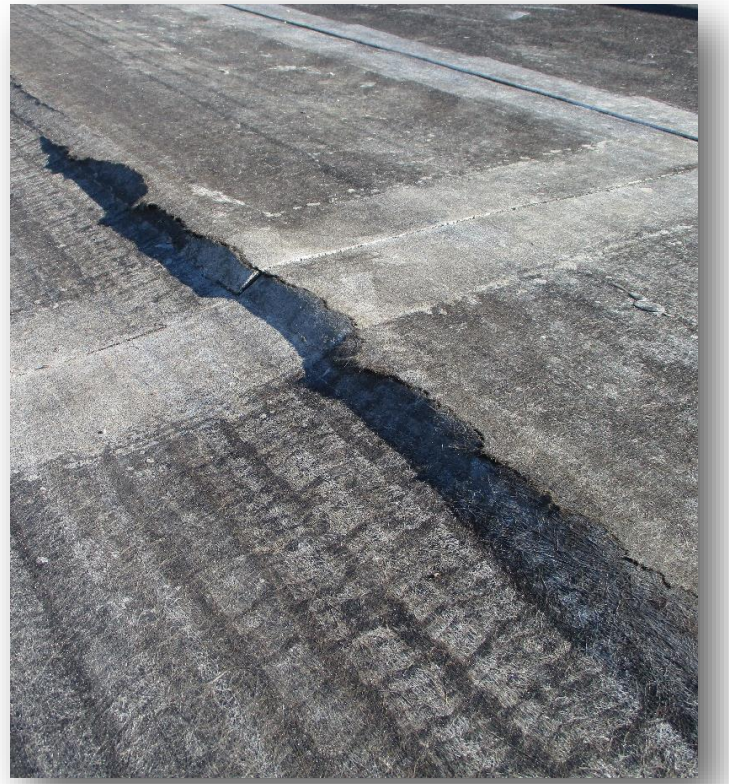
- Brightline over SR-417 (East – West Corridor)

Prestressed Concrete Deck Beams

- Brightline over SR-417 (East – West Corridor)
  - UHPC Batching and Casting

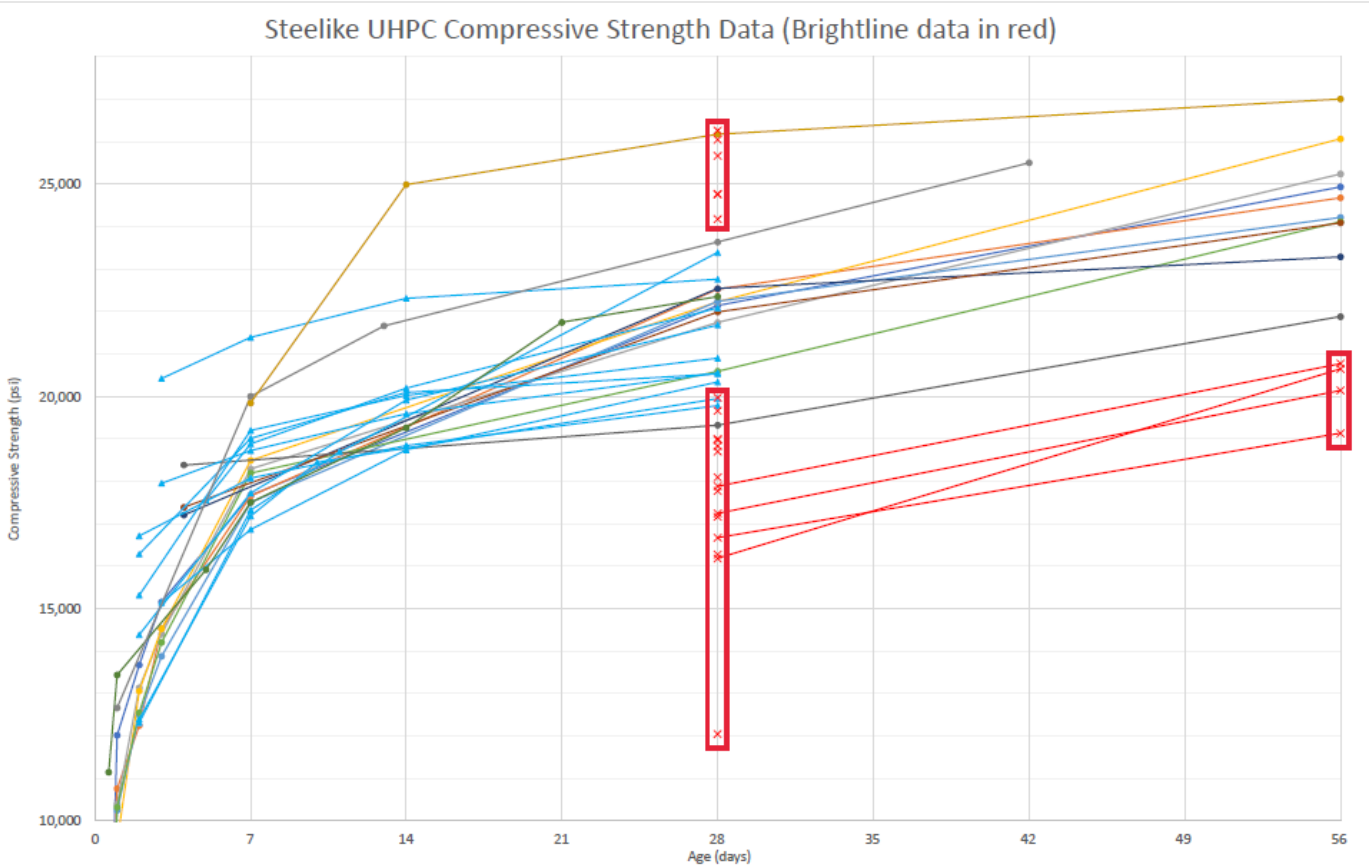
Prestressed Concrete Deck Beams

- Early UHPC Issues – Sharp Edges



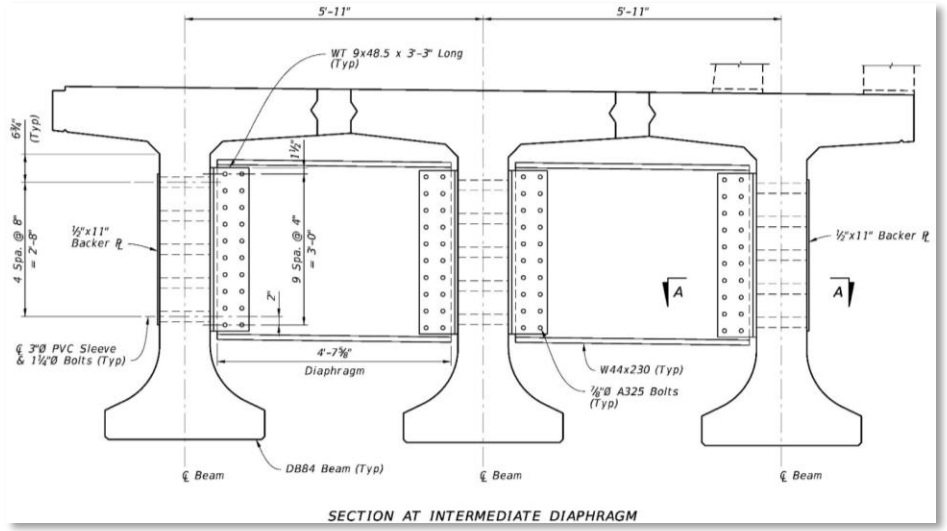
Prestressed Concrete Deck Beams

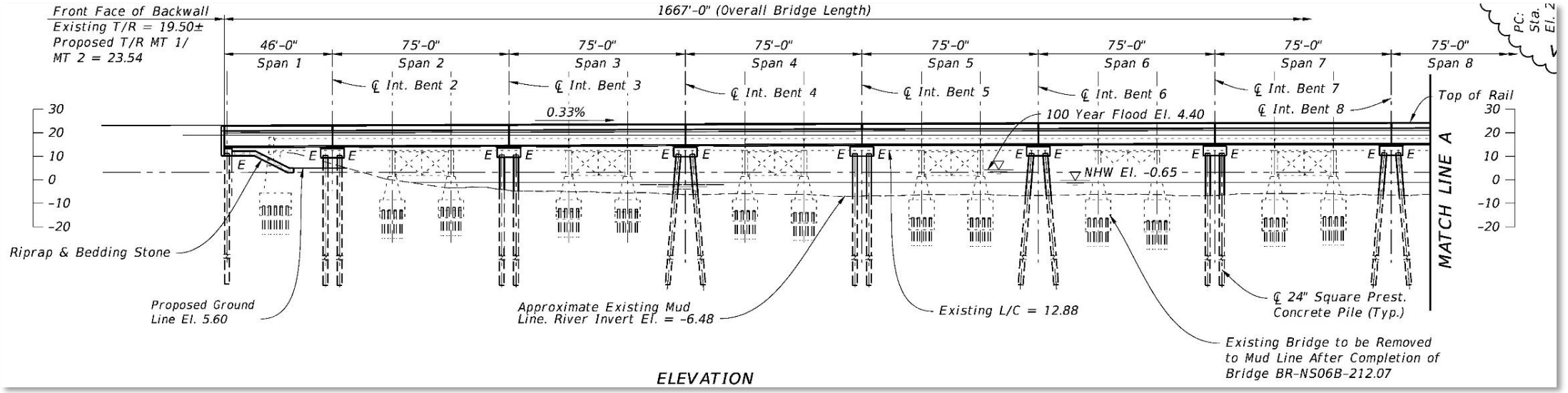
- Early UHPC Issues – Test Results
  - Sampling and testing is critical
  - Use national lab with UHPC experience



Prestressed Concrete Deck Beams

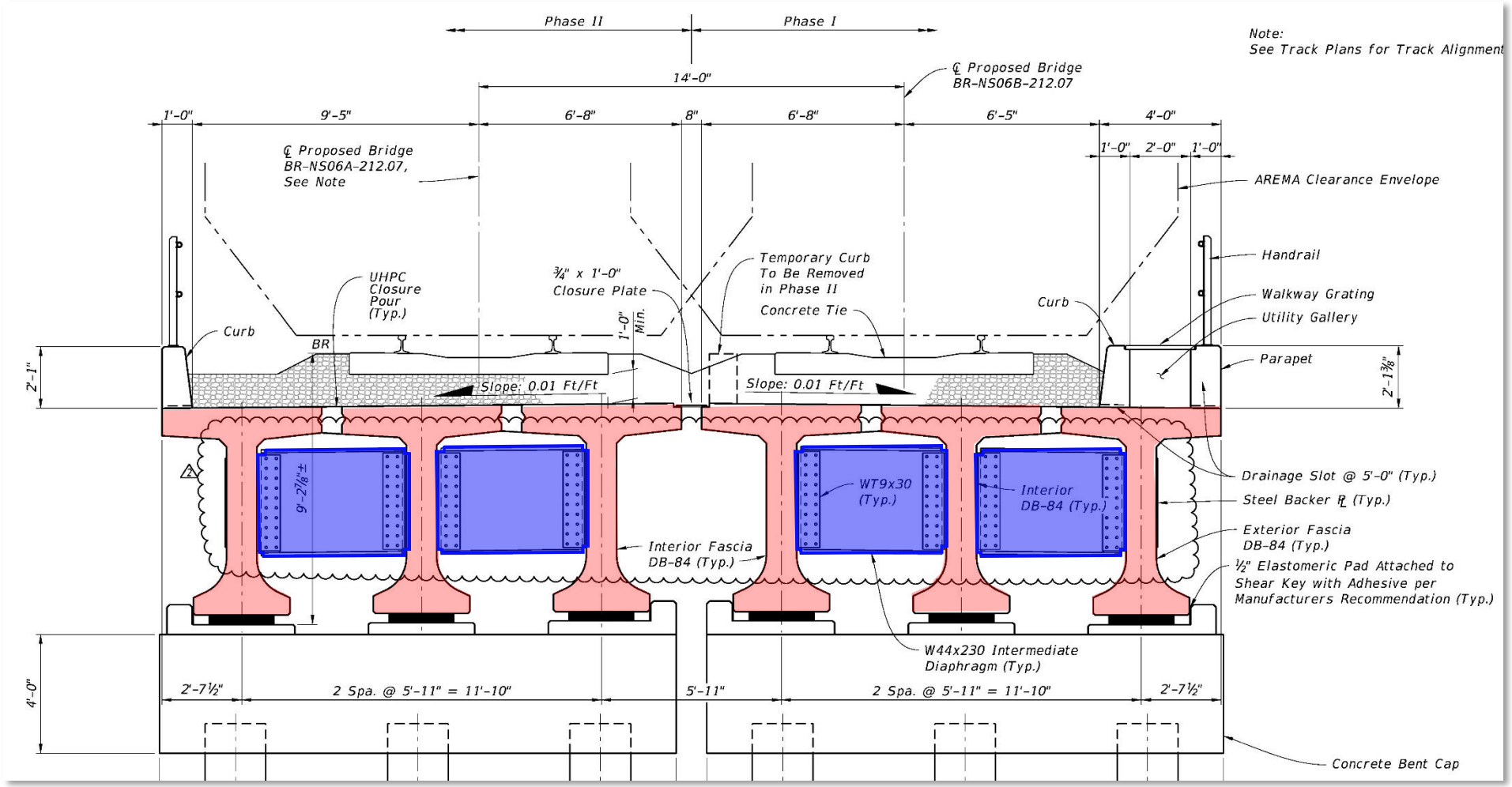
- Brightline over Sebastian River (Freight Corridor)
  - Max Load Cooper E-80
  - 1667-ft long (max span 75 feet)
  - Intermediate Steel Diaphragms





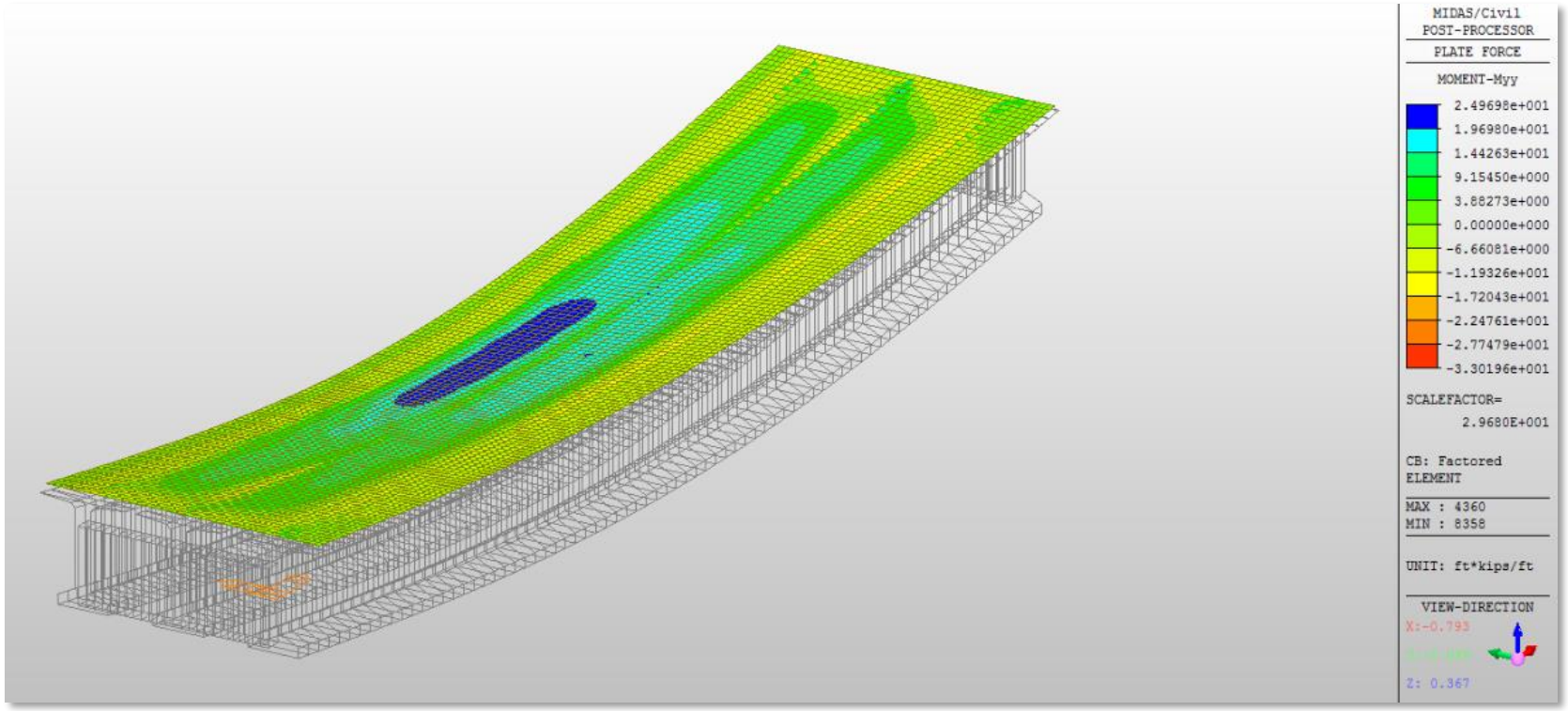
Prestressed Concrete Deck Beams

- Intermediate Steel Diaphragms



Prestressed Concrete Deck Beams

- Intermediate Steel Diaphragms
  - Refined FEM of UHPC Joint – confirm load transfer, UHPC stress
  - Broad FEM to determine LLDF



Prestressed Concrete Deck Beams

- Brightline over Sebastian River (Freight Corridor)

Prestressed Concrete Deck Beams

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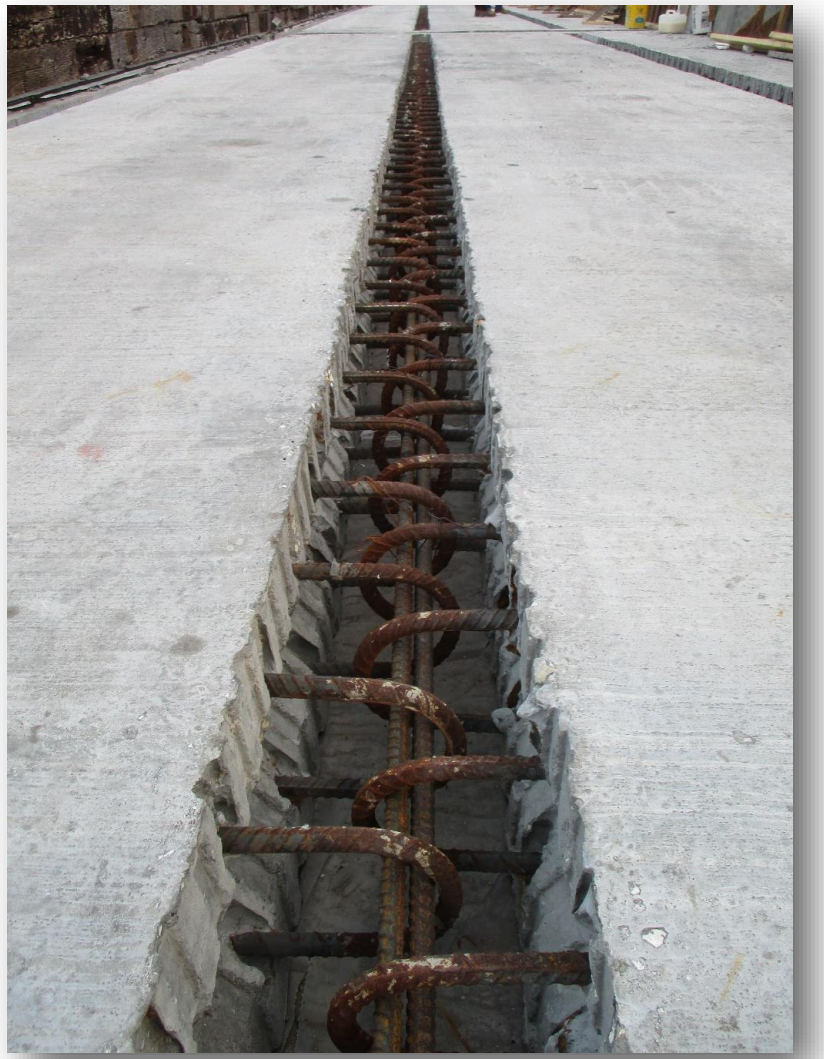


Prestressed Concrete Deck Beams

- Brightline over Sebastian River (Freight Corridor)

Prestressed Concrete Deck Beams

- Brightline over Sebastian River (Freight Corridor)

Construction Constraints

- Limited Right-of-Way in East-West
  - Greenfield corridor, but tight to expressway
  - Limited access points
  - Long water crossings (longest bridge 538 ft)

Construction Constraints

- Working on an Airport
  - Constrained ROW
  - Critical utility infrastructure
  - Maintaining airfield security
  - No impacts to air operations

Construction Constraints

- Limited Right-of-Way in Freight Corridor
  - Linear corridor
  - Active freight traffic
  - Long water crossings (longest bridge 1667 ft)
  - Very shallow water (no barges)

Construction Constraints

- Active Freight Corridor
  - 10+ Trains per day
  - All work to stand down for train traffic
  - Access established to one side of existing bridge requires reaching over live track

Construction Constraints

- Pile Driving Near Freight
  - Continuous driving
  - Piles within clear zone cut off below rail by end of day
  - Piles outside clear zone cut off at end of week
  - Extensive monitoring of existing structures
  - Established test piles outside envelope to allow for set checks

Construction Constraints

- Subsurface Conditions
  - New Fiber Optic ductbank
  - A century of unknown railroad debris

Bascule Bridges

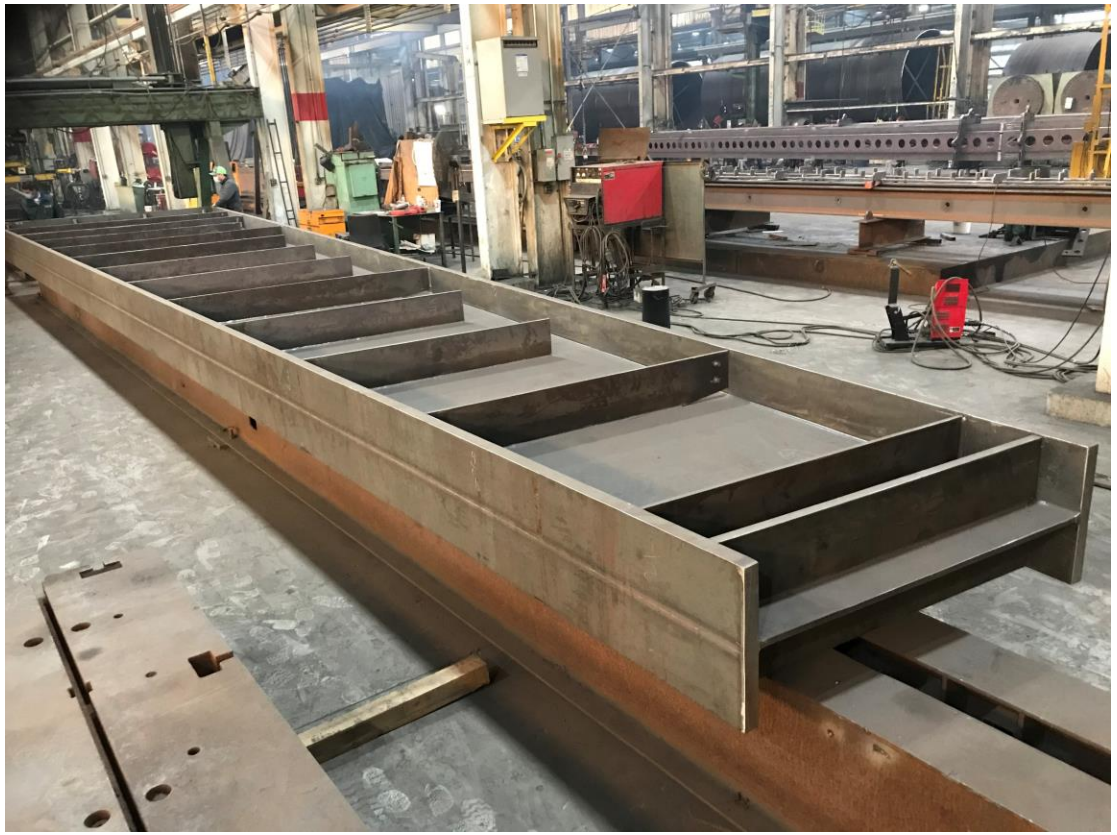
- Three Bridges, one Crown Jewel
  - Loxahatchee River: Replace nearly all of it
  - St. Lucie River: Rehab Mech/Elec
  - New River: Rehab Mech/Elec

Loxahatchee

- Existing Bridge
  - Trunnion Bascule built 1924
  - 583 feet long, 9 spans
  - 55-ft navigation span
- Original Scope
  - Replace superstructure
  - Replace all mechanical systems
  - Replace all electrical systems
  - Add “Small Boat Span”

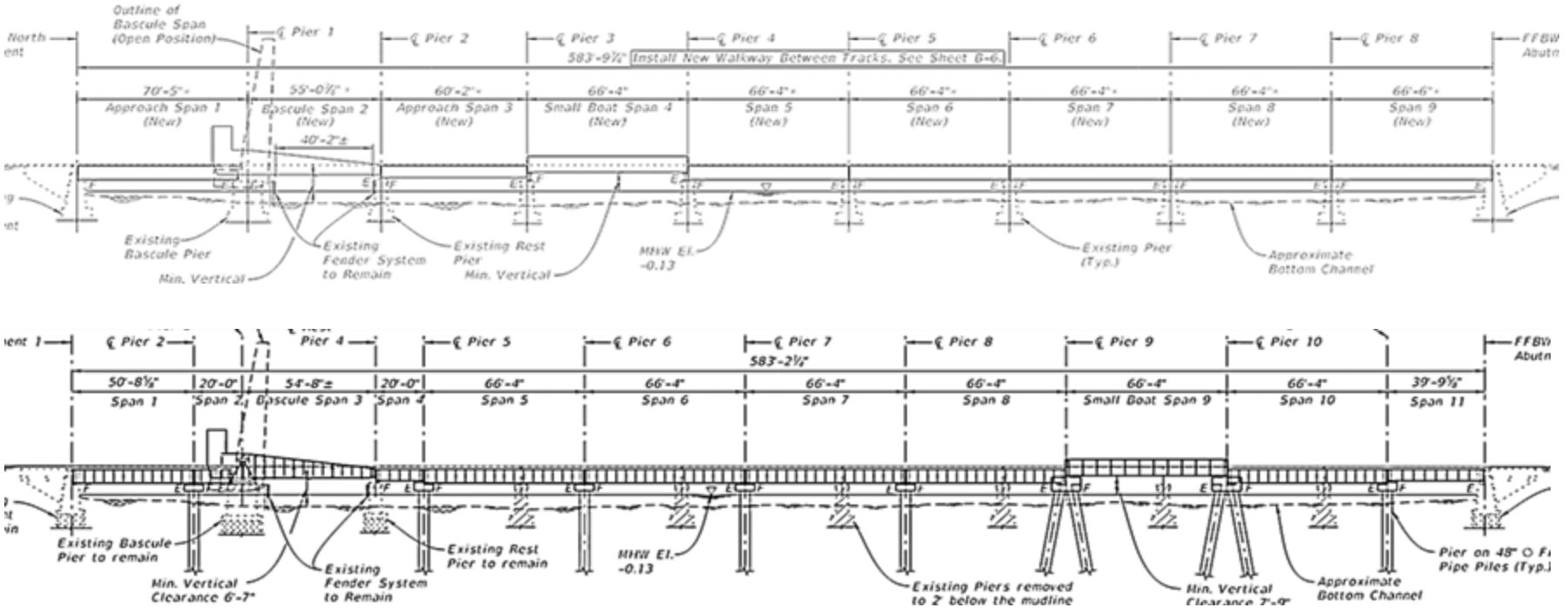
Loxahatchee

- Procurement
  - Brightline contracted directly with Fabricator
  - General Contractor was selected later
- Scope Change
  - Decided to replace all approach piers
  - Structural steel fab was almost finished



Loxahatchee

- Change to CMGC
  - Brightline, GC & EOR worked jointly on bridge redesign
  - New piers had to be between existing piers
  - Minimize waste of steel girders with new span arrangement

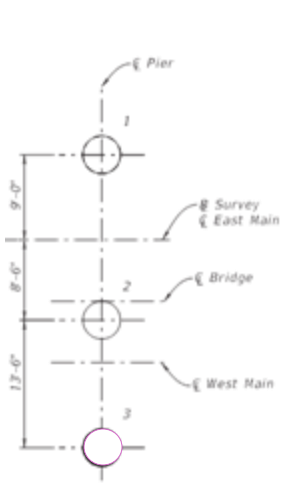


Loxahatchee

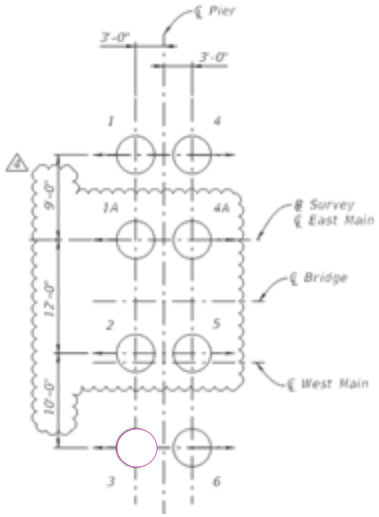
- Foundations - CMGC
  - Steel pipe piles were selected
  - Contractor preference
  - Available supply
  - 48” diameter, 1” walls
  - Filled with concrete above scour elevation

Loxahatchee

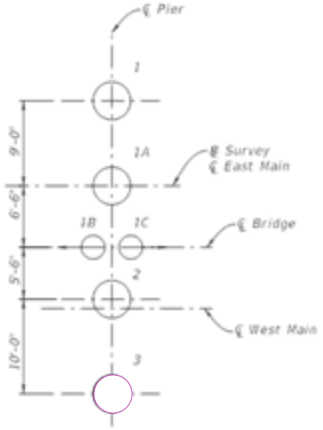
- Foundations - Issues
  - Lack of Capacity at three piers
  - Added 4th 48” pile at Piers 6, 7 & 8
  - Driven between rails during track window
  - But….STILL lacked capacity at P6 & P7
  - Added two 30” battered piles



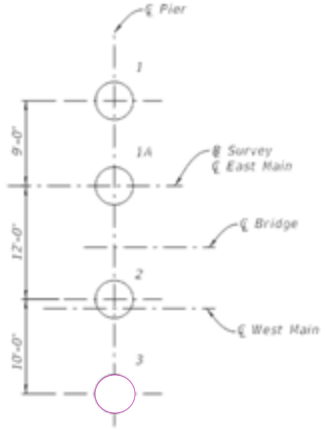
Original Design
Piers 5-8 & 11



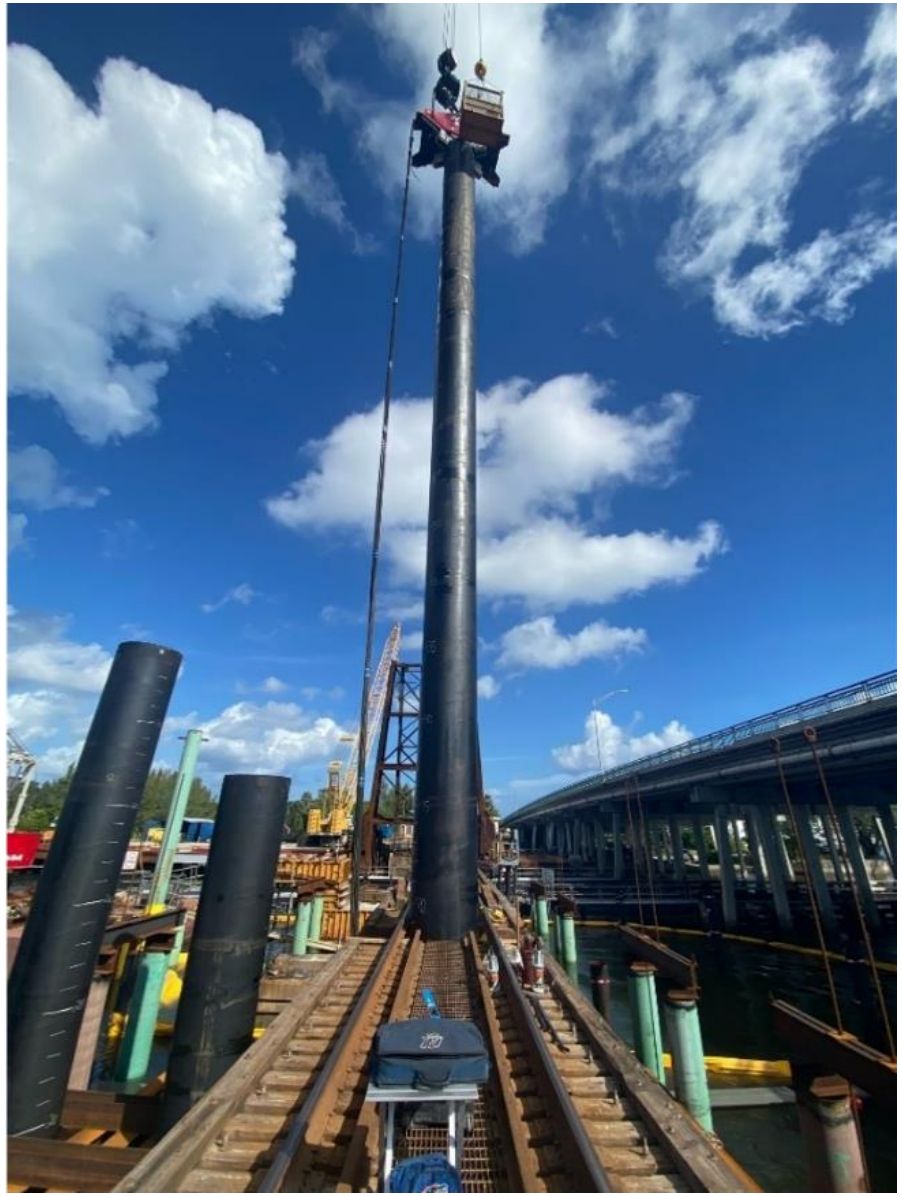
Original Design
Piers 9 & 10



Constructed
Piers 6 & 7



Constructed
Piers 8 & 11



Loxahatchee

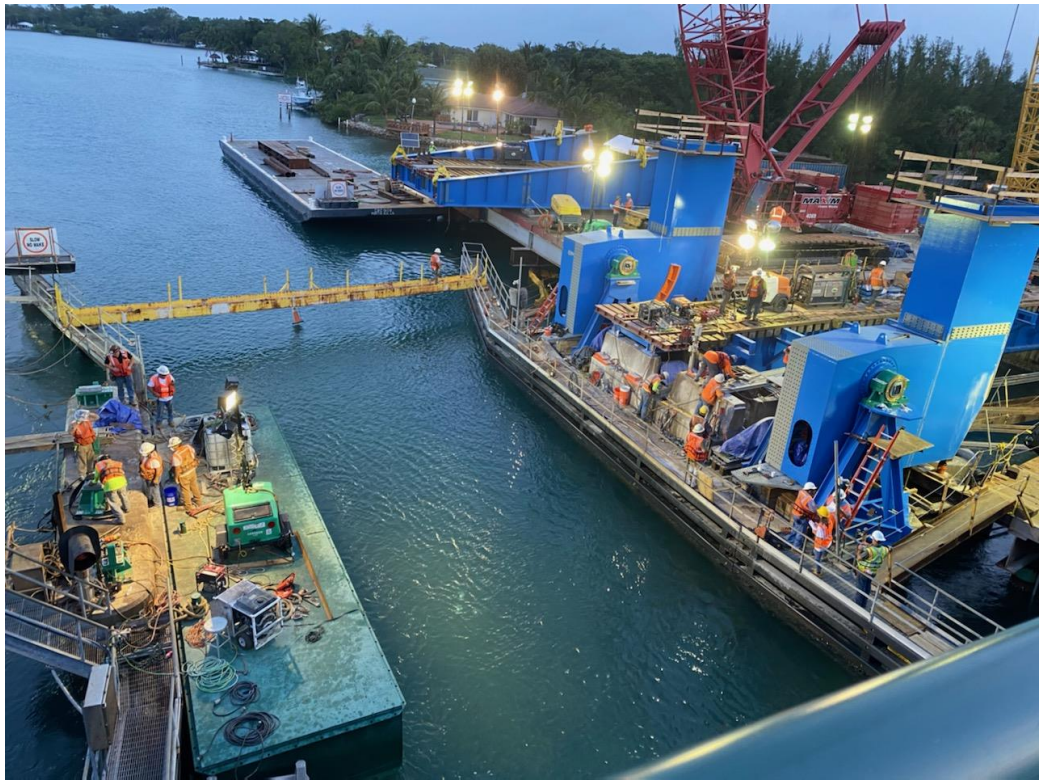
- Substructures
  - Shallow caps to limit underwater in formwork
  - Tight fit with existing caps

Loxahatchee

- Track & Navigation Outages
  - Multi-day closures of channel & track
  - Long duration limited navigation using “flying jump span”
  - Opened channel 2x per day

Loxahatchee

- Leaf Installation
  - Heels installed with track open
  - Toe installed in a 48-hour outage



Loxahatchee

- Open for Business

Loxahatchee

- Small Boat Span
  - Local grant funding
  - Small boats bypass the channel
  - Through Girder: 21” extra headroom
  - Span built offline and slid into place

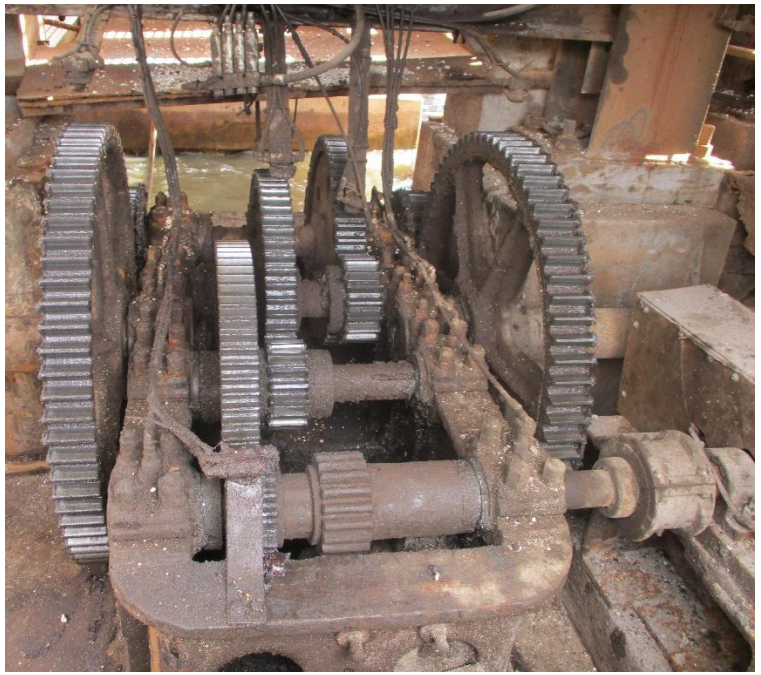
Loxahatchee

St. Lucie

- Existing Bridge
  - Trunnion Bascule built 1924
  - 1270 feet long, 50 spans
  - 55-ft navigation span
  - Approach spans replaced 1950
- Scope – 10yr band-aid
  - Replace all mechanical systems
  - Replace all electrical systems
  - Repair trunnions
  - Add bridge tender house

St. Lucie

- Mechanical Upgrades



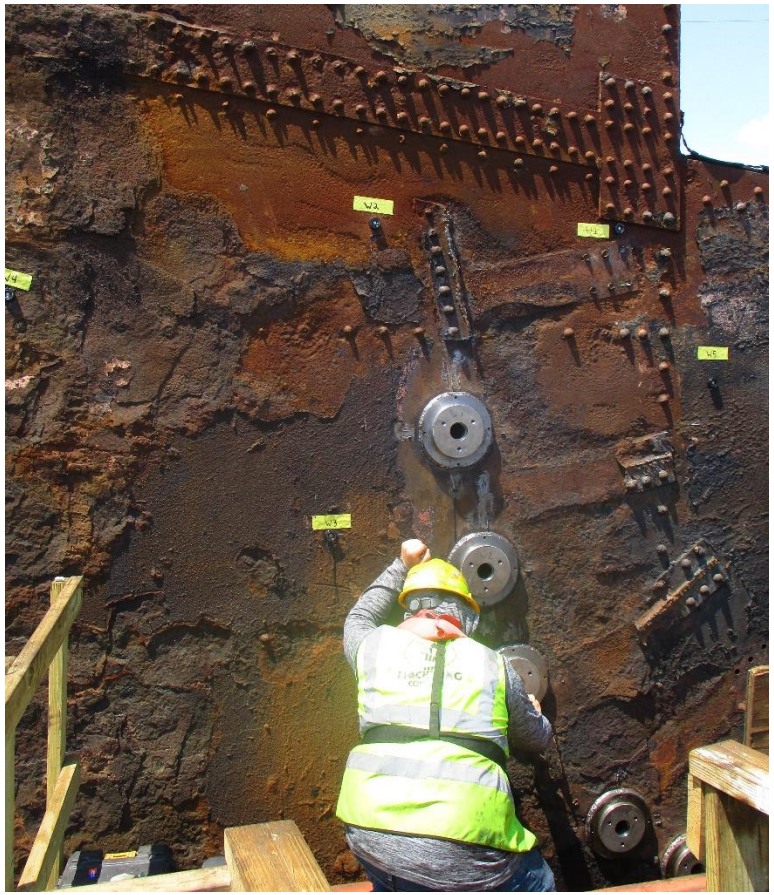
Existing Gearing

New Primary Reducer

New Secondary

St. Lucie

- New Rack Gear



High-Precision Pucks Attached to Very Old Leaf

New Rack Bolted to Pucks

St. Lucie

- Machining Trunnions

St. Lucie

- New Monitor House
  - Mandated by Feds & Local Gov

St. Lucie

Summary and Conclusions

- Jan. 13, 2018 – 1st service on the North-South Corridor (WPB-MIA)
- Sept. 22, 2023 – Full corridor open (ORL-MIA)

- Awards:
  - ASCE Outstanding Civil Engineering Achievement (OCEA) – 2025
  - ACEC National Grand Award – 2025
  - AREMA Dr. William W. Hay Award for Excellence – 2025
  - ACEC Florida Grand Conceptor Award – 2025
  - ENR Southeast Project of the Year – 2024
  - HNTB Project of the Year – 2023

Summary and Conclusions

- Future projects:
  - Florida – Orlando to Tampa
  - Florida – Replace St. Lucie River Bascule
  - Brightline West – Las Vegas, NV to Rancho Cucamonga, CA

Acknowledgements

- HNTB (9 Offices)
- GFT (Bascules)
- AECOM (Phase 1)
- EAC Consulting (Phase 1)
- Colliers Engineering (Phase 2)

Questions

THANK YOU!