

# 2021 Transportation Infrastructure Durability Conference

*The Mission is Possible: Solving Critical Issues in Transportation*

## **FDOT experience using FRP structural composites and the evolution of implementation.**

- **FDOT perspective and project examples**

Steven Nolan, P.E.

Florida Department of Transportation

State Structures Design Office (Tallahassee, FL)



Wednesday July 28<sup>th</sup>, 2021

**Structural Composites in Highway Transportation – Guest Speaker and Panel Discussion**

# Outline

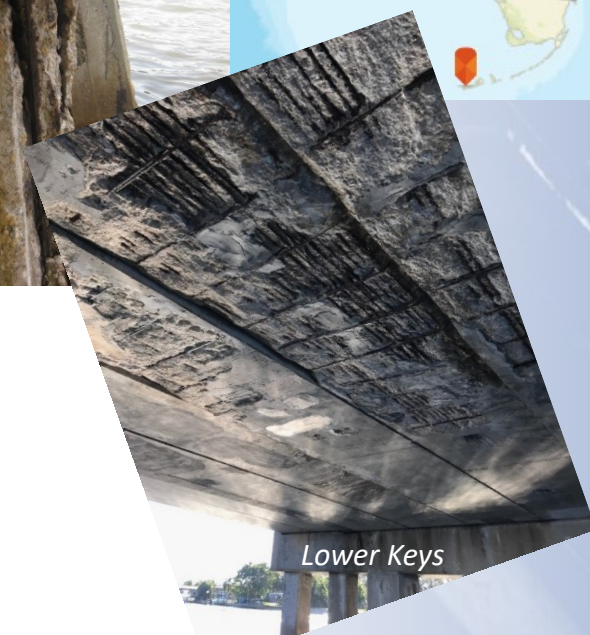
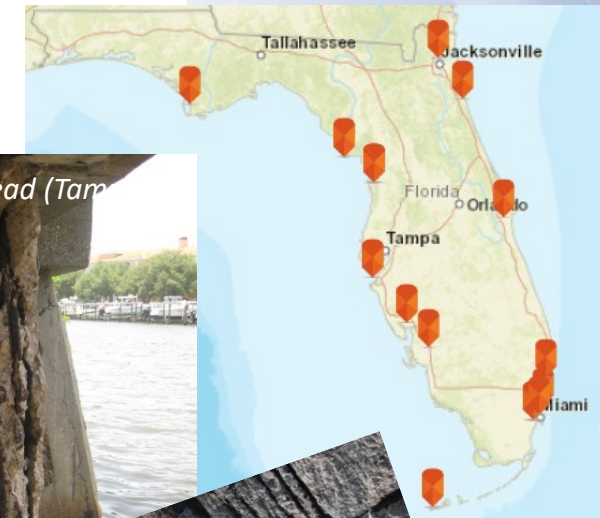
- FRP Structural Composite Type
- FDOT Research
- Implementation
- Typical Project Examples
- Scaling up for broader deployment

# Why use FRP materials for Bridges & Structures

- Florida maintains more than 150 million sq.ft. of bridge area (7044 FDOT bridges<sup>2</sup>);
- Florida has more than 4,000 miles seawall-bulkheads<sup>3</sup>.

WebTable 3. Shoreline hardening and population statistics by state (1)

	Hard sheltered shore (km)	Sheltered shore (km)	Hard sheltered shore (%)	Hard open shore (km)	Open shore (km)	Hard open shore (km)	Hard shore (km)	Total shore (km)	Hard shore (%)
<i>Atlantic</i>									
Connecticut	477	1907	25	0	0	477	1907	25	
Delaware	287	2163	13	5	45	11	292	2208	13
DC	29	54	53	0	0	29	54	53	
<b>Florida</b>	<b>2694</b>	<b>11 365</b>	<b>24</b>	<b>58</b>	<b>628</b>	<b>9</b>	<b>2752</b>	<b>11 992</b>	<b>23</b>
Georgia	92	6340	1	14	158	9	106	6498	2
<i>Gulf</i>									
Alabama							356	2606	14
<b>Florida</b>							<b>4427</b>	<b>26 383</b>	<b>17</b>



(1) Gittman et al. (2015) <https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/150065>  
 (2) FDOT Bridge Inventory – 2020 Annual Report  
 (3) Estimates from Gittman et al. (2015)

# FRP Structural Composite Types

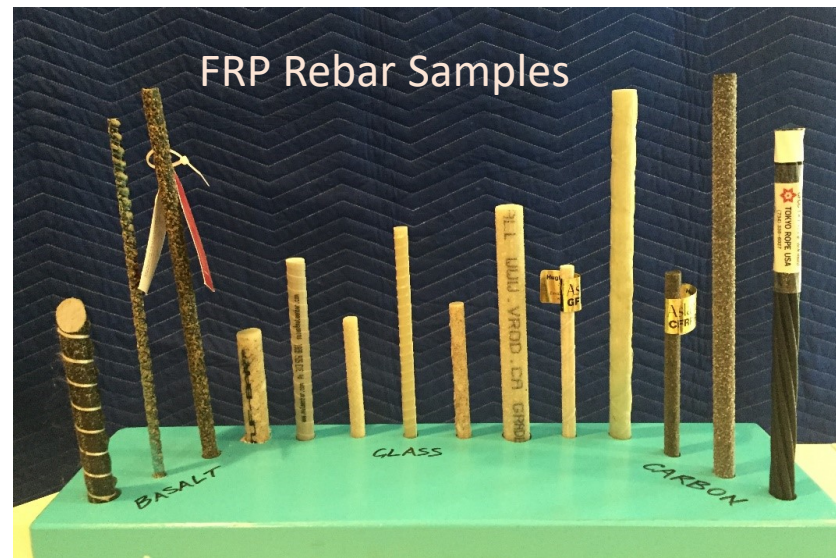
FDOT FRP-Design Innovation Initiative

# FRP Structural Reinforcement & Members

- Prestressing (*internal - pretensioned concrete*)
  - Carbon FRP Cable
  - GFRP & BFRP rods emerging



- Reinforcing Bars (*internal & NSM*)
  - Basalt FRP
  - Carbon Bar FRP
  - Glass FRP



- FRP Structural Members & Systems
  - Fender Piles & Wales (incl. internal bars)
  - Hollow Profiles (square, rectangular, circular)
  - Assembled Frames and Trusses
  - Beams and Arch CFFT



# FRP Structural Reinforcement for Repairs/Rehab.

- Girder Strengthening for load capacity
- Restoration due to Corrosion
- Repair from Over-height Truck Impact Damage.



Strengthening – Corrosion Damage



Impact Damaged Concrete

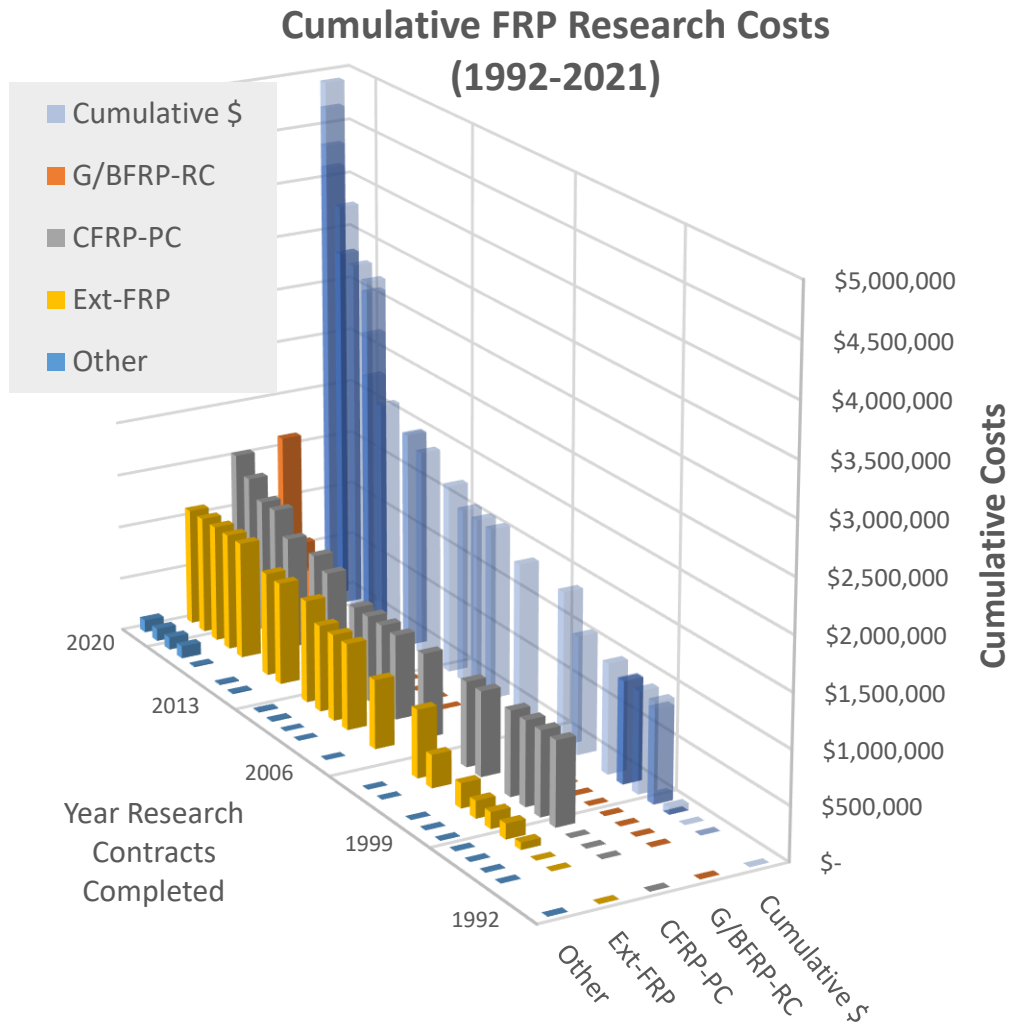


03/24/2007

# FDOT Research on FRP Structural Composites

Materials & Structures Research 1990-2020+

# FDOT Research on FRP Structural Composites



1992	Feasibility of Fiberglass Pretensioned Piles in a Marine Environment	Sen, R.	USF
1995	Active Deformation Control of Bridges with AFRP Cables	Arockiasamy, M.	FAU
1995	Durability of CFRP Pretensioned Piles in a Marine Environment – Phase II	Sen, R.	USF
1997	Mechanical and Microscopy Analysis of CFRP Matrix Composite Materials	Garmestani, H.	FAMU/SU
1997	FRP Composite Column and Pile Jacket Splicing	Mirmiran, A.	UCF
1997	An Analytical and Experimental Investigation of Concrete Filled FRP Tubes	Mirmiran, A.	UCF
1997	Flexural Reliability of RC Bridge Girders Strengthened with CFRP Laminates	Okeil, A.	UCF
1998	Studies of CFRP Prestressed Concrete Bridge Columns and Piles in Marine Environment	Arockiasamy, M.	FAU
1998	Analysis and Modeling of Fiber-Wrapped Columns and Concrete-Filled Tubes	Shahawy, M.	FDOT
1999	LRFD Flexural Provisions for PSC Bridge Girders Strengthened with CFRP Laminates	El-Tawil, S.	UCF



# FDOT Research on FRP Structural Composites



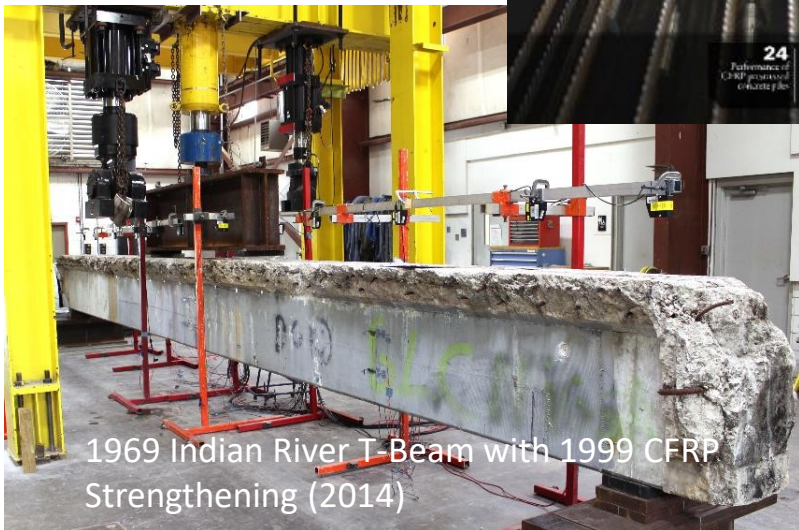
CFRP Laminate Strengthening for Berth 21 - Port of Tampa (2011)



NSM of Old Overseas Highway Deck in Florida Keys (2006)

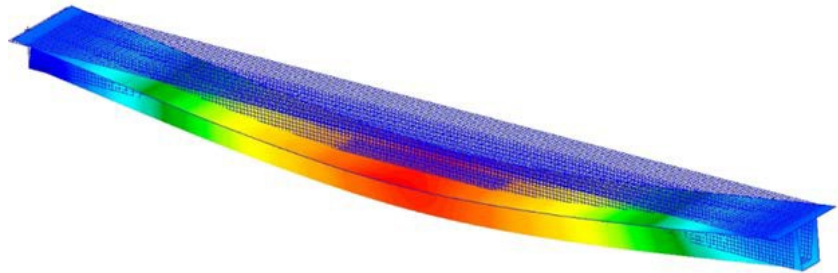
1999	Behavior of Reinforced Concrete Beam-Column Retrofitted with Composite Wrapping Systems	Chaallal, O.	FDOT
2000	Effect of Concrete Strength on the Performance of FRP Wrapped RC Column Under Combined Axial-Flexure Loading	Chaallal, O.	FDOT
2000	Behavior of Axially Loaded Short Rectangular Columns Strengthened with CFRP Composite Wrapping	Chaallal, O.	FDOT
2000	Investigation of Fender Systems for Vessel Impact	Yazdani, N.	FAMU/F SU
2000	Short-Term Tensile Strength of CFRP Laminates for Flexural Strengthening of Concrete Girders	Okeil, A.	UCF
2001	Design of Concrete Bridge Girders Strengthened with CFRP Laminates	El-Tawil, S.	UCF
2003	Hybrid FRP-Concrete Column	Mirmiran, A.	NC State
2004	CFRP Repair of Impact Damaged Bridge Girders	Hamilton, T.	UF
2007	Testing Bridge Decks with Near-Surface mounted FRP Bars Embedded in Cement Based Grout	Hamilton, T.	UF
2009	Thermo-Mechanical Durability of CFRP Strengthened RC Beams	Mackie, K.	UCF

# FDOT Research on FRP Structural Composites

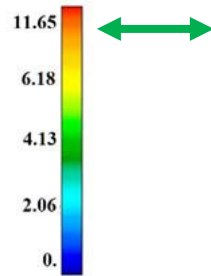


2010	Testing Precast Piles with Carbon Fiber Reinforced Polymer Mesh	Abalo, V.	FDOT
2011	Testing of Trelleborg Structural Plastics	Wagner, D.	FDOT
2012	The Repair of Damaged Bridge Girders with CFRP Laminates	El-Safty, A.	UNF
2014	Investigation of CFCC in Prestressed Concrete Piles	Roddenberry, M.	FAMU/SU
2015	Use of CFRP Cable for Post-Tensioning Applications	Mirmiran, A.	FIU
2015	Repair of Impact Damaged Utility Poles with FRP, Phase II	Mackie, K.	UCF
2017	Durability Evaluation of Florida's FRP Composite Reinforcement for Concrete Structures	Hamilton, T.	UF
2018	Testing, Evaluation, and Specification for Polymeric Materials used for Transportation Structures	El-Safty, A.	UNF
2018	Degradation Mechanisms and Service Life Estimation of FRP Concrete Reinforcements	El-Safty, A.	UNF

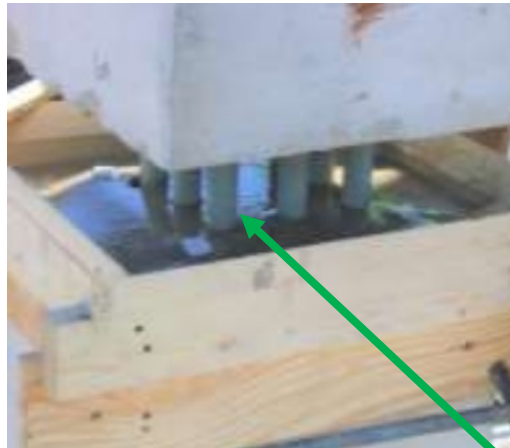
# FDOT Research on FRP Structural Composites



FEA Optimizing FRP Bridge Girders (2018)



Epoxy Dowel Splice (2021)



2018	Bridge Girder Alternatives for Extremely Aggressive Environments	Brown, J.	ERAU
2018	Performance Evaluation of GFRP Reinforcing Bars Embedded in Concrete Under Aggressive Environments	Kampmann, R.	FAMU/FSU
2019	Performance Evaluation, Material and Specifications for Basalt FRP Reinforcing Bars Embedded in Concrete	Kampmann, R. Roddenberry, M.	FAMU/FSU
2020	Basalt FRP-FRC Link-Slab Demonstration Project Monitoring (STIC-Phase 1)	El-Safty, A.	UNF
2020	Inspection and Monitoring of Fabrication and Construction for the Halls River Bridge Replacement	Roddenberry, M.	FAMU/FSU
2020	HSSS Strands and Lightweight Concrete for Pretensioned Concrete Girders (w/ Shear & Confinement Rebar)	Roddenberry, M.	FAMU/FSU
2021	Testing Protocol and Material Specifications for Basalt Fiber Reinforced Polymer Bars (Long-term Durability Modelling)	Kampmann, R. Tang, Y	FAMU/FSU
2021	Evaluation of GFRP Spirals in Corrosion Resistant Concrete Piles	Jung, S.	FAMU/FSU
2021	Development of GFRP Reinforced Single-Slope Railing	Consolazio, G.	UF
2021	Epoxy Dowelled Pile Splice Evaluation & Testing	Mehrabi, A.	FIU

# FDOT Implementation

Design and Construction

# FRP Implementation for Florida Bridges and Structures...

- **Mid-1990's** 1<sup>st</sup> recorded GFRP & CFRP bridge beam strengthening (*Spray up & Wraps*)
- **1990-2000's** Expanded CFRP bridge beam strengthening (*Wraps & Laminate Strips*)
- **2006** 1<sup>st</sup> FRP fender system Specs & Standard Index issued (*Piles & Wales*)
- **2014** PortMiami: Tunnel approach retaining walls 5 & 6 (*BFRP Rebar*)
- **2015** University of Miami: FRP-Prestress Double-T Innovation Bridge (*CFRP Strands, BFRP & GFRP Rebar*)
- **2016-19** Halls River: FDOT 1<sup>st</sup> complete FRP-PC/RC/HCB bridge (*Hybrid Composite Beam, CFRP Strands, BFRP & GFRP Rebar*)
- **2019** US41/North Creek & NE 23rd/Ibis Waterway: 1<sup>st</sup> 2-span & 3-span cast-in-place GFRP-RC Flat-Slab bridges, and soldier pile precast panels (*FRP Rebar & Strands*)

# FDOT Implementation of FRP Structural Reinforcement

## Why?

- **Durability** needs – low-maintenance, extended service-life, cost-effective solutions, reducing work zones.
- **Structural** needs – Inspectable, repairable, robust, extended span lengths (light-weight and/or high-strength & high-endurance):

**Structural Advancement**

**Highly Corrosion-Resistant**

## What?

- **FRP-Prestressed Concrete** (*Carbon strands*)
- **FRP-Reinforced Concrete** (*Glass & Basalt*)
- **TP Piles and TS Structural Shapes** (*GFR/GFRP reinforced*)

## Complementary or Competitive?

- **Light-weight Concrete or FRP** (*Longer spans and/or less shipping cost*)
- **Ultra-High Performance Concrete** (*UHPC*)
- **HSSS-Prestressed Concrete** (*2205 Duplex Stainless-Steel*)

# FDOT Implementation of FRP Structural Reinforcement



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<https://www.fdot.gov/design/innovation/>

## Office of Design

Office of Design / Design Innovation

## Design Innovation

Office of Design  
Florida's Transportation Engineers

### Non-Corrosive

The Florida Department of Transportation (FDOT) continually strives to enhance all areas of its operations. In support of these efforts, the department recently moved into a bold new era for innovative ideas, research and accelerated implementation. Success will depend on our ability to carefully evaluate or implement the products and services provided to the users of Florida's transportation system. Our goal is to utilize newly developed technology or employ creative thinking to generate greater value for every transportation dollar invested.

After researching and evaluating many innovative ideas, the Central Office has developed a list of concepts, products and services that may be the best solution to the project's needs or design challenges. Some items on the list are completely developed, and only need tailoring to your project. We encourage you to propose one or more of these innovations for project specific solutions with confidence of approval by the Districts. Other items are not fully detailed and will require coordination with and approval by the District's Design Office. Many of these innovations have been successfully implemented in other states and countries. Not all projects benefit from these innovations and the Department is not advocating the general use of new products or designs where an economical well proven solution exists and is the most appropriate solution for the situation.

### FDOT Transportation Innovation Challenge

### Highly Corrosion-Resistant

The Department invites you to share your thoughts on ways we can challenge ourselves to be innovative, efficient and exceptional at our [invitation to innovation website](#)

## Structures Design Office

### Curved Precast Spliced U-Girder Bridges

Fiber Reinforced Polymer Reinforcing [ 2015 ]

FRP Members and Structures [ 2019 ]

Geosynthetic Reinforced Soil Integrated Bridge System

Geosynthetic Reinforced Soil Wall

Prefabricated Bridge Elements and Systems

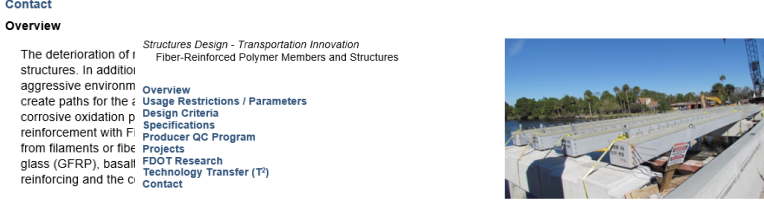
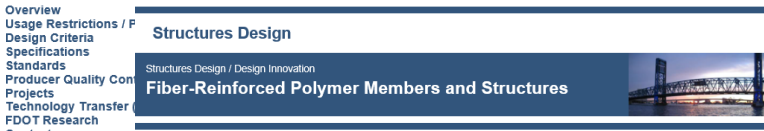
Segmental Block Walls

Ultra-High Performance Concrete (UHPC) [ 2020 ]

+ Stainless-Steel Prestressing Strand & Rebar [ 2021 ]

# FDOT FRP Implementation Resources

- FDOT's Implementation Strategy (Design, Construction, Manufacturer Approval)



The deterioration of carbon-steel reinforced/prestressed (RC/PC) concrete and structural steel is one of the prime causes for increasing maintenance costs and structurally deficient structures. In addition to being exposed to weather effects, transportation structures in Florida are also commonly located in aggressive environments such as chloride ion-rich coastal locations and inland water crossings with low pH (acidic) or high sulfate content (SO4). Structural steel is not permitted for use in the splash-zone as defined by the **FDOT Structures Manual**, and RC/PC structures with the splash-zone are typically required to utilize corrosion-resistant materials. Another innovative approach to combat this major issue is to utilize Fiber Reinforced Polymer (FRP) structures, members and/or components. FRP members are made from filaments or fibers bound in a polymeric resin matrix. FRP members of current interest are made from various inorganic fibers such as glass (GFRP), basalt (BFRP) or carbon (CFRP). A surface coating is often provided for exposed elements to provide UV protection, or alternatively surface treatment (aggregate coating, deformations, or grooving) may be required at an interface to improve shear transfer to composite concrete surfaces.

## FLORIDA DEPARTMENT OF TRANSPORTATION



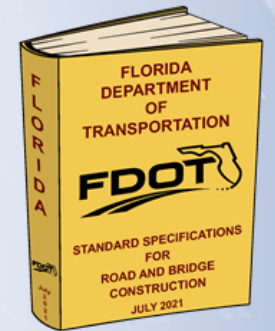
Image courtesy of BCC Engineering

## STRUCTURES MANUAL

- [Introduction - General Introduction](#)
- [Volume 1 - Structures Design Guidelines](#)
- [Volume 2 - Structures Detailing Manual](#)
- [Volume 3 - FDOT Modifications to LRFDLTS-1](#)
- [Volume 4 - Fiber Reinforced Polymer Guidelines](#)

- [Frequently Asked Questions](#)
- [2021 Revision History](#)
- [Archived Structures Manuals](#)
- [Additional Links](#)

<https://www.fdot.gov/programmanagement/Implemented/SpecBooks/default.shtm>



## Materials Acceptance and Certification System


Select Report to View

Production Facility	
<a href="#">Aggregate Production Facility Listing</a>	Lists all Aggregate Production Facilities
<a href="#">All Producers (Excel)</a>	Lists all non-expired Production Facilities in an Excel file
<a href="#">Approved Aggregate Products For Friction Course</a>	Lists all Aggregate Friction Course Products by Geological
<a href="#">Approved Aggregate Products From Mines or Terminals Listing</a>	Lists Approved Aggregate Products for Mines or Terminals
<a href="#">Approved Products at Expired Mines or Terminals</a>	A summary report to identify Approved Products at Expired Terminals Expired at Mine
<a href="#">Asphalt Production Facility Listing</a>	Lists all Asphalt Production Facilities
<a href="#">Asphalt Recycled Products</a>	Approved Asphalt Recycled Products Report by Plant
<a href="#">Asphalt Targets</a>	A listing of the asphalt gradation and gravity (Gsb) data for
<a href="#">Cementitious Materials Production Facility Listing</a>	Lists Cementitious Materials Production Facilities
<a href="#">Coatings Production Facility Listing</a>	Lists all Coatings Production Facilities
<a href="#">Fiber Reinforced Polymer Production Facility Listing</a>	Lists all Fiber Reinforced Polymer Production Facilities



# FDOT FRP Implementation Resources

- FDOT's Implementation Strategy (Design, Construction, Manufacturer Approval)



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## Fiber Reinforced Polymer Production Facility Listing

FDOT State Materials Office, 5007 N.E. 39th Avenue, Gainesville, FL 32609 (352) 955-6600



<https://mac.fdot.gov/smreports>

**FRP-02 OWENS CORNING (SEWARD NE)**

Company: Hughes Brothers, Inc.

**FRP-06 PULTRALL**

Company: Pultrall Inc.

**FRP-07 MATEENBAR MIDDLE EAST FZE**

Company: Mateenbar Middle East FZE

**FRP-08 ATP**

Company: ATP

**FRP-10 B&B FRP MANUFACTURING**

Company: B&B FRP Manufacturing

**FRP-12 TUF-BAR INC (EDMONTON CANADA)**

Company: Tuf-Bar Inc.

**FRP-11 TOKYO ROPE USA (MICHIGAN)**

Company: Tokyo Rope MFG. CO., LTD

Physical Address: 40 Millwick Dr Unit 9

Physical Address: 8301 Ronda Dr Canton, MI 4818

Physical Address: 5715-76 / CANADA

Physical Address: CANADA

**FRP-14 TUF-BAR INC (ONTARIO CANADA)**

Company: Tuf-Bar Inc.

Physical Address: 7 Erin Park Dr

Physical Address: CANADA

Physical Address: CANADA

Physical Address: CANADA

Physical Address: CANADA

Physical Address: CANADA

Physical Address: CANADA

Physical Address: CANADA

Email: kyuso.morino@tokyorope.com

Fax:

Email: jay@tufbarcan.com

Fax:

Mailing Address:

7 Erin Park Dr

CANADA

QC Plan Status: Quality Control Plan ACCEPTED 12/11/2019

**FRP-01 CREATIVE PULTRUSIONS**

Company: Creative Pultrusions

Contact: Donald A

Phone: (814) 835

Physical Address:

214 Industrial Lane Alum Bank, PA 15521

QC Plan Status:

FRP FENDE

FRP SHEET

FRP SPLICE

**FRP-05 TANGENT TECHNOLOGIES LLC - WINCHESTER VA PLANT**

**FRP-18 TANGENT TECHNOLOGIES**

Company: Tangent Technologies, LLC

Contact: Dave Schaefer

Phone: (507) 372-1

Physical Address:

1001 Sullivan Road Aurora, IL 60506

Physical Address:

750 Rosedale Drive Dayton, OH 45402

QC Plan Status: Qu

PLASTIC LUM

PLASTIC WAL

FRP FENDE

FRP SPLICE

Quality Control Plan ACCEPTED 5/30/2019

FRP STRUCTURAL SHAPES

Thermoset Pultrusion

**FRP-13 COMPOSITE ADVANTAGE**

Company: Composite Advantage LLC

Contact: JONATHAN

Phone: (937) 721

Physical Address:

11 Ballera Ct

FRP FENDE

FRP SPLICE

AUSTRAL

Quality Control Plan ACCEPTED 5/30/2019

FRP STRUCTURAL SHAPES

Thermoset Pultrusion



GFRP rebar for precast panels & bent caps of NE 23<sup>rd</sup> Ave (2020-21)



GFRP Secant-Pile Shaft cages for A1A-Flagler Beach seawall (2019)



CFRP-PC FSB's US-1/Cow Key Span replacements (2020)



CFRP-PC Sheet Pile Bulkheads for Halls River Bridge (2017-18)

# Typical Project Examples of Structural FRP Reinforcement

Design and Construction  
Prestressed Concrete  
Reinforced Concrete  
Structural Members & Systems



Navigation Fender Systems



HCBs Halls River Bridge (2017-19)



# Typical Project Examples: FRP-RC & PC

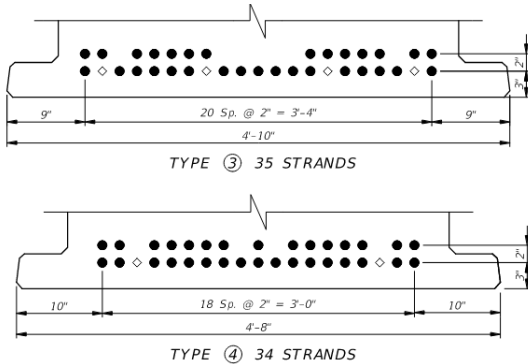
Fast-Facts:

<https://www.fdot.gov/structures/innovation/FRP.shtm#link9>

Structures Design / Design Innovation  
**Fiber Reinforced Polymer**

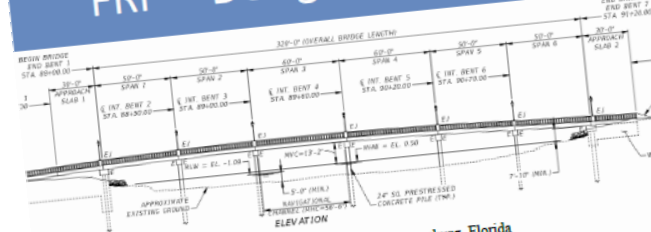
Structures Design - Transportation Innovation  
Fiber Reinforced Polymer (FRP)  
Reinforcing Bars and Strands

Overview  
Usage Restrictions / Parameters  
Design Criteria  
Specifications  
Standards  
Producer Quality Control Program  
Projects  
Technology Transfer (T<sup>2</sup>)  
FDOT Research  
Contact



40<sup>th</sup> Ave NE/Placido Bayou

## FDOT Transportation Innovation Initiative: FRP – Design Innovation



Fast Facts:  
Carbon & Glass  
Fiber-Reinforced  
Polymer



Project Location: St Petersburg, Florida  
Agency: Florida Department of Transportation  
URL: <http://www.fdot.gov/structures/innovation/FRP.shtm>  
Project Name: 40<sup>th</sup> Ave NE over Placido Bayou  
Bridge No. 157141  
FPID: 443600-1-58-01

Project Description: Bridge replacement and over Placido Bayou with CFRP/GFRP FSBs, Bent Caps and Piling  
Project Purpose & Need: Replacement of local agency 2-lane bridge, with widened raised sidewalks and bicycle lanes using corrosion-resistant prestressed and reinforced concrete elements for extended durability. The new bridge is 320-foot long x 58-foot wide, four (4) 50-foot spans and two (2) 60-foot spans in the navigation channel with 13-foot vertical clearance at MHW, for passage of recreational watercraft. The existing 19xx superstructure is composed of hollow prestressed "Sonovoid" slab units with severe underside corrosion above the channel navigation spans.

Overall Budget/Cost Estimate: \$5,300,000 (Bridge)

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◇ - STRANDS DEBONDED 3'-0" FROM END OF BEAM

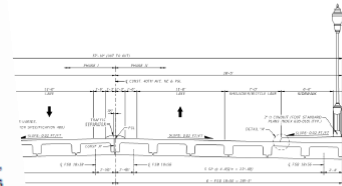
is project? Florida's first new vehicular bridge to use CFRP prestressed slab bent caps and bulkhead caps using GFRP-RC. Abutments and embankment sheet piles.

tech: Superstructures located in the splash-zone require concrete using ternary silica fume, metakaoline, ultrafine flyash or calcium nitrate additives. Also, vice load are usually limited to zero, and waterproofing sealants may be

orida Slab Beams (FSB18) using CFRP prestressing strands and GFRP egradation due to steel corrosion with no need for reduction in the AASHTO resses.

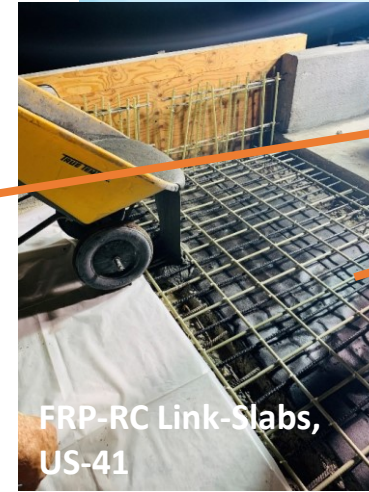
- 0 0.6-inch diameter CFRP strands (approx. 90,000 LF + 15,000 LF Strands N) for prestressing 72'-FSB (18'x36" and 18'x38") x 49" & 59" units.
- 1) GFRP shear stirrups and transverse reinforcement in FSBs (approx. 111,000 LF)
- GFRP reinforcement in pile bent caps and bulkhead caps (approx. 119,000 LF #5's and 7,000 #6's)
- CFRP & SS 24" square prestressed concrete piles (approx. 4350 LF)
- FRP sheet piles (approx. 6,800 SF)

cted: FRP reinforcement eliminates the need for additional concrete waterproofing sealants for corrosion protection. Lightweight significantly lower labor and equipment costs because of the handling. Other life and low maintenance costs for the owner.



- TBA  
onsultant: Cardno  
ontractor: TBA  
on Engineering Inspection: TBA  
er of Record: Christopher Gamache, P.E.  
[christopher.gamache@cardno.com](mailto:christopher.gamache@cardno.com)  
ject Manager: Ziba Mohammadi, P.E.

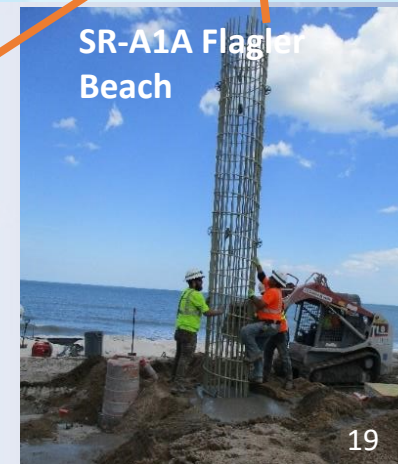
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FRP-RC Link-Slabs,  
US-1



US-1/Cow Key Channel

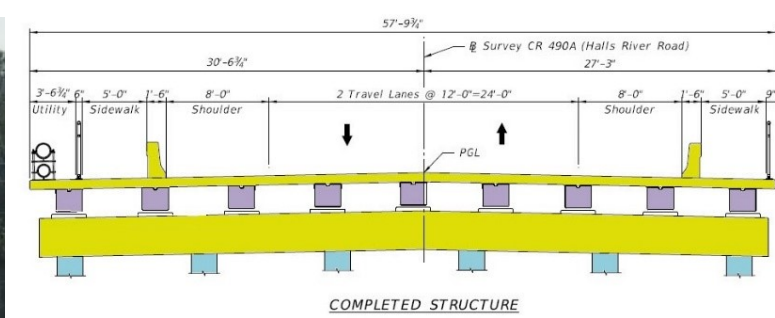


SR-A1A Flagler  
Beach

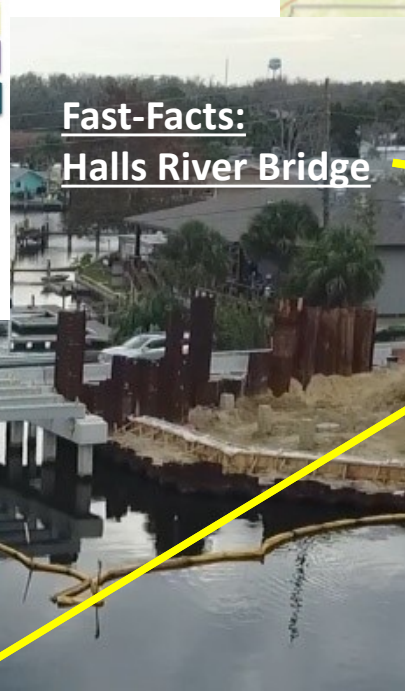
# Typical Project Examples: FRP-RC & PC



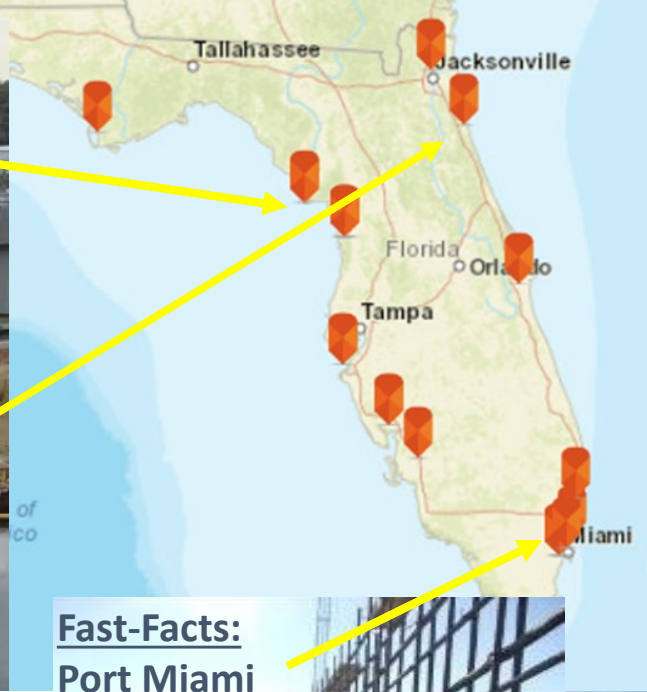
PC Sheet Pile



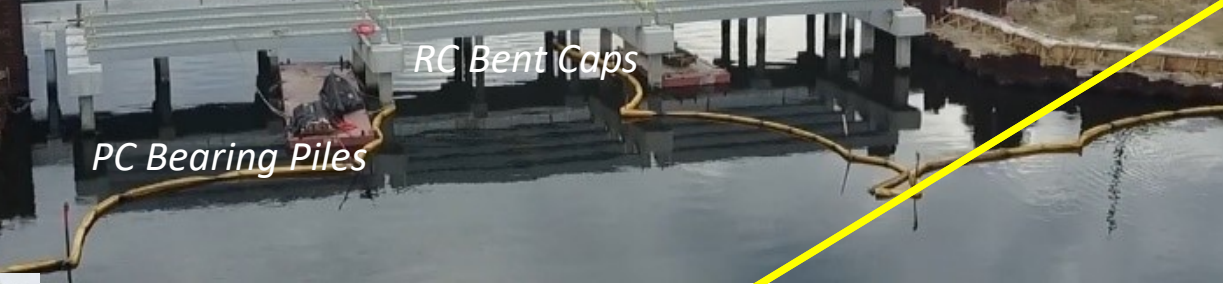
- GFRP
- HCB
- CFRP



Fast-Facts:  
Halls River Bridge

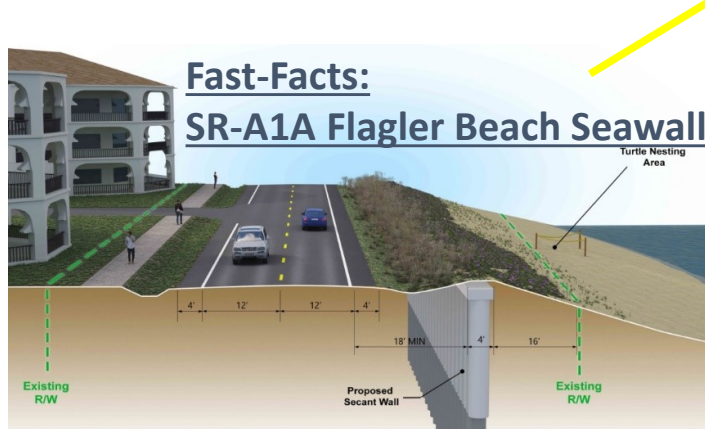


PC Sheet Piles



RC Bent Caps

PC Bearing Piles



Fast-Facts:  
Port Miami  
Tunnel

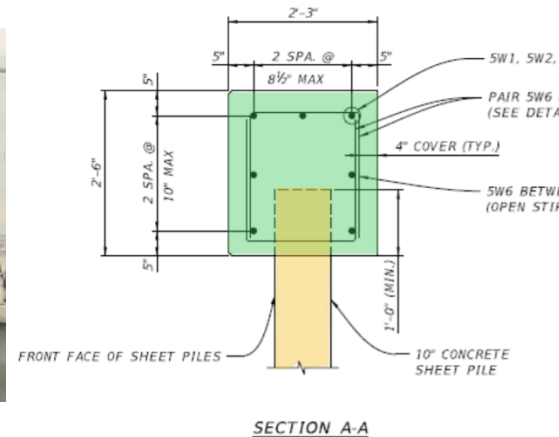
RC Retaining  
Walls

# Typical Project Examples: FRP-RC & PC

- Bridge Superstructures (US-1/Cow Key Channel, US41/North Creek, NE23rd Ave/Ibis; 40th Ave N/Placido Bayou)

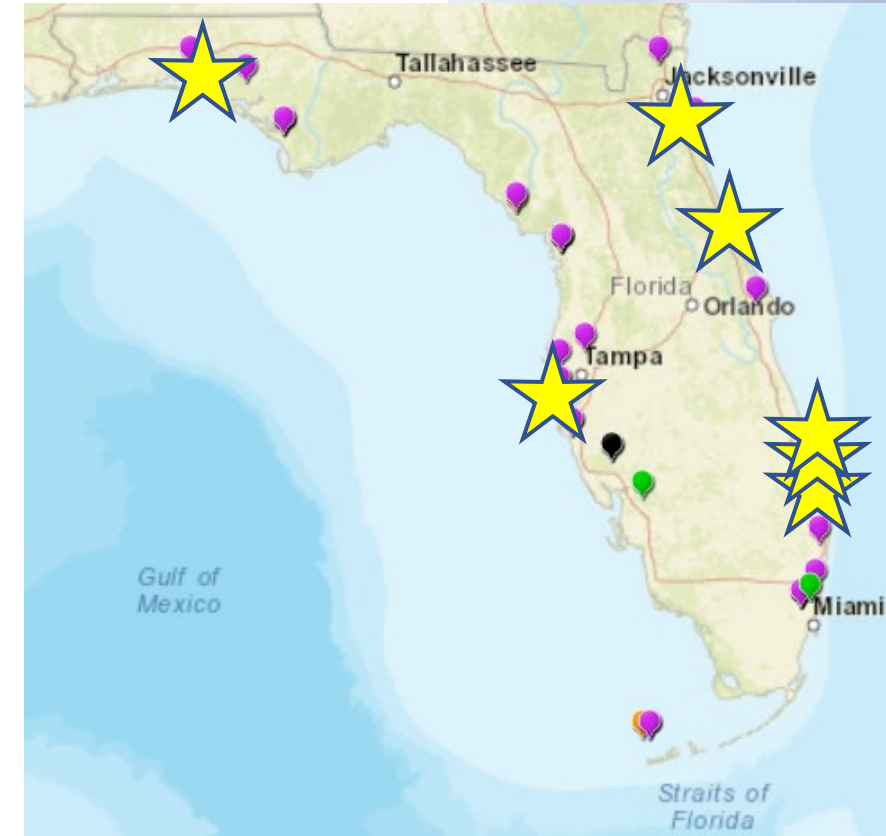


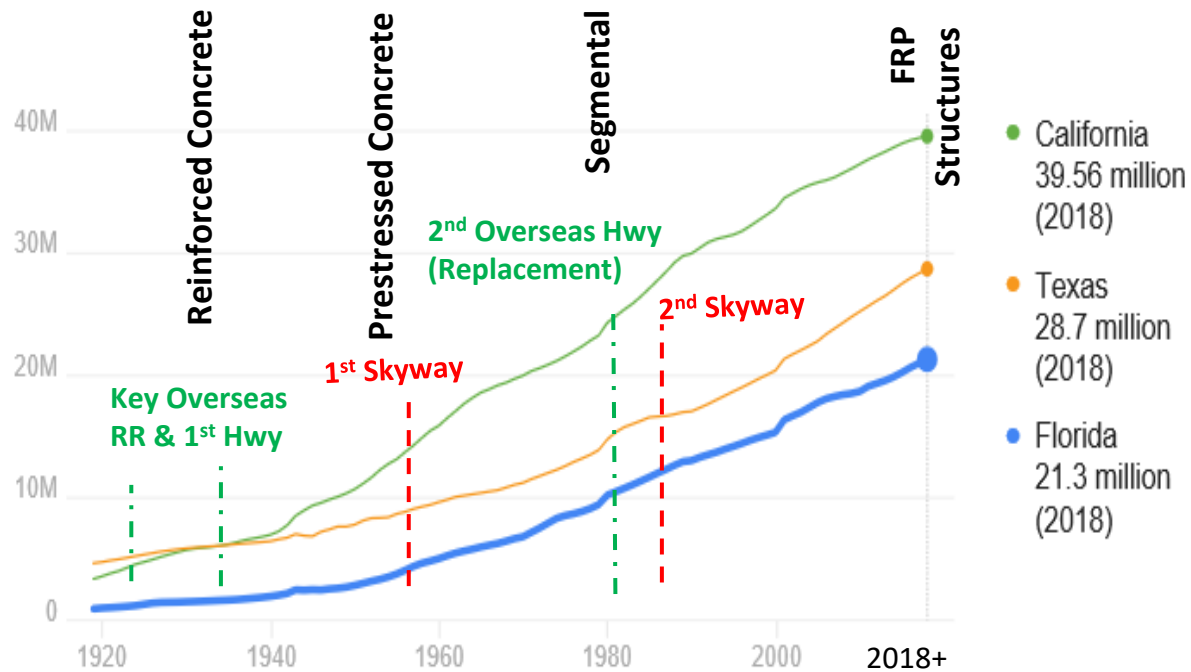
- Bridge Foundations (South Maydell Dr; SR30 Inlet Beach Underpass)
- Seawalls (Skyway SB Approach, SR30/St Joe Bay Inlet, Pinellas Bayway E)



# New FRP-PC/RC Projects in Design

- Low-level Pedestrian Piers -
  - SR-A1A North Bridge/Indian River Lagoon
  - US-1/Jupiter Inlet
- Prestressed Bridges
  - CR30A/Western Lake
  - SR82/Earman Canal
  - Kings St/San Sebastian River;
- Bridge Foundations –
  - 4<sup>th</sup> St over Big Island Gap (bent caps & piles)
  - Barracuda Ave/North Indian Lagoon





## POPULATION GROWTH & STRUCTURAL TECH. IMPLEMENTATION

# What is needed for scaling deployment

Design and Manufacturing

# What is needed for scaling deployment

- Design

1. Cost Justification & competitive bidding
2. Standards & Specs that reflect current material properties
3. Harmonize provisions from different codes (national & international)
4. Improve detailing of structural members to reflect FRP specificity
5. Standardized Precast/Prestressed Design Shapes... but FRP shapes???
6. Reliable Design Software...

- Manufacturing

1. Reliable Producer approval/certification and Quality Assurance.
2. Improve the procurement process
3. Improve production and supply of rebar bent shapes potentially separate from pultruder of straight bars
4. Rebar cage prefabrication?
5. Improve connections/coupling



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## 2021 Transportation Infrastructure Durability Conference

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