2017 FTBA Construction Conference

February 2 & 3, 2017

Orlando, FL

Halls River Bridge Replacement – Example FRP Project Application

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Cristina Suarez

1. Project Overview

2. Design Challenges

3. Design References - Specs and Standards

4. Construction

5. Lessons Learned

Project Overview – Corrosion Issues

Severe Pile Damage

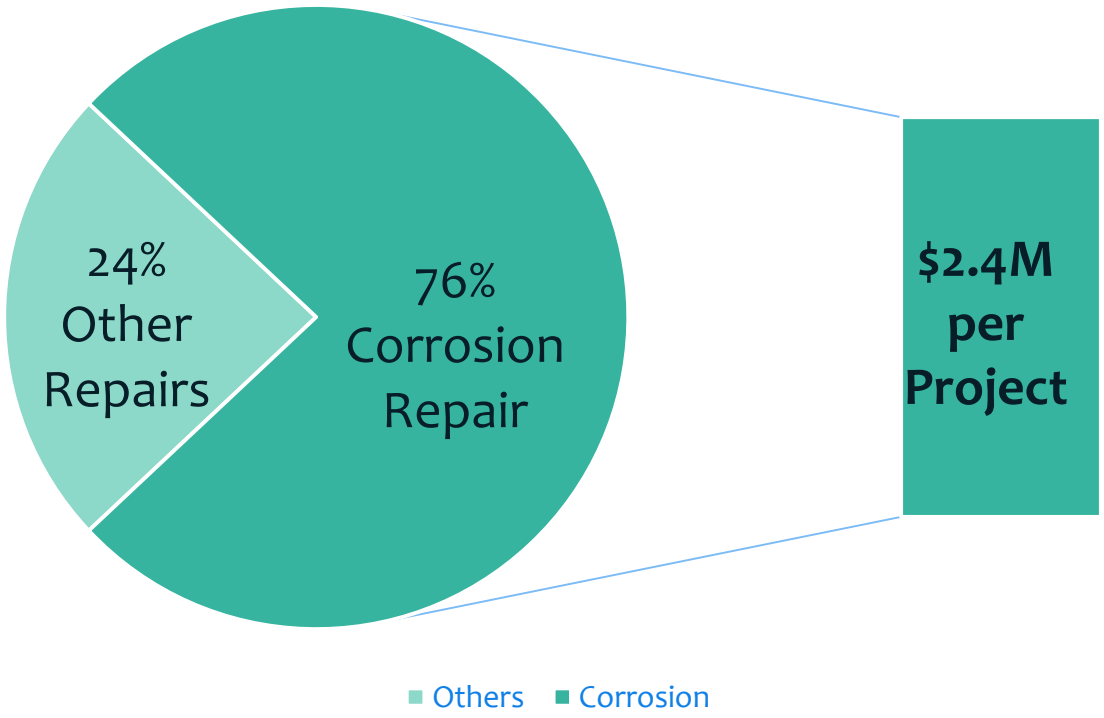
Pile Damage

Beam Damage

Project Overview – Corrosion Issue

District 7 (FY 02/03 to Present)

- 54 Total projects:
- 20 Steel
- 34 Concrete



Source: FDOT D7 District Structures Maintenance Office (DSMO)

Project Overview – Prevention Methods

- New Concrete Structures
  - Adequate Concrete Cover
  - Concrete Quality
  - Alternative Reinforcements
  - Corrosion Inhibiting Admixtures
- Existing Concrete Structures
  - Pile Jacket
  - FRP Wrapping
  - Cathodic Protection

- Epoxy
- Galvanized
- ECR
- Z-bar
- ✓ **FRP**
- Stainless
- MMFX

Project Overview - Background Info

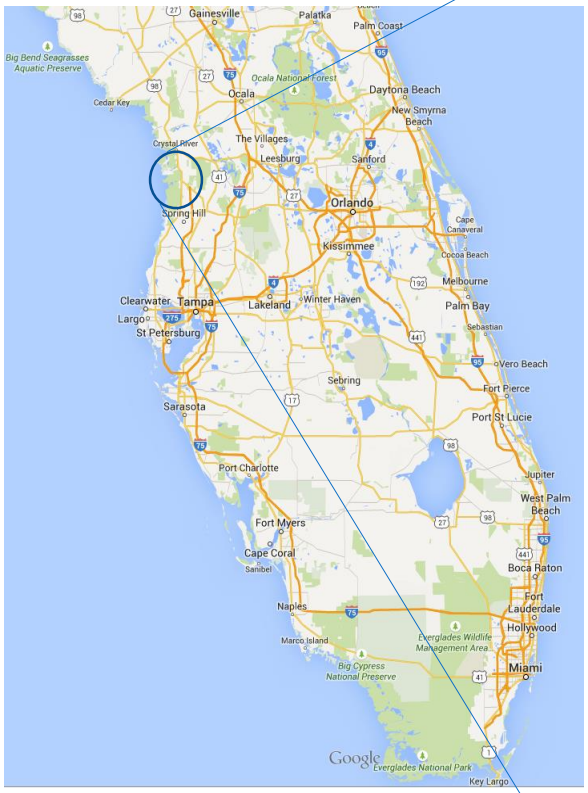
- **Relevant Information**
  - Demonstration Project - First of its kind in Florida
  - Category II Structure - D7 Structures In-house Design
- **Sole Source Items**
  - Hybrid Composite Beam (HCB) - *HC Bridge Company*
  - Carbon Fiber Composite Cable (CFCC) - *Tokyo Rope Mfg. Company Ltd.*
- **Contractor Bid** -
  - $6.016 Million (Overall Project Cost)
  - $4.06 Million – Structures
    - (Bridge $2.35M /
    - Sheet Pile Walls $1.71M)
  - Roadway, Utility etc.
- **Funding –** FHWA
- **Construction Date:** January 09, 2017

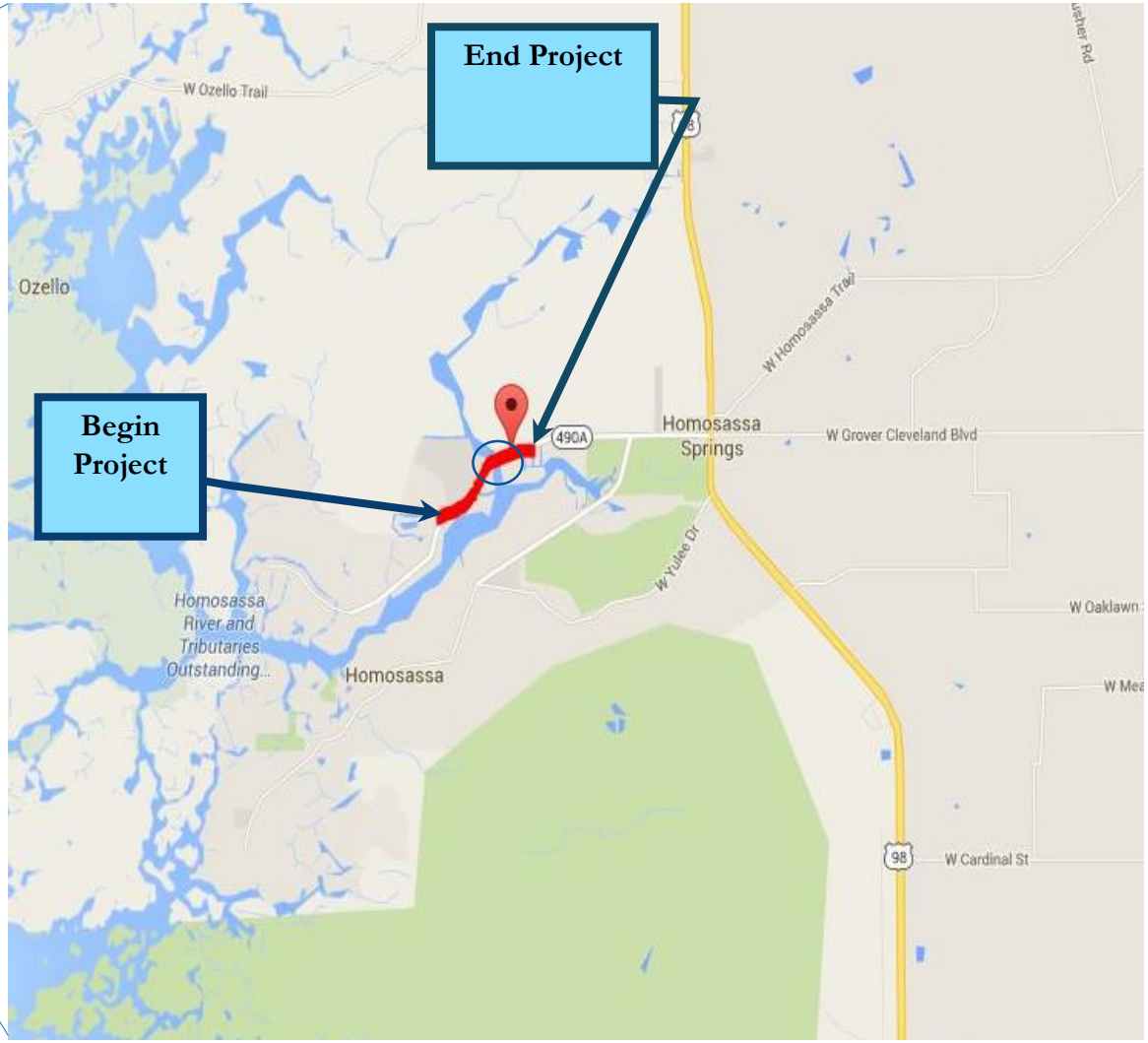
Project Overview - Background Info

- Owner
- Maintaining Agency

- Bi-Annual Inspection
- Design and Build Proposed Bridge

Project Overview – Project Location

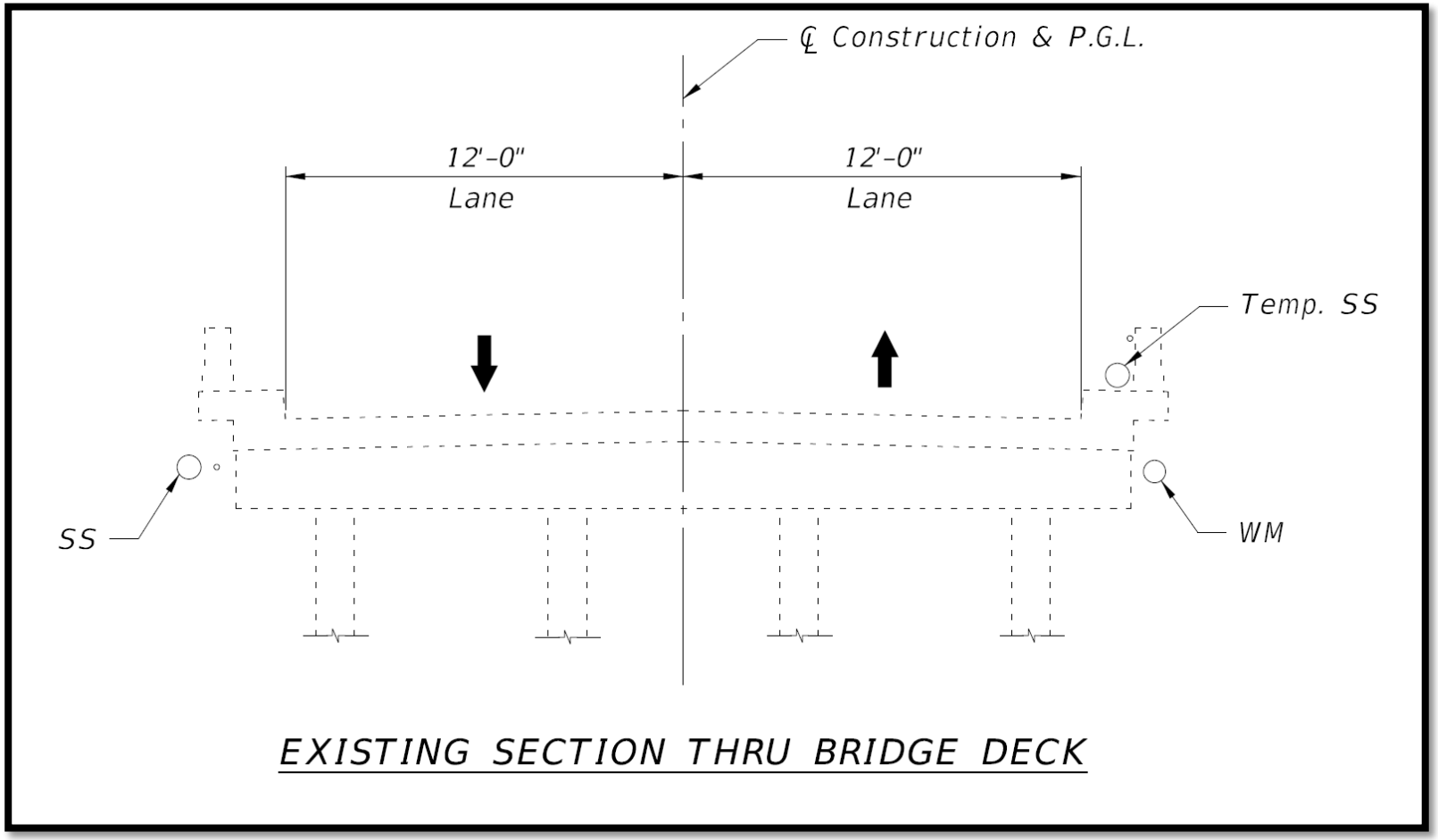




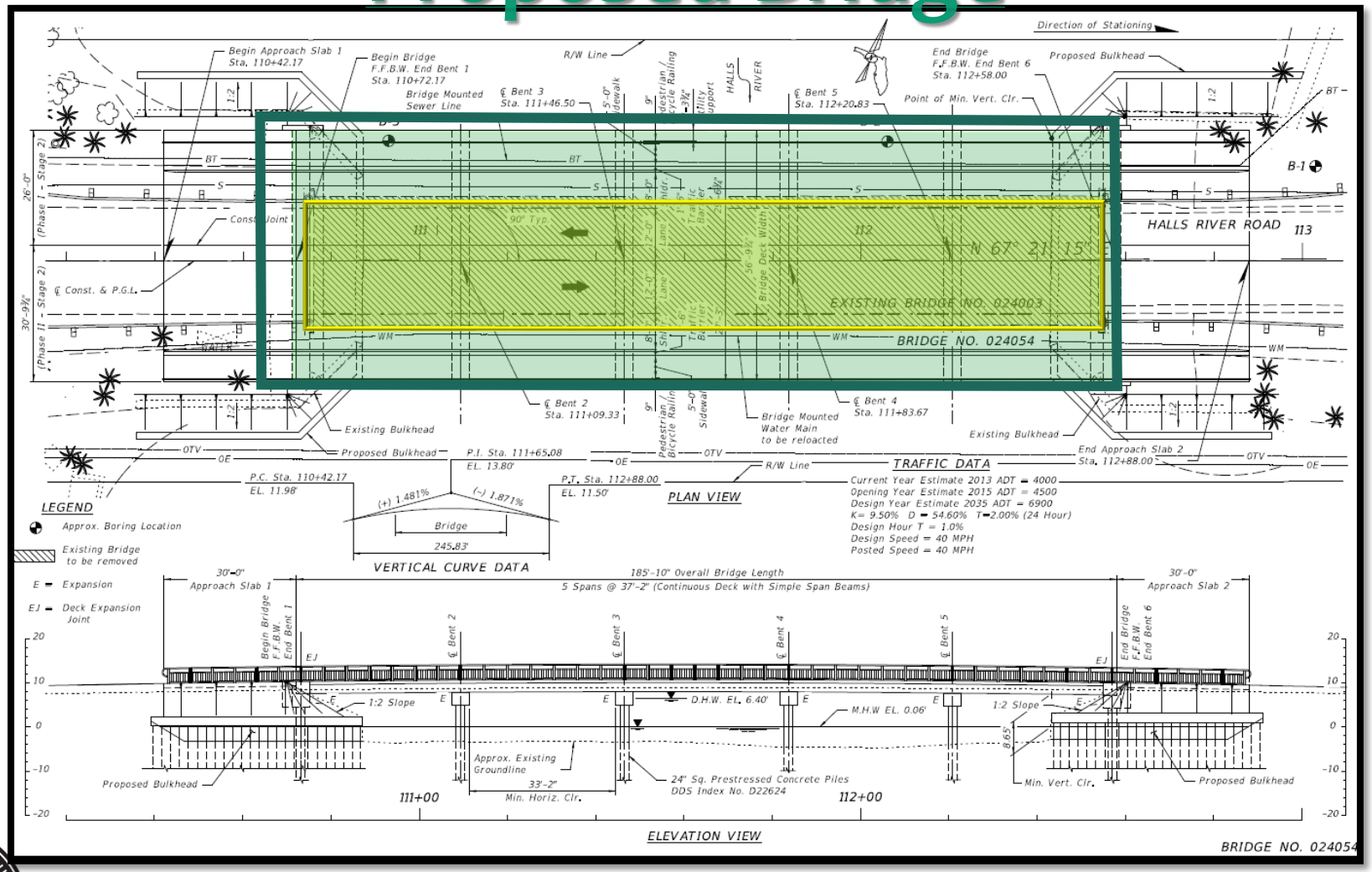
BRIDGE LOCATION

FRP for New Construction

Project Overview – Existing Bridge

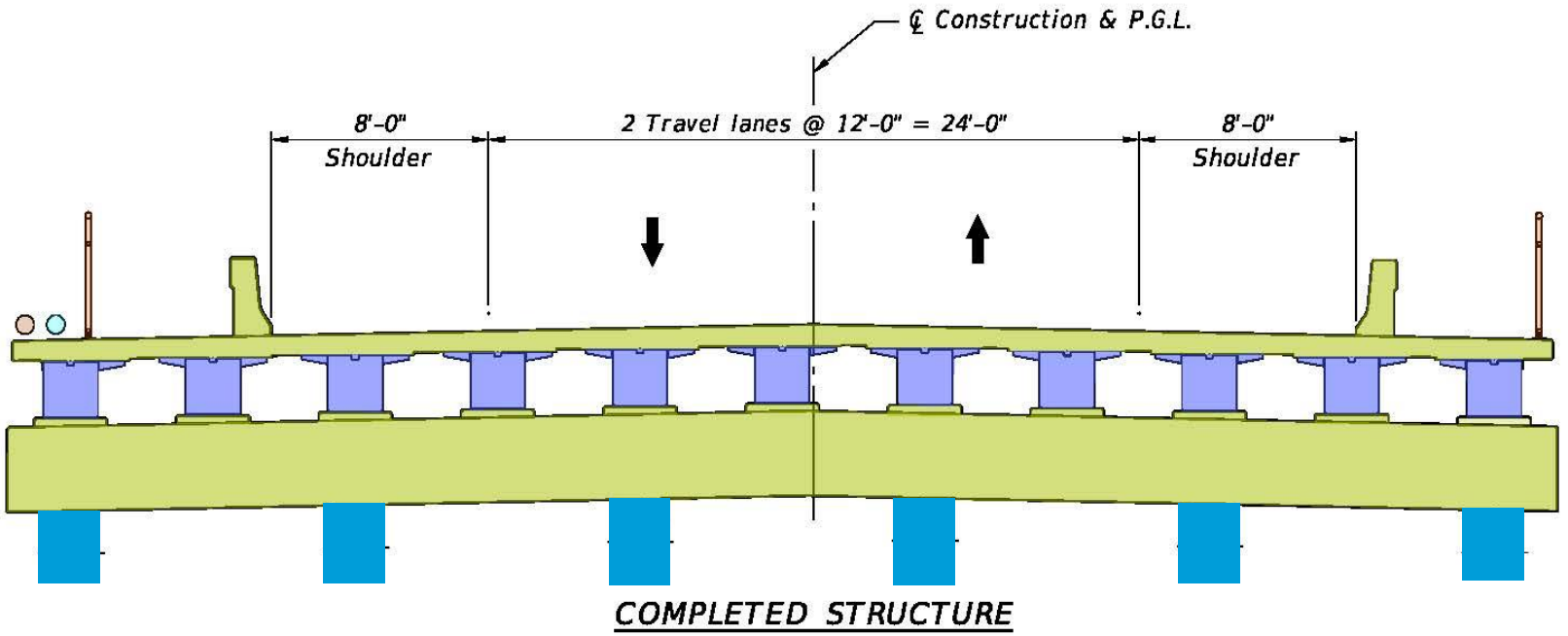


Project Overview – Existing and Proposed Bridge



FRP for New Construction

Project Overview – Proposed Bridge FRP Materials



COMPLETED STRUCTURE

GFRP

HCB

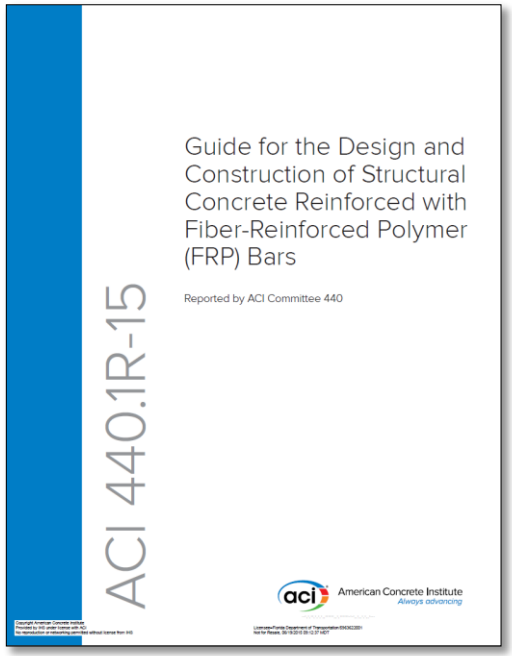
CFCC

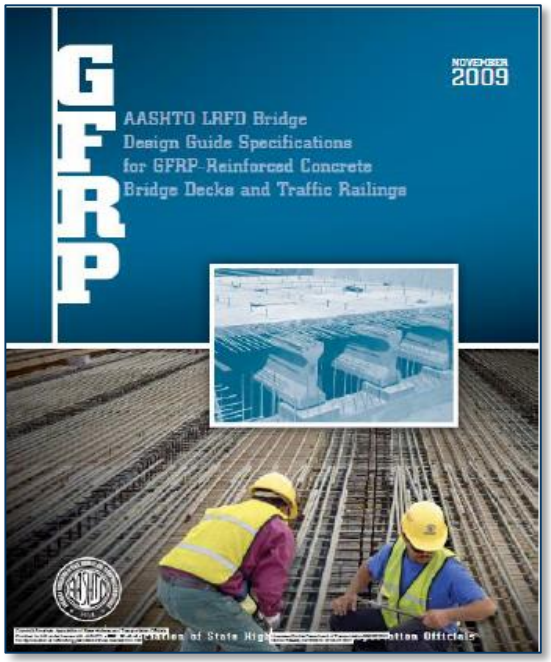
Design Challenges: FRP VS Steel Reinforcing

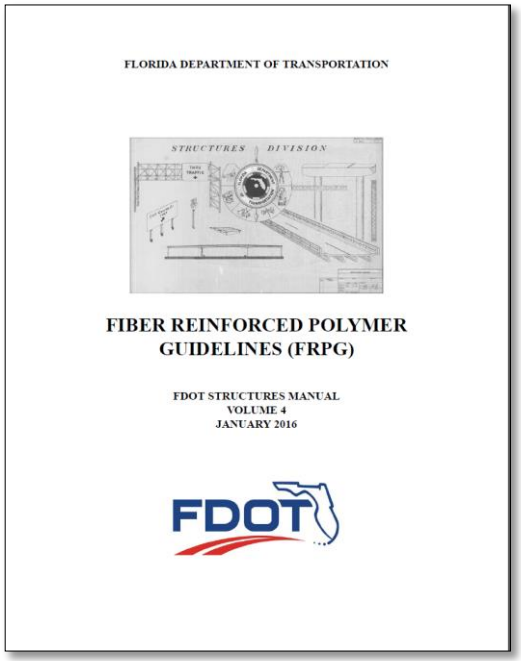
- Direct substitution between FRP and steel reinforcement is not possible,
- Modulus of elasticity much lower than steel,
- FRP reinforced concrete sections do not show ductility,
- Safety against failure for FRP is higher than the conventional steel,

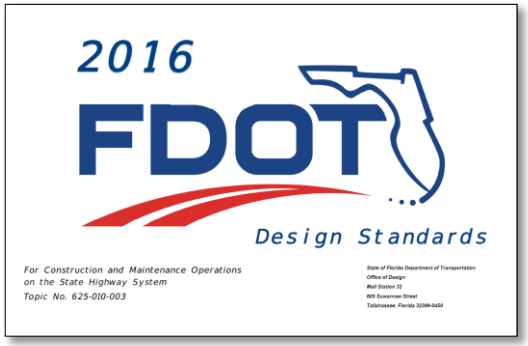
Design References

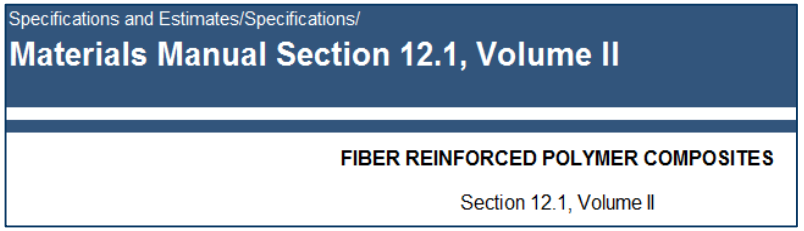
Codes, Standards and References





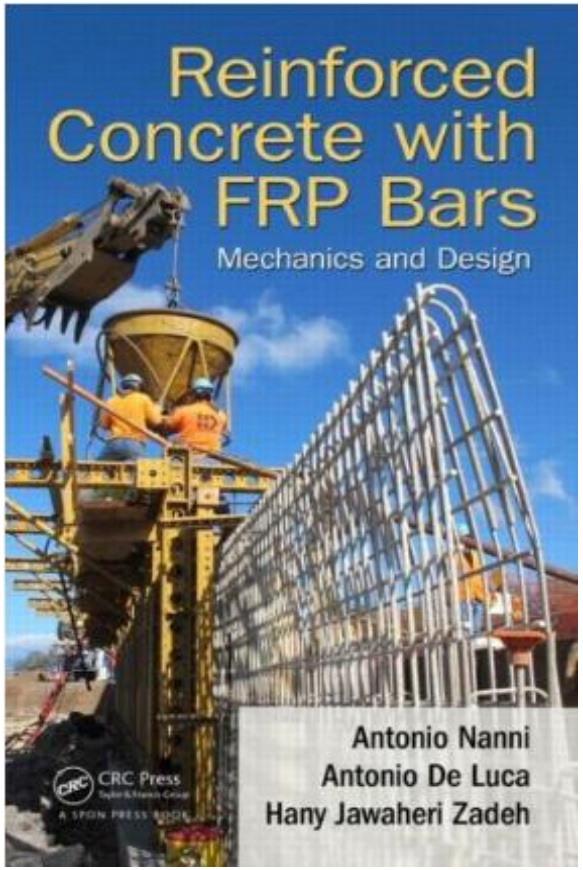


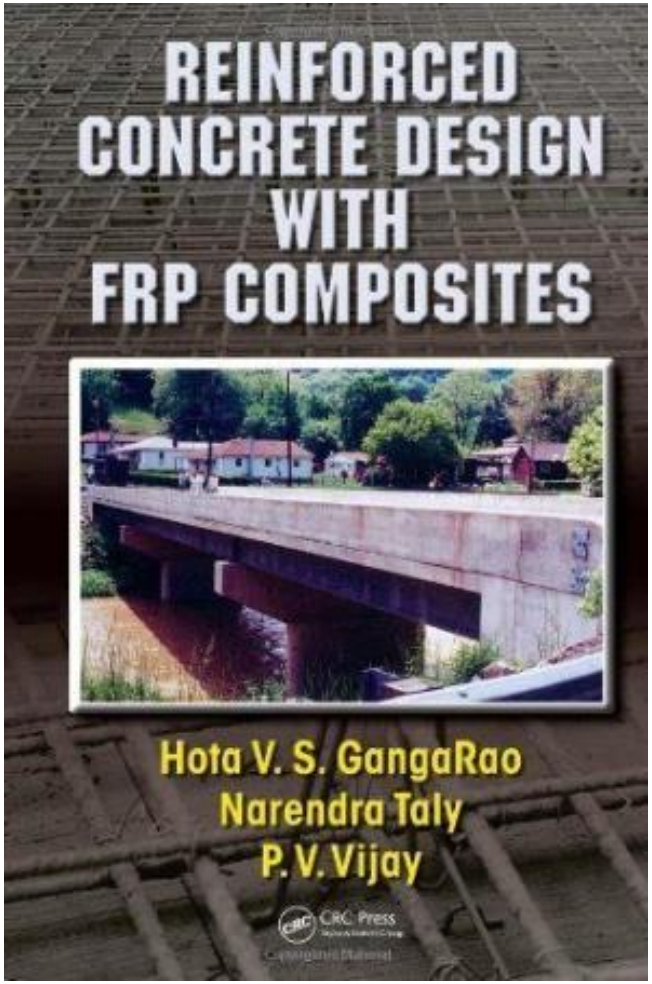




FRP for New Construction

Design References





Design References

Hybrid Composite Beam (HCB) – Manuals and References

Hybrid-Composite Beam (HCB®)
Design and Maintenance Manual

RTE 205 (RIDGE RD.)
Over Tide Mill Stream, Westmoreland Co.
State Project No.: 0205-096-101, B601
Federal Aid Project No.: BR-096-6(015)
NBIS No. 27818

Prepared for
The Virginia Department of Transportation

John R. Hillman, PE, SE
HCB, Inc.

TECHNICAL SPECIAL PROVISION

FOR

SECTION T450 - FURNISHING & INSTALLING HYBRID-COMPOSITE BEAMS

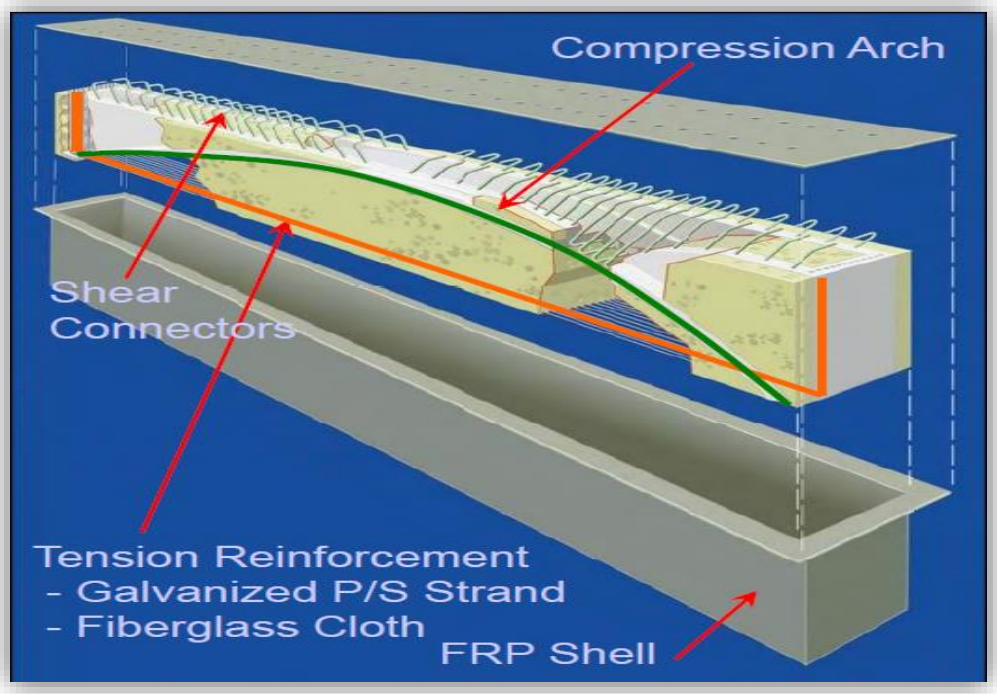
FINANCIAL PROJECT ID: 430021-1-52-01

The official record of this Technical Special Provision has been electronically signed and sealed using a Digital Signature as required by Rule 61G 15-23.004, F.A.C. Printed copies of this document are not considered signed and sealed and the signature must be verified on an electronic copies.

Professional Engineer: Mamunur Rashid Siddiqui, P.E.
Date: March 3, 2016
Fla. License No.: 70094
Firm Name: FDOT
Firm Address: 11201 N McKinley Dr.
City: Tampa, State: FL, Zip code: 33612
Certificate of Authorization: N/A.
Pages: 1-13

Materials

Hybrid Composite Beam (HCB)



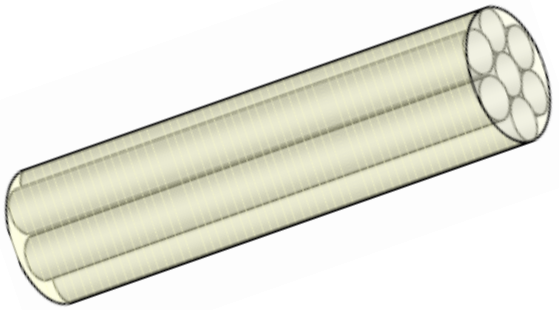
Materials

Fiber Reinforced Polymer (FRP) Reinforcing

So how does it work?

GFRP Rebar is made of Glass Fibers embedded in Polymeric Resin

- ✓ Fibers provide strength and durability
- ✓ Resin holds fibers together, transfers load between fibers and protects from abrasion/environment



Materials

Fiber Reinforced Polymer (FRP) Reinforcing

Pros:

- Corrosion Resistance
- High Strength
- Lightweight
- Fatigue Endurance

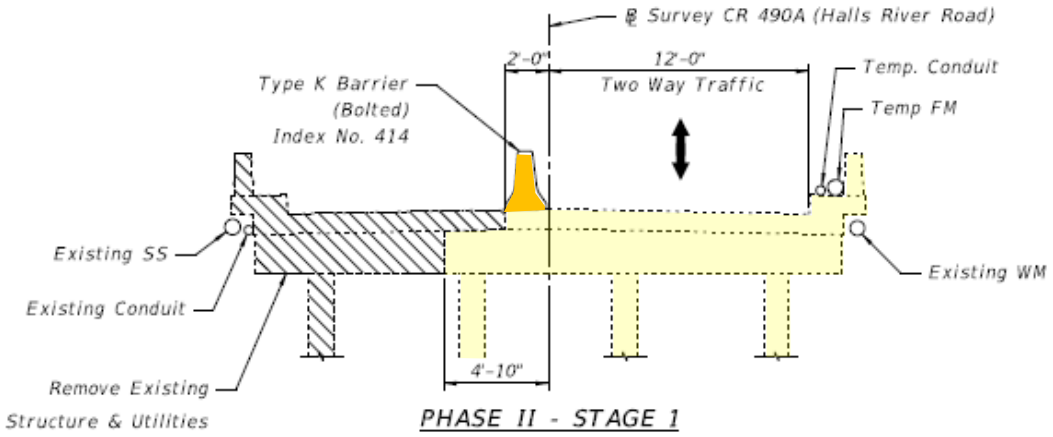
Cons:

- High Initial Cost
- Brittle Failure

Construction Coordination

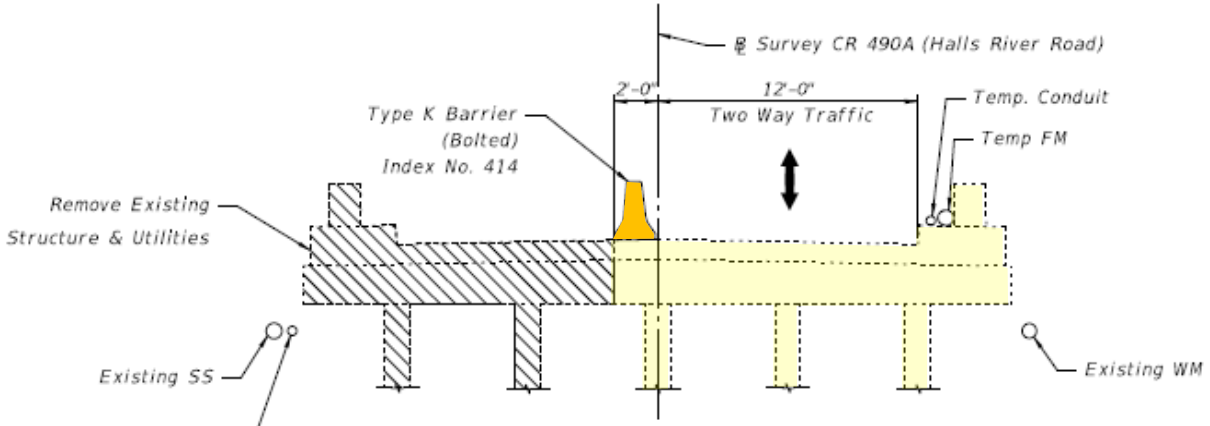
- Construction coordination is key
- Quick resolution of issues
- Construction coordination includes:
  - Pre-construction planning
  - Safety coordination and management
  - RFI, RFM program implementation and resolution
  - Quality assurance and control
  - Material control and procurement support
  - Field contract administration
  - Inspection coordination

Construction



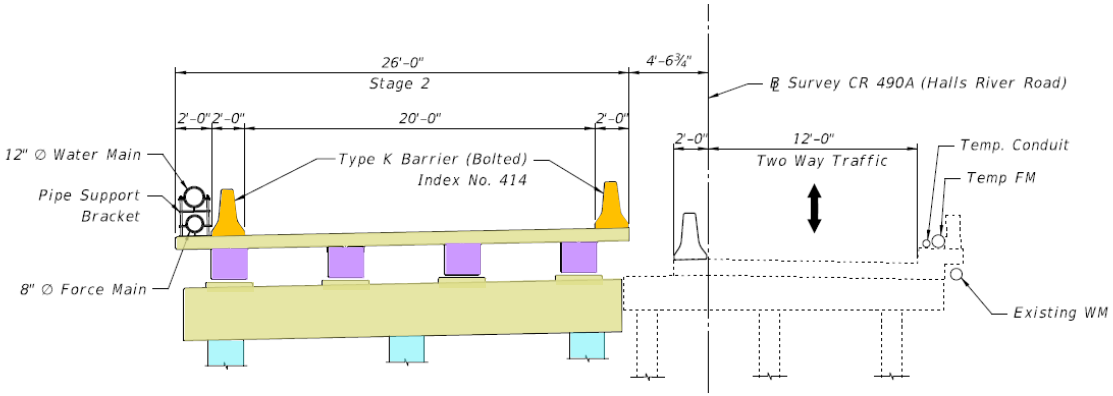
PHASE II - STAGE 1

EXISTING STRUCTURE REMOVAL (INTERMEDIATE BENTS)



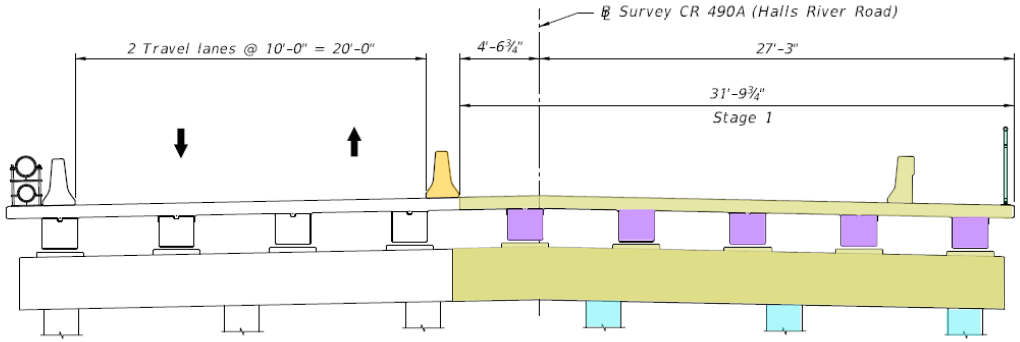
PHASE II - STAGE 1

Construction



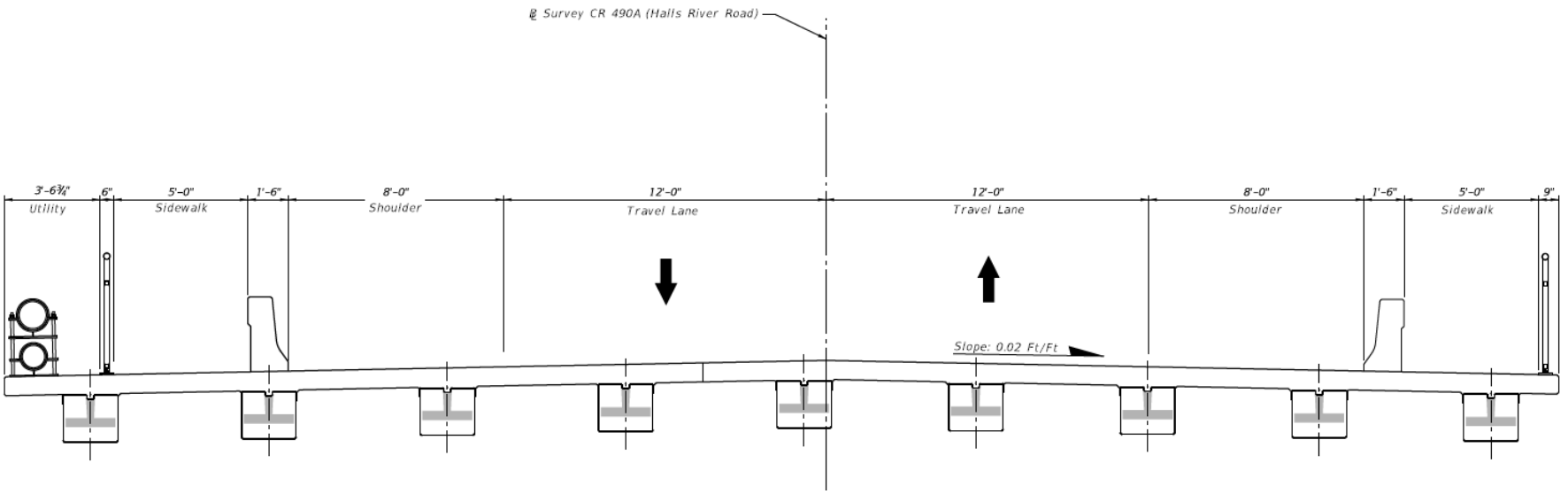
PHASE II - STAGE 2

(Intermediate Bent Shown, End Bent Similar)



PHASE III - STAGE 1

Construction



COMPLETED BRIDGE SECTION

Construction

Hybrid Composite Beam – *Fabrication*

HYBRID COMPOSITE BEAMS

STANDARD CONCRETE BEAMS

Construction

Hybrid Composite Beam – *Handling and Storage*

HYBRID COMPOSITE BEAMS

STANDARD CONCRETE BEAMS

Construction

Hybrid Composite Beam – *Transportation*

HYBRID COMPOSITE BEAMS
Union St., Maine
(4 - 70 ft. beams @ 9 kips = 36 kips total)

PRESTRESSED SLAB BEAMS
Gospel Island, Florida
(2 – 39 ft. beams @ 25 kips = 50 kips total)

Construction

Hybrid Composite Beam – *Installation*

HYBRID COMPOSITE BEAMS

PRESTRESSED SLAB BEAMS

Construction

Construction Photos

FRP for New Construction

Construction

FRP Rebar

FRP Bars are vulnerable to surface damage

Checklist: Handling and Storage of FRP Rebars	
☑	Store bars in a clean environment
	Protect bars against:
☑	- UV radiation
☑	- High temperature
☑	- Damaging chemicals
☑	Lift bundles of bars with care
☑	Do not shear bars when cutting
SAFETY*	Work gloves should be worn at all times

* In addition to typical safety precautions and procedures

Construction

CFRP Prestressed Piles

- **FDOT Research**
  - Lab Testing
  - Field Testing
- **Production**
  - Similar to Conventional Piles
  - Handling of CFRP
- **Installation**
  - Driving Method and Behavior similar to Conventional Piles
- **Performance**
  - Strength and Capacity similar to Conventional Piles

Monitoring

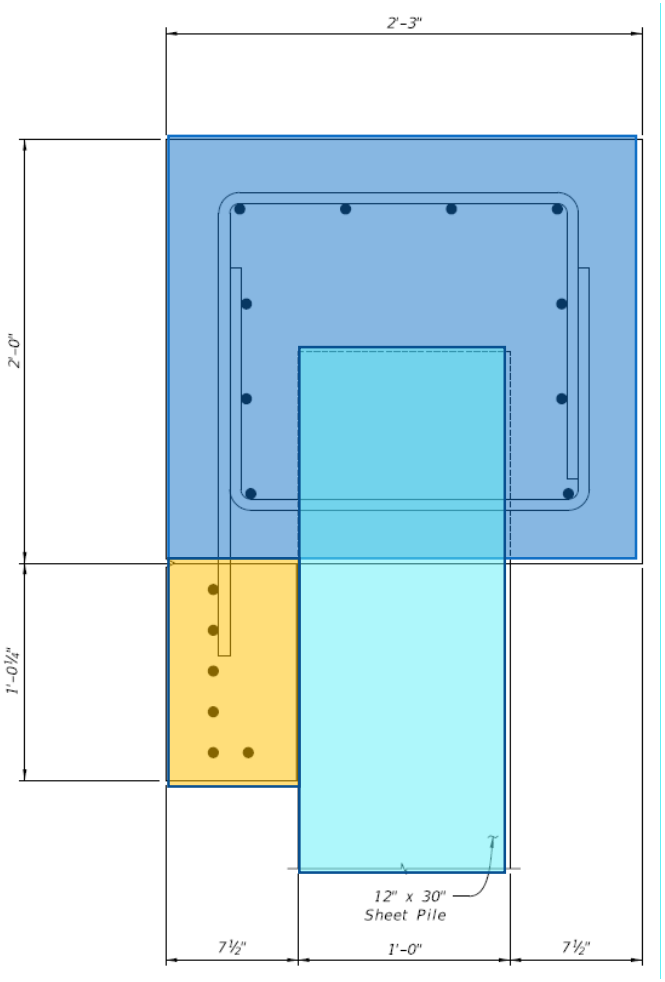
- **3rd Party Monitoring**
  - HCB Beams
  - CFRP & GFRP Reinforcement
- **Monitoring Phases**
  - Fabrication
  - Construction
  - Performance (6 months, 1 & 2 Years - Post Construction)
- **Test Blocks**
  - Sheet Pile Wall Cap and Gravity wall
  - 3 Composite Materials- GFRP, CFCC and Basalt
  - Green Concrete
- **Load Test**

Monitoring

Test Blocks

Materials

- CFRP
- GFRP
- Basalt



GFRP

CFRP

Test Block

Lessons Learned

- To develop standard details and specifications
- Design for Phase Construction
- Rebar arrangement –no mechanical coupler
- Lead time, Sole source of CFCC (Tokyo Rope)
- HCB QA/QC plan

Summary

- **Demonstration Project with Innovative Materials – First in Florida**
  - ✓Superstructure: Hybrid Composite Beams; GFRP Bars: Deck, Barriers & Approach Slabs
  - ✓Substructure: CFRP Pre-stressed Piles; Bent Caps: GFRP Bars
  - ✓Sheet Pile Walls: CFRP/GFRP Sheet Piles; Wall Cap: GFRP Bars
- **Contractor Bid Cost - $6.016 Million (Structures = $4.06 Million)**
  - Bridge Cost = **$218 / sq. ft.**
    (Conventional Construction = **$166 / sq. ft.**)
- **Accelerated Construction**
  - Lighter Materials – Beams and Rebar
  - Faster Transportation and Delivery – reduced construction time

QUESTIONS