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

24% Other Repairs

76% Corrosion Repair

$2.4M per Project

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

- **Materials**
  - 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

*FRP for New Construction*
Project Overview - Background Info

- Owner
- Maintaining Agency

- Bi-Annual Inspection
- Design and Build Proposed Bridge
Project Overview – Project Location

Begin Project

End Project

BRIDGE LOCATION

FRP for New Construction
Project Overview – Existing Bridge

EXISTING SECTION THRU BRIDGE DECK
Project Overview – Existing and Proposed Bridge

Vertical Curve Data

Traffic Data

Current Year Estimate 2018 ADT = 4000
Opening Year Estimate 2035 ADT = 4900
Design Year Estimation 2050 ADT = 4900

K = 2.5%  D = 34.69%  T = 2.00% (24 Hour)
Design Hour T = 1.0%
Design Speed = 45 MPH
Furrow Speed = 45 MPH

30'-0" Approach Slab 1

30'-0" Approach Slab 2

Elevation View

Bridge No. 024054

Existing Bridge No. 024003

Bridge No. 024054

FRP for New Construction
Project Overview – Proposed Bridge
FRP Materials

Completed Structure

- GFRP
- HCB
- CFCC

FRP for New Construction
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

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

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

FLORIDA DEPARTMENT OF TRANSPORTATION

FIBER REINFORCED POLYMER GUIDELINES (FRPG)

FDOT STRUCTURES MANUAL
VOLUME 4
JANUARY 2016

FLORIDA DEPARTMENT OF TRANSPORTATION

Fiber Reinforced Polymer Composites

Specifications and Estimates/Specifications/
Materials Manual Section 12.1, Volume II

FIBER REINFORCED POLYMER COMPOSITES
Section 12.1, Volume II

FRP for New Construction
Design References

FRP for New Construction
Design References

Hybrid Composite Beam (HCB) – Manuals and References

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

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: Manmurt Rashid Siddiqui, P.E.
Date: March 5, 2016
Fla. License No.: 70994
Firm Name: FDOT
Firm Address: 11201 N McKinley Dr.
City: Tampa, State: FL, Zip code: 33612
Certificate of Authorization: N/A.
Pages: 1-13

FRP for New Construction
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
Fiber Reinforced Polymer (FRP) Reinforcing Materials

**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)

FRP for New Construction
Construction

PHASE II - STAGE 2
(Intermediate Bent Shown, End Bent Similar)

PHASE III - STAGE 1

FRP for New Construction
Construction

COMPLETED BRIDGE SECTION

FRP for New Construction
Construction

Hybrid Composite Beam – Fabrication

HYBRID COMPOSITE BEAMS

STANDARD CONCRETE BEAMS
Hybrid Composite Beam – *Handling and Storage*

**HYBRID COMPOSITE BEAMS**

**STANDARD CONCRETE BEAMS**
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)
Hybrid Composite Beam – *Installation*

HYBRID COMPOSITE BEAMS

PRESTRESSED SLAB BEAMS
Construction

Construction Photos

FRP for New Construction
FRP Rebar

FRP Bars are vulnerable to surface damage

<table>
<thead>
<tr>
<th>Checklist: Handling and Storage of FRP Rebars</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️ Store bars in a clean environment</td>
</tr>
<tr>
<td>Protect bars against:</td>
</tr>
<tr>
<td>✔️ - UV radiation</td>
</tr>
<tr>
<td>✔️ - High temperature</td>
</tr>
<tr>
<td>✔️ - Damaging chemicals</td>
</tr>
<tr>
<td>✔️ Lift bundles of bars with care</td>
</tr>
<tr>
<td>✔️ Do not shear bars when cutting</td>
</tr>
</tbody>
</table>

**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
Test Blocks

Materials

- CFRP
- GFRP
- Basalt
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