Halls River Bridge:  
Corrosion-Free Design with FRP Composites

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FDOT State Structures Design Office

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Graduate Student  
FAMU-FSU College of Engineering

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Graduate Student,  
University of Miami, College of Engineering
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

Lu the hippo, honorary citizen of Florida since 1991.

Wild Manatees reside in the park year round.
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
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: \( E_f = 6,500 \text{ ksi} \) << Steel \( (E_s = 29,000 \text{ ksi}) \)
   b. Resistance factors:
      » Flexure and Tension: \( \phi_f = 0.55 \) to \( 0.65 \) << Steel \( (\phi_f = 0.90) \)
      » Shear and Torsion: \( \phi_v = 0.75 \) = 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

AASHTO LRFD Bridge Design Guide Specifications for FRP Reinforced Concrete Bridge Decks and Traffic Railings

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

Reported by ACI Committee 440

ACI 440.1R-15

TECHNICAL SPECIAL PROVISION
FOR

SECTION T150 - 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 63G 11-23.004 F.A.C. Printed copies of this document are not considered signed and sealed and the signature must be verified on an electronic copy.

Professional Engineer: Munnanu Rashid Siddiqui, P.E.
Date: March 3, 2014
Firm License No.: 7694
Firm Name: FDOT
Firm Address: 11281 N McKinley Dr.
City: Tampa, State: FL, Zip code: 33612
Certificate of Authorization: N.A.
Pages: 1-15
References, Codes and Specifications

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 12
665 South Street
Tallahassee, Florida 32399-0400

For Construction and Maintenance Operations
at the State Highway System:
Toll No. 625-010-063
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)

<table>
<thead>
<tr>
<th>SIZE</th>
<th>LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1'-10&quot;</td>
</tr>
<tr>
<td>5</td>
<td>1'-10&quot;</td>
</tr>
<tr>
<td>6</td>
<td>2'-3&quot;</td>
</tr>
<tr>
<td>8</td>
<td>2'-6&quot;</td>
</tr>
</tbody>
</table>
Part 2:

Topic #3 - Construction Oversight Perspective/CEI

Topic #4 - Researcher Perspective

Michelle Gartman – FAMU-FSU, College of Engineering
Construction Oversight Perspective (Topic #3)

a) Corrosion-free transportation infrastructure:
   • less concern during construction for protection from chloride contamination
b) Longer Service Life:
c) Simple and Scalable Implementation:
   • minimal learning curve for oversight of “Means and Method”
   • use similar material verification processes
Researcher Perspective (Topic #4)

a) Corrosion-free transportation infrastructure:
   • research on this is very mature
<table>
<thead>
<tr>
<th>Completion Date</th>
<th>Title</th>
<th>Researcher</th>
<th>Institution</th>
<th>Research No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/31/2018</td>
<td>Performance Evaluation of GFRP Reinforcing Bars Embedded in Concrete Under Aggressive Environments</td>
<td>R. Kampmann</td>
<td>FSU</td>
<td>BDV30 977-18</td>
</tr>
<tr>
<td>3/31/2018</td>
<td>Degradation Mechanisms and Service Life Estimation of FRP Concrete Reinforcements</td>
<td>A. El Safty</td>
<td>UNF</td>
<td>BDV34 977-05</td>
</tr>
</tbody>
</table>

**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)*

**SQUARE AND ROUND CONCRETE PILES (Corrosion Resistant):**

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>22600</td>
<td>Notes and Details For Square CFRP &amp; SS Prestressed Concrete Piles</td>
</tr>
<tr>
<td>22601</td>
<td>Square CFRP &amp; SS Prestressed Concrete Pile Splices</td>
</tr>
<tr>
<td>22612</td>
<td>12” Square CFRP &amp; SS Prestressed Concrete Pile</td>
</tr>
<tr>
<td>22614</td>
<td>Errata 14” Square CFRP &amp; SS Prestressed Concrete Pile</td>
</tr>
<tr>
<td>22618</td>
<td>Errata 18” Square CFRP &amp; SS Prestressed Concrete Pile</td>
</tr>
<tr>
<td>22624</td>
<td>24” Square CFRP &amp; SS Prestressed Concrete Pile</td>
</tr>
<tr>
<td>22630</td>
<td>Errata 30” Square CFRP &amp; SS Prestressed Concrete Pile</td>
</tr>
</tbody>
</table>

**WALL SYSTEMS (Corrosion Resistant):**

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>22440</td>
<td>Precast Concrete CFRP/GFRP &amp; HSSS/GFRP Sheet Pile Wall</td>
</tr>
</tbody>
</table>
b) Longer Service Life:
   • needs further refinement and supporting studies
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

<table>
<thead>
<tr>
<th>GFRP BARS</th>
<th>STRENGTH (SERIVCE LIMIT STATE - ksi)</th>
<th>STEEL – GRADE 60 ALLOWABLE TENSILE STRENGTH (ksi)</th>
<th>K = (GFRP)/(STEEL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#4 (0.5 in)</td>
<td>20 ksi</td>
<td>#4 (0.5 in) 20 ksi</td>
<td>1</td>
</tr>
<tr>
<td>#5 (0.625 in)</td>
<td>19.6 ksi</td>
<td>#5 (0.625 in) 20 ksi</td>
<td>0.98</td>
</tr>
<tr>
<td>#6 (0.750 in)</td>
<td>20.4 ksi</td>
<td>#6 (0.750 in) 20 ksi</td>
<td>1.02</td>
</tr>
<tr>
<td>#8 (1 in)</td>
<td>17.2 ksi</td>
<td>#8 (1 in) 20 ksi</td>
<td>0.86</td>
</tr>
</tbody>
</table>

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): $f_{fat} = 24 - 20 \cdot \left(\frac{f_{min}}{f_y}\right)$, 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

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

(*) 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.

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

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

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

Construction challenges correlated in general with GFRPs

Procurement & Lead Time

- 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

FROM NAPLES (ITALY) TO PORT EVERGLADES TO HOMOSASSA

1 Month shipping time
# Means and Methods

**Material supplier - ATP**

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

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

**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>
<thead>
<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>
</thead>
<tbody>
<tr>
<td>Degree of cure</td>
<td>ASTM E2160</td>
<td>≥ 95% of total polymerization enthalpy</td>
<td>5</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Fiber content</td>
<td>ASTM D2584 or ASTM D3171</td>
<td>Weight fraction ≥ 70%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture absorption</td>
<td>ASTM D570</td>
<td>≤ 0.25% in 24 hours at 122°F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured Cross Sectional Area</td>
<td>ASTM D7205</td>
<td>95% to 110% of nominal area (Table 1-1)</td>
<td>5</td>
<td>7</td>
<td>30 + 40 times the nominal diameter</td>
</tr>
<tr>
<td>Ultimate Tensile Load</td>
<td></td>
<td>≥ nominal ultimate load (Table 1-1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile Modulus of Elasticity</td>
<td></td>
<td>≥ 18,000 ksi</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</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
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

Turbidity
Means and Methods

Turbidity – Extra turbidity sheet piles
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
Project Example 2 – Bakers Haulover Cut Bridge Bulkhead Replacement

Bridge No. 870071

North Wall

South Wall

Baker’s Haulover Inlet

914-415-104 FIBER-REINFORCED POLYMER BAR #4

914-415-105 FIBER-REINFORCED POLYMER BAR #5

TYPICAL SECTION

BULKHEAD CAP, PARAPET & FASCIA PANEL

FL
12-199-32

FL
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
Outreach & Technology Transfer (Topic #7)

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

Technology Transfer (T³)

The following links to FDOT meetings, seminars and workshops are provided 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 8, 2017)
- International Workshop on GFRP Bars: FDOT GFRP Implementation - Current Status, Projects, and Challenges (July 18, 2017)
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
4. Face-to-Face:

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