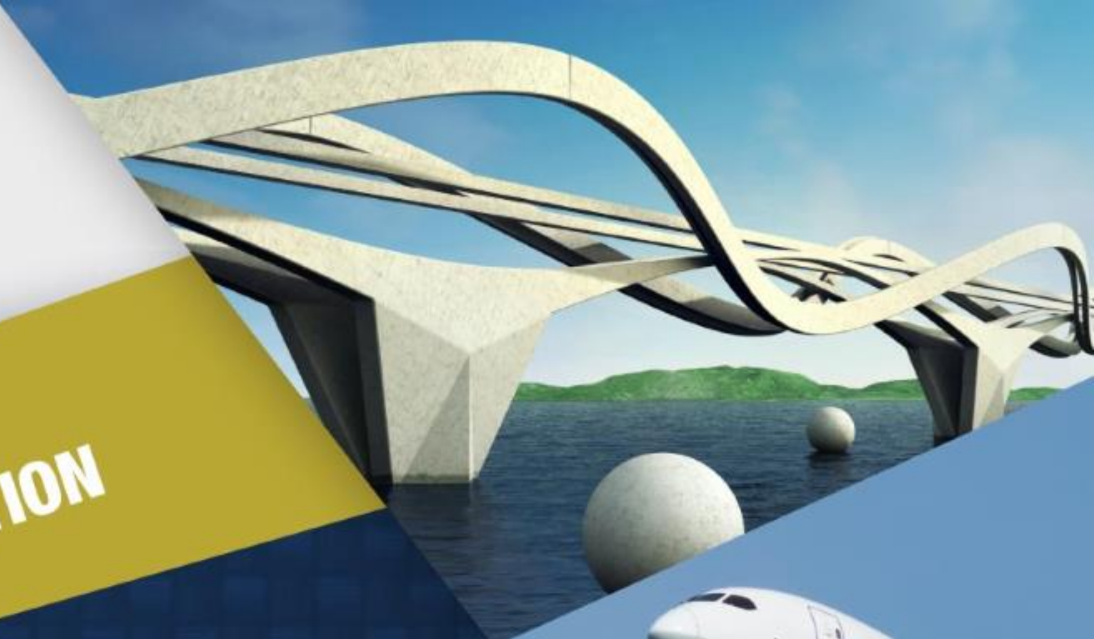
CAMX
THE COMPOSITES AND ADVANCED MATERIALS EXPO

September 11-14, 2017: Conference / September 12-14, 2017: Exhibits
Orange County Convention Center / Orlando, Florida



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Halls River Bridge:
Corrosion-Free Design with FRP Composites

Felix Padilla, P.E. -

Structures Design Engineer

FDOT State Structures Design Office

Michelle Gartman -

Graduate Student

FAMU-FSU College of Engineering

Thomas Cadenazzi -

Graduate Student,

University of Miami, College of Engineering

CAMX 2017 Award Finalist

CAMX THE COMPOSITES AND ADVANCED MATERIALS EXPO

Orange County Convention Center | Orlando, Florida, USA

ABSTRACT

Florida Department of Transportation (FDOT) recently embarked on a series of innovations under their Invitation for Innovation initiative, one of which focused on Fiber Reinforced Polymer (FRP) deployment for structural applications. The goal was to improve durability, encourage innovation and investment in the FRP transportation infrastructure market to ultimately reduce life-cycle costs and improve performance.

This presentation describes FDOT's flagship FRP-reinforced concrete demonstration project (Halls River Bridge Replacement) and many of the necessary components for successful scalable deployment for transportation agencies. One of the primary benefits of FRP composites identified by the FDOT was improved durability with the expectation for longer service life and lower maintenance liability. The further benefit of FRP-concrete reinforcement and prestressing, is the advantage of maintaining tradition procurement, construction practices, equipment and personnel, to assist stakeholders in expediting the successful implementation and wider deployment of the innovation. Stakeholders in this demonstration project include the owners, designers, inspectors, FRP manufacturers and fabricators, precast concrete producers and construction contractors.

Monitoring and documentation of this demonstration project was undertaken by FAMU-FSU College of Engineering, and also as part of the field demonstration portion (WP4) of the Infravation-SEACON project coordinated by the University of Miami, College of Engineering. In addition to the bridge and seawall components, 400 feet of removable test beams with four different types of FRP reinforcing (carbon strand, carbon bar, glass bar and basalt bar) are located in the splash-zone of this marine environment and will be periodically removed for destructive testing to verify the degradation models that are assumed for FRP-reinforced concrete design under ACI 440.1R, and possibly refinement for future AASHTO design specifications.

Outline

- **Part 1** *(by Felix Padilla – FDOT, State Structures Design Office)*
  - **Owner Perspective** (Topic #1)
  - **Designer Perspective** (Topic #2)
- **Part 2** *(by Michelle Gartman – FAMU-FSU, College of Engineering):*
  - **Construction Oversight Perspective/CEI** (Topic #3)
  - **Researcher Perspective** (Topic #4)
- **Part 3** *(by Thomas Cadenazzi – University of Miami, College of Engineering):*
  - **Contractor Perspective** (Topic #5)
- **Part 4** *(by Felix Padilla – FDOT, State Structures Design Office)*
  - **Other Project Examples** (Topic #6)
  - **Outreach & Technology Transfer** (Topic #7)

Part 1:

Topic #1 - Owner Perspective

Topic #2 - Designer Perspective

Owner Perspective (Topic #1)

a) Project Overview:

- Bridge elements
- Seawall elements

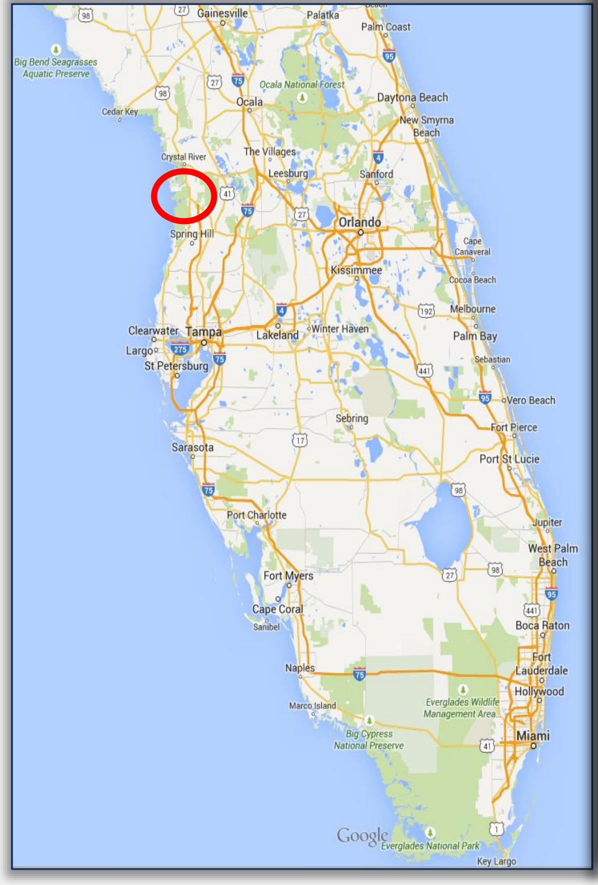
b) Corrosion Free Transportation Infrastructure:

- Why, How, & When (peace of mind, reduced liability, standardization, US infrastructure D rating)

c) Summary:

- Why, How, & When (Experimental project, accelerated construction)

Project Overview



Wild Manatees reside in the park year round.

Lu the hippo, honorary citizen of Florida since 1991.

Project Overview

Designer: FDOT District 7 Structures Design Office

Bridge EOR: Mamunur Siddiqui, P.E.

Bulkhead/Seawall EOR: Richard Hunter, P.E. (ACE)

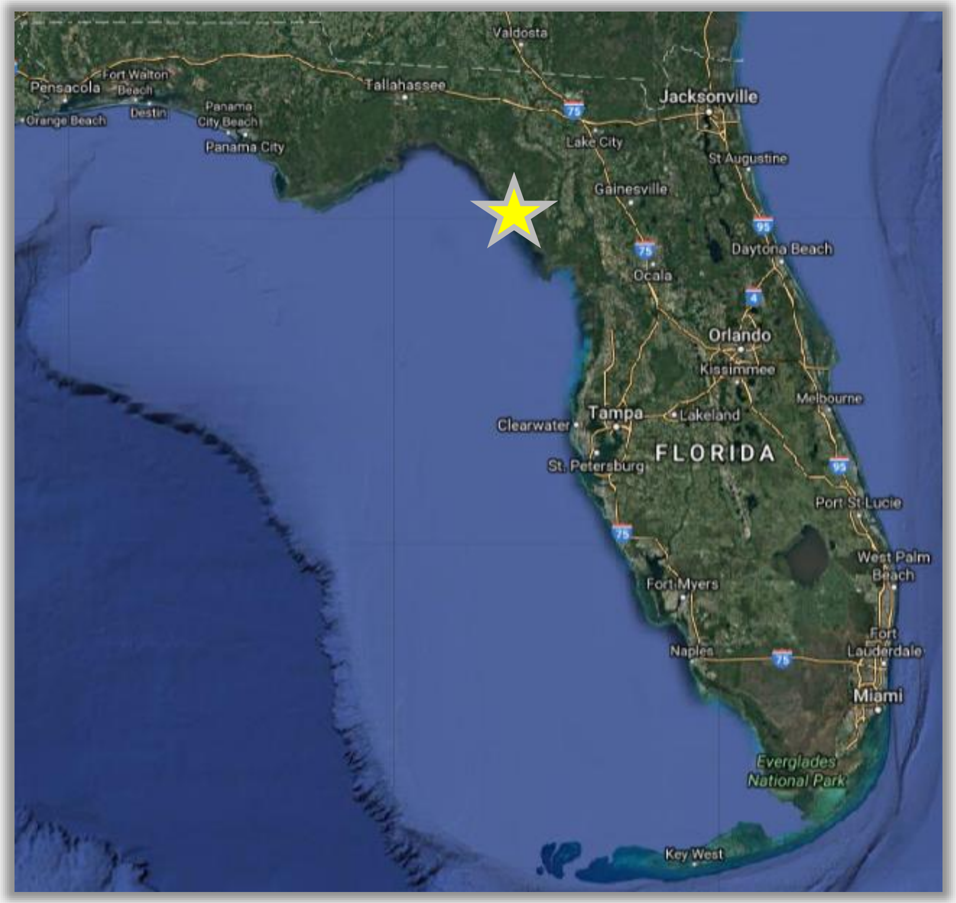
FDOT Developmental Standards EOR: Steven Nolan, P.E.

Owner & Maintaining Agency

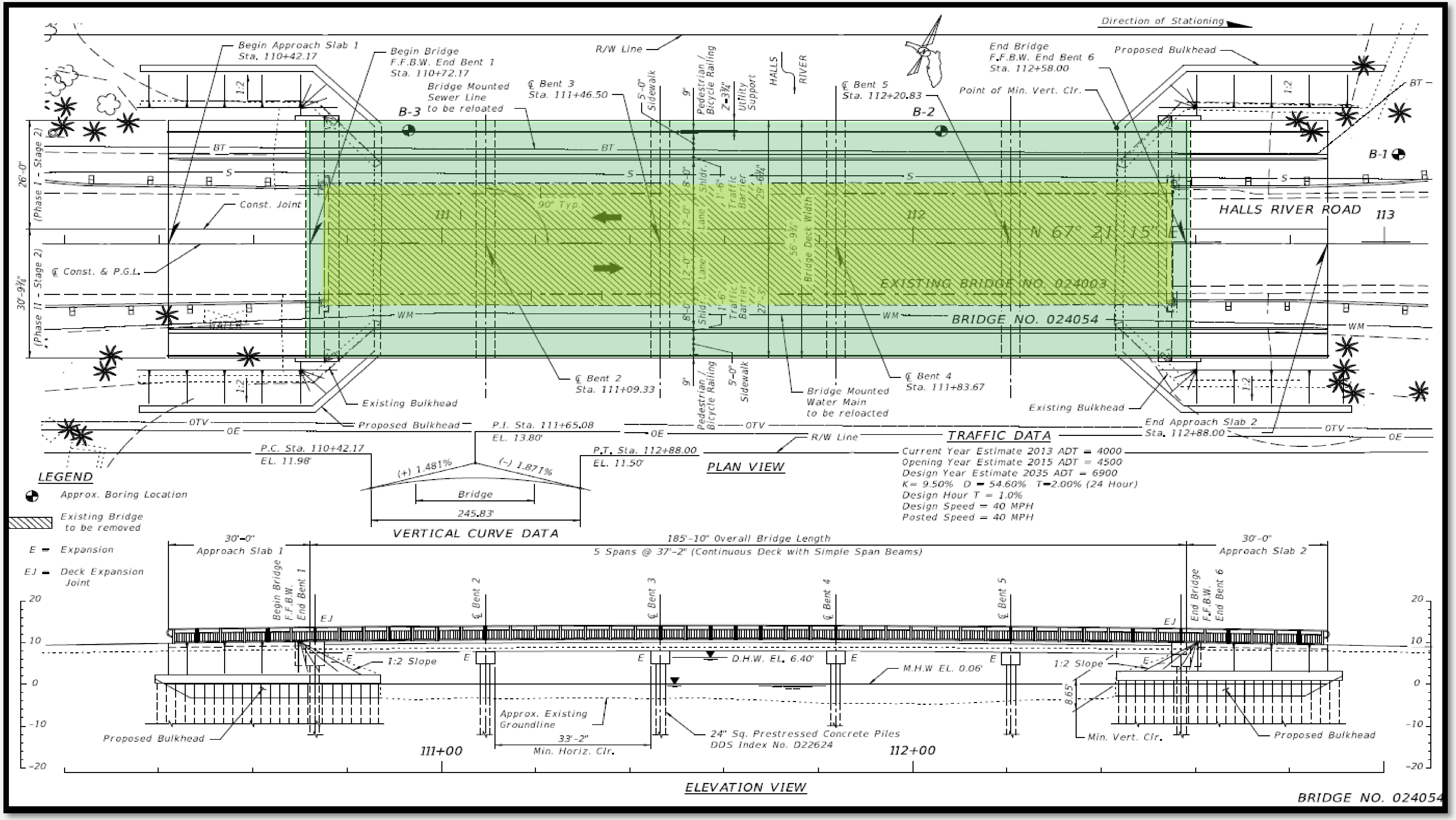
Design & Bi-Annual Inspection

Collaboration Research

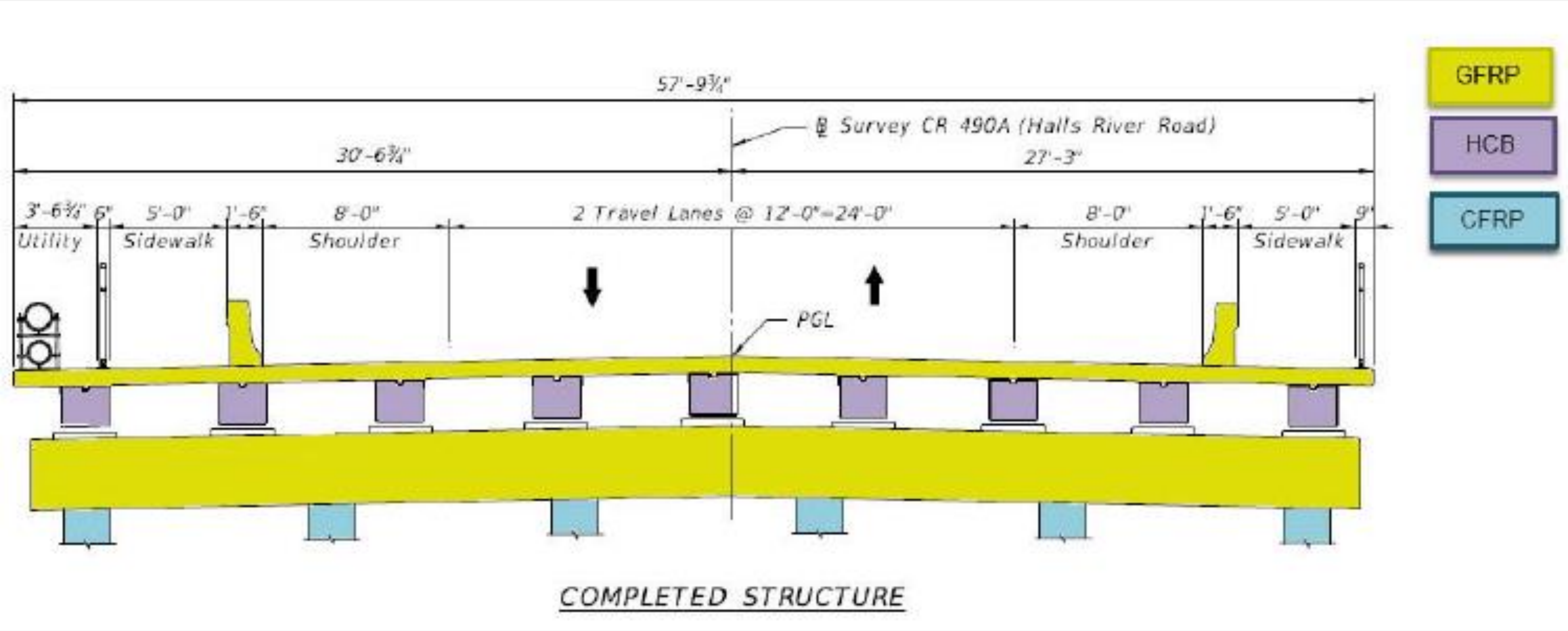
Funding & Oversight



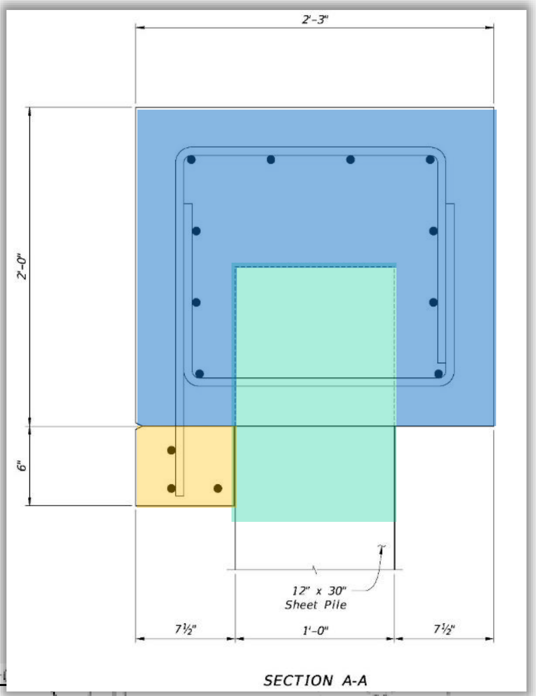
Project Overview



Bridge Elements



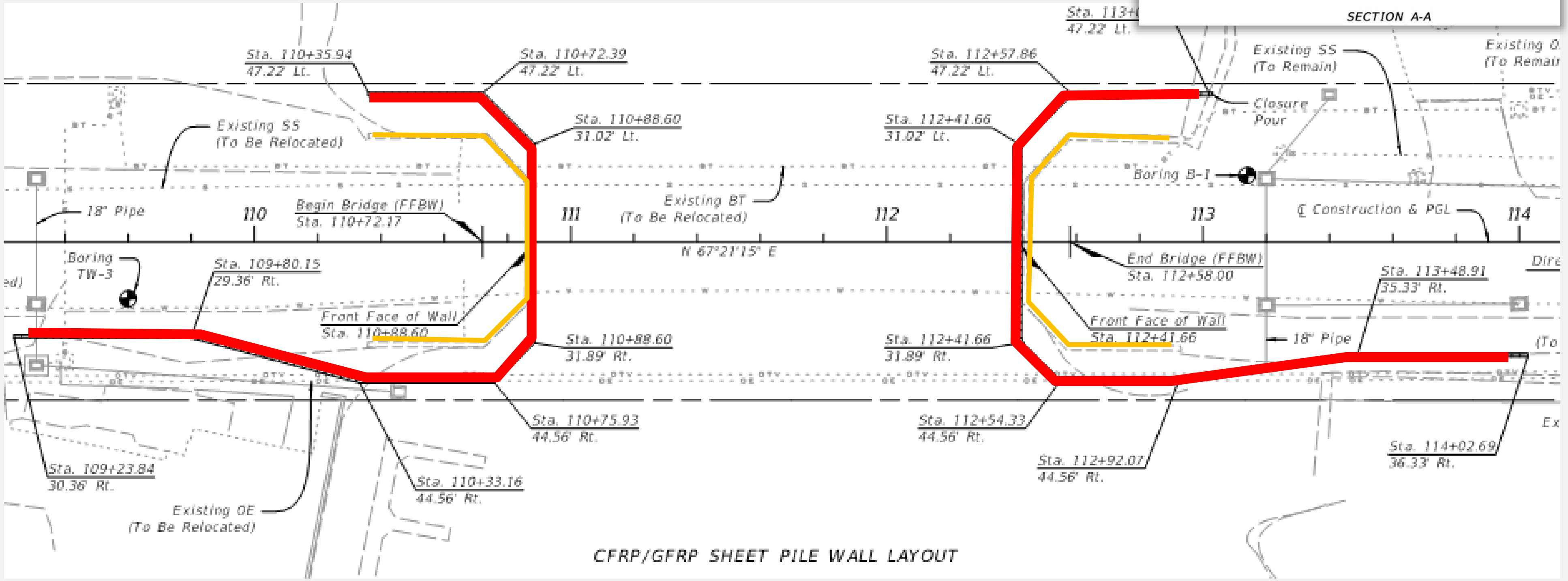
Seawall Elements



GFRP

CFCC / CFRP

Test Block



Corrosion-Free Structure

Summary

Experimental Project with Innovative Materials – First Complete Vehicular Bridge 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 Sheet Piles; Wall Cap: GFRP Bars

Contractor Bid Cost - $6.1 Million (Structures = $3.7 Million)

- Bridge Cost = **$221 / sq. ft.**

  (Conventional Construction Estimate = **$166 / sq. ft.**)

Accelerated Construction

- Lighter Materials – Beams and Rebar
- Faster Transportation and Delivery – reduced construction time

Designer Perspective (Topic #2)

a) Reinforced Concrete Design:
   - Why, How, & When (potentially more efficient with no sacrificial (unreliable) section loss)

b) References, Codes and Specifications:
   - Why, How, & When (Standardization, less risk for construction claims, need strive for national consensus)

c) Challenges:
   - Why, How, & When (Steep learning curve, need design tools)

Reinforced Concrete Design

Glass Fiber-Reinforced Polymer Rebar:

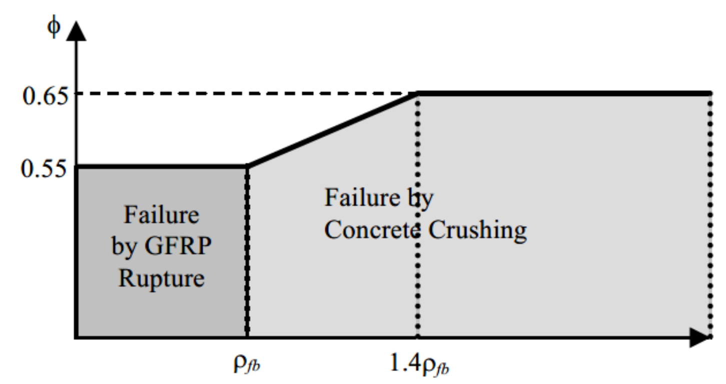
i. General

a. Modulus of elasticity: E_f = 6,500 ksi *<< Steel (E_s = 29,000 ksi)*

b. Resistance factors:

» Flexure and Tension: ϕ_f = 0.55 to 0.65 *<< Steel (ϕ_f = 0.90)*

» Shear and Torsion: ϕ_v = 0.75 *= Steel-RC*



ii. Principles

a. Equilibrium, Compatibility of Strains, Stress-Strain characteristics.

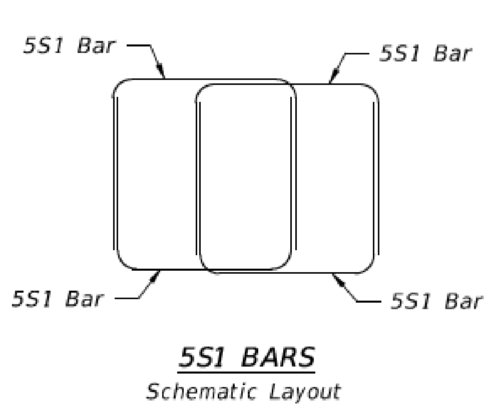
b. Crack width, Bond factor, Minimum reinforcement.

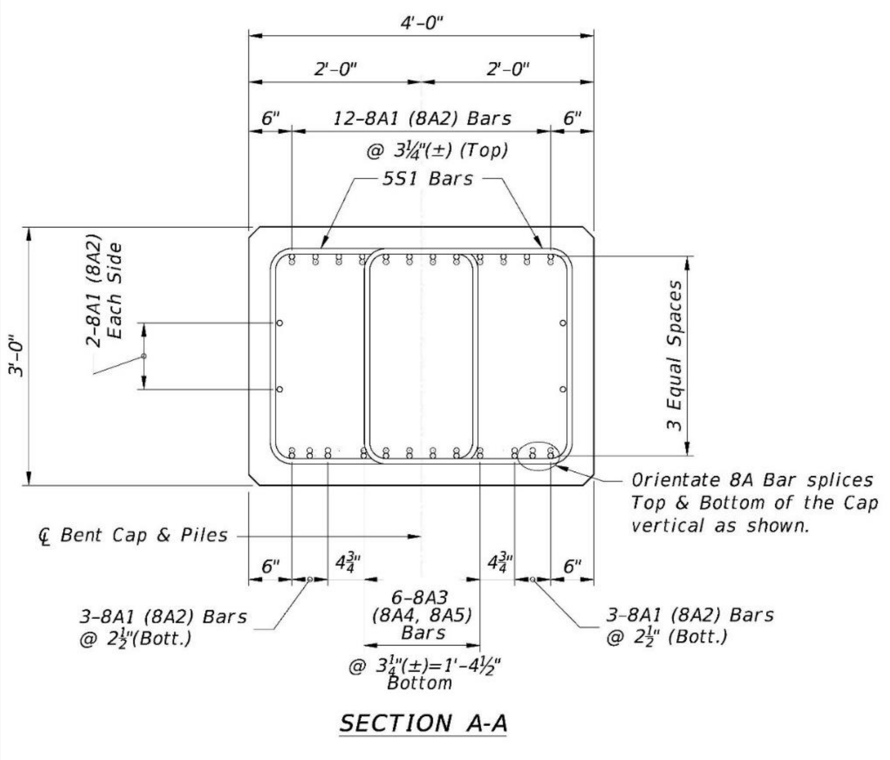
Reinforced Concrete Design

Glass Fiber-Reinforced Polymer Rebar (cont.):

iii. Failure Mode
   a. Non-Ductile Failure.
   b. Margin of Safety Increased.

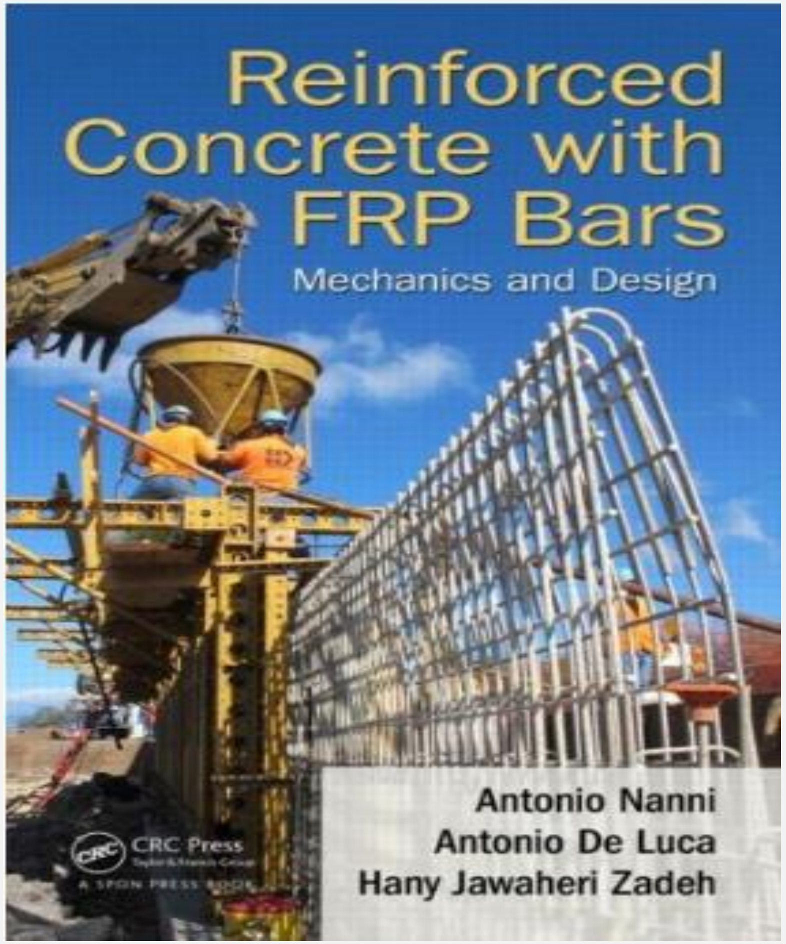
iv. Challenges
   a. Crack Control.
   b. Shear.
   c. Traffic Railing.
   d. Bar Detailing.

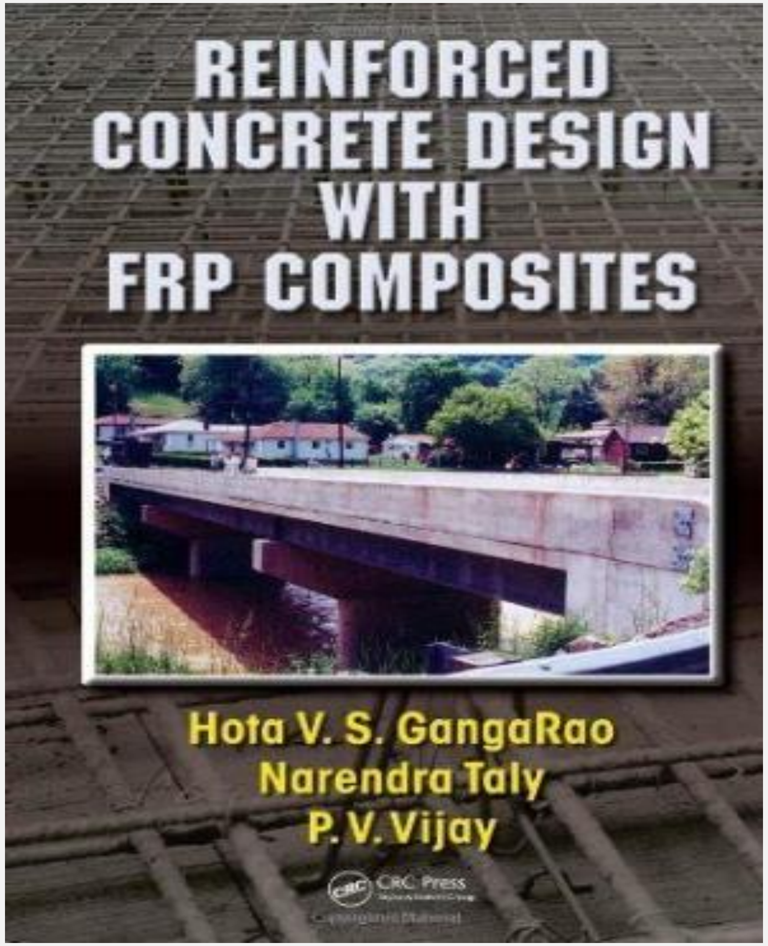


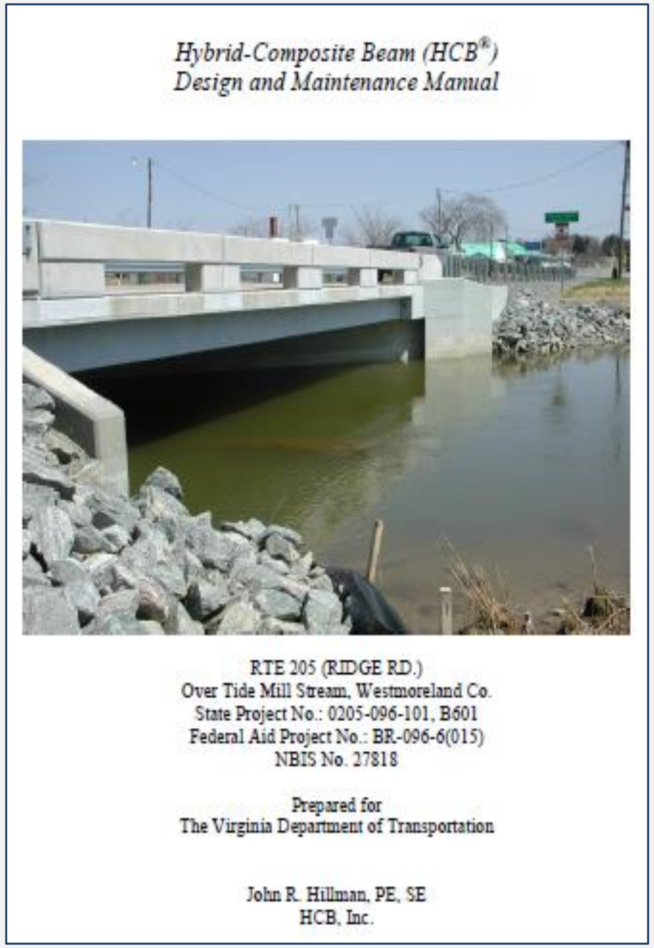


Bent Cap Plan Sheet Details:

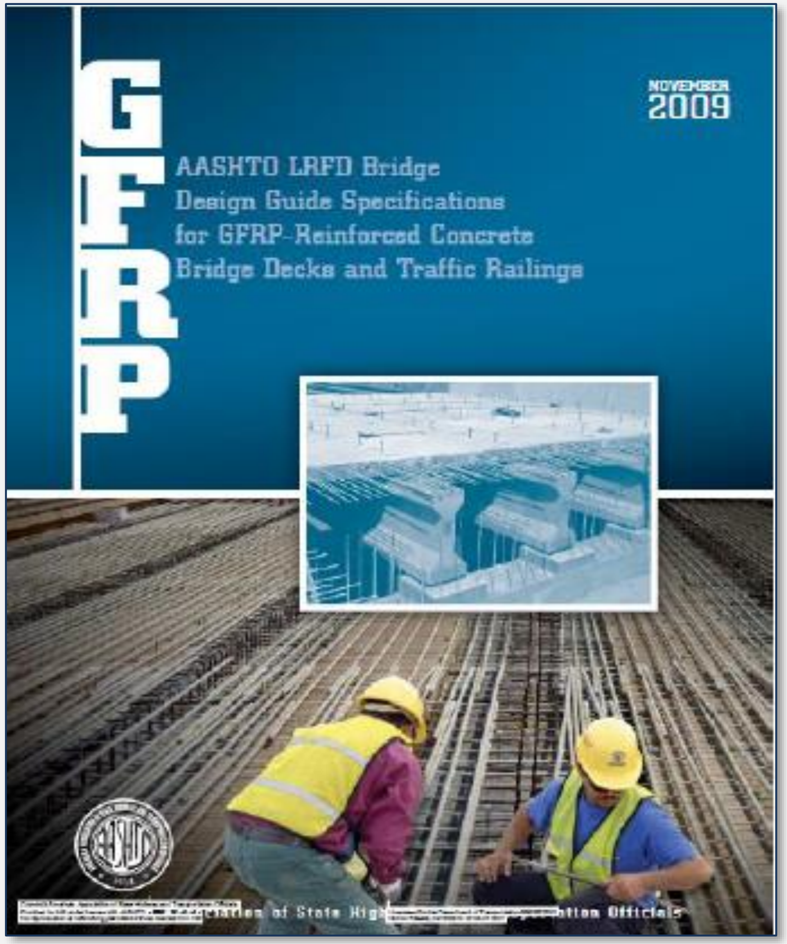
References, Codes and Specifications

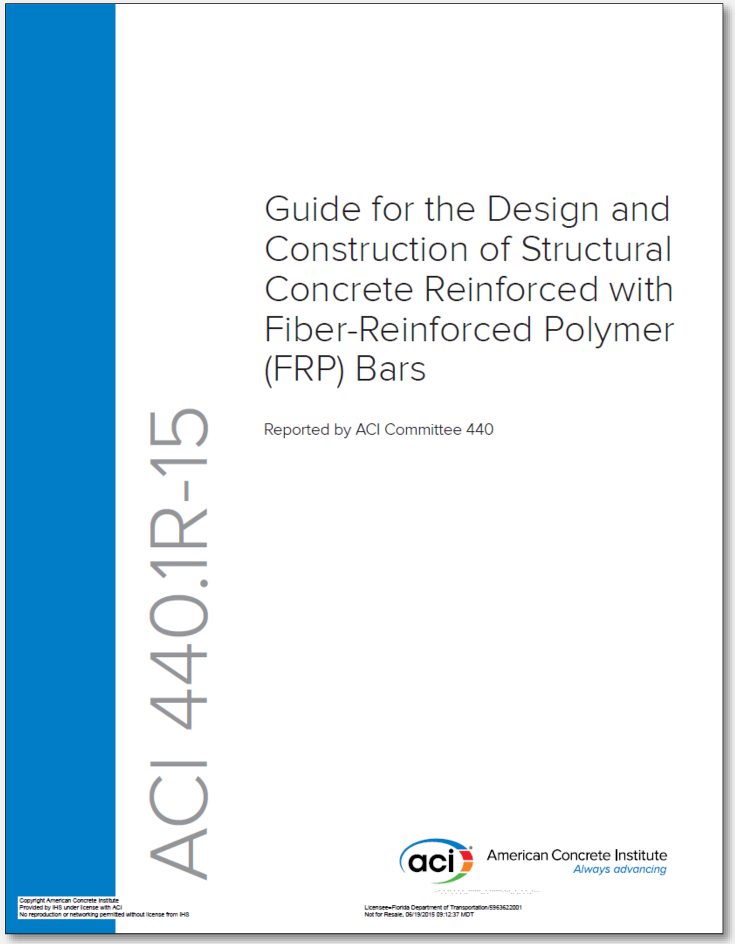






References, Codes and Specifications



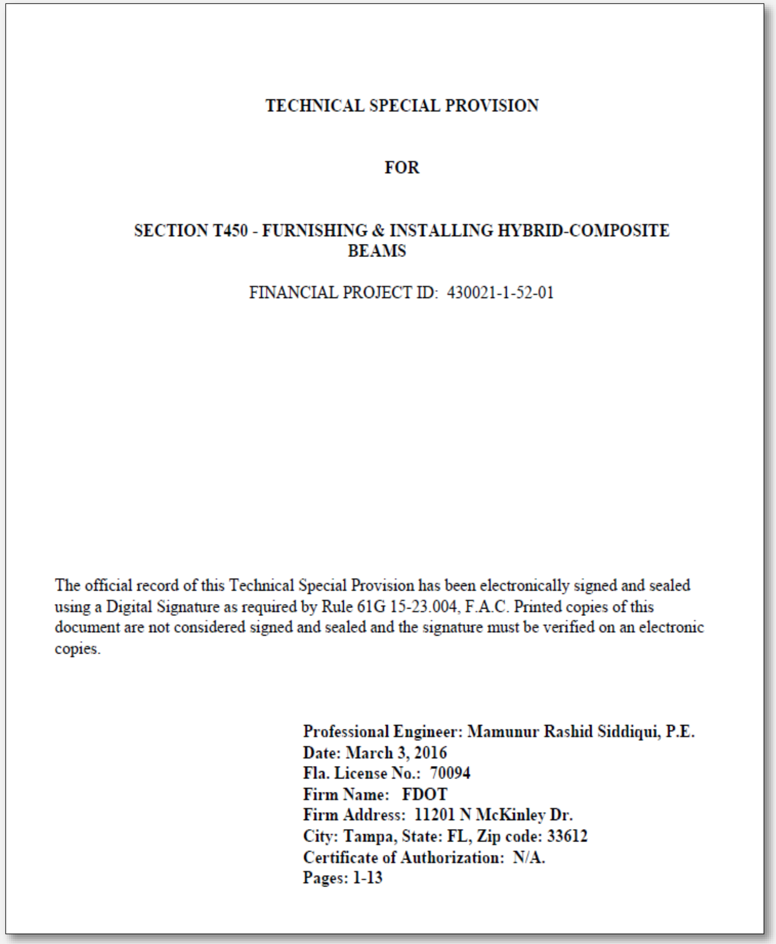


ACI 440.1R-15

Guide for the Design and Construction of Structural Concrete Reinforced with Fiber-Reinforced Polymer (FRP) Bars

Reported by ACI Committee 440

American Concrete Institute
Always advancing



TECHNICAL SPECIAL PROVISION

FOR

SECTION T450 - FURNISHING & INSTALLING HYBRID-COMPOSITE BEAMS

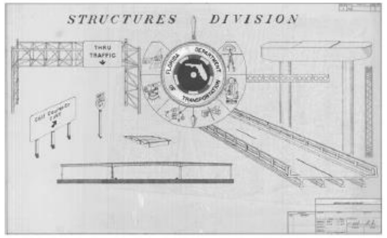
FINANCIAL PROJECT ID: 430021-1-52-01

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

References, Codes and Specifications

FLORIDA DEPARTMENT OF TRANSPORTATION



FIBER REINFORCED POLYMER GUIDELINES (FRPG)

FDOT STRUCTURES MANUAL
VOLUME 4
JANUARY 2017

FDOT

Specifications and Estimates/Specifications/

Materials Manual Section 12.1, Volume II

FIBER REINFORCED POLYMER COMPOSITES

Section 12.1, Volume II

FDOT

FY 2017-18 Design Standards

Effective for Projects with Lettings in the Fiscal Year (FY) from July 1, 2017 through June 30, 2018

State of Florida Department of Transportation
Office of Design
Mail Station 32
605 Suwannee Street
Tallahassee, Florida 32399-0450

For Construction and Maintenance Operations on the State Highway System
Topic No. 625-010-003

FIBER REINFORCED POLYMER BAR BENDING DETAILS					
D21310 Certification Statement	**FRP Bar Bending Details** Permitted Projects FPID No(s): 430021-1 432194-1-52-01 435815-1	Steve Nolan	IDDS-D21310	--	--
FRP REINFORCED TRAFFIC RAILINGS RAILINGS					
D22420 Certification Statement	**Traffic Railing (32" F Shape - GFRP Reinforced)** Permitted Projects FPID No(s): 430021-1	Steve Nolan	IDDS-D22420	--	--
FRP REINFORCED PILES					
D22440 Certification Statement	**Precast Concrete CFRP/GFRP Sheet Pile Wall** Permitted Projects FPID No(s): 430021-1-52-01 432194-1 435815-1	Steve Nolan	IDDS-D22440	CEL-D22440-CSPSA CEL-D22440-CSPDA CEL-D22440-CSPC	--
D22600 Certification Statement	**Notes and Details For Square CFRP Prestressed Concrete Piles** Permitted Projects FPID No(s): 430021-1-52-01	Steve Nolan	IDDS-D22600	CEL-20600	
D22601 Certification Statement	**Square CFRP Prestressed Concrete Pile Splices** Permitted Projects FPID No(s): 430021-1-52-01				
D22614 Certification Statement	**14" Square CFRP Prestressed Concrete Pile** Permitted Projects FPID No(s):				
D22618 Certification Statement	**18" Square CFRP Prestressed Concrete Pile** Permitted Projects FPID No(s): 430021-1-52-01				
D22624 Certification Statement	**24" Square CFRP Prestressed Concrete Pile** Permitted Projects FPID No(s):				
FRP REINFORCED APPROACH SLABS					
D22900 Certification Statement	**Approach Slab - GFRP Reinforced (Flexible Pavement Approach)** Permitted Projects FPID No(s): 430021-1	Steve Nolan	IDDS-D22900	CEL-D22900	--

Challenges

A. HCB

  i. Proprietary product

  ii. Design Criteria

  iii. Inspection for closed system

  iv. Durability verification

  v. Fabrication QA/QC

B. GFRP Reinforced Concrete

  i. Lap Splice: deck, cap, and diaphragm

  ii. Rebar unit price

  iii. Reinforcing Bar List (bent bars, length vs. weight)

REINFORCING BAR LAPS

SIZE	LENGTH
4	1'-10"
5	1'-10"
6	2'-3"
8	2'-6"

Part 2:

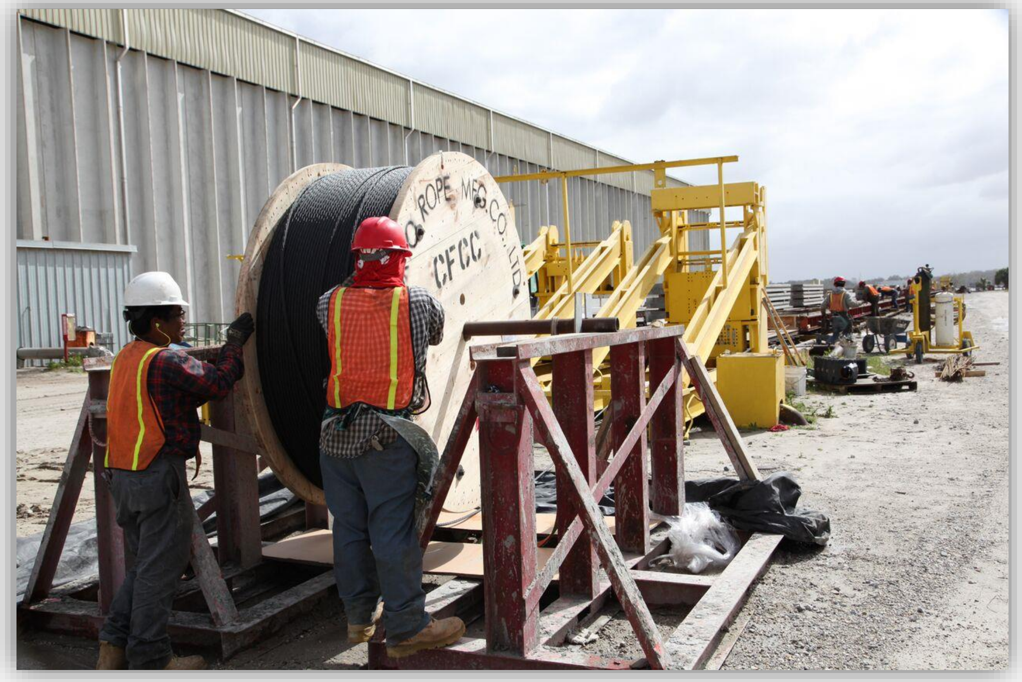
Topic #3 - Construction Oversight Perspective/CEI

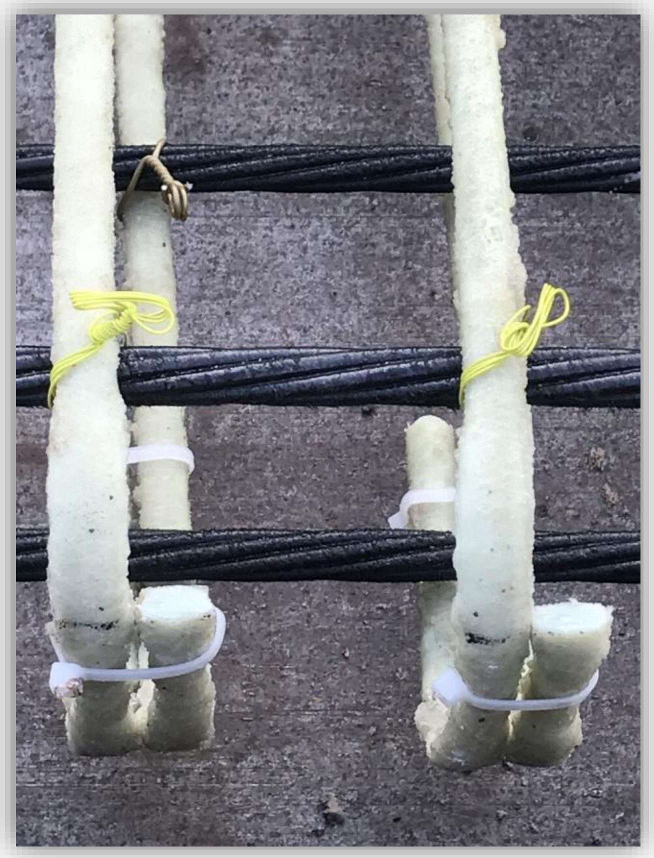
Topic #4 - Researcher Perspective

Construction Oversight Perspective (Topic #3)

a) Corrosion-free transportation infrastructure:

- less concern during construction for protection from chloride contamination

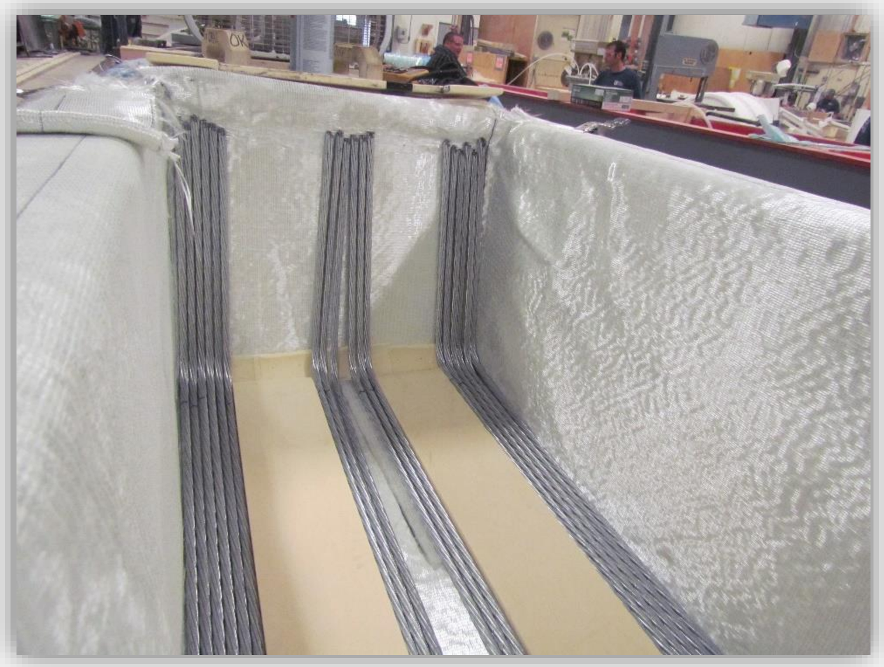





CDS-QC


CAT
ASTALDI

b) Longer Service Life:

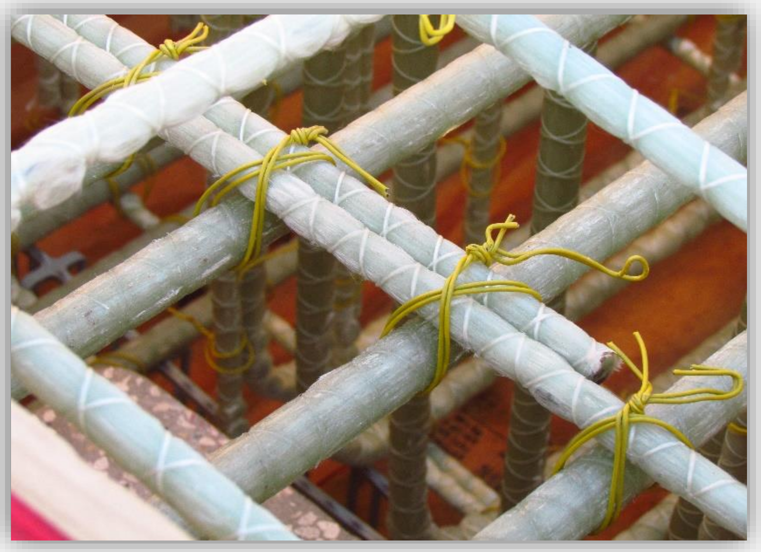



VECTORPLY


2

c) Simple and Scalable Implementation:

- minimal learning curve for oversight of “Means and Method”
- use similar material verification processes

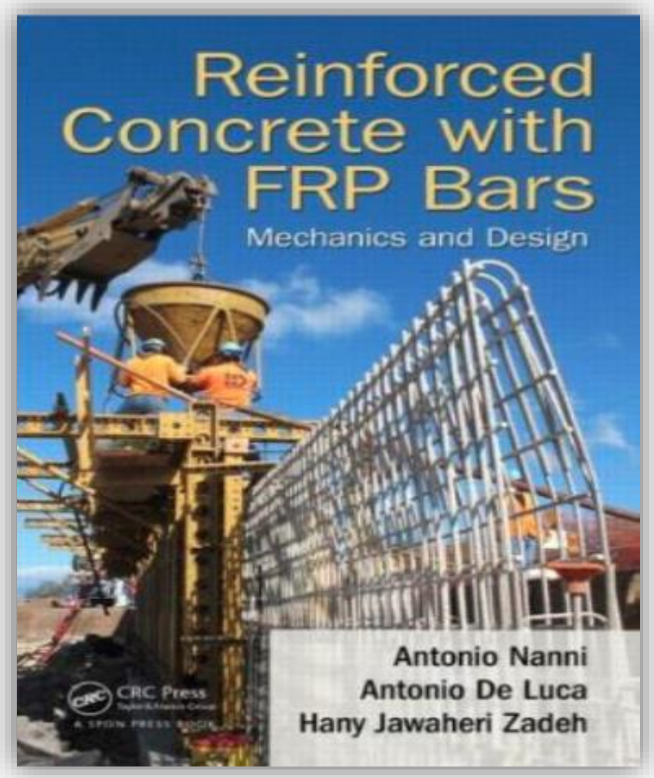


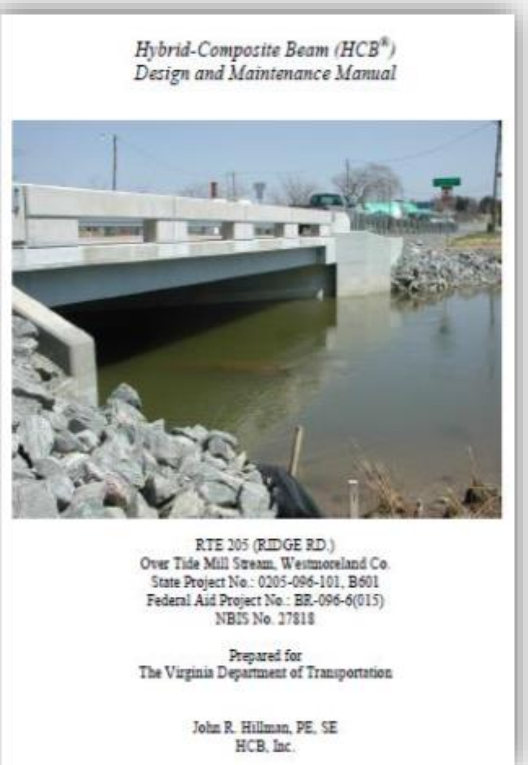

MI-JACK
TRAVELIFT
JCB

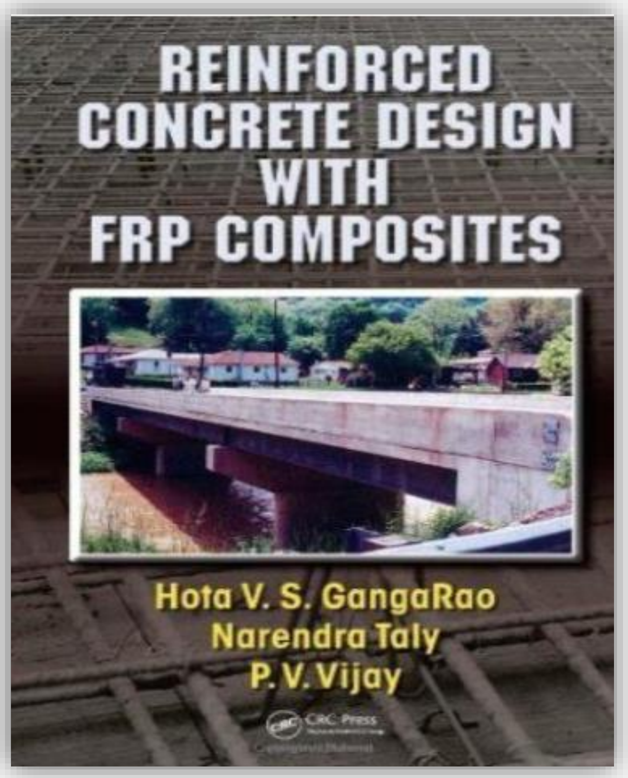
Researcher Perspective (Topic #4)

a) Corrosion-free transportation infrastructure:

- research on this is very mature







Completion Date	Title	Researcher	Institution	Research No.
5/31/2018	Performance Evaluation of GFRP Reinforcing Bars Embedded in Concrete Under Aggressive Environments	R. Kampmann	FSU	BDV30 977-18
3/31/2018	Degradation Mechanisms and Service Life Estimation of FRP Concrete Reinforcements	A. El Safty	UNF	BDV34 977-05

FDOT Developmental Standards:

- Pultruded FRP Bar Bending Details (**Index *D21310***)
- 18" CFRP Prestressed Piles (***Index D22618***)
- CFRP Prestressed Piles Splices (***Index D22601***)
- CFRP/GFRP Sheet Piles Walls (***Index D22440***)
- Traffic Railing - GFRP Reinforced (***Index D22420***)
- Approach Slab – GFRP Reinforced (***Index D22900***)

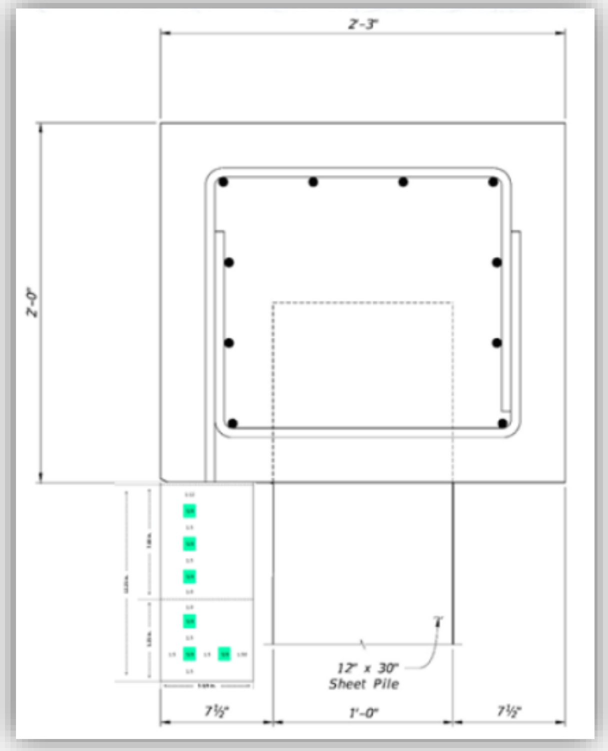
FDOT Design Standards

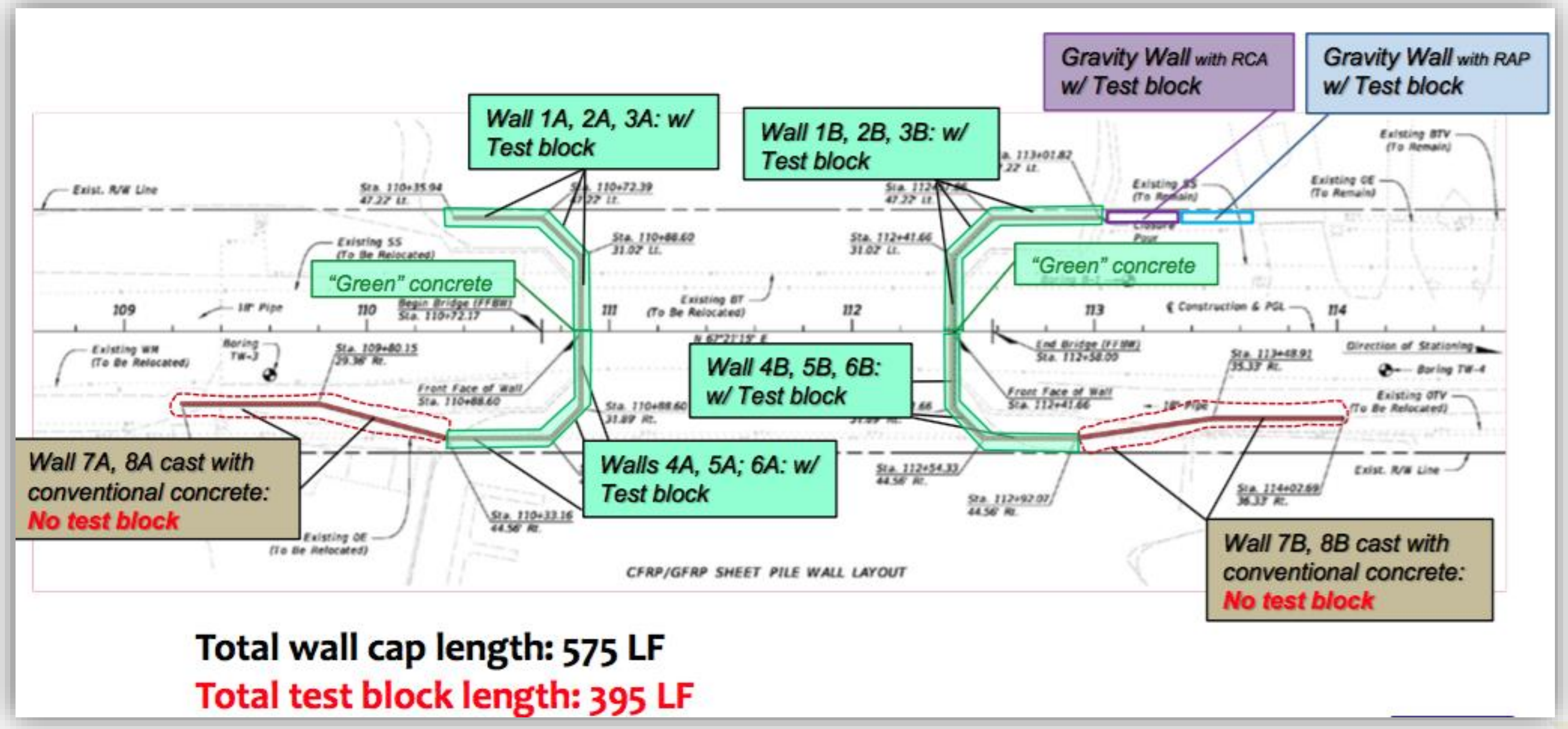
		SQUARE AND ROUND CONCRETE PILES (Corrosion Resistant)
22600		Notes and Details For Square CFRP & SS Prestressed Concrete Piles
22601		Square CFRP & SS Prestressed Concrete Pile Splices
22612		12" Square CFRP & SS Prestressed Concrete Pile
22614	Errata	14" Square CFRP & SS Prestressed Concrete Pile
22618	Errata	18" Square CFRP & SS Prestressed Concrete Pile
22624		24" Square CFRP & SS Prestressed Concrete Pile
22630	Errata	30" Square CFRP & SS Prestressed Concrete Pile

		WALL SYSTEMS (Corrosion Resistant)
22440		Precast Concrete CFRP/GFRP & HSSS/GFRP Sheet Pile Wall

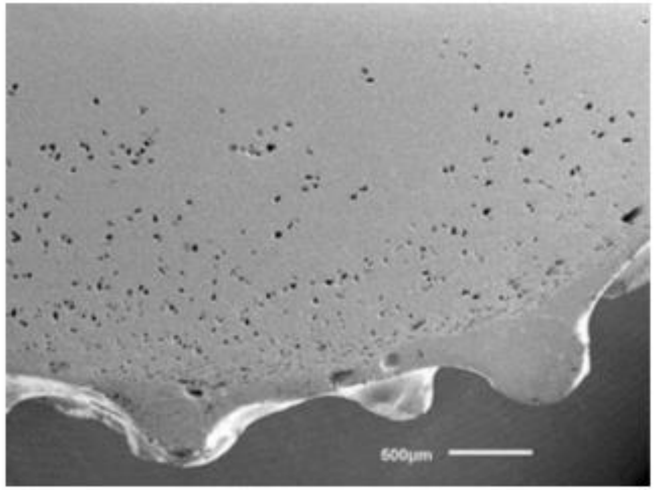
b) Longer Service Life:

- needs further refinement and supporting studies

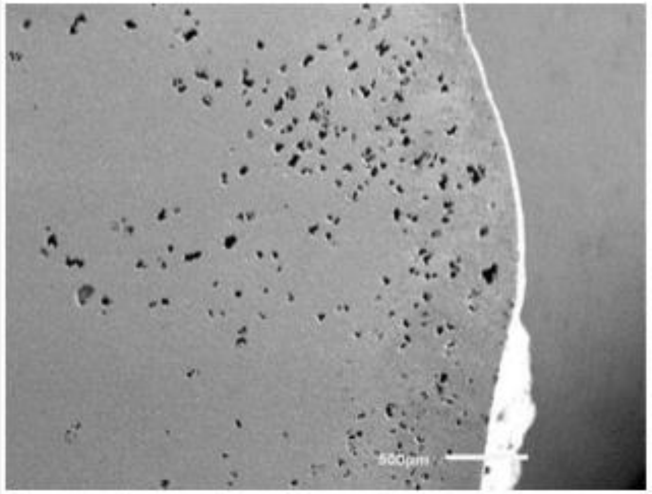




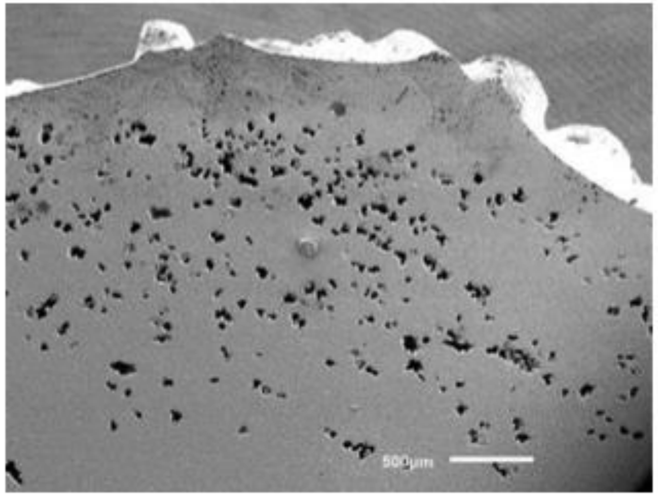
Pristine Bar



Mix B (Seawater Concrete)

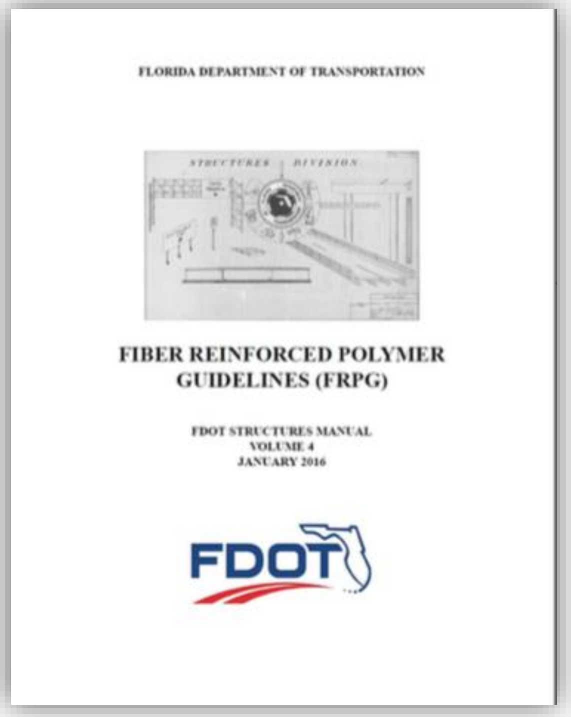


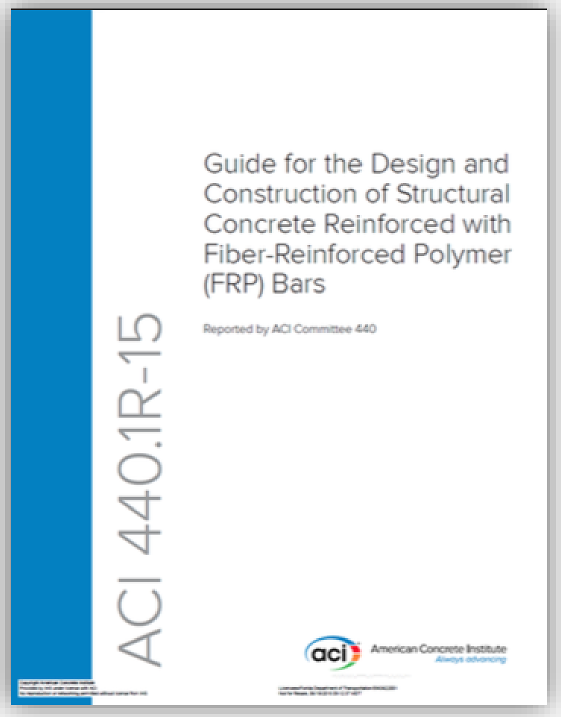
Mix A (Conventional Concrete)

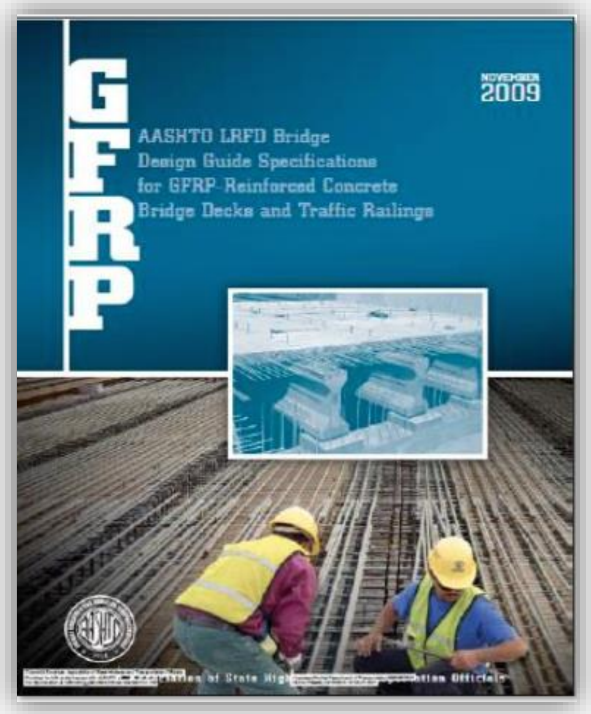


c) Simple and Scalable Implementation:

- try to align design requirements for innovative materials with traditional materials







Part 3:

Topic #5 - Contractor Perspective

Contractor Perspective (Topic #5)

a) Corrosion-free transportation infrastructure:
   - Why, How, & When (Opportunity for “Added Value” by providing enhance durability under design-build procurement)

b) Longer Service Life:
   - Why, How, & When (Cost/Efficiency, Cost/Service Life Approach)

c) Simple and Scalable Implementation:
   - Why, How, & When (Less risk for “Means and Methods”, need a reliable supply chain to minimize risk of delays, time = money)

Corrosion-free transportation infrastructure

GFRP vs Carbon-Steel (Black)

Advantages:

- Reduced concrete cover requirements
- Labor savings during Installation
- Concrete properties less stringent
- Weighs only one quarter as steel
- Tensile strength greater than that of steel
- Highly resistant to corrosion
- It is transparent to magnetic fields and radar frequencies
- GFRP has low electrical and thermal conductivity

Disadvantages:

- Higher initial costs of materials

Corrosion-free transportation infrastructure

Construction challenges correlated in general with GFRPs

- Splicing of FRP bars complicated and time consuming
- NO FLAME – no heat sources allowed near FRP bars - LIMIT UV EXPOSURE
- Fragility of rebar
- Trained labor
- Specialized lifting plans required for prefabricated cages.

Longer Service Life

Cost/Efficiency approach

Strength/Ultimate Limit State (ULS) using the current resistance factors, and then a Service Limit State (SLS) comparison

GFRP BARS	STRENGTH (SERIVCE LIMIT STATE - ksi) HALLS RIVER BRIDGE BARS	VS	STEEL – GRADE 60	ALLOWABLE TENSILE STRENGTH (ksi)	K = (GFRP)/ (STEEL)
#4 (0.5 in)	20 ksi		#4 (0.5 in)	20 ksi	1
#5 (0.625 in)	19.6 ksi		#5 (0.625 in)	20 ksi	0.98
#6 (0.750 in)	20.4 ksi		#6 (0.750 in)	20 ksi	1.02
#8 (1 in)	17.2 ksi		#8 (1 in)	20 ksi	0.86

Per ACI 440 guideline, design strength of GFRP bar at fatigue limit: $f_{fat} = 0.2 \cdot C_E \cdot f_u$ where C_E is environmental reduction factor and 0.2 is a stress limit imposed for permanent loads. $f_{service\ ultimate} = f_{fatigue}$

For steel (normalized equation from AASHTO): $f_{fat} = 24 - 20 \cdot (\frac{f_{min}}{fy})$, with $f_{min} = 0.2 \cdot f_y$

Longer Service Life

Cost/Efficiency approach

Cost expressed in terms of efficiency: $/K of the service limit state

GFRP BARS	Unite Price LF	Unite Price /K	VS Grade 60 steel BARS	Unit price*
#4 (0.5 in)	1.00 $/LF	1.00 $/LF/K	#4 (0.5 in)	0.51 $/LF
#5 (0.625 in)	1.10 $/LF	1.12 $/LF/K	#5 (0.625 in)	0.79 $/LF
#6 (0.750 in)	1.40 $/LF	1.37 $/LF/K	#6 (0.750 in)	1.14 $/LF
#8 (1 in)	1.70 $/LF	1.98 $/LF/K	#8 (1 in)	2.03 $/LF

(*) unit price based on FDOT average prices

Longer Service Life

Cost/Service life (SL) approach

Cost expressed in terms of service life: $/K/X of the service limit state;

Approximation initial cost rationing AASHTO codes;

Codes and standards as design basis: Assumed life for steel reinforced bridge is typically 75-years. Engineers and researchers expect Halls River Bridge to last 125 years.

X= GFRP SL /STEEL SL	GFRP BARS	Unite Price/K/X	VS Grade 60 steel BARS	Unit price*
75/125= 0.6	#4 (0.5 in)	0.6 $/LF/K/X	#4 (0.5 in)	0.51 $/LF
75/125= 0.6	#5 (0.625 in)	0.67 $/LF/K/X	#5 (0.625 in)	0.79 $/LF
75/125= 0.6	#6 (0.750 in)	0.82 $/LF/K/X	#6 (0.750 in)	1.14 $/LF
75/125= 0.6	#8 (1 in)	1.19 $/LF/K/X	#8 (1 in)	2.03 $/LF

(*) unit price based on FDOT average prices

Quantify the ecological impact of FRP products that results in further savings (LCA/LCC analysis)

Longer Service Life

Lightweight

GFRP BARS	Unit weight [lb/ft]	VS	Grade 60 steel BARS	Unit weight [lb]	Y = (GFRP)/ (STEEL)
#4 (0.5 in)	0.189		#4 (0.5 in)	0.668	0.28
#5 (0.625 in)	0.287		#5 (0.625 in)	1.043	0.28
#6 (0.750 in)	0.408		#6 (0.750 in)	1.502	0.27
#8 (1 in)	0.730		#8 (1 in)	2.670	0.27

Additional cost savings: the material allows less haul costs, given its significant lightweight

Means and Methods

Construction challenges correlated in general with GFRPs

<u>Procurement & Lead Time</u>

- Procurement must consider lead time for manufacturing and shipping
- Procurement of additional quantities of FRP bars to ensure immediate replacements in case of damages on site
- QA/QC - additional verifications at manufacturing plant needed prior to shipment to mitigate risk of delays due to non compliances

Means and Methods

Material supplier - ATP

- Deck / Bulkhead caps / Bent caps/ Approach slabs/ Gravity Wall/ Traffic railings / Test blocks GFRP bars from ATP

Means and Methods

Material supplier - ATP

- Deck / Bulkhead caps / Bent caps/ Approach slabs/ Gravity Wall/ Traffic railings / Test blocks GFRP bars from ATP

	Contract Quantity	Supplied Quantity
Bars Type	**LF**	**LF**
#4	23,194	25,098
#5	60,832	62,732
#6	86,486	93,722
#8	17,471	19,013
Traffic Railing	14,003	14,003
Traffic Railing Revision South Side	10,605	10,605
#3	747	807
Test Blocks #5	1,447	1,447
Pendulum Test #4	455	455
Pendulum Test #5	1,238	1392

EXTRA MATERIAL ORDERED: 8% SPARES

Bending / welding / threading / meshing of bars on-site still not feasible

Means and Methods

Material supplier - ATP

- Deck / Bulkhead caps / Bent caps/ Approach slabs/ Gravity Wall/ Traffic railings / Test blocks GFRP bars from ATP

TEST BARS OUT OF EACH LOT (EACH SHIPMENT)

Means and Methods

Material supplier - ATP

- Tests performed at UM, in accordance with ASTM Standard Test Method

<table>
<tr><th colspan="6">Table 5-2
Testing requirements for Product Acceptance of Prestressing CFRP Strand for a Project</th></tr>
<tr><th>Property</th><th>Test Method</th><th>Requirement</th><th>Number of Tests</th><th>Number of Samples</th><th>Minimum Sample Length (in.)</th></tr>
<tr><td>Degree of cure</td><td>ASTM E2160</td><td>≥ 95% of total polymerization enthalpy</td><td rowspan="3">5</td><td rowspan="3">7</td><td rowspan="3">10</td></tr>
<tr><td>Fiber content</td><td>ASTM D2584 or ASTM D3171</td><td>Weight fraction ≥ 70%</td></tr>
<tr><td>Moisture absorption</td><td>ASTM D570</td><td>≤ 0.25% in 24 hours at 122°F</td></tr>
<tr><td>Measured Cross Sectional Area</td><td rowspan="3">ASTM D7205</td><td>95% to 110% of nominal area (Table 1-1)</td><td rowspan="3">5</td><td rowspan="3">7</td><td rowspan="3">30 + 40 times the nominal diameter</td></tr>
<tr><td>Ultimate Tensile Load</td><td>≥nominal ultimate load (Table 1-1)</td></tr>
<tr><td>Tensile Modulus of Elasticity</td><td>≥18,000 ksi</td></tr>
</table>

Means and Methods

Material supplier – GATE PRECAST (Jacksonville, FL)

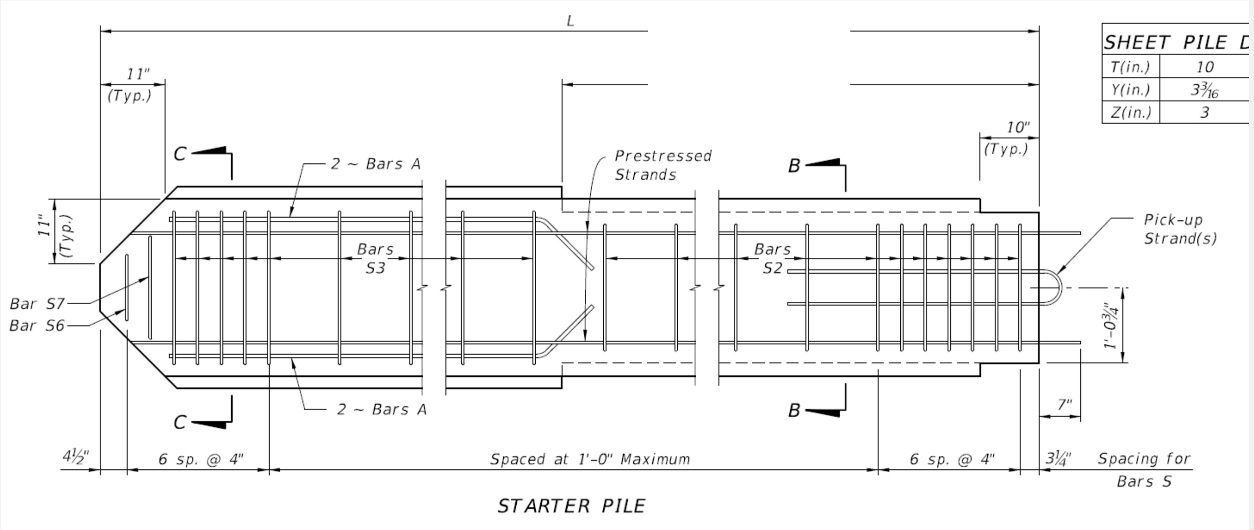
- Concrete sheet piles 12”X30” with CFRP strands from Japan and GFRP bars from Canada

REINFORCING BARS:

Glass Fiber Reinforced Polymer (GFRP) bars meeting the requirements of Developmental Specification 932.

PRESTRESSING STRAND

Carbon Fiber Reinforced Polymer (CFRP) strand meeting the requirements of Developmental Specification 933.



Means and Methods

Material supplier – GATE PRECAST (Jacksonville, FL)

- Concrete sheet piles 12”X30” with CFRP strands from Japan and GFRP bars from Canada

Means and Methods

Material supplier – GATE PRECAST (Jacksonville, FL)

- Concrete sheet piles 12”x30” with CFRP strands from Japan (soon available from Michigan) – encourage locally sourced FRP strands for the future.

Means and Methods

Material supplier – GATE PRECAST (Jacksonville, FL)

- Concrete sheet piles 12”x30” with CFRP strands from Japan and GFRP bars from Canada

FROM PULTRALL INC. (CANADA)
TO JACKSONVILLE,
TO HOMOSASSA

Means and Methods

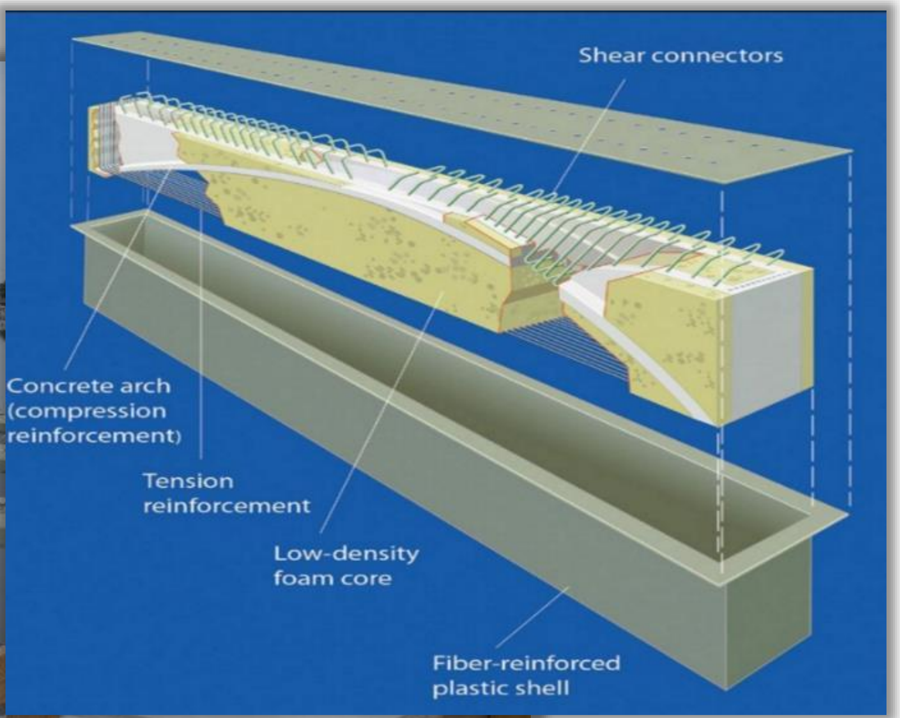
Material supplier – GATE PRECAST (Jacksonville, FL)

- Prestressed concrete CFRP 18" piles with CFCC strands from Japan

Means and Methods

Material supplier – HCB (Augusta, Maine)

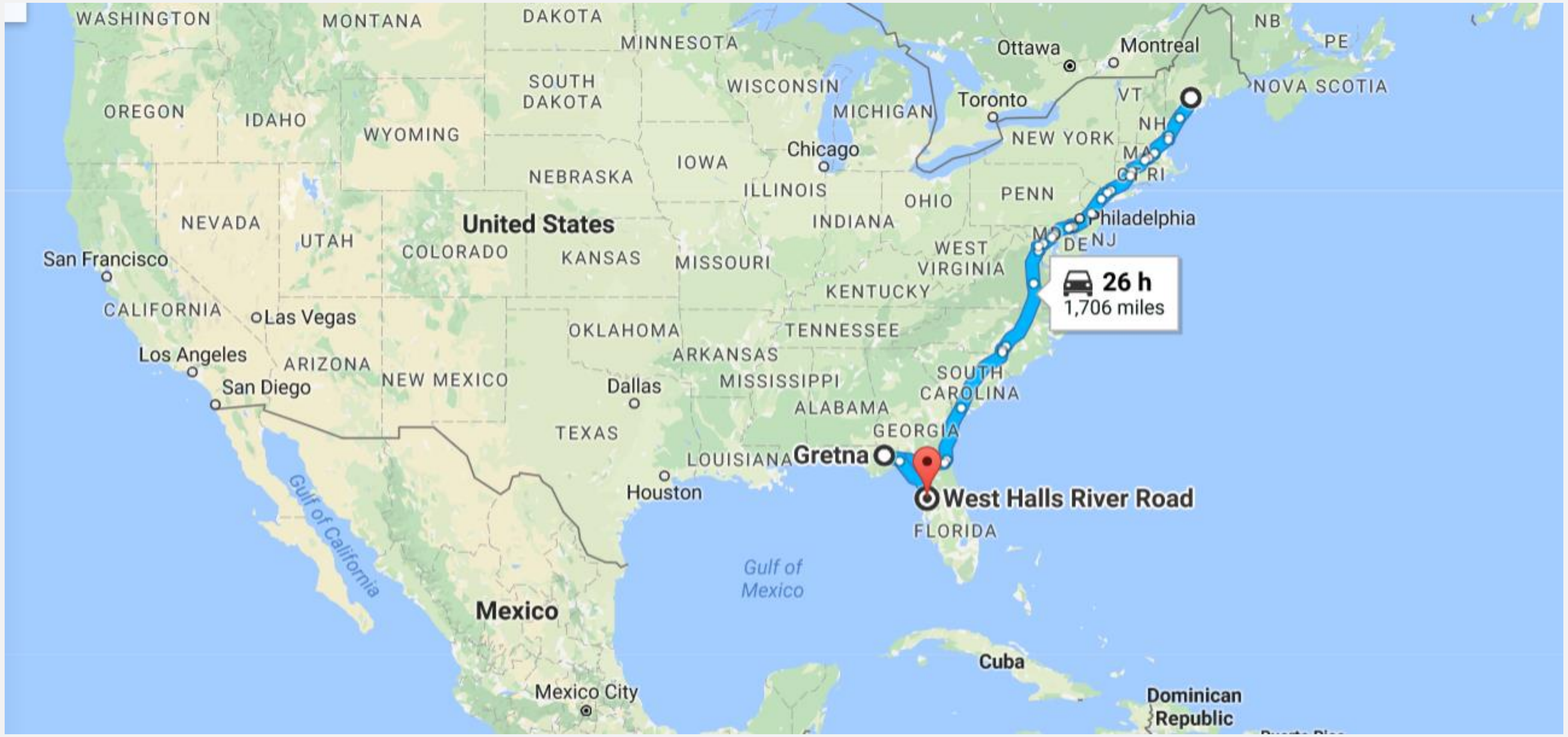
- Hybrid Composite Beams, 21” T Shape



Means and Methods

Material supplier – HCB (Augusta, Maine)

- HCB's Augusta, Maine via Gretna, FL



Gretna (FL) is where the precast/prestressed concrete plant is located and where Self-Consolidating Concrete (SCC) was placed in the core of the HCB beams

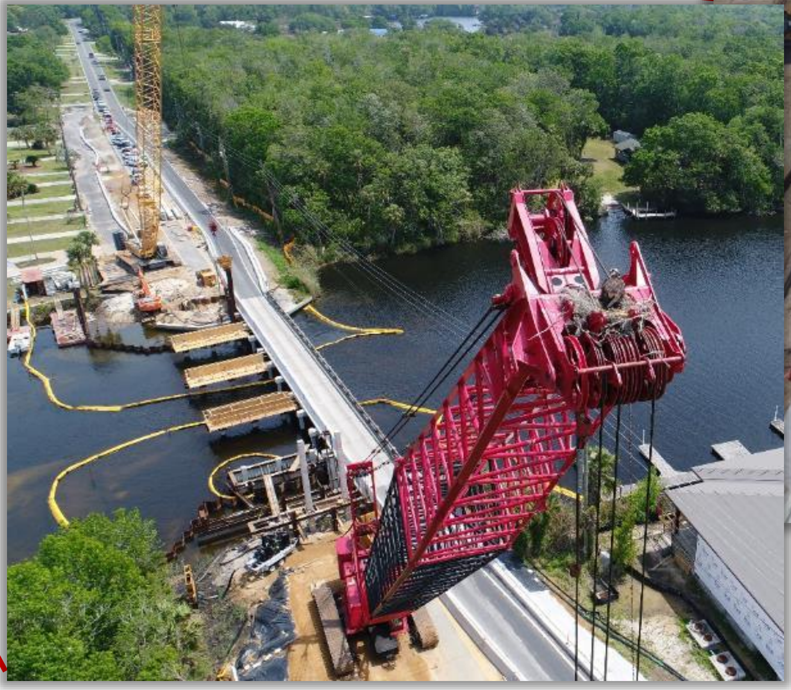
Means and Methods

Construction challenges correlated with Halls River Bridge Site

- Osprey nest on crane tip
- Intense wildlife activity (Manatees, Eastern Indigo Snakes, Dolphins, Ospreys)
- Soil conditions – few borings
- Pile splices in Phase 2
- Constricted site

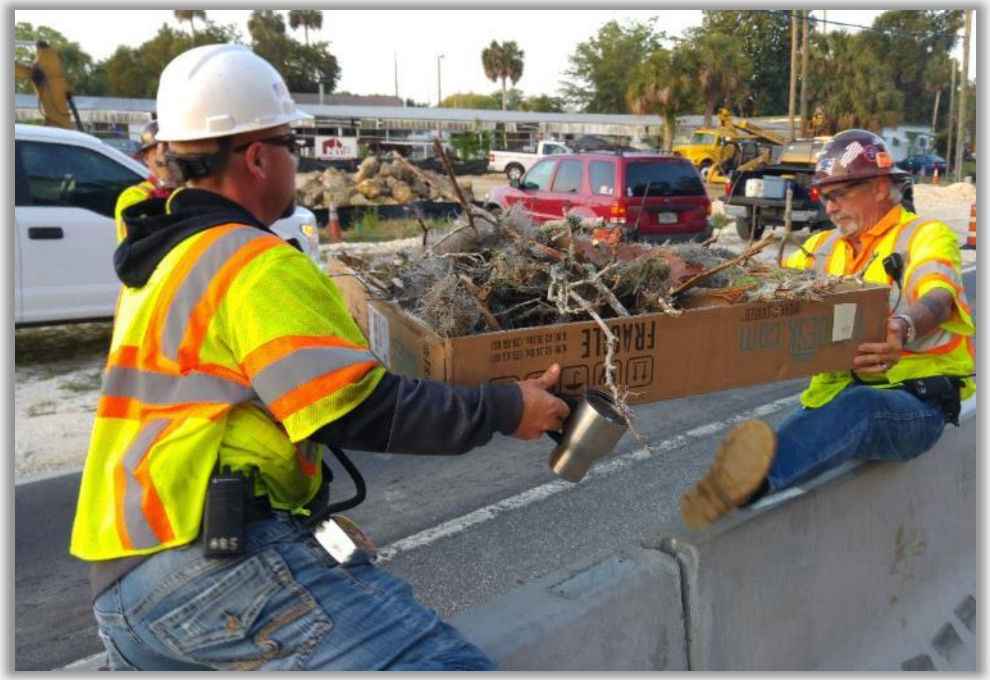
Means and Methods

Osprey Nest Relocation



Means and Methods

Osprey Nest Relocation



16 work days lost, costs of equipment/labors in stand-by

Means and Methods

Intense Wildlife activity

Means and Methods

Turbidity – Extra turbidity sheet piles

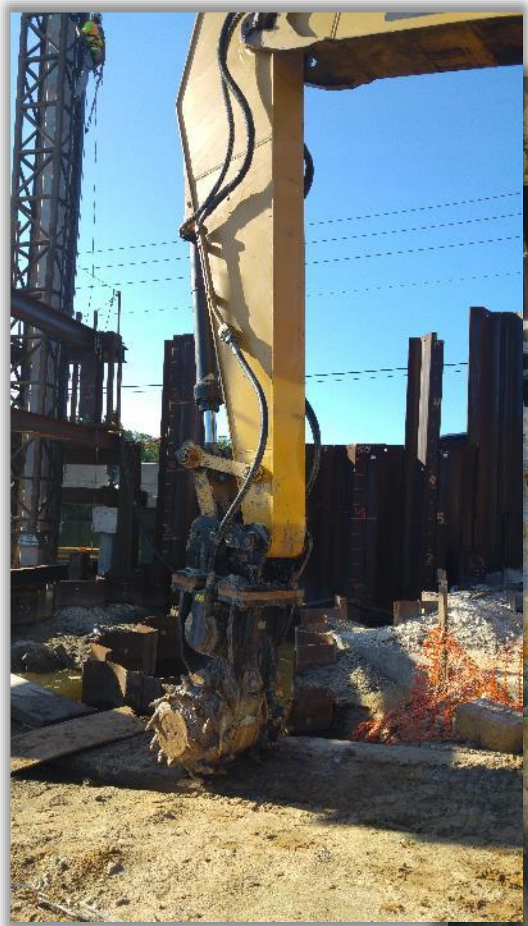
Means and Methods

Soil Conditions

Contractor attempted to install the concrete sheet piles utilizing different methods of installation including driving with hydraulic hammer, driving with jetting, driving with preformed hole (augering).

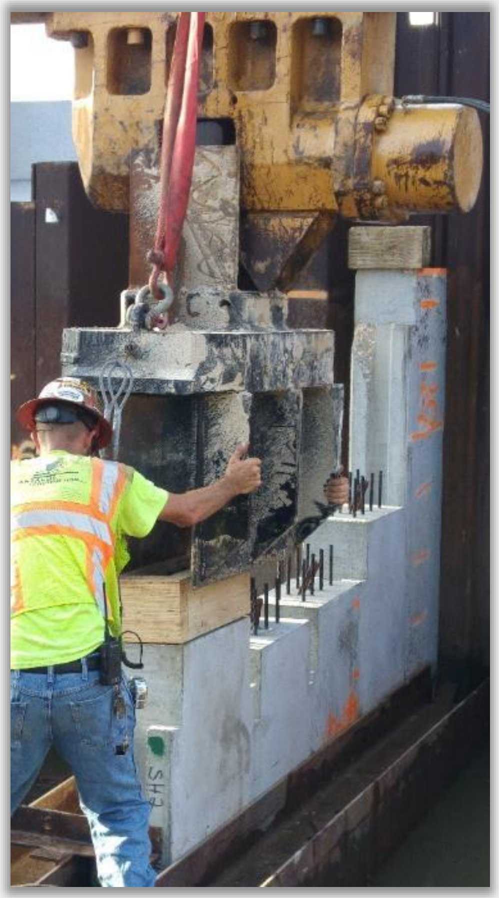
Contractor in a last stage proceeded with trenching with the help of a specialized excavator mounting hydraulic rock cutters

Means and Methods



Trenching to tip elevation could have affected the structural integrity of the existing bridge and consequently the safety of the travelling public. For this reason, Contractor installed Temporary Critical Sheet Piles.

Means and Methods



Setting to grade the CFRP sheet piles at elevation tip (-25 ft) with vibratory hammer

Means and Methods

Pile splicing

32 in. depth holes drilled on the existing CFRP piles in bent 2 for splicing. Temporary jig set-up

Means and Methods

Epoxy the pile splices male-female joint (SS dowels)

Means and Methods

Driving of the 42 foot pile splices

Explore possibility for using CFRP bars in splice, if manufacturer's step up for QC Plan approval

Part 4:

Topic #6 - Other Project Examples

Topic #7 – Outreach & Technology Transfer

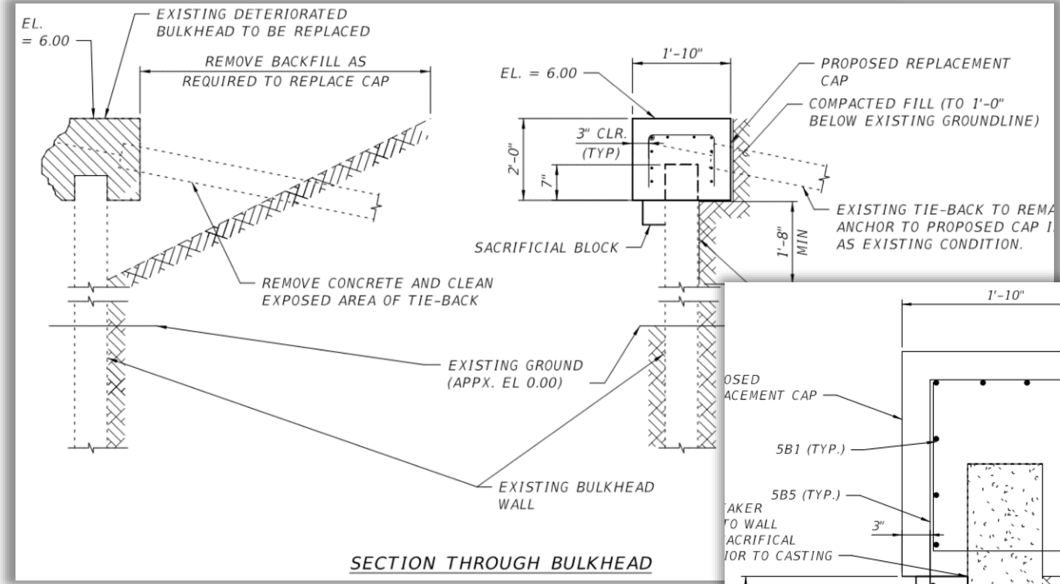
Other Project Examples (Topic #6)

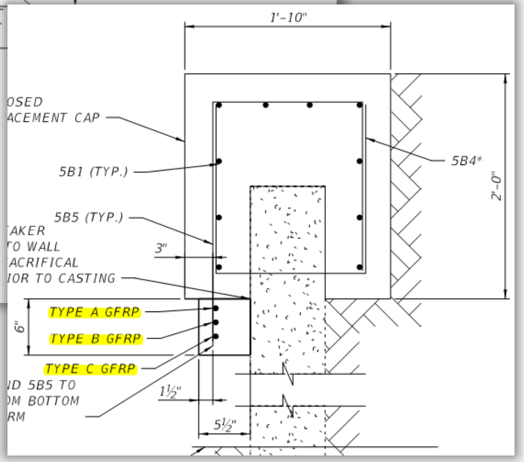
1. Cedar Key SR24 Bulkhead Rehabilitation:
   - Construction completed June 2016 *(FPID 432194-1-52-01)*
   - Construction Project Overview
2. Bakers Haulover Cut Bridge Bulkhead Rehabilitation:
   - Under Construction since 1/9/2017 *(FPID 433378-1-52-01)*
3. Skyway South Rest Area Seawall Rehabilitation:
   - Design-Build contract E1P44 *(FPID 438528-1-52-01)*
   - Under Design/Construction
4. Airport Road at Daughtry Bayou Bridge Replacement:
   - Under Construction since 7/1/2017 *(FPID 415252-1-52-01)*

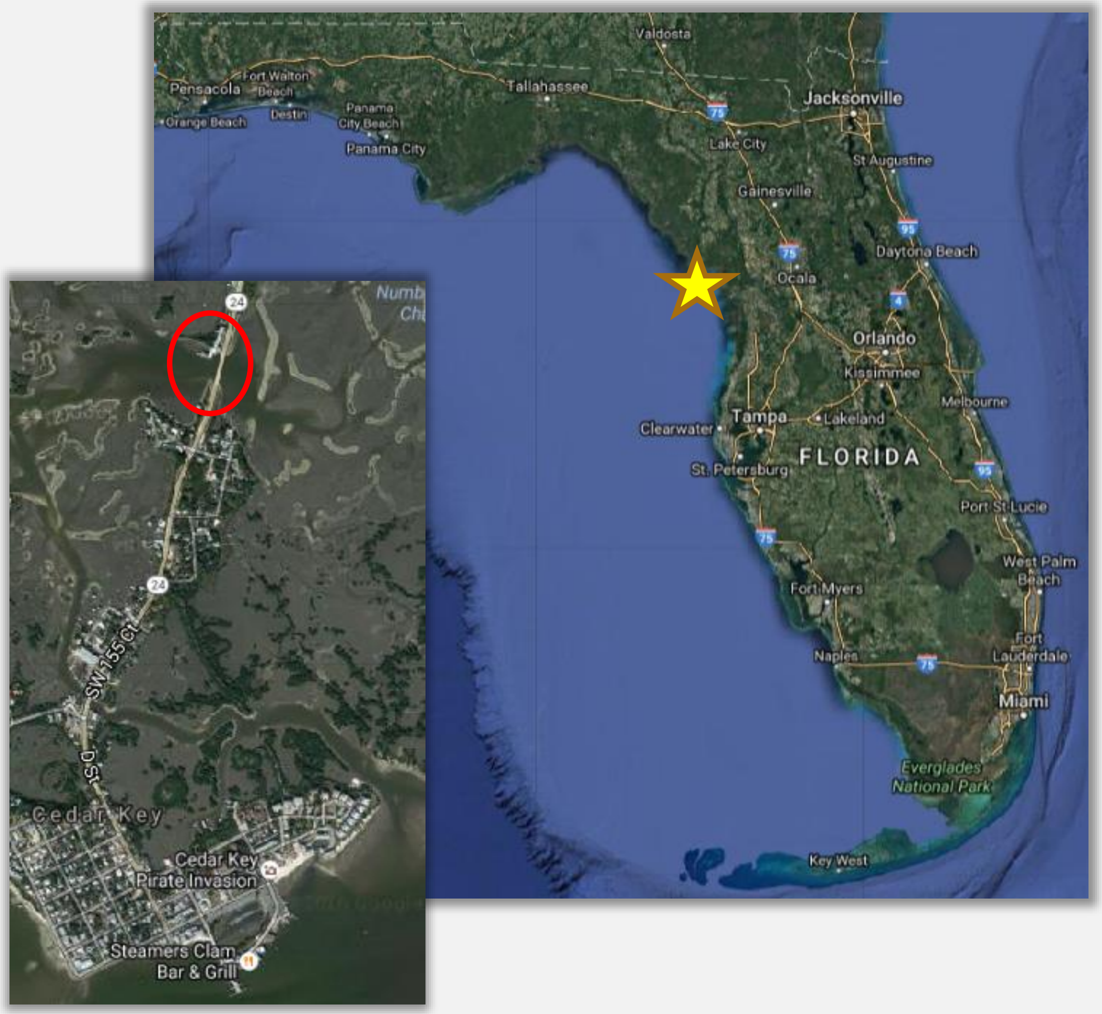
Project Example 1 – Cedar Key SR24 Bulkhead Rehabilitation

GFRP BAR TYPE CHART	
TYPE A	SIZE 5 GFRP BAR COATED WITH GRANULAR MATERIAL AND WITH SURFACE INDENTATIONS/DEFORMATIONS CREATED BY HELICAL WRAPPING.
TYPE B	SIZE 5 GFRP BAR COATED WITH GRANULAR MATERIAL AND WITHOUT SURFACE INDENTATIONS/DEFORMATIONS.
TYPE C	SIZE 5 GFRP BAR COATED WITH POLYMER (NO GRANULAR COATING) AND WITH SURFACE INDENTATIONS/DEFORMATIONS CREATED BY SHAPING THE POLYMER COATING (NO EXTERNAL WRAPPING).

TABLE APPLIES ONLY TO REBAR IN SACRIFICIAL BLOCK

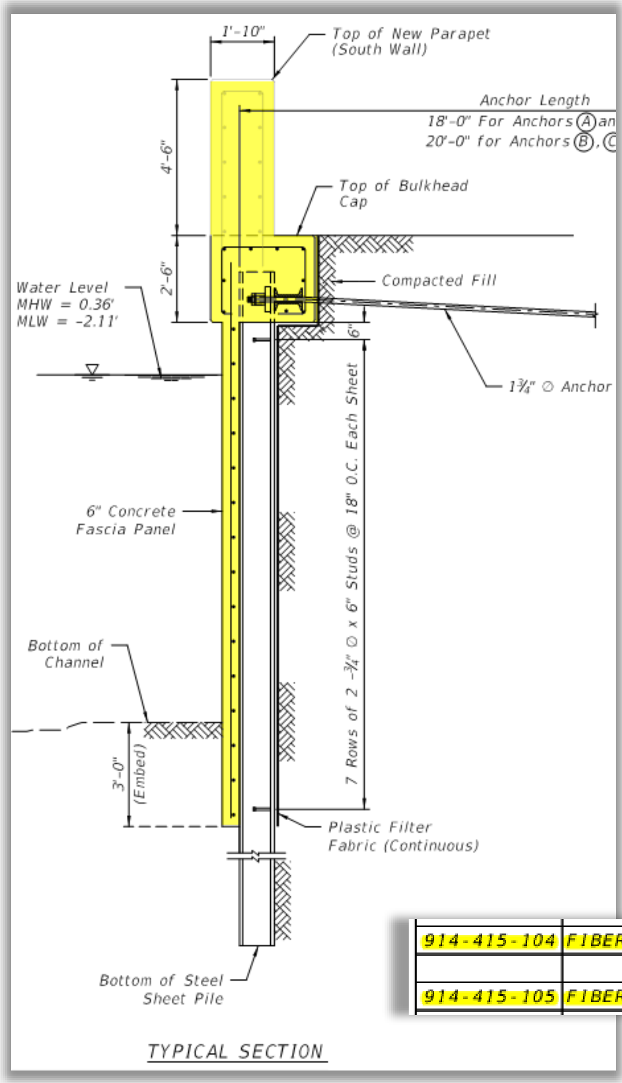






914-415-105	GLASS FIBER REINFORCING POLYMER BAR	BULKHEADS	LF	5088
		UNUSED	LF	131

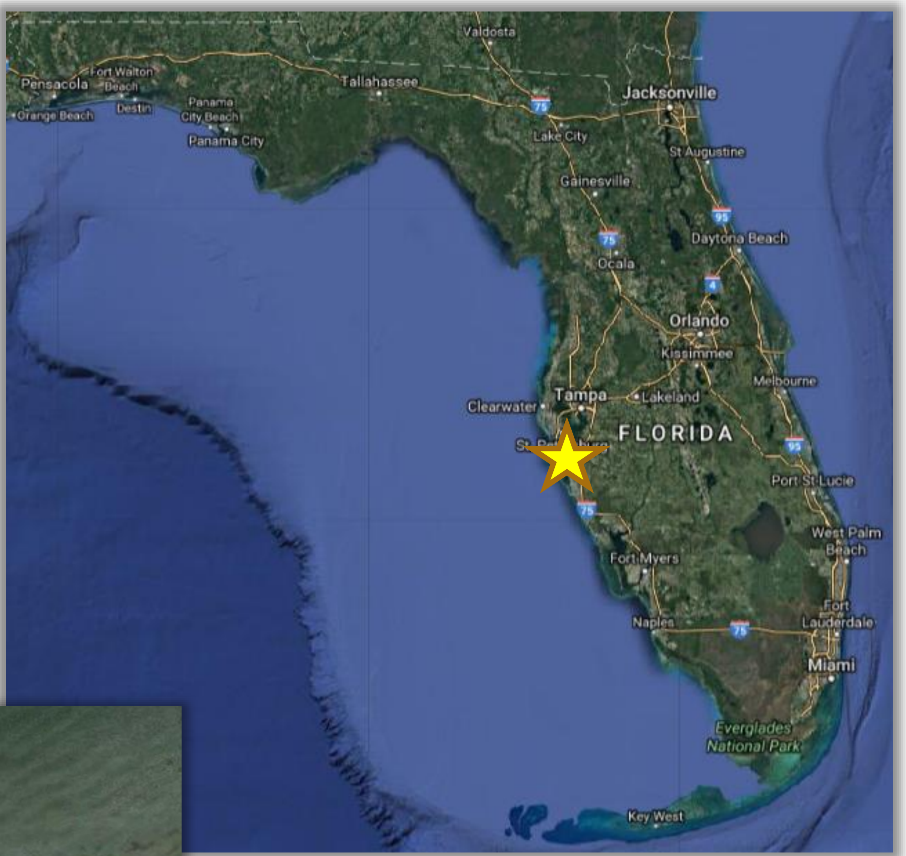
Project Example 2 – Bakers Haulover Cut Bridge Bulkhead Replacement



914-415-104	FIBER REINFORCED POLYMER BAR #4	BULKHEAD CAP, PARAPET & FASCIA PANEL	LF	12,199.32
914-415-105	FIBER REINFORCED POLYMER BAR #5	BULKHEAD CAP, PARAPET & FASCIA PANEL	LF	7,071.14

Project Example 3 – Skyway South Rest Area Seawall Rehabilitation

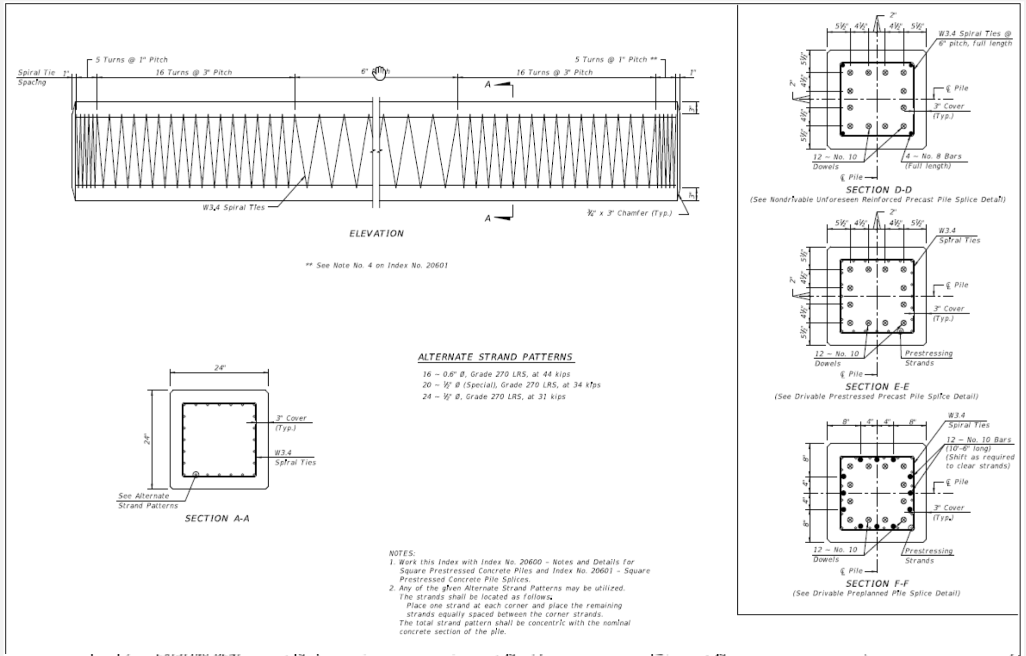
Cracking of existing seawall bulkhead cap

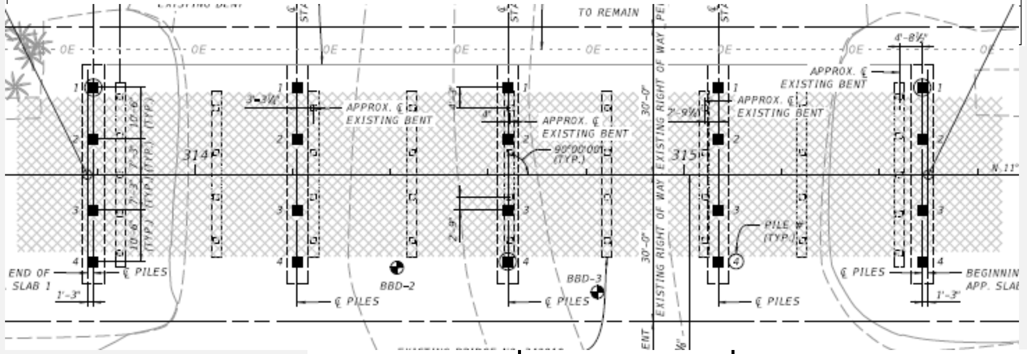


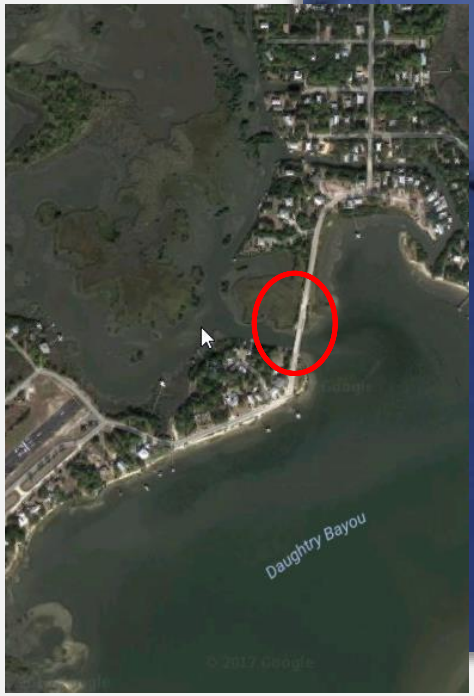
Limits of seawall bulkhead cap replacement

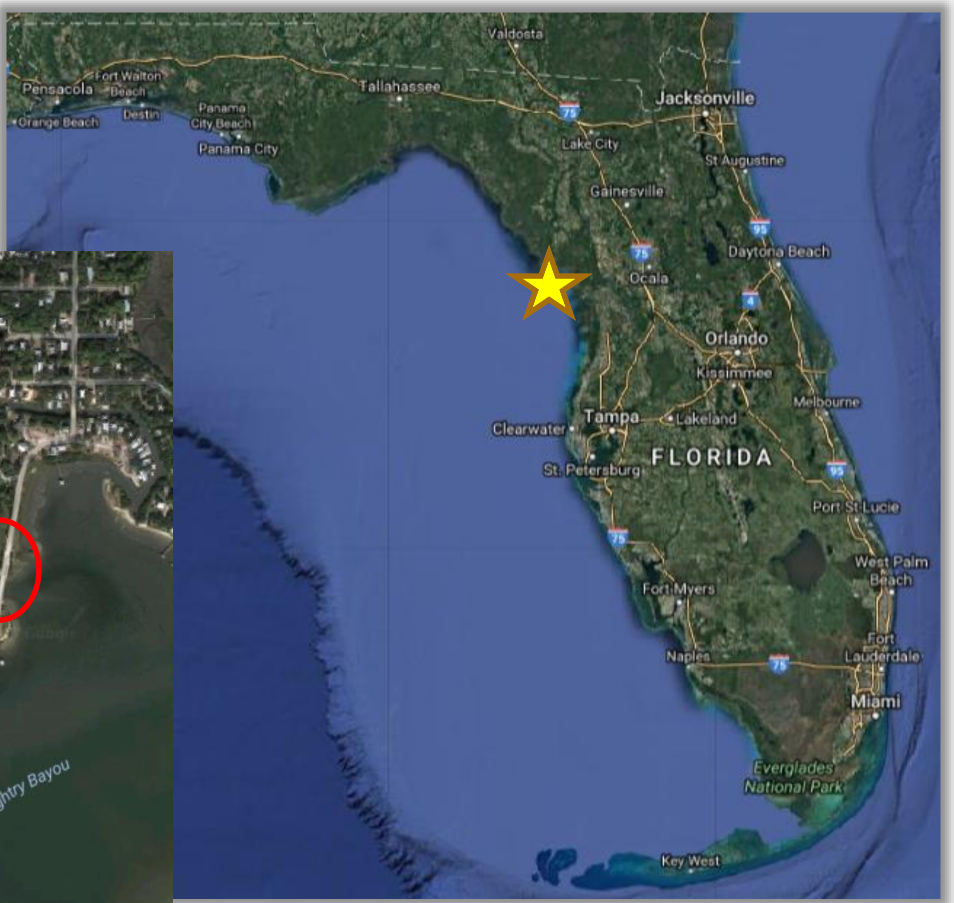
Limits of seawall bulkhead cap replacement near Rest Area

Project Example 4 – Airport Rd over Daughtry Bayou Bridge Replacement









FOUNDATION	0455- 34- 5	PRESTRESSED CONCRETE PILING, 24" SQ.		LF	575
	0455-143- 5	TEST PILES-PRESTRESSED CONCRETE, 24" SQ.		LF	145

Outreach & Technology Transfer (Topic #7)

1. FDOT's ***FRP-Reinforcing*** *Design Innovation initiative*:
   - http://www.fdot.gov/structures/innovation/FRP.shtm
2. Projects GIS-Mapping Tool:
   - Active and Completed FRP projects;
   - Includes FRP-Fender Systems, but not strengthening (20+ year history of wet-layup repairs)
3. Fast-Facts Sheets:
   - EOR's requested to complete for each new project
4. Face-to-Face:
   - FDOT conferences, workshops and coordination with ***AASHTO*** *Subcommittee on Bridges and Structures*: Task Group T-6 (FRP) & T-10 (Concrete)

Outreach & Technology Transfer

1. FDOT's ***FRP-Reinforcing** Design Innovation initiative*:
   - http://www.fdot.gov/structures/innovation/FRP.shtm

innovationrising
Transportation in the Sunshine State

FDOT Florida Department of TRANSPORTATION

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Structures Design

Structures Design / Design Innovation

Fiber Reinforced Polymer Reinforcing

Structures Design - Transportation Innovation

Fiber Reinforced Polymer (FRP) Reinforcing Bars and Strands

- Overview
- Usage Restrictions / Parameters
- Design Criteria
- Specifications
- Standards
- Producer Quality Control Program
- Technology Transfer (T^2)
- Contact

Overview

The deterioration of reinforcing and prestressing steel within concrete is one of the

Photo Slideshow

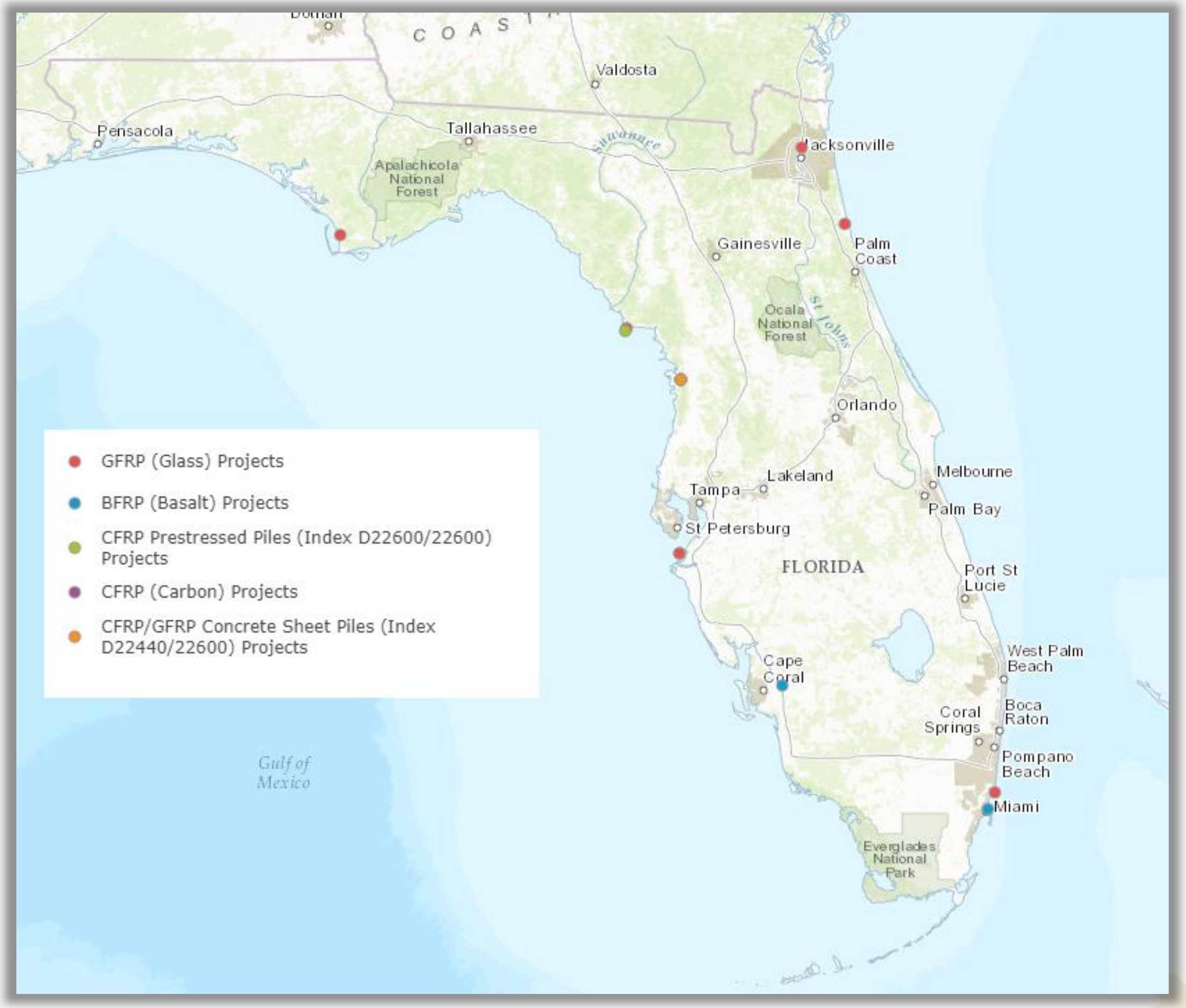
Technology Transfer (T^2)

The following links to FDOT meetings, seminars and workshops are provide as background information for potential users and industry partners:

- FHWA/NCHRP 20-68A U.S. Domestic Scan 13-03 meeting with FDOT (June 4-5, 2015)
- FDOT-FRP Rebar Industry Workshop (June 15, 2016)
- Composites-Halls River Bridge Promotional Video for CAMX 2016 (September 26-29, 2016)
- CAMX 2016: FDOT-FRP Deployment for Structural Applications (for new construction) (September 29, 2016)
- ACMA-Transportation Structures Council (TSC) Meeting - FDOT Presentation (September 29, 2016)
- FDOT-CO Winter FRP-RC Workshop & FDOT/FTBA Construction Conference (February 3, 2017)
- Halls River Bridge Replacement FRP Demonstration Project Workshop (May 2-3, 2017)
- FDOT 2017 Design Training Expo - FRP Reinforced Concrete Design (June 6, 2017)
- International Workshop on GFRP Bars: FDOT GFRP Implementation - Current Status, Projects, and Challenges (July 18, 2017)
- FES/FICE 2017: The Halls River Bridge - Perspective of Owner/Designer, Contractor and Researcher (August 4, 2017)

Outreach & Technology Transfer

2. Projects GIS-Mapping Tool:
    - Active and Completed FRP-RC projects;
    - Includes FRP-Fender Systems,
    - Hope to add bridge beam repair/strengthening projects in future (20+ year history of wet-layup repairs)



Outreach & Technology Transfer

3. Fast-Facts Sheets:
    - EOR's requested to complete for each new project


FDOT Transportation Innovation Initiative:

FRP – Design Innovation

Fast Facts: Glass Fiber Reinforced Polymer

Project Location: FDOT District Two, Levy County, Cedar Key, Florida

Agency: Florida Department of Transportation

URL: http://www.fdot.gov/structures/innovation/FRP.shtm

Project Name: SR 24 over Number Three Channel, Bridge No. 340003, FPID: 426169-1

Project Description: Rehabilitation of three bridges in Cedar Key

Project Purpose & Need: Bridge Inspection Reports identified deterioration, including evidence of corroded steel reinforcement in the bulkhead cap on bridge 340003. Work activities included removal of the existing bulkhead cap and installation of a new bulkhead cap with GFRP reinforcement.

…et/Cost Estimate: $741,630.00 (Construction Contract)

…que about this project? GFRP reinforcement is used in the bulkhead cap, which is within the splash zone, to reduce future maintenance requirements. Removable blocks, reinforced with varying types of FRP, were cast with the bulkhead cap for monitoring long-term durability.

Describe Traditional Approach: Traditional approach includes installation of grade 60 steel rebar in a cast-in-place bulkhead cap.

Describe New Approach: Utilization of GFRP bars in lieu of traditional grade 60 steel rebar in the bulkhead cap, located in the splash zone.

Top Innovations Employed: Utilization of GFRP bars within the splash zone/marine environment.

Primary Benefits Realized/Expected: Longer service life of the bulkhead cap.

Project Start Date/Substantial Completion Date: 11/30/2015 – 8/3/2016

PE Consultant: Kisinger Campo & Associates Corp.

Construction Contractor: Pneumatic Concrete Co, Inc.

Construction Engineering Inspection: JEA Construction Engineering Services

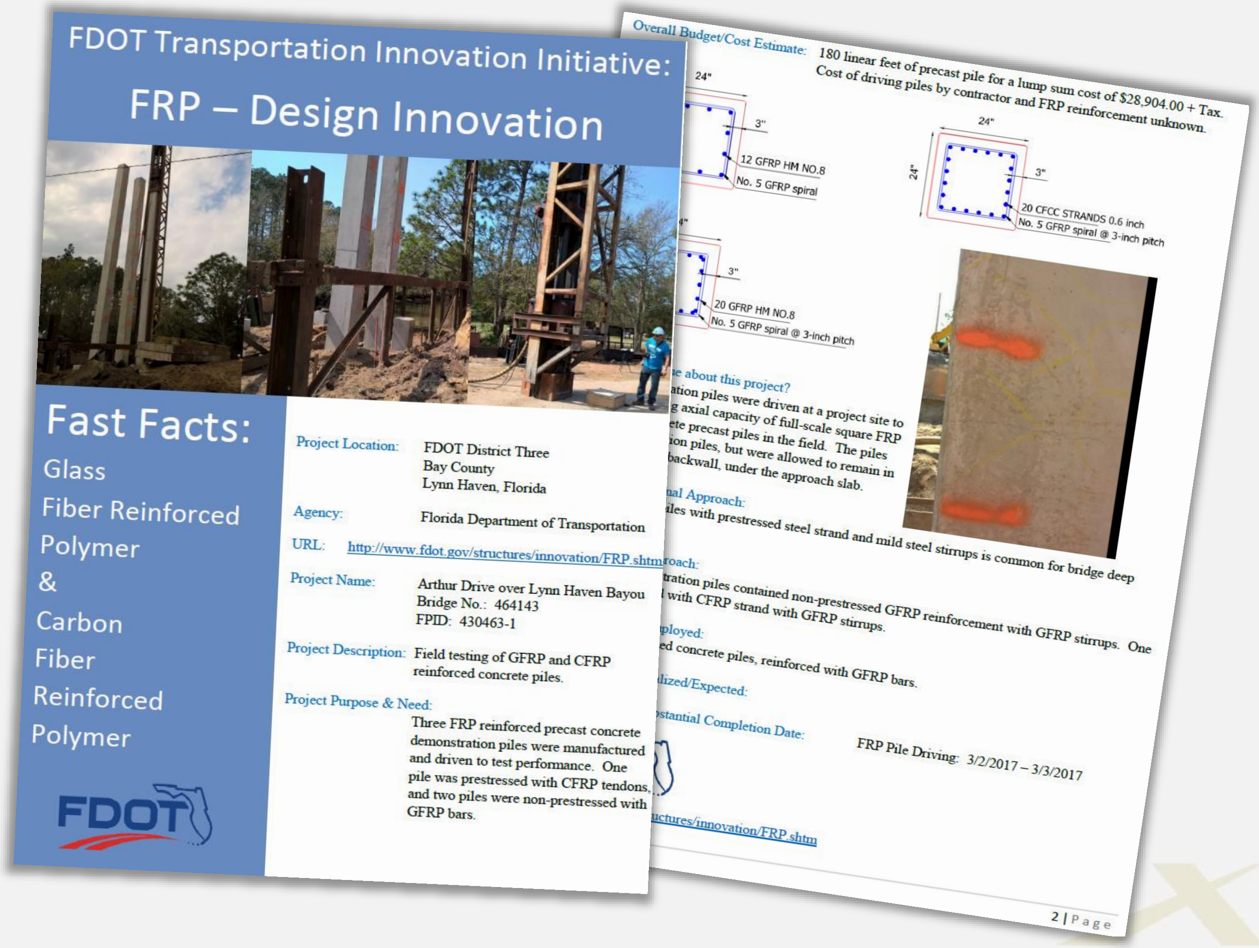
Engineer of Record: Patrick Mulhearn, P.E., Kisinger Campo & Associates Corp.

FDOT Project Manager: Jeff Bailey, FDOT District Two, Jeff.Bailey@dot.state.fl.us

FDOT State Materials Office: Chase C. Knight, Ph.D., FDOT Composite Materials Specialist, Chase.Knight@dot.state.fl.us

…structures/innovation/FRP.shtm

2 | Page


FDOT Transportation Innovation Initiative:

FRP – Design Innovation

Fast Facts: Glass Fiber Reinforced Polymer & Carbon Fiber Reinforced Polymer

Project Location: FDOT District Three, Bay County, Lynn Haven, Florida

Agency: Florida Department of Transportation

URL: http://www.fdot.gov/structures/innovation/FRP.shtm

Project Name: Arthur Drive over Lynn Haven Bayou, Bridge No.: 464143, FPID: 430463-1

Project Description: Field testing of GFRP and CFRP reinforced concrete piles.

Project Purpose & Need: Three FRP reinforced precast concrete demonstration piles were manufactured and driven to test performance. One pile was prestressed with CFRP tendons, and two piles were non-prestressed with GFRP bars.

Overall Budget/Cost Estimate: 180 linear feet of precast pile for a lump sum cost of $28,904.00 + Tax. Cost of driving piles by contractor and FRP reinforcement unknown.

…e about this project? …ation piles were driven at a project site to …g axial capacity of full-scale square FRP …ete precast piles in the field. The piles …ion piles, but were allowed to remain in …backwall, under the approach slab.

…nal Approach: …iles with prestressed steel strand and mild steel stirrups is common for bridge deep …

…roach: …tration piles contained non-prestressed GFRP reinforcement with GFRP stirrups. One … with CFRP strand with GFRP stirrups.

…ployed: …ed concrete piles, reinforced with GFRP bars.

…lized/Expected:

…stantial Completion Date: FRP Pile Driving: 3/2/2017 – 3/3/2017

…uctures/innovation/FRP.shtm

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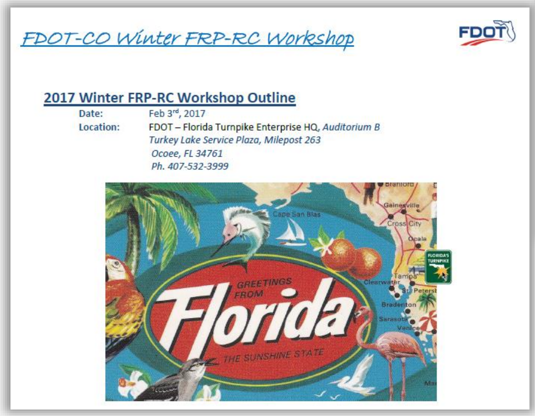
Outreach & Technology Transfer

4. Face-to-Face:

   - FDOT Conferences, Workshops and coordination with ***AASHTO*** *Subcommittee on Bridges and Structures*: Task Group T-6 (FRP) & T-10 (Concrete)



FDOT-CO Winter FRP-RC Workshop

2017 Winter FRP-RC Workshop Outline

Date: Feb 3rd, 2017

Location: FDOT – Florida Turnpike Enterprise HQ, *Auditorium B*, *Turkey Lake Service Plaza, Milepost 263*, *Ocoee, FL 34761*, *Ph. 407-532-3999*

FDOT – Halls River Bridge FRP Workshop Outline

Date: May 3rd - 4th 2017

Location: FDOT - District 7 HQ, *Auditorium*, *11201 North Malcom McKinley Drive*, *Tampa, Florida 33612*

13-03 — Leading Practices in Use of Fiber Reinforced Polymer (FRP) Composites in Transportation Infrastructure

Fiber reinforced polymer (FRP) composite materials have been researched and demonstrated in structural applications for more than 25 years. Among transportation agencies, FRP materials have been used for bridge decks, beams, piling, buried structures, concrete reinforcing, and post-tensioning, as well as for repair and strengthening of existing structures. However, FRP has been used little as a primary structural material.

It is reported that other industries and agencies—notably the U.S. Navy—are studying and using FRP more extensively. The purpose of this scan is to inform the transportation industry on successful applications of FRP within DOTs as well as techniques that may be appropriate/adaptable for DOT use.

2017 FTBA Construction Conference – FRP Structures Session Outline

Date: Feb 2-3, 2017

Location: Hyatt Regency Orlando, 9801 International Drive, Orlando, FL 32819, Telephone: (407) 284-1234

View the Tentative Schedule

Register Now

PRELIMINARY OUTLINE

Thursday (2/2/2017)

S1: FDOT FRP Deployment for New Construction – Steve Nolan (1:30-1:50pm)

S2: Halls River Bridge Replacement - Example FRP Project Application - Mamun Siddiqui, Cristina Suarez (2:00-2:20pm)

S3: FRP Constructability Issues and Contractor's Perspective – Antonio Nanni (University of Miami) & Astaldi (Contractor – Sergio Notarianni, Pietro Banov) (2:30-2:50pm)

Questions

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(850) 410-6125
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University of Miami, College of Engineering
Thomas Cadenazzi, MS
Halls River Road Bridge Field Office
5311 S Suncoast Blvd, Homosassa, FL 34446
(954) 908-0585 or (786) 223-5645
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State Materials Office:
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Design 7 Structures Office / EOR:
Mamun Siddiqui, P.E. (Designer)
(813) 975-6093
Mamunur.Siddiqui@dot.state.fl.us

What is next ???
Composite Bridge Girders
GFRP Reinforcing Bars
CFRP Prestressed Piles
Navigation Fender Systems
External FRP Laminate Repairs

FDOT's Fiber-Reinforced Polymer Deployment Train