Halls River Bridge
- Composites Replace Steel Reinforcement

Steven Nolan, P.E.
FDOT State Structures Design Office

Antonio Nanni, P.E., PhD
University of Miami, College of Engineering
Outline:

- Halls River Bridge Replacement Project Overview
  1. SEACON Concrete Types
  2. Gravity Wall
  3. Cantilever Sheet Pile Walls (Bulkhead/Seawall)
  4. Bridge Substructure (Bent Cap & Bearing Piles)
  5. Hybrid Composite Beams
  6. GFRP-RC Decks, Diaphragms and Approach Slabs
  7. Traffic Railings
- Beyond Halls River Bridge
- Technology Transfer ($T^2$)

“Some contributions to the project were made possible with the financial support received from the Infravation Program under Grant Agreement No. 31109806.005-SEACON. The opinions in this presentation are those of the authors and not necessarily those of the sponsors or collaborators.”
Typical Bridge Components with potential use of FRP-RC/PC
Project Overview – Halls River Bridge Replacement

Designer: FDOT District 7 Structures Design Office

Bridge EOR: Mamunur Siddiqui, P.E.

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

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

Owner & Maintaining Agency

Design & Bi-Annual Inspection

Funding & Oversight

Collaboration Research

Research Testing and Monitoring
Project Overview –
Halls River Bridge Replacement

Existing (blue) and Proposed Layout
**Project Overview** –
Halls River Bridge Replacement

Existing (blue) and Proposed Bulkhead (Red) Layout
HRB Project Demonstrator – SEACON Concrete Types

A. Concrete Types (FDOT Class):
   i. Recycled Concrete Aggregate (RCA – Class NS)
   ii. Recycled Asphalt Pavement (RAP – Class NS)
   iii. “Green” (Class IV)
   iv. White Cement (Class II)
   v. Slag Cement-60/40 (Class II)

B. Component Use of SEACON concretes:
   i. Gravity Walls
   ii. Bulkhead/Seawall Cap
   iii. Test Blocks

C. Design Criteria – see SEACON-WP1 & 2 for more details;

D. FDOT Concrete Material Specifications affected
   i. 347 (Non-Structural Class) - RAP & RCA
   ii. 346 (Structural Class); Modified Special Provision
HRB Project Demonstrator – Retaining Walls (with GFRP & RAP or RCA)

A. Components
   i. RAP concrete
   ii. RCA concrete

B. Structural System
   i. **Index D6011c** – Gravity Wall
   ii. GFRP temperature and shrinkage reinforcing design

C. Other example retaining wall projects
   i. Maui C-I-P seawall with GFRP rebar (2012)
   iii. Pearl Harbor Dry Dock Rehab (2001)
HRB Project Demonstrator – Retaining Walls (with GFRP & RAP or RCA)

FDOT Index D6011c (project version):

**Plan of Test Blocks**

**Typical Section**

**Keyway & Wall Joint Detail (Top View)**

**Project Notes:**
1. Class NS concrete mix contain between 1, and between 10% and 20% content of 2. Cast twenty-four (24) test blocks of 3. Test Blocks shall be in accordance with the test in accordance with the test... 4. Cost of test blocks to be included in the cost of the Gravity Wall... 5. Corrosion Resistant Gravity Wall Notes:
   1. C-I-P Gravity Wall... 2. Oct. 31, 2016... 3. No... 4. RCA and RAP... 5. Compression... 6. RCA, or...
HRB Project Demonstrator – Cantilever Concrete Sheet Pile Walls (with CFRP/GFRP)

A. Components
   i. CFRP/GFRP Prestressed Concrete Sheet Piles (FDOT Index D22440)
   ii. GFRP-RC Bulkhead Cap (Structures Manual-Vol.4...)

B. Structural Systems
   i. Cantilevered
   ii. Anchored/Tied-Back Wall (Not use on HRB)

C. Other FDOT projects
   i. Cedar Key SR 24 over Channel 5 bulkhead cap rehab.
   ii. Bakers Haulover Cut bulkhead cap & wall fascia
   iii. Sunshine Skyway South Rest Area seawall rehab.

D. Design Criteria - ACI 440.1R & 440.4R

E. Material Specifications - Dev932 & Dev933
HRB/SR24 Project – Cantilever Concrete Sheet Pile Walls (with CFRP/GFRP)

Example from SR24/Cedar Key Project:

- Installing 2-piece stirrup bars in bulkhead cap
- Curing concrete bulkhead cap prior to form removal
- Plastic zip ties for securing GFRP rebar
- Forming bulkhead cap
HRB Project – Concrete Sheet Pile Walls (with CFRP/GFRP)

Plan Sheet Summary: Total wall cap length: 575 LF

Wall 3A: CFRP 0.6" TBlock
Wall 2A: CFRP 0.6" TBlock
Wall 1A: CFRP 0.6" TBlock
Wall 2B: CFRP 0.5" TBlock
Wall 3B: CFRP 0.5" TBlock
Wall 1B: CFRP 0.5" TBlock
Wall 4B: GFRP #5 TBlock
Wall 2B: GFRP #5 TBlock
Wall 3B: GFRP #5 TBlock
Wall 4B: GFRP #5 TBlock

Hybrid (Type “H”) Prestressed Sheet Piles

“Green” concrete

Gravity Wall = with RCA GFRP #5 TBlock
Gravity Wall = with RAP GFRP #5 TBlock

Hybrid (Type “H”) Prestressed Sheet Piles

PROJECT NOTES:
1. Class A concrete mix shall contain between 10% and 30% content of Recycled Concrete Aggregate (RCA) in Section 1, and between 10% and 20% content of Recycled Asphalt Pavement (RAP) in Section 2.
2. Cast twenty-four (24) Test Blocks of each RCA and RAP concrete mix at dosing concrete placement for the Gravity Wall.
3. Test Blocks shall be in accordance with DETAIL "E", cast in either individual or ganged wooden sawed forms, coded with an approved form-release agent and covered with polyethylene sheeting for curing.
4. Cast and strike Test Blocks adjacent to the Gravity Wall in an unobstructed location for collection by the Engineer within 7 days of casting.
5. Cost of Test Block to be included in the cost of the Gravity Wall.
HRB Project – Anchored/Cantilever Concrete Sheet Pile Walls (with CFRP/GFRP & CFCC/SS Anchor Bars)

Example Plan Sheet Details:
HRB Project – Cantilever Concrete Sheet Pile Walls (with CFRP/GFRP – Type “A”)

Example Plan Sheet Details:

**Wall Thickness** | **CFRP STRAND DIA.** | **MAXIMUM L** | **n** | **D** | **TOTAL # OF STRANDS**
---|---|---|---|---|---
T=10 in. | 0.49 (12.5mm) | 26'-0" | 4 | 4 | 10
 | 0.5 (12.7mm) | 27'-0" | 3 | 5\(\frac{1}{4}\) \(^{(1)}\) | 8
 | 0.6 (15.2mm) | 27'-0" | 3 | 5\(\frac{1}{4}\) \(^{(2)}\) | 8
T=12 in. | 0.49 (12.5mm) | 31'-0" | 5 | 3\(\frac{1}{4}\) \(^{(1)}\) | 12
 | 0.5 (12.7mm) | 31'-0" | 3 | 5\(\frac{1}{4}\) \(^{(1)}\) | 8
 | 0.6 (15.2mm) | 31'-0" | 3 | 5\(\frac{1}{4}\) \(^{(2)}\) | 8

* Unit Prestress after losses
** Based on lifting using single point pick-up.

Alternate symmetrical:
(1) 4 sp. @ 2" & 1`
(2) 2 sp. @ 4" & 1`
HRB Project –

Pile Bent Substructure (with CFRP/GFRP-RC/PC)

A. Components
   i. Square CFRP Prestressed Bearing Piles
   ii. GFRP-RC Bent Cap

B. Structural System
   i. GFRP-RC Intermediate Bent Cap
   ii. GFRP-RC End Bent Cap.

C. Other projects
   i. Test Pile Research at FAMU/FSU

D. Design Criteria - ACI 440.1R & 440.4R

E. Material Specifications - Dev932 & Dev933
HRB Project – Pile Bent Substructure (with GFRP-RC)

Example Plan Sheet Details:

SECTION B-B
Beam Seat reinforcing not shown for clarity.

SECTION A-A
Beam Seat reinforcing not shown for clarity.
**HRB Project – Hybrid Composite Bridge Beams**

A. Components
   i. HCB Proprietary Product background (Hillman Composite Beam)
   ii. Wings/No wings, CIP compression arch, fabric selection for shell design
   iii. Strands, interface shear reinforcing

B. Structural System
   i. Customized design for project specific needs

C. Other projects
   i. DOT’s (Maine, …)
   ii. Railroads …

D. Design Criteria - **ACI 440.1R & 440.4R**

E. Specifications – **Technical Special Provisions (TSP)**
HRB Project – Hybrid Composite Bridge Beams

Example Plan Sheet Details:
HRB Project –
Hybrid Composite Bridge Beams

Example Plan Sheet Details (cont.):
HRB Project –
GFRP-RC Decks and Approach Slabs

A. Components
   i. Interior bay
   ii. Deck overhang
   iii. Adjacent to traffic railings
   iv. Approach Slab

B. Structural System

C. Other projects (from ACMA)
   i. 67+ USA
   ii. 400+ Canada


E. Material Specifications - Dev932 & Dev933

(Photographs) Hughes Bros. GFRP Bars.
HRB Project – GFRP-RC Decks and Diaphragms

Example Plan Sheet Details:

TYPICAL SECTION AT MID SPAN

NOTE:
2. For Section thru Diaphragms see Sheet No. B1-30.
3. See D22429, sheet 4 of 4, Alternate Reinforcing Note 2 for reinforcing requirements and Sheet No. B1-31 for additional details.
4. Concrete cover shall be 2" unless otherwise noted.
5. Survey CR 490A (Halls River Road)

30-60'
28-30' (Phase II - Stage 2 Construction)
31-40' (Phase III - Stage 1 Construction)

TYPICAL SECTION AT END OF SPAN

NOTE:
Diaphragm Bars 6D2, 6D4, 6D3 & 8D6 to be lapped with Bars 6H3, 6H4, TH3 & TH5 in the HD's.
HRB Project – GFRP-RC Approach Slabs

Example Plan Sheet Details:

Superstructure Layout - Plan View

Approach Slab Index No. 20900 Table of Dimensions

Location

Dimensions

<table>
<thead>
<tr>
<th>Location</th>
<th>L1</th>
<th>L2</th>
<th>M1</th>
<th>M2</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach Slab 1</td>
<td>30.0'</td>
<td>30.0'</td>
<td>10.67'</td>
<td>7.3'</td>
<td>40.0'</td>
</tr>
<tr>
<td>Approach Slab 2</td>
<td>30.0'</td>
<td>30.0'</td>
<td>10.67'</td>
<td>7.3'</td>
<td>40.0'</td>
</tr>
</tbody>
</table>

Dimension Notes:
Dimensions L1 & L2 are measured along gutter line, inside face of parapet or inside face of railing on raised sidewalks.

Reinforcing Bar Laps

<table>
<thead>
<tr>
<th>Size</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1-10&quot;</td>
</tr>
<tr>
<td>6</td>
<td>1-10&quot;</td>
</tr>
<tr>
<td>8</td>
<td>2-3&quot;</td>
</tr>
</tbody>
</table>
HRB Project – GFRP-RC Traffic Railings

A. Components
   i. Inboard Section (Post Installed Anchorage – Phase III)
   ii. Edge Railing Section (Cast-in Anchorage)

B. Structural System

C. Similar crash tested designs
   i. V-Rod, Schloek, & Temcorp: MASH TL-5 42” F-Shape
   ii. GFRP Adhesive Anchor Tests by Hilti/Canadian Research Centre

D. Design Criteria
   i. AASHTO Guide Spec.
   ii. NCHRP 350/MASH

E. Material Specifications
   i. GFRP Rebar - Dev932;
   ii. White Cement & Slag Cement – Spec. 346
HRB Project – GFRP-RC Traffic Railings

Example Plan Sheet Details:

- **HRB Project**
- **GFRP-RC Traffic Railings**

**SECTION A-A**
TYPICAL SECTION THRU TRAFFIC RAILING
(Section thru Bridge Deck shown, Section thru Approach Slab and Retaining Walls similar)

**OPTIONAL HEADED ANCHOR SECTION USING BAR 5V1 CONFIGURATION**
(Bars 5V3 Similar)
HRB Project – CAMX Award Finalist: “Combined Strength”

Mockups (December 2018):
Beyond Halls River Bridge

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

✓ Developing design criteria for:

i. **Glass-FRP** prestressing

ii. **Basalt-FRP** reinforcing

✓ FHWA's *Innovations Deserving of Exploratory Analysis (IDEA)*
  - GFRP Prestressing - **MILDGLASS** (University of Miami);

✓ FHWA's *State Transportation Innovation Councils (STIC)* Incentive Program
  - BFRP Reinforcing Standards Development - **MACTBr** (FDOT)
Technology Transfer – Implementation, Nurturing & Tracking

Developmental Standards provide a bridge across the “Trough of Disillusionment” for effective implementation!

Source: Gartner Inc. Hype Cycle

Research (TRL 1-3)

Demonstration Project (TRL 4-5)

Developmental (DDS) Index (TRL 6-8)

Design Standard Index (TRL 9)

Source: NASA
Technology Transfer - Tools

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)

http://www.fdot.gov/structures/innovation/FRP.shtm
Technology Transfer - Tools

✓ Fast-Facts
✓ Presentations & Workshops

Technology Transfer (T²)

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)

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

FDOT Transportation Innovation Initiative:
FRP – Design Innovation

Fast Facts:
Glass Fiber Reinforced Polymer

Projects:

FDOT and affiliated projects in Florida (completed and under construction) can be explored using the FRP-Projects GIS-Mapping Tool (pending). Please contact the coordinators at the bottom of the page to have your project included in the Map.

Fast-Facts sheets for selected projects are listed below:

- Halls River Bridge
- Sunshine Skyway Seawall Rehabilitation
- Bakers Haulover Cut Bulkhead Replacement
- Cedar Key Bulkhead Rehab
- PortMiami Tunnel Retaining Walls
- US-17 (SR-5) Over Trout River
- SR-312 Over Matanzas River
- Arthur Drive over Lynn Haven Bayou
- UM Innovation Bridge
- UM Fate Bridge
Face-to-Face:

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

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.
Universities Contact Information:

FAMU-FSU College of Engineering:
Michelle Gartman, MS
2525 Pottsdamer St., Rm A129
Tallahassee, FL 32310-6046
(850) 410-6125
Roddenberry.Gartman.fsu@gmail.com

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
txc470@miami.edu | t.cadenazzi@astaldi.com

FDOT Contact Information:

Structures Design Office:
Steven Nolan, P.E. (Standards Coordinator)
(850) 414-4272
Steven.Nolan@dot.state.fl.us

State Materials Office:
Chase C. Knight, PhD.
(352) 955-6642
Chase.Knight@dot.state.fl.us

Structures Design Office:
Rick Vallier, P.E. (FRP Coordinator)
(850) 414-4290
Rick.Vallier@dot.state.fl.us

Design 7 Structures Office / EOR:
Mamun Siddiqui, P.E. (Designer)
(813) 975-6093
Mamunur.Siddiqui@dot.state.fl.us

Questions