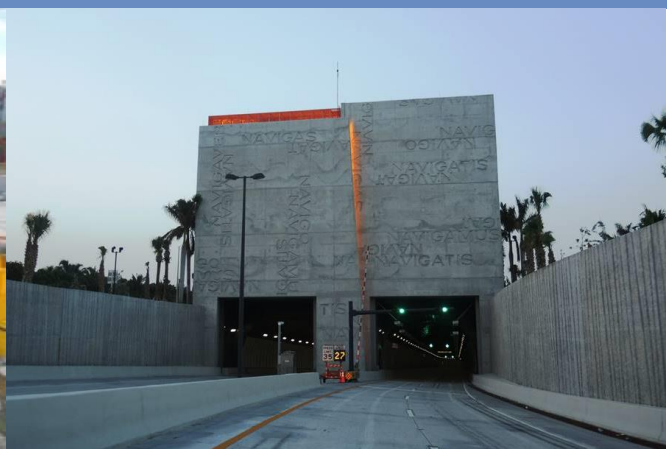
FDOT Transportation Innovation Initiative:

FRP – Design Innovation



Fast Facts:

Basalt Fiber Reinforced Polymer

Project Location:	FDOT District Six Miami-Dade County Miami, Florida
Agency:	Florida Department of Transportation
URL:	http://www.fdot.gov/structures/innovation/FRP.shtm
Project Name:	Port of Miami Tunnel FPID: 251156-3
Project Description:	Retaining Wall Demonstration Site for Basalt Fiber Reinforced Polymer
Project Purpose & Need:	As a demonstration project, basalt rebar (BFRP) was used in concrete retaining walls to evaluate performance under service and environmental conditions, identify and quantify the interface between BFRP bars and concrete, and evaluate thermal and physical properties of BFRP. Assessment program identifies cores are to be taken at 5, 10, and 20 years.

What was unique about this project? Bouygues Civil Works Florida, the contractor on the project, proposed an alternative reinforcement system for two retaining walls on the project.

"Basalt is one quarter the weight of steel but has more than three times the tensile strength of steel. It is acid and alkali resistant and will not corrode, which makes reinforced concrete structures extremely durable, a major benefit in the highly aggressive environments frequently encountered in Florida. Basalt rebar is very cost effective as reinforced concrete structures would require one-third the reinforcing area. Concrete Structures could be designed with reduced concrete thickness and cover."

Bouygues Civil Works Florida

Overall Budget/Cost Estimate: $668.5 Million (Design and Construction)

Financial Information Source: http://www.portofmiamitunnel.com/project-overview/project-overview-1/

Describe Traditional Approach: Steel is commonly used as concrete reinforcement.

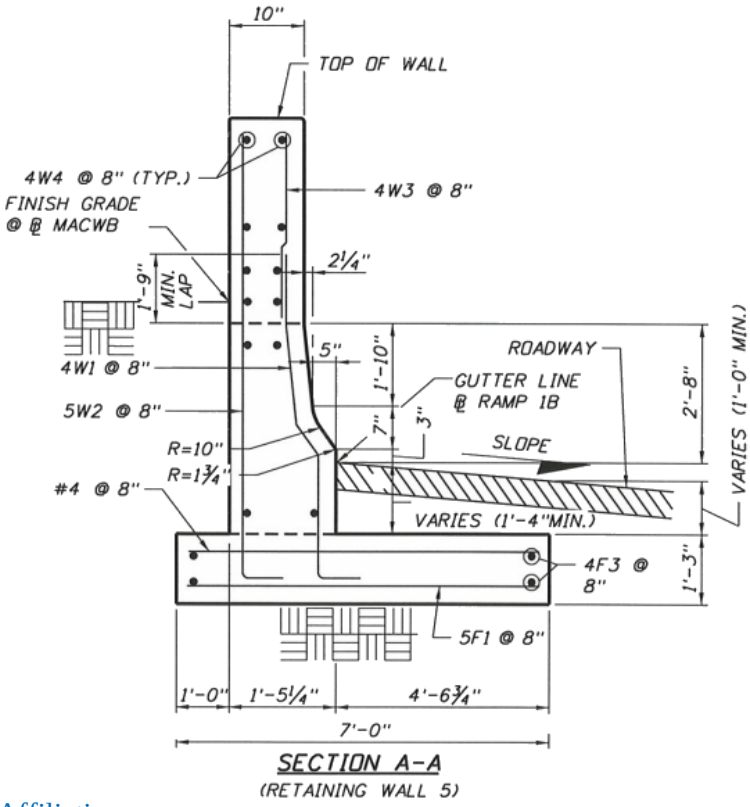
Describe New Approach: Basalt replaced steel as retaining wall reinforcement in Retaining Walls 5 and 6. Bars of 8 mm and 12 mm diameter basalt rebar with 3 inch clear cover used. Wall thickness and shape remain per conventional design.

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

Top Innovations Employed: Use of BFRP in service conditions.

Primary Benefits Realized/Expected: Assessment data on BFRP reinforcement.

Project Start Date/Substantial Completion Date: Construction and installation of the retaining walls reinforced with basalt bars started at end of January 2014.



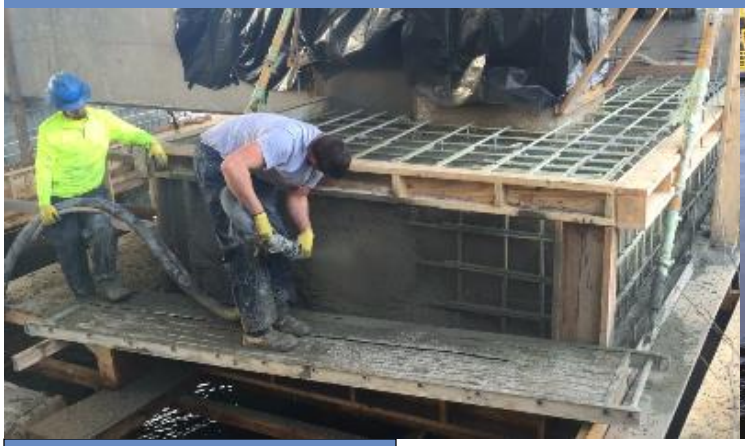
Affiliations:

Concessionaire:	MAT Concessionaire, LLC
Construction Contractor:	Bouygues Civil Works Florida Miami, Florida
FRP Supplier:	ASA.TEC (Austria)
Engineer of Record:	Frank P. Guyamier, P.E. Project Engineer Port of Miami Tunnel Project
Testing Program By:	Dr. Brahim Benmokrane Brahim.Benmokrane@USherbrooke.ca University of Sherbrooke Sherbrooke, Quebec, Canada

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

FDOT Transportation Innovation Initiative:

FRP – Design Innovation



Fast Facts:

Glass Fiber Reinforced Polymer

Project Location:	FDOT District Two Duval County Jacksonville, Florida
Agency:	Florida Department of Transportation
URL:	http://www.fdot.gov/structures/innovation/FRP.shtm
Project Name:	US-17 (SR-5) Over Trout River Bridge No. 720011 FPID: 426169-1
Project Description:	Bridge Substructure Rehabilitation
Project Purpose & Need:	Bridge Inspection Reports identified concrete deterioration in the substructure. Work activities included removal of existing Pile Jackets and installation of new Pile Jackets and Pier Footing Jackets with Impressed Current Cathodic Protection (ICCP). Glass Fiber Reinforced Polymer (GFRP) dowels and reinforcement were used in select locations.

Overall Budget/Cost Estimate: $2,759,262.00 (Construction Contract)

What was unique about this project?

No. 4 GFRP bars with epoxy were embedded into existing Pier Footings 9 and 10 to attach the new Footing Jacket to the existing Pier Footer. The Pier 10 Footing Jacket included No. 6 GFRP reinforcement.

Shotcrete (pneumatically applied concrete), was used to apply concrete to Pier 9 and Pier 10 Footings to form the Pier Jacket. However, due to problems with concrete quality issues, the shotcrete was removed from the Pier 10 footing and the process of forming the jacket and pouring concrete was used. This provided an opportunity to explore removal of concrete from FRP bars. Below are the list of pilot projects incorporated:

- GFRP bars used in conjunction with Shotcrete
- GFRP bars used in the splash zone
- GFRP bars used with traditional pour in place construction methods

Describe Traditional Approach: Traditional approach includes installation of grade 60 steel rebar in conjunction with cast-in-place concrete.

Describe New Approach: Utilization of GFRP bars in lieu of traditional grade 60 steel rebar in a variety of settings, including in conjunction with Shotcrete; in the splash zone; with traditional pour in place construction methods; and removal of concrete from GFRP bars.

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

Primary Benefits Realized/Expected: Lifted the restrictions on use of GFRP bars within the splash zone/marine environment. The restriction was in place due to reaction of GFRP bar resin with chlorides

Project Start Date/Substantial Completion Date: 5/4/2014 – 3/26/2016

Affiliations:	PE Consultant:	Stantec Consulting Services Inc.
	Construction Contractor:	Coastal Gunite Construction Company
	Construction Engineering Inspection:	JEA Construction Engineering Services
Project Contact:	Engineer of Record:	Mohit D. Soni, P.E. Stantec Consulting Services Inc. Mohit.Soni@stantec.com
	FDOT Project Manager:	Jeff Bailey FDOT District Two Jeff.Bailey@dot.state.fl.us
	FDOT State Materials Office:	Chase C. Knight, Ph.D. FDOT Composites Material Specialist Chase.Knight@dot.state.fl.us

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

FDOT Transportation Innovation Initiative:

FRP – Design Innovation

Fast Facts:

Glass Fiber Reinforced Polymer & Basalt Reinforcing Mesh

Project Location:	FDOT District Two St. Johns County St. Augustine, Florida
Agency:	Florida Department of Transportation
URL:	http://www.fdot.gov/structures/innovation/FRP.shtm
Project Name:	SR-312 Over Matanzas River Bridge No. 780089 FPID: 428229-1
Project Description:	Bridge Substructure Rehabilitation
Project Purpose & Need:	Bridge Inspection Reports identified concrete deterioration in the substructure. Work activities included removal of existing multi-column pier jackets and installation of new jackets on the multi-column pier. New jackets were installed at the specific multi-column piers. Pier Footing Jackets with Impressed Current Cathodic Protection (ICCP) were installed. Ribbon anodes were installed between the piles on the pier footing. GFRP dowels and Basalt Reinforcing Mesh were used in select locations.

What was unique about this project?

Pier 15, Pier 19, Pier 20, Pier 21, Pier 22, Pier 23, Pier 26, Pier 29, Pier 30, and Pier 31 were rehabbed as follows:

Columns: No. 4 L-shape GFRP dowel bars with epoxy were embedded into the columns to attach the 150mm x 150mm x 4mm Basalt Reinforcing Mesh to protect the Titanium Anode Mesh.

Struts: No. 4 L-shape GFRP dowel bars with epoxy were embedded into the strut to attach the No. 4 GFRP bars in longitudinal and No. 3 GFRP bars in transverse direction to protect the Titanium Anode Mesh. Dowel spacing was 6-in and GFRP bars were spaced at 1-ft in both direction alongside of strut.

Footing: This is among the first projects to implement Ribbon Anodes.

Shotcrete: Pneumatically applied concrete was used in the Column and Strut to form the Jacket. However, due to problems with concrete quality issues, the shotcrete was removed from a few piers and was applied again. This provided an opportunity to explore removal of concrete from the Basalt Mesh and GFRP bars.

Below is the list of innovations unique to this project:

- Use of GFRP in conjunction with Shotcrete
- GFRP bar use in the marine environment
- Use of Basalt Mesh in conjunction with GFRP
- Use of Ribbon Anode in Footings

Overall Budget/Cost Estimate: $2.4 Million Construction Contract

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

Describe Traditional Approach: Traditional approach includes installation of traditional Grade 60 rebar in conjunction with cast-in-place concrete.

Describe New Approach: Utilization of GFRP rebar and Basalt Reinforcing Mesh in lieu of traditional Grade 60 rebar in variety of settings including in conjunction with Shotcrete; in the marine environment; and with traditional pour in place construction method and opportunity to explore the removal of concrete from basalt bars.

Top Innovations Employed: Utilization of GFRP rebar and Basalt Reinforcing Mesh within the splash zone/marine environment

Primary Benefits Realized/Expected: Lifted the restrictions on use of GFRP and Basalt within the splash zone/marine environment. Gave the opportunity to explore the use of Basalt. The restriction was in place due to reaction of GFRP resin with chlorides.

Project Start Date/Substantial Completion Date:		01/06/2014 – 6/12/2015
Affiliations:	PE Consultant:	Stantec Consulting Services Inc.
	Construction Contractor:	Orion Marine Construction, Inc.
	Construction Engineering Inspection:	JEA Construction Engineering Services
	Material Testing:	Ellis & Associates, Inc.
Project Contact:	Engineer of Record:	Mohit D. Soni, P.E. Stantec Consulting Services Inc. Mohit.Soni@stantec.com
	FDOT Project Manager:	Jeff Bailey FDOT District Two Jeff.Bailey@dot.state.fl.us
	FDOT State Materials Office:	Chase C. Knght, Ph.D. FDOT State Materials Office Chase.Knight@dot.state.fl.us
		Matthew Duncan FDOT State Materials Office Matthew.Duncan@dot.state.fl.us

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

FDOT Transportation Innovation Initiative:

FRP – Design Innovation



Fast Facts:

Glass Fiber Reinforced Polymer
&
Carbon Fiber Reinforced Polymer
&
Hybrid Composite Beam

Project Location:	FDOT District Seven Citrus County Homosassa Spring, Florida
Agency:	Florida Department of Transportation
URL:	http://www.fdot.gov/structures/innovation/FRP.shtm
Project Name:	CR-490A Halls River Road over Halls River Bridge No. 024054 FPID: 430021-1-52-01
Project Description:	Bridge Replacement
Project Purpose & Need:	The existing bridge was functionally obsolete and listed on the Citrus County Bridge Replacement Program. The purpose of this project is to increase capacity and improve safety of the existing transportation facility.
Overall Budget/Cost Estimate:	$6,015,645.00 (Construction Contract)

What was unique about this project?

This project is a demonstration project. Work activities included replacement of the bridge with Hybrid-Composite Beams (HCB) from HC Bridge Company; Prestressed precast concrete square piles and sheet pile walls reinforced with carbon fiber-reinforced polymer (CFRP) strands and stirrups; and Cast-in-place concrete bulkhead caps, pile caps, wing walls, back walls, deck, traffic barriers, approach slabs reinforced with glass fiber-reinforced polymer (GFRP) bars and stirrups. Removable test blocks, reinforced with varying types of FRP bars and strands, will cast with the bulkhead cap for monitoring long-term durability.

Describe Traditional Approach: Traditional approach includes addition of flyash, blast furnace slag, silica fume and other corrosion inhibitors into cement rich concrete mixes to protect carbon steel prestressing strands and reinforcing with limited long-term success, especially in the presence of concrete cracking.

Describe New Approach: HCB uses galvanized steel strands (as tension reinforcement) encased in polymer resin with Glass fiber-reinforced polymer beam shell and SCC concrete arch core. GFRP bars and stirrups used in the cast-in-place pile cap, bulkhead cap, deck, traffic railing, approach slab, back wall, wing wall, CFRP strands and spirals in piles, sheet pile walls, in lieu of traditional grade 60 steel rebar and steel strands.

Top Innovations Employed: Utilization of FRP bars and strands in marine environment.

Primary Benefits Realized/Expected: Longer service life of the bridge without major maintenance.

Project Start Date/Substantial Completion Date: 1/9/2017 – 2018

Affiliations:	PE Designer:	FDOT District Seven
	PE Consultant:	American Consulting Engineers of FL.
	Construction Contractor:	Astaldi Construction Corp.
	Construction Engineering Inspection:	FDOT/Brooksville Operation, JACOBS Engineering, and Cardno TBE.
Project Contact:	Engineer of Record:	Mamunur R. Siddiqui, P.E. FDOT District Seven mamunur.siddiqui@dot.state.fl.us
	FDOT Roadway Project Manager:	Michael Ojo. P.E. FDOT District Seven michael.ojo@dot.state.fl.us
	FDOT State Materials Office:	Chase C. Knight, Ph.D. FDOT State Materials Office Chase.Knight@dot.state.fl.us

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

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

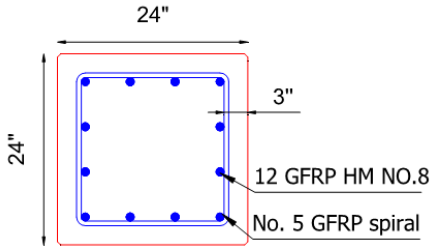
URL: http://www.fdot.gov/structures/innovation/FRP.shtm

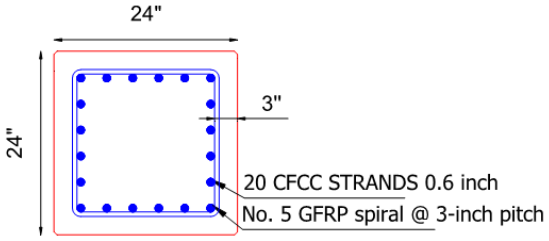
Project Name: Arthur Drive over Lynn Haven Bayou
Bridge No.: 464143
FPID: 430463-1

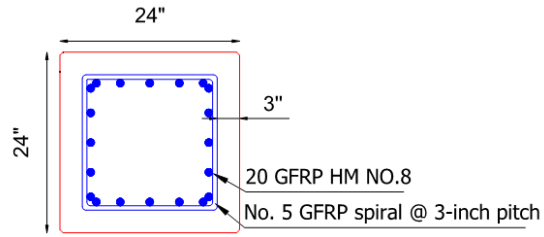
Project Description: Field testing of GFRP and CFRP reinforced concrete piles.

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.







What was unique about this project?
Three demonstration piles were driven at a project site to assess the driving axial capacity of full-scale square FRP reinforced concrete precast piles in the field. The piles were not production piles, but were allowed to remain in place behind the backwall, under the approach slab.

Describe Traditional Approach:
Precast concrete piles with prestressed steel strand and mild steel stirrups is common for bridge deep foundations.

Describe New Approach:
Two of the demonstration piles contained non-prestressed GFRP reinforcement with GFRP stirrups. One pile was prestressed with CFRP strand with GFRP stirrups.

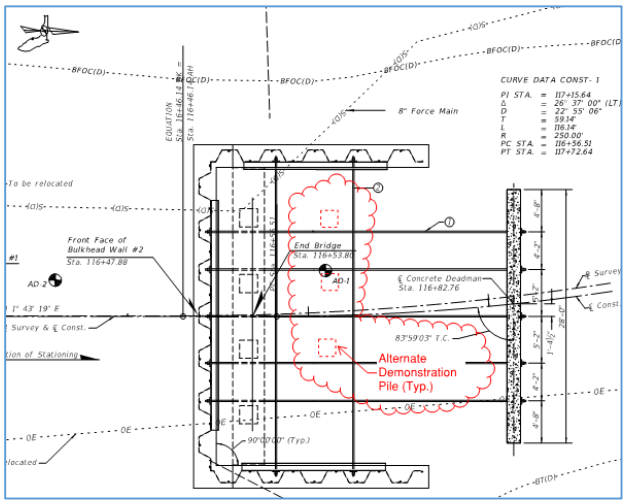
Top Innovations Employed:
Use of non-prestressed concrete piles, reinforced with GFRP bars.

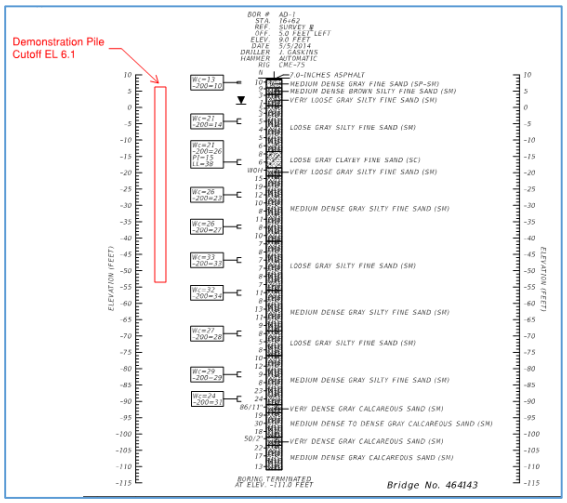
Primary Benefits Realized/Expected:

Project Start Date/Substantial Completion Date: FRP Pile Driving: 3/2/2017 – 3/3/2017

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

Affiliations:	University of Sherbooke:	Dr. Brahim Benmokrane, P. Eng. Sherbrooke, Canada Brahim.Benmokrane@USherbrooke.ca
		Dr. Hamdy M. Mohamed, P. Eng. Sherbooke, Canada
	University of North Florida:	Dr. Adel Elsafty, P.E., P. Eng. Jacksonville, Florida adel.el-safty@unf.edu
	Precast Pile Supplier:	Gate Precast Company Jacksonville, Florida
	CFCC Strand:	Tokyo Rope Tokyo, Japan
	GFRP Reinforcement:	Pultrall Quebec, Canada
	Contractor:	F&W Construction Company
Project Contact:	FDOT Structures Design Office:	Steven Nolan, P.E. Steven.Nolan@dot.state.fl.us
Research Project:	A Laboratory and Field Study of Precast Concrete Piles Reinforced with GFRP Bars, Ties, and Spirals	





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

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.

Overall Budget/Cost Estimate: $741,630.00 (Construction Contract)

What was unique 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

Affiliations:

PE Consultant:	Kisinger Campo & Associates Corp.
Construction Contractor:	Pneumatic Concrete Co, Inc.
Construction Engineering Inspection:	JEA Construction Engineering Services

Project Contact:

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

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

FDOT Transportation Innovation Initiative:

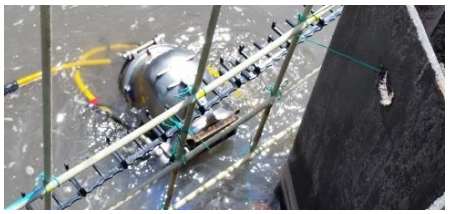
FRP – Design Innovation

Fast Facts:

Glass Fiber Reinforced Polymer

Project Location:	FDOT District Six Miami-Dade County Bal Harbour, Florida
Agency:	Florida Department of Transportation
URL:	http://www.fdot.gov/structures/innovation/FRP.shtm
Project Name:	SR-A1A/Collins Avenue over Haulover Cut Bridge Rehabilitation Bridge No. 870071 FPID: 433378-1
Project Description:	Bridge and Bulkhead Rehabilitation
Project Purpose & Need:	District Six Bridge Maintenance identified repairs that included bridge coatings and replacing the deteriorated concrete bulkhead retaining wall on both sides of the Haulover Cut channel. Work activities included replacing the existing bulkhead walls with a steel sheet pile wall system that included a reinforced concrete cap and a protective concrete fascia panel over the steel sheets. GFRP reinforcement was used in the concrete cap and fascia panels.

Overall Budget/Cost Estimate:	$8,960,957.50 – Bridge and bulkhead wall rehabilitation
What was unique about this project?	The unique features of this project include the use of GFRP reinforcement in the concrete cap and protective concrete fascia panel. No. 4 and No. 5 GFRP bars were used as reinforcement in the cap and fascia panel. The fascia panel was built partially submerged below the tidal water level. The formwork and reinforcement were placed below the water level, while the drilled shaft concrete mix was pumped beginning from the bottom of the form up to the top, displacing the water.



Describe Traditional Approach:	The traditional approach would have used the conventional carbon steel reinforcement. Given the highly corrosive marine environment, future corrosion and concrete delamination would likely occur within a short period of time, leading to costly maintenance repairs throughout the life of the walls.
Describe New Approach:	The new approached employs the use of GFRP reinforcement, eliminating future corrosion and concrete delamination, and saving costly maintenance repairs.
Top Innovations Employed:	Use of GFRP reinforcing bars.
Primary Benefits Realized/Expected:	Top benefits realized with the use of GFRP reinforcement is the elimination of future corrosion and concrete delamination, and saving future maintenance cost.

Project Start Date/Substantial Completion Date:		1/9/2017 – 11/27/2018
Affiliations:	Prime Consultant:	Transystems
	Construction Contractor:	Kiewit Southern
	Construction Engineering Inspection:	Bolton Perez & Associates
Project Contact:	Engineer of Record (Bulkhead Wall):	Joaquin Perez, P.E. Bolton Perez & Associates Jperez@bpamiami.com
	FDOT Project Manager:	Pablo J. Orozco, PE FDOT District Six Pablo.Orozco@dot.state.fl.us
	FDOT State Materials Office:	Chase C. Knight, Ph.D. FDOT State Materials Office Chase.Knight@dot.state.fl.us

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

FDOT Transportation Innovation Initiative:

FRP – Design Innovation

Fast Facts:

Glass Fiber Reinforced Polymer

UNIVERSITY OF MIAMI

Project Location:	Coral Gables, Florida
Agency:	University of Miami
URL:	http://www.fdot.gov/structures/innovation/FRP.shtm
Project Name:	Fate Pedestrian Bridge
Project Description:	This three-span pedestrian bridge with a short cantilever end allows for the crossing of the Lake Osceola at the University of Miami, Coral Gables Campus.
Project Purpose & Need:	Designed by renowned Arquitectonica, the Fate Bridge not only connects two sides of the campus, but also intends to become itself a place for gathering and reflection. The silhouette of the bridge with its variable cross-section is like an extension of the water surface. The bridge with an embedded monitoring system is a living laboratory to educate engineering and architecture students.

Overall Budget/Cost Estimate: $ 2,500,000.

What was unique about this project?

The hybrid superstructure combines the composite action of two wide-flange steel girders encased in reinforced concrete (RC) to provide the required strength and aesthetic appearance. The RC deck in turn combines traditional bottom black steel reinforcement with glass fiber reinforced polymer (GFRP) rebars as top reinforcement closer to the surface exposed to pedestrian traffic and temperature variations.

Describe Traditional Approach:

This project's superstructure initially specified the use of traditional black steel for all reinforced concrete elements. The superstructure is supported by RC pile-caps over driven piles made of conventional precast-prestressed concrete.

Describe New Approach:

UM Civil, Architectural & Environmental Engineering Department proposed to replace the steel reinforcement top mat of the deck with an equivalent one made of non-corrosive GFRP rebars. Although bridge decks with GFRP reinforcement have been built in other states, this is a first attempt in Florida aiming at addressing low maintenance and improved sustainability.

Top Innovations Employed:

Bent GFRP rebar technology is now available providing numerous shape bents for different purposes such as open or closed stirrups and standard hooks.

Primary Benefits Realized/Expected:

In addition to demonstrating the deployment of new technology with advantages on ease of installation, the bridge deck will not require traditional maintenance. The instrumented superstructure will contribute to the education of future engineers and architects by demonstrating the relationships load-strain and temperature-strain in a field structure.

Project Start/Completion Dates:

6/2015 – 9/2015

Affiliations:

General Contractor: Moss & Associates
Engineer of Record: Brill Rodriguez Salas & Associates Inc.

Project Contact:

Antonio Nanni, Prof. and Chair, University of Miami, Dept. of Civil, Arch. & Environ. Engineering.
nanni@miami.edu

UNIVERSITY
OF MIAMI

FDOT Transportation Innovation Initiative:

FRP – Design Innovation

Fast Facts:

Glass Fiber Reinforced Polymer

UNIVERSITY OF MIAMI

Project Location:	Coral Gables, Florida
Agency:	University of Miami
URL:	http://www.fdot.gov/structures/innovation/FRP.shtm
Project Name:	Innovation Pedestrian Bridge
Project Description:	Although this pedestrian bridge is a simple, single-span, 70 ft.-long construction, it offers a number of features intended to ensure a 75-year service life to its owner, the University of Miami. The bridge consists of the following concrete elements reinforced with FRP: auger-cast piles; cast-in-place pile caps and back walls; precast prestressed girders; and, cast-in-place deck topping and curbs. Stainless steel is used for the bearing plates of the girders, the anchor bolts for the lampposts, and the railings.
Project Purpose & Need:	The University of Miami deliberately chose this type of structure to demonstrate its commitment to innovation and sustainability for a pedestrian bridge used by students to access the sports and intermural fields on campus.

Overall Budget/Cost Estimate: $ 750,000.

What was unique about this project? There is not a single pound of "black steel" (carbon steel) in any element of the bridge; in fact, all reinforcement and tendons are made of composite materials.

Describe Traditional Approach: This project initially specified the use of steel-strand prestressed girders supported on traditional steel reinforced concrete piles and pile caps.

Describe New Approach: This project achieved special impact because it allowed the use of non-corrosive reinforcement, addressing sustainable practices towards low maintenance with zero anticipated repair costs due to corrosion. For the first time, this simple structure combines novel materials including Basalt FRP (BFRP), Glass FRP (GFRP), Carbon FRP (CFRP) and novel composite manufacturing technologies (continuous closed stirrups and automated-preassembled cages) to ensure that degradation due to steel corrosion no longer reduces the longevity of the transportation infrastructure.

Top Innovations Employed: a) Prefabricated reinforcing cage for auger cast piles. Cages consisted of six #6 BFRP bars and #3 spirals made by taking advantage of precision manufacturing.
b) Girders in the shape of double-tees prestressed with nine 0.6-inch diameter, seven-wire CFRP strands. CFRP tendons have been used for other precast or post-tensioned applications, but never before in the fabrication of double-tees. The reinforcement grids for both stems and flange were made of pre-assembled interwoven BFRP bars (#3 and #4, respectively).
c) Cast-in-place elements such as curbs and pile caps reinforcement consisted of a combination of continuous closed BFRP stirrups and straight BFRP bars.

Primary Benefits Realized/Expected: FRP reinforcement eliminates the need for additional concrete cover for corrosion protection as well as the use of waterproofing sealants. This project allows for significantly lower labor and equipment costs because of the lightweight reinforcement handling. Other benefits of this projects range from low maintenance costs for the owner.

Project Start/Completion Dates: 11/2015 – 4/2016

Affiliations: General Contractor: OHL Arellano Construction Co.
Engineer of Record: Brill Rodriguez Salas & Associates Inc.

Project Contact: Antonio Nanni, Prof. and Chair,
University of Miami, Dept. of Civil, Arch. & Environ. Engineering.
nanni@miami.edu