THE COMPOSITES iacmi INSTITUTE WINTER 2021 MEMBERS MEETING

Advancements in FRP composite usage for Highway Infrastructure in Florida

Steven Nolan, P.E.
Senior Structures Design Engineer
Florida Department of Transportation

(February 17, 2021)

FDOT

PUT IT DOWN IT'S THE LAW

Advancements in FRP composite usage for Highway Infrastructure in Florida

Steven Nolan, P.E.
Senior Structures Design Engineer
Florida Department of Transportation

Biography:
Steve has worked for the FDOT since 1996 and a registered Professional Engineer in Florida. He currently leads the Advanced Materials for Structures initiatives within the State Structures Design Office and includes FRP composites, High-Strength Stainless Steel strands, Fiber-Reinforced Concrete, and Ultra-High Performance Concrete materials. In his 24 years with FDOT he has worked with in-house bridge design and developed many of the Department's precast and prestressed concrete Standards. He is an active member of the Transportation Research Board's AFF80/AKB10 Committee on Structural Composites/Innovative Highway Structures; the Bridge Engineering Institute's Scientific Advisory Panel; and a reviewer for several engineering journals. Steven has co-authored and presented numerous papers on FRP and prestressed concrete related to bridges and coastal structures.

ABSTRACT

Advancements in FRP composite usage for Highway Infrastructure in Florida

FDOT has been involved in researching composite FRP's since the late 1980's. This research led to successful project applications beginning in the 1990's for bridge structure repair and strengthening typically required due to either corrosion and/or truck impact damage and continues to evolve today.

Broad use of composite FRP structures for new construction began in the 2000's with navigational fender systems that are used to guide vessels and protect bridge piers. Later research and demonstration of lightweight applications for bridge deck panel evaluation and other minor structural components. Hybrid composite beams coupling FRP and concrete are now gaining acceptance and have been showcased on a few Florida structures, bolstered by the success of other state DOTs. The broadest implementation for new construction applications is with composite rebar starting in the 2010's and the progressing to prestressed concrete applications by mid-decade. Other ancillary structures find use of composites under new construction in minor applications but the reinforced & prestressed concrete are currently receiving the most attention with broadening of fiber types and resin systems.

A robust framework for manufacturer approval and product verification, coupled with standard specification and design guidance is evolving. Proliferation of design practices and partnering with other state and infrastructure stakeholders is consider key to driving further development of innovation and delivering cost effective solutions that can succeed at an infrastructure scale and within the existing culture of the construction industry. This presentation will walk thru FDOT's journey and provide some insights on what a successful value proposition for the future could entail.

OUTLINE

Need, Rules & Tools

1. The Value Proposition
2. Expanding Range of Product Solutions
3. Recent Full-Scale Testing Examples
4. Implementation Tools for Designers, Contractors, & Owners

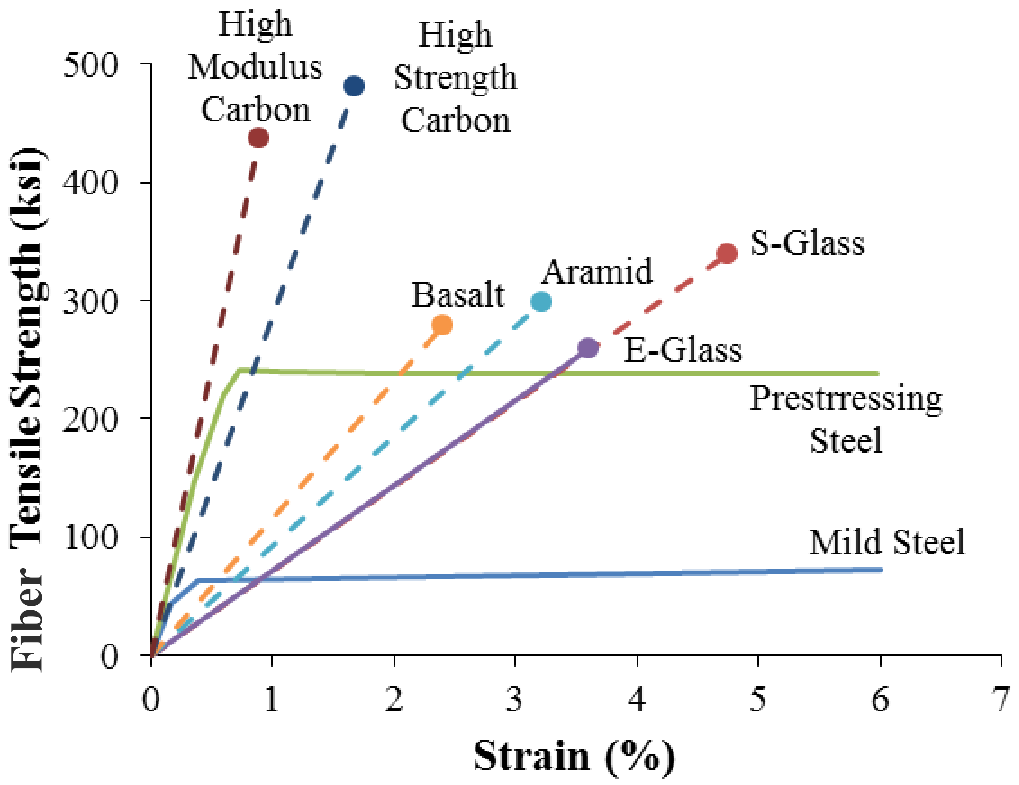
Case Studies

5. Projects Examples
6. Lessons Learned from the Real World
7. Forecasting the Future

The Value Proposition –
Structural Advancement & Durability

(Resilience & Sustainability)

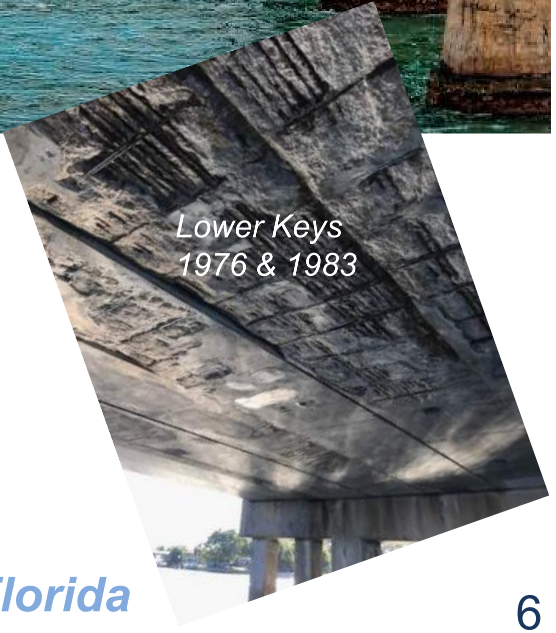
1. **High Tensile Strength**
2. **Low Unit Weight**
3. **High Durability (corrosion-free)**
4. **Innovative Technology Development**
5. **Local/Regional Manufacturing Opportunities**
6. **Low Carbon Footprint?**



The Value Proposition

Durable Solutions and Life Cycle Cost Benefits

- Service Life Expectations for Structures
- Alternative Design Strategies
- Life Cycle Cost policy and comparisons



GUIDE SPECIFICATION FOR SERVICE LIFE DESIGN OF HIGHWAY BRIDGES, 1ST EDITION

Item Code: HBSLD-1

2020

This guide specification is intended to offer design recommendations for agencies wishing to implement service life design principles and detailing recommendations. It was developed to incorporate quantitative approaches, along with proven deemed-to-satisfy provisions, into a single comprehensive design document for implementation on a national level. It also establishes a framework for service life design, while providing opportunities for refinement and expansion, especially as new models capable of simulating deterioration mechanisms become available.

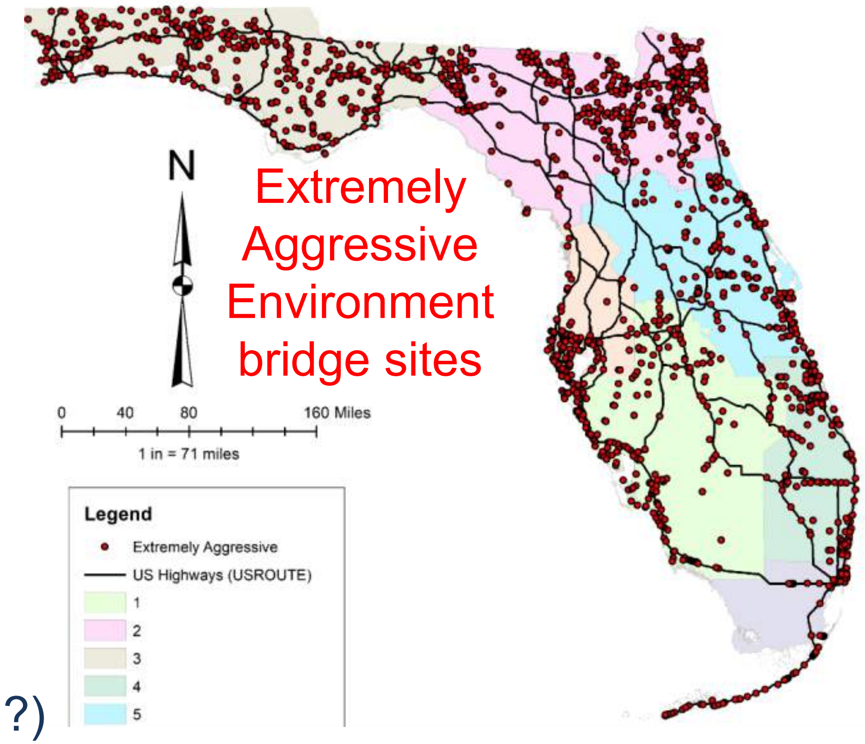
Taking stock of our Bridge & Structures Infrastructure

- **FDOT's Structures Asset Inventory (2019/20)**
  - 12,529 bridges in the State of Florida
  - 7,044 bridges maintained by **FDOT**
  - 150,227,048 SF of deck area
  - 5,485 maintained by others (County, City, Federal)
  - 2,143,163 SY of noise barrier wall
  - 379.22 miles of retaining wall
  - 72.8 miles of seawall

- **FDOT** bridges classified in an **aggressive environment**:
  - 1,534 Bridges
  - 68,857,118 SF Deck
    or about 46%

FRP material systems used in FDOT's Highway Bridges & Structures

1. **FRP-Prestressed Concrete (PC):**
   - **Prestressed Beams** - CFRP strands, GFRP/BFRP auxiliary rebar
   - **Bearing Piles –** CFRP strands, spirals, & splice dowels, (GFRP/BFRP? auxiliary rebar)
   - **Sheet Piles -** CFRP strands, GFRP (BFRP ? *submerged)* stirrups
2. **FRP-Reinforced Concrete (RC):**
   - **CIP Decks & Flat-Slab Bridges -** GFRP (BFRP *now allowed*)
   - **Seawalls –** GFRP *(submerged)*
   - **Bulkhead Caps –** GFRP/BFRP
   - **Retaining Walls -** GFRP/BFRP
   - **Drainage Structures/Box Culverts** – *(no recent examples)*
3. **FRP Elements (MS):**
   - **Fenders, Piles, HCBs, Pedestrian Structures**
4. **Maintenance Repair & Rehabilitation (MR&R)**
   - **Externally Bonded Repairs** (CFRP wrap & laminates, GFRP ?)
   - **Pile Jackets** (Cathodic Protection w/ GFRP shells, FRP dowels & bars)

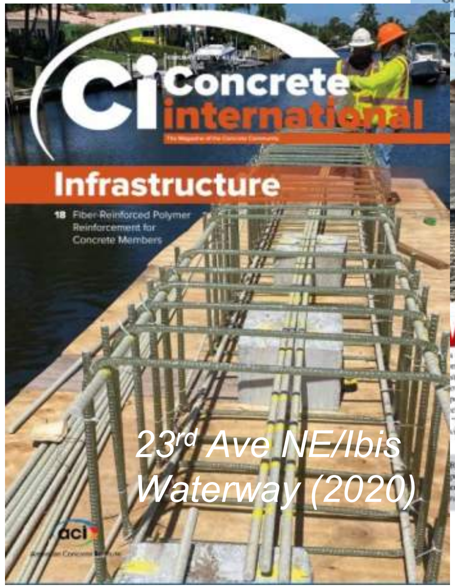


Expanding Range of Reliable FRP Materials & Structural Solutions

i. GFRP rebar & improved properties
ii. BFRP rebar implementation
iii. Improving CFRP strand & bar performance and economy
iv. Pultruded & Molded Structural Components

Halls River Bridge - Traffic Railing Retrofit (2019)

HRB GFRP-RC BentCap (2017)



23rd Ave NE/Ibis Waterway (2020)

Composite Reinforcing Bars for Future Infrastructure

GFRP increases durability of reinforced concrete to meet demands as traffic, rbanization, and extreme weather increase

Ginger Gardiner

Jizan Canal (2020)

Expanding Range of Reliable FRP Materials & Structural Solutions

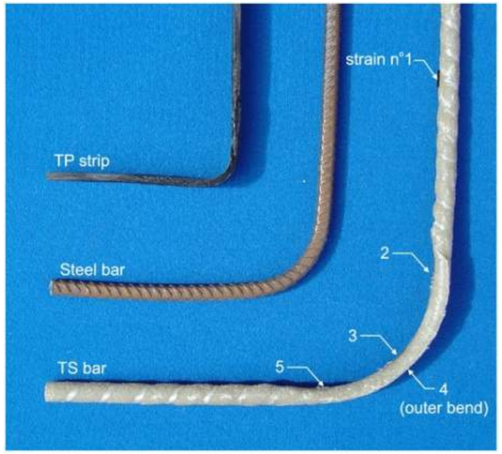
i. GFRP rebar & improved properties

Elastic Tensile Modulus

- ✓ Smaller bars =
  - Higher strength
  - Better crack control
  - Better fit-up *(especially for bent bars bend radius must be ≥ 3 bar diameters)*
- ✓ Less bars *(reducing congestion)*
- ✓ Higher allowable shear stresses
- ✓ Lower deflections

Why is this important for FDOT?

← Improves efficiency in design requiring either



Expanding Range of Reliable FRP Materials & Structural Solutions

i. GFRP rebar & improved properties

Tensile Strength:

✓ Smaller bars =
- better fit-up
- x higher stress - larger crack widths
- x higher fatigue stresses
- x higher sustained loads

✓ Less bars - reduces congestion

x Greater deflections?

x Great surface bond stress demands
- – *May need higher bond strength standard (>> 1.1 ksi)*

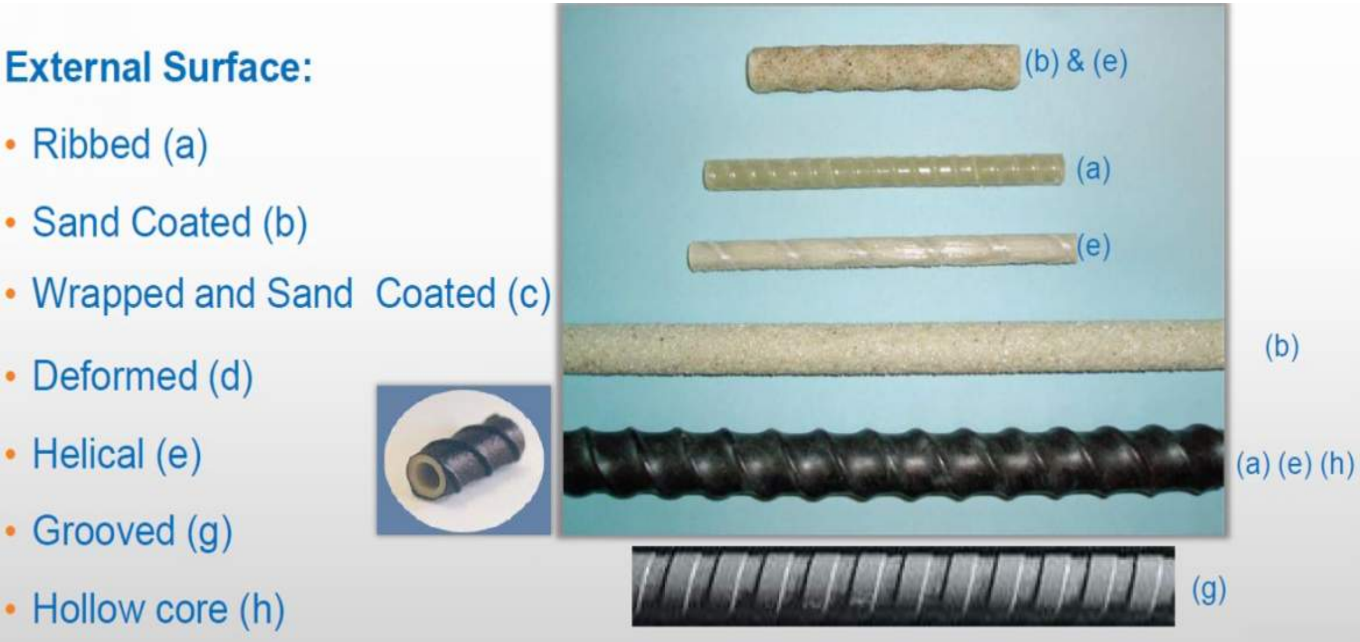


Figure: Different types of FRP [Fu et al. 2019]

Expanding Range of Reliable FRP Materials & Structural Solutions

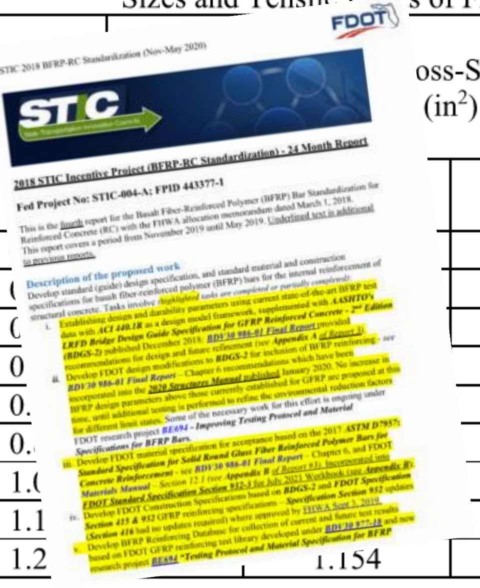
i. GFRP rebar & improved properties

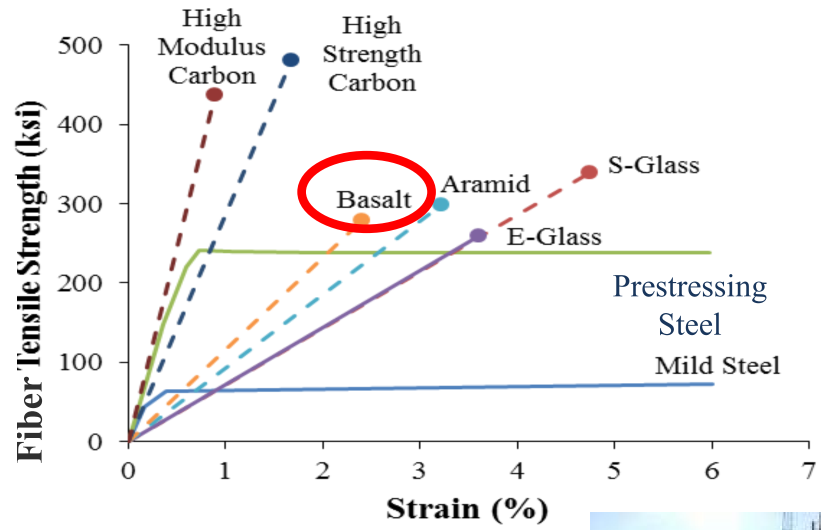
ii. BFRP rebar implementation

932-3.2 Bar Sizes and Loads: The sizes and loads of FRP reinforcing bars shall meet the requirements in Table 3-1. The measured cross-sectional area, including any bond enhancing surface treatments, shall be determined according to Table 3-2.

Table 3-1
Sizes and Tensile L[illegible]s of FRP Reinforcing Bars

Bar Size Designation	I[illegible]	[illegible]oss-Sectional Area (in^2)		Minimum Guaranteed Tensile Load (kips)	
		[illegible]	Maximum	BFRP and GFRP Bars	CFRP Bars
2	[illegible]	[illegible]	0.085	6.1	10.3
3	([illegible]	[illegible]	0.161	13.2	20.9
4	([illegible]	[illegible]	0.263	21.6	33.3
5	0[illegible]	[illegible]	0.388	29.1	49.1
6	0.[illegible]	[illegible]	0.539	40.9	70.7
7	0.[illegible]	[illegible]	0.713	54.1	-
8	1.[illegible]	[illegible]	0.913	66.8	-
9	1.1[illegible]	[illegible]	1.137	82.0	-
10	1.2[illegible]	1.154	1.385	98.2	-


FDOT
STIC 2018 BFRP-RC Standardization (Nov-May 2020)
STIC
STIC Incentive Project (BFRP-RC Standardization) - 24 Month Report
2018 STIC Incentive Project: STIC-004-A; FPID 443377-1
Fed Project No: STIC-004-A; FPID 443377-1
Description of the proposed work




University of Miami – End Bent (2016)


Port Miami Tunnel - Walls 5 & 6 (2014)

Expanding Range of Reliable FRP Materials & Structural Solutions

i. GFRP rebar & improved properties
ii. BFRP rebar implementation
iii. Improving CFRP strand & bar performance and economy
iv. Pultruded & Molded Structural Components

July 2020 & Jan 2021 updates

Table 1-2
Typical Sizes and Loads of CFRP Prestressing Strands and Bars

Type	Nominal Diameter (in)	Nominal Cross Sectional Area (in^2)	Nominal Ultimate Load (P_u) (kips)	Nominal Ultimate Tensile Stress (ksi)
Single Strand - 5.0mm Ø	0.20	0.025~~30~~	9.1	364~~00~~
7-strand - 7.9~~5~~mm Ø	0.31~~0~~	0.048~~50~~	17.8	37~~4~~0
7-strand - 10.8~~5~~mm Ø	0.43~~1~~	0.090	33.1~~2~~	367~~56~~
Single Strand - 9.5mm Ø	0.38	0.110	35.0	318
7-strand - 12.5mm Ø	0.49	0.117~~8~~	43.3~~1~~	370~~47~~
Single Strand - 12.7mm Ø	0.50	0.196	59.0	301
7-strand - 15.2mm Ø	0.60	0.179	66.2~~1~~	369~~41~~
~~19-strand - 20.5mm Ø~~	~~0.81~~	~~0.320~~	~~71~~	~~222~~
7-strand - 17.2mm Ø	0.68	0.234	86.6~~79~~	370 ~~338~~

Expanding Range of Reliable FRP Materials & Structural Solutions

i. GFRP rebar & improved properties
ii. BFRP rebar implementation
iii. Improving CFRP strand & bar performance and
iv. Pultruded & Molded Structural Components

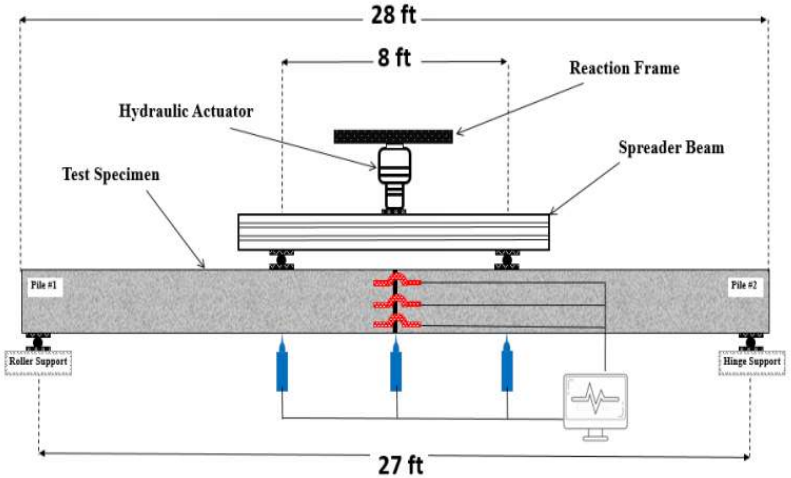

Skyplex Blvd. (2018)

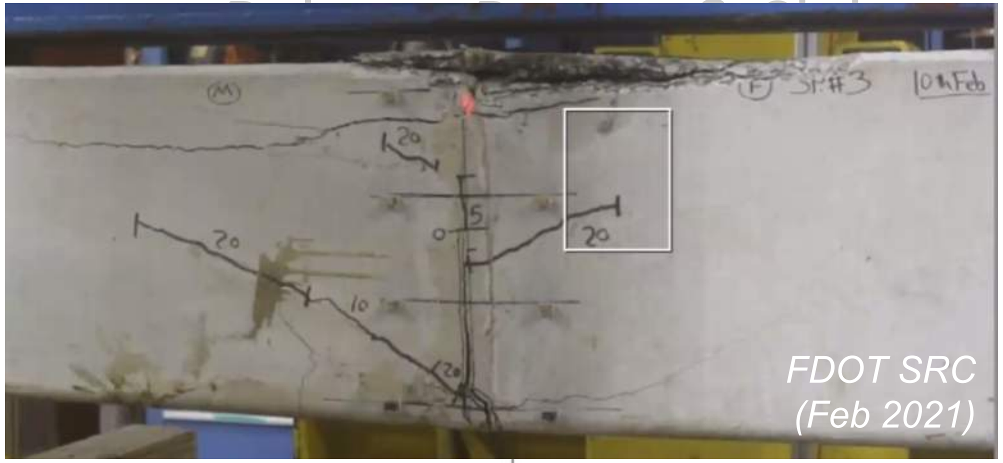
Halls River Bridge (2017)

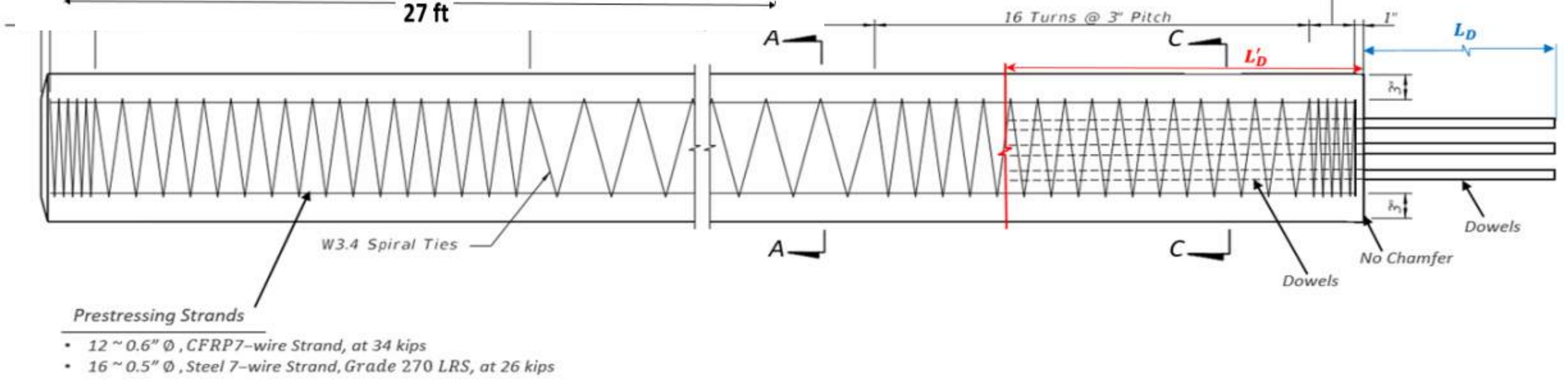
Ocala Water-Recharge Park (2019)

Recent Full-Scale Testing and Research on Beams and Piles

i. GFRP Pile prestressing, spirals and dowel splicing







Recent Full-Scale Testing and Research on Beams and Piles

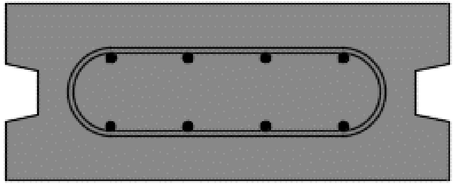
i. GFRP Pile prestressing, spirals and splicing

ii. FRP Shear and Confinement Rebar – Beams & Slabs

iii. Durability Sampling and Testing of Submerged Rebar

Gate Precast, FL (2017)

Halls River Bridge, FL (2017)



Durastress, FL (2019)

Recent Full-Scale Testing and Research on Beams and Piles

i. GFRP Pile prestressing, spirals and splicing
ii. FRP Shear and Confinement Rebar – Beams & Slabs
iii. Durability Sampling and Testing in Wet Environments

Ongoing Project: BE694
Improving *"Testing Protocol and Material Specifications for Basalt Fiber Reinforced Polymer Bars" …* (2019-2021)


Materials Research Report
Final Report
July 2014

UNF Project
Contract No. BDK82-977-05

Degradation Assessment of Internal Continuous Fiber Reinforcement in Concrete Environment

Adel ElSafty, Ph.D., P.E. (Principal Investigator)
Brahim Benmokrane, Ph.D., P.E.
Sami Rizkalla, Ph.D., P.E.
Hamdy Mohamed, Ph.D., P.E.
Mohamed Hassan, Ph.D.

School of Engineering
College of Computing, Engineering, and Construction
University of North Florida
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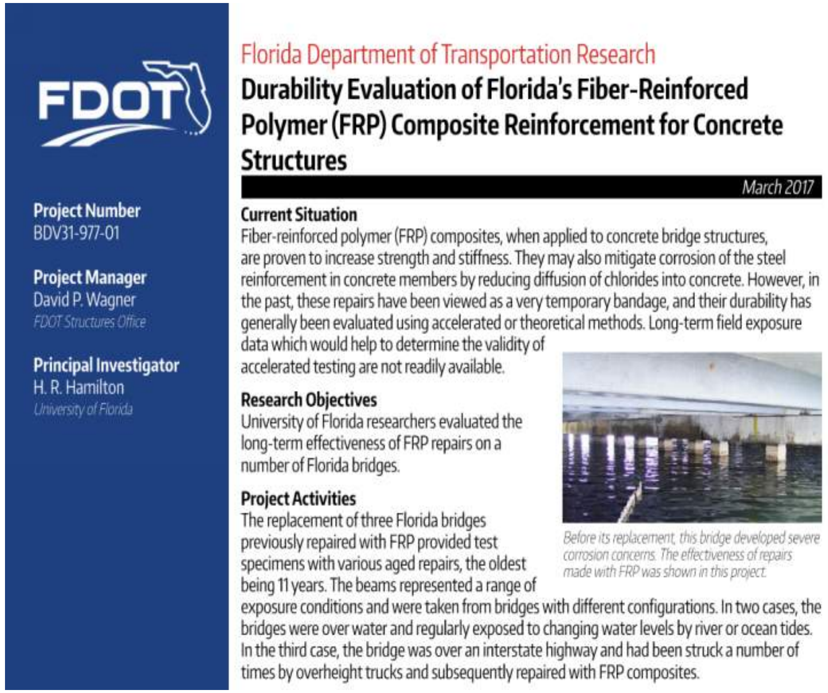
UNF UNIVERSITY of NORTH FLORIDA


FDOT

Project Number
BDV31-977-01

Project Manager
David P. Wagner
FDOT Structures Office

Principal Investigator
H. R. Hamilton
University of Florida

Florida Department of Transportation Research

Durability Evaluation of Florida's Fiber-Reinforced Polymer (FRP) Composite Reinforcement for Concrete Structures

March 2017

Current Situation
Fiber-reinforced polymer (FRP) composites, when applied to concrete bridge structures, are proven to increase strength and stiffness. They may also mitigate corrosion of the steel reinforcement in concrete members by reducing diffusion of chlorides into concrete. However, in the past, these repairs have been viewed as a very temporary bandage, and their durability has generally been evaluated using accelerated or theoretical methods. Long-term field exposure data which would help to determine the validity of accelerated testing are not readily available.

Research Objectives
University of Florida researchers evaluated the long-term effectiveness of FRP repairs on a number of Florida bridges.

Project Activities
The replacement of three Florida bridges previously repaired with FRP provided test specimens with various aged repairs, the oldest being 11 years. The beams represented a range of exposure conditions and were taken from bridges with different configurations. In two cases, the bridges were over water and regularly exposed to changing water levels by river or ocean tides. In the third case, the bridge was over an interstate highway and had been struck a number of times by overheight trucks and subsequently repaired with FRP composites.

Before its replacement, this bridge developed severe corrosion concerns. The effectiveness of repairs made with FRP was shown in this project.


Testing Protocol and Material Specifications
for Basalt Fiber Reinforced Polymer Bars

Contract Number BE694
FSU Project ID: 0428

Submitted to:
Florida Department of Transporta…
Research Center
605 Suwannee Street
Tallahassee, Florida 32399-04…

Chase C. Knight, P…
Project Manager
FDOT State M…

Prepared by:
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FAMU-FSU Engineering

Implementation Tools for Designers, Contractors, & Owners

FDOT Florida Department of TRANSPORTATION

Safety, Innovation, Mobility, Attract, Retain & Train

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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.

Highly Corrosion-Resistant

FDOT Transportation Innovation Challenge

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**

"Higher-Performance Materials"

Structures Design Office

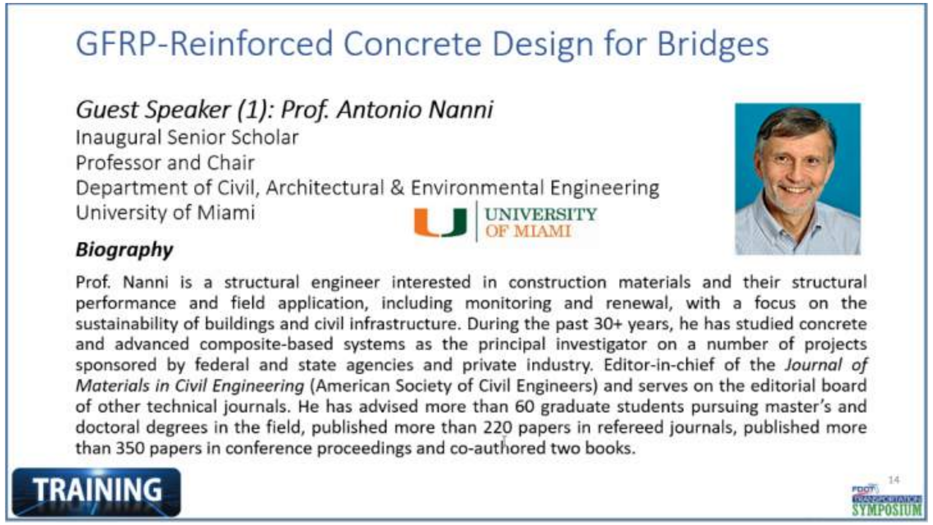
- Curved Precast Spliced U-Girder Bridges
- Fiber Reinforced Polymer Reinforcing
- FRP Members and Structures
- Geosynthetic Reinforced Soil Integrated Bridge System
- Geosynthetic Reinforced Soil Wall
- Prefabricated Bridge Elements and Systems
- Segmental Block Walls
- Ultra-High Performance Concrete (UHPC)

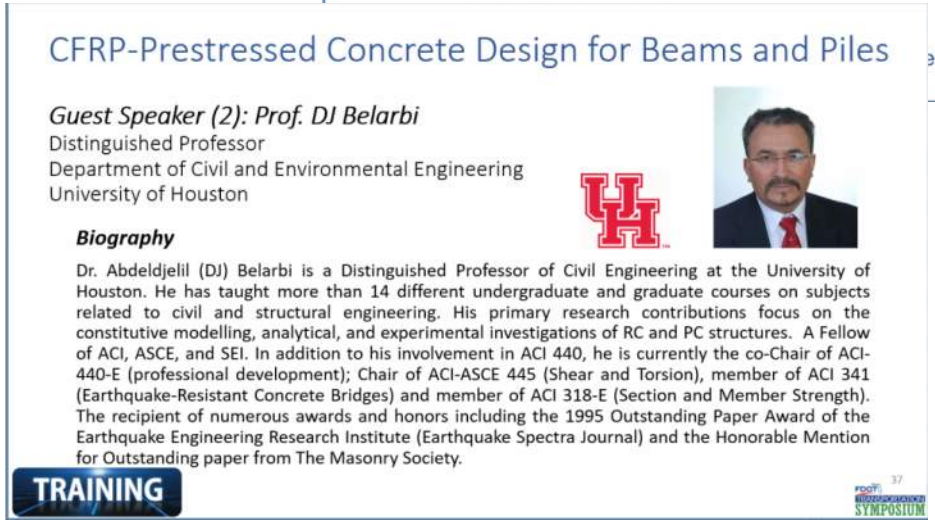
+ Stainless-Steel Prestressing Strand & Rebar

Implementation Tools for Designers, Contractors, & Owners

i. FRP Designer Training
ii. Structural Design and LCC Tools
iii. Technology Transfer Participation

https://www.fdot.gov/structures/innovation/FRP.shtm#link7 (2020)





Implementation Tools for Designers, Contractors, & Owners

i. FRP Designer Training

ii. **Structural Design** and LCC Tools

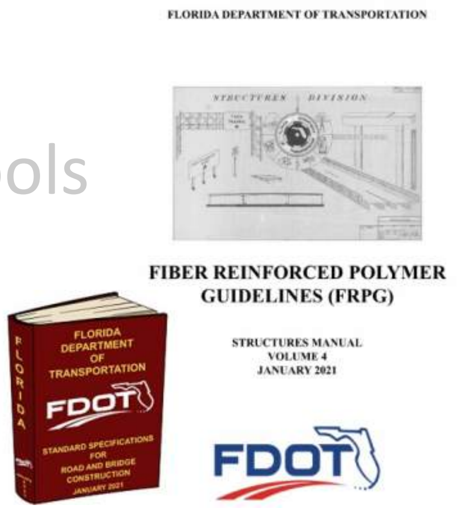
- New construction:
  - **Glass FRP rebar** & **Carbon FRP strands** with improving mechanical properties
  - **Basalt FRP rebar** & possible prestressing applications
  - **Composite Bridge Beams** *(Pultruded, VARTM, Molded & Built-up composite members)*
  - **Hybrid systems** *(HCB, Concrete-Filled FRP Tubes…)*

Implementation Tools for Designers, Contractors, & Owners

i. FRP Designer Training

ii. Structural Design and LCC Tools

- New construction:
- Repair & strengthening.



US Standards

2017

Update for 2021 Under NCHRP 20-07(428)

Current

Future harmonization ???

2019

International Standards


SR-404 over Banana River


SR-404 over Banana River

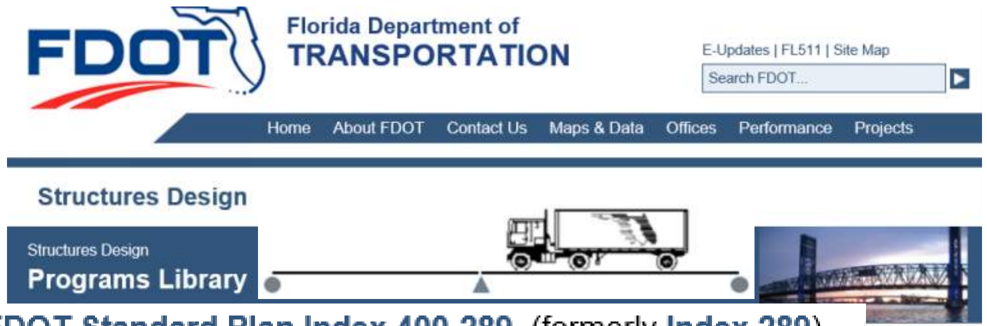
Implementation Tools for Designers, Contractors, & Owners

i. FRP Designer Training

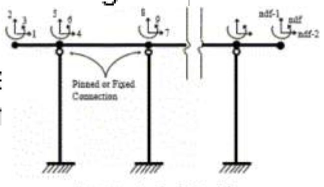
ii. Structural Design and LCC Tools

iii. Technology Transfer Participation

FDOT Design Software



GFRP-RC in development →	**Box Culvert v4.0**	11/07/2018	Exe (Zip) (Mathcad 15)	Used with **FDOT Standard Plan Index 400-289** (formerly **Index 289**) to design concrete box culverts, wingwalls, headwalls, and cutoff walls in accordance with the AASHTO LRFD Bridge Design Specification.
*CFRP-PC Beta version ** (V6.0 coming 2021) →*	**Prestressed Beam v5.2**	11/07/2018	Exe (Zip) (Mathcad 15)	Used with **FDOT Standard Plan Index 450-010 to 450-299** (formerly **Index 20010 to 20299**) to design simple span prestressed beams (Florida-I, AASHTO, Florida Bulb-T, Florida-U, Florida Double-T, Flat Slab, Inverted-T, FSB) in accordance with the AASHTO LRFD Bridge Design Specification.
GFRP-RC included (Worksheet 3b) →	**Bent Cap v1.0**	11/07/2018	Exe (Zip) (Mathcad 15)	Analyzes and designs fixed or pinned bent caps, including la loads, in accordance with the AASHTO LRFD Bridge Desigr Specifications.
GFRP-RC included →	**Retaining Wall v4.0**	06/01/2020	Zip (Exe) (Mathcad 15)	Used with **FDOT Standard Plan Index 400-010** (formerly **Index 6010**) to design and analyze cast-in-place retaining walls in accordance with the AASHTO LRFD Bridge Design Specification.



Bent Cap Analysis Model

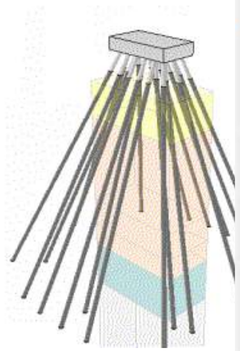
*** Available on request*

Implementation Tools for Designers, Contractors, & Owners

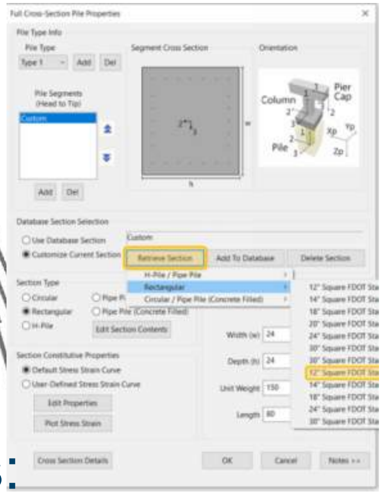
i. FRP Designer Training

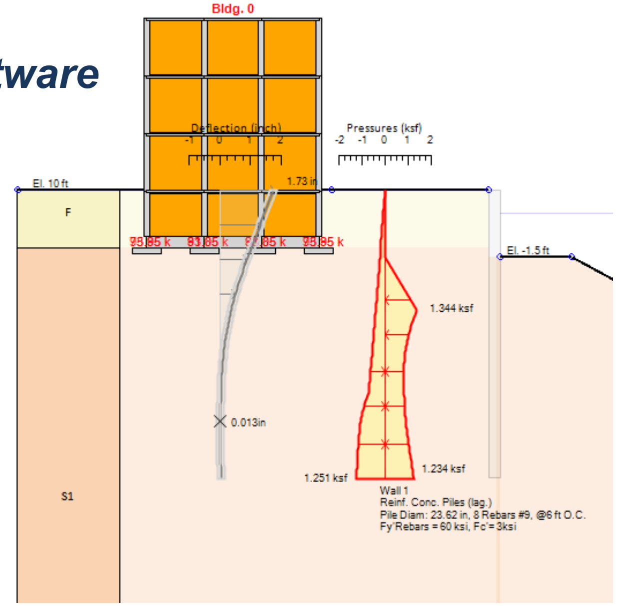
ii. Structural Design and LCC Tools

iii. Technology Transfer Participation



US Design Software





Other Design Software:

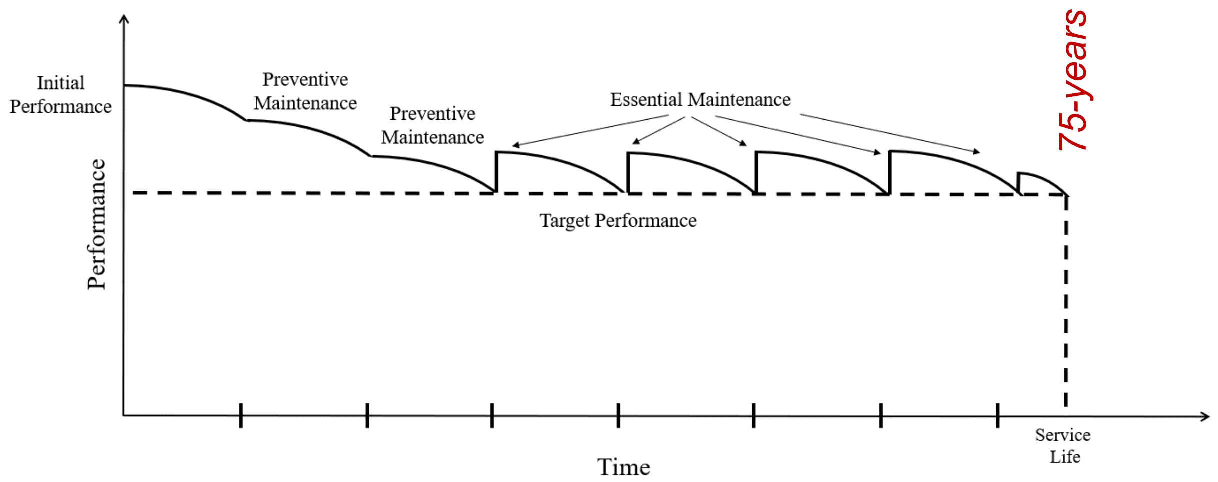
Adaption for FRP analysis or design enhancements:

- **FBMP** (*BSI*) *added Jan. 2021 (see newsletter)*
- **DeepEx** (*Deep Excavation, LLC*)
- **FRPpro™** *emerging tools*
- **Michigan DOT/LTU** CFRP-Beam Design Mathcad: *https://mdotjboss.state.mi.us/SpecProv/trainingmaterials.htm* *(also see TRB Webinar Dec 3, 2019)*
- ...

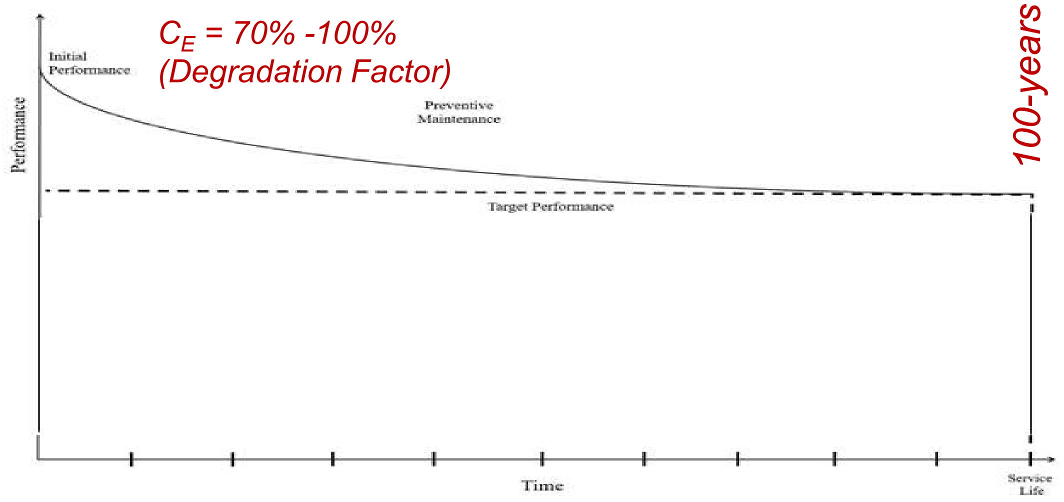
FRPpro™
Manufacturer Private Design Bundle

Implementation Tools for Designers, Contractors, & Owners

i. FRP Designer Training
ii. Structural Design and LCC Tools
iii. Technology Transfer Participation



CS-RC/PC alternative



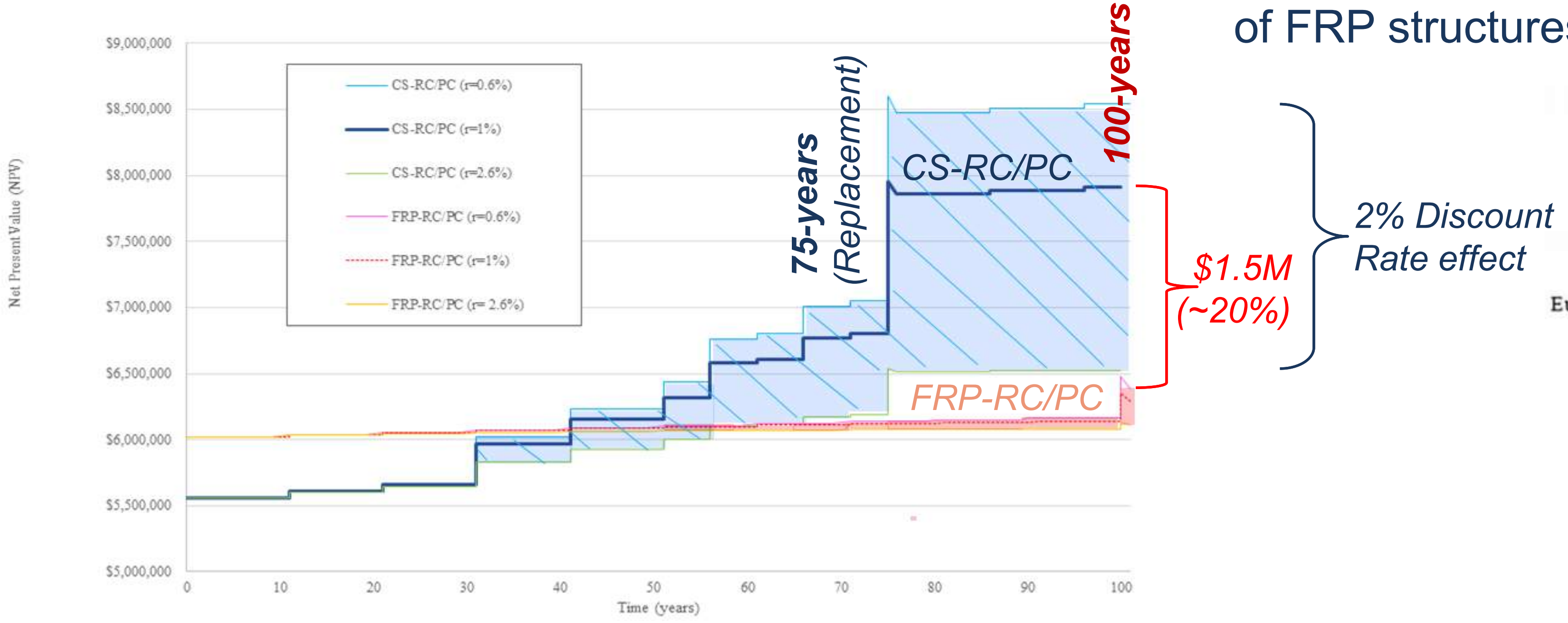
FRP-RC/PC alternative

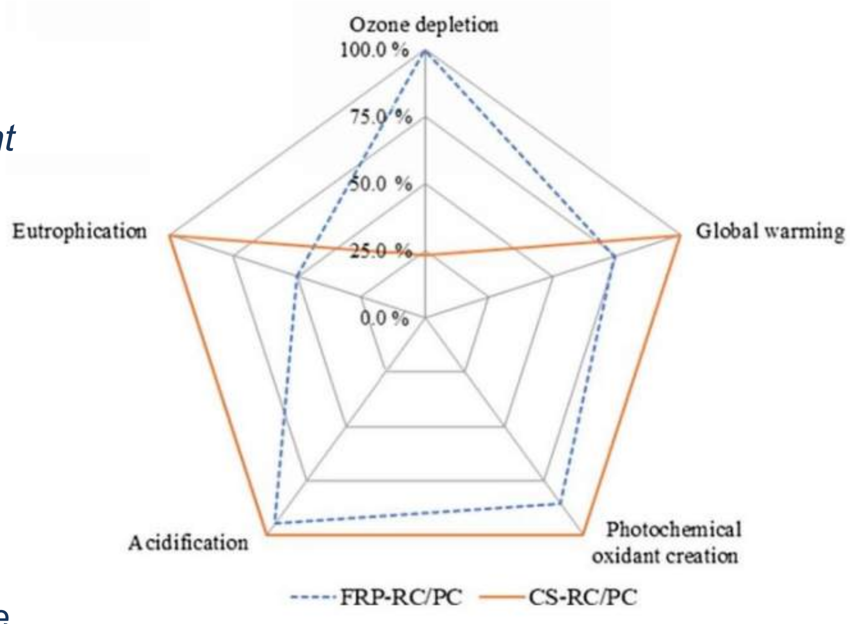
Charts: *Cadenazzi, T., Dotelli, G., Rossini, M., Nolan, S., and A. Nanni. (2019). Cost and Environmental Analyses of Reinforcement Alternatives for a Concrete Bridge. Structure and Infrastructure Engineering.*

Implementation Tools for Designers, Contractors, & Owners

i. FRP Designer Training
ii. Structural Design and LCC Tools

→ Life-Cycle Cost (LCC) analysis & LCA can show the sustainable (economic and environmental) advantage of FRP structures in the coastal environment:

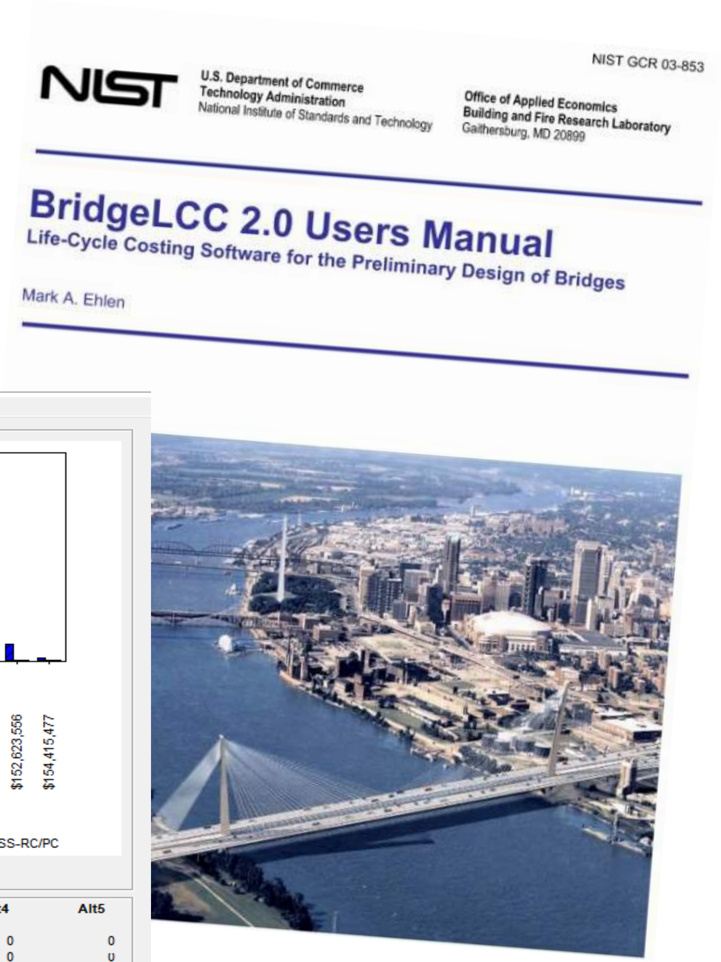


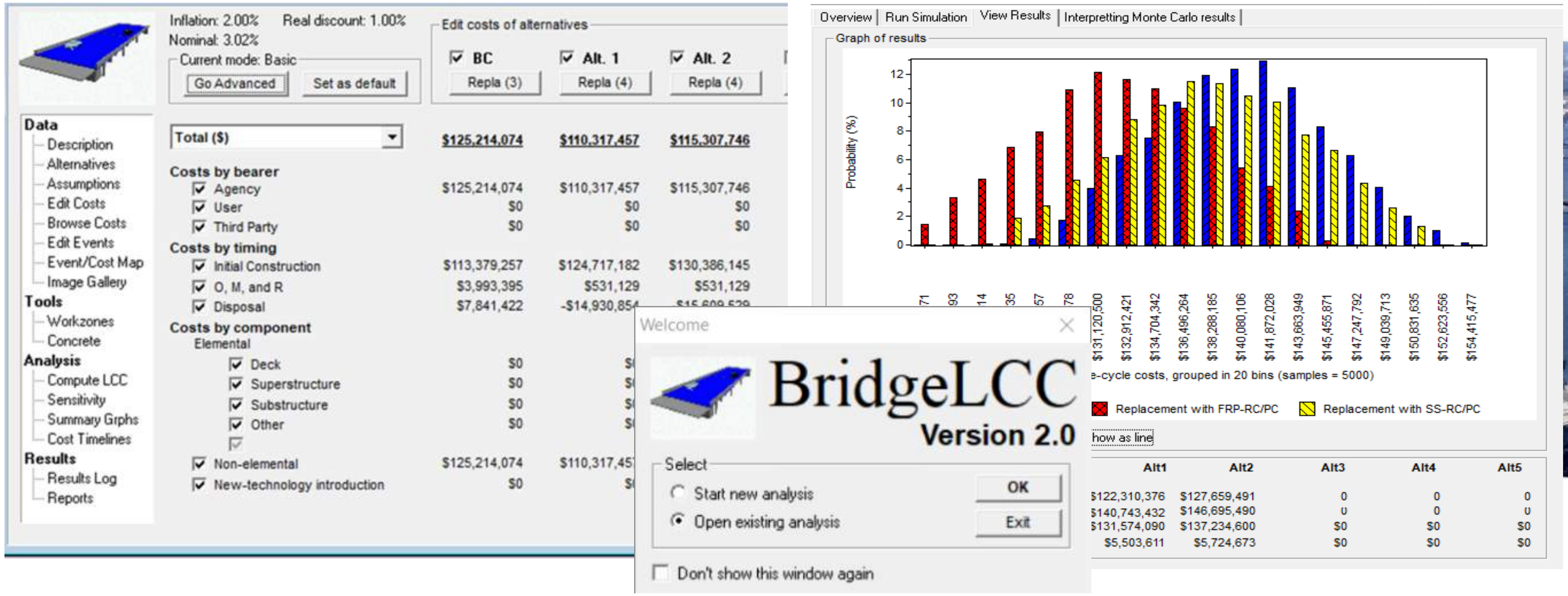


Example LCC & LCA Comparison of Carbon Steel-RC/PC verses FRP-RC/PC bridge (adapted from Cadenazzi et al. 2019)

Implementation Tools for Designers, Contractors, & Owners

i. FRP Designer Training
ii. Structural Design and LCC Tools
iii. Technology Transfer Participation





Implementation Tools for Designers, Contractors, & Owners

iii. Technology Transfer Participation:

1. **Research & Bridge Code Development:**
   TRB *AKB30 &* ***AASHTO*** *COBS T-6 & T-10*
   – **GFRP-RC Bridge Guide Spec – 2nd Edition:** 2018 Task team participation with UM and FDOT staff.
2. **National Training – *AASHTO*** *COBS T-6 &* ***TRB*** *ABK10*:
   – **CFRP-PC Design** - *Under* ***NCHRP 20-44*** program for report implementation assistance for CFRP-1, has ***FHWA*** & ***AASHTO*** *T-6* support.
   – **GFRP-RC Design** - not eligible under this program, so *State* ***DOT****s* and ***FHWA*** are working on it.
3. **AASHTO Guide Specs Review Panels:**
   – ***NCHRP 12-121:*** Developing Specs for FRP Auxiliary Reinf. in PC Girders. (2020-2022)
4. **CAMX**
   – 2016, 2017, 2018, 2019, 2020 (Featured Speaker/Panel)
5. **International:**
   – *International Workshop on GFRP Bars for Concrete Structures (2017, 2019, 2021)*
   – *Lyon (FR) LMC²/AFGC GFRP-RC workshop (2019)*
   – *International Bridge Conference (2018 FRP Workshop)*
6. **TRB Annual Meetings:**
   – **Committee Meeting** participation AFF30, AFF80
   – **FRP Workshops:** *2019* & *2020*
   – **Technical Sessions:** *2018*, *2019*, *& 2021*
7. **TRB 2019 *Webinar*** **-** *Advanced Structural Materials for Concrete Bridges:*
   – UHPC, HSSS/CFRP-PC & GFRP-RC *(Dec. 3, 2019)*
8. **ACI coordination** (informal)
   – **343 & 440 Committees (Bridge & FRP)** *2020 Fall Convention*
   – ***Strategic Development Council*** – *Forum 46 (2019)*
9. **State Level Engagement:**
   – **FRP Industry Workshops** *(2016, 2017, 2018, & 2020)*
   – **FTBA/Contractors** *(2017 & 2018)*
   – **FES/FICE** *(2017)* & **ASCE-FL** *(2018)*
   – **GFRP-RC & CFRP-PC Training** *(Aug & Sept 2020)*

FRP RC/PC material systems used in Florida's Highway Bridges & Structures

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

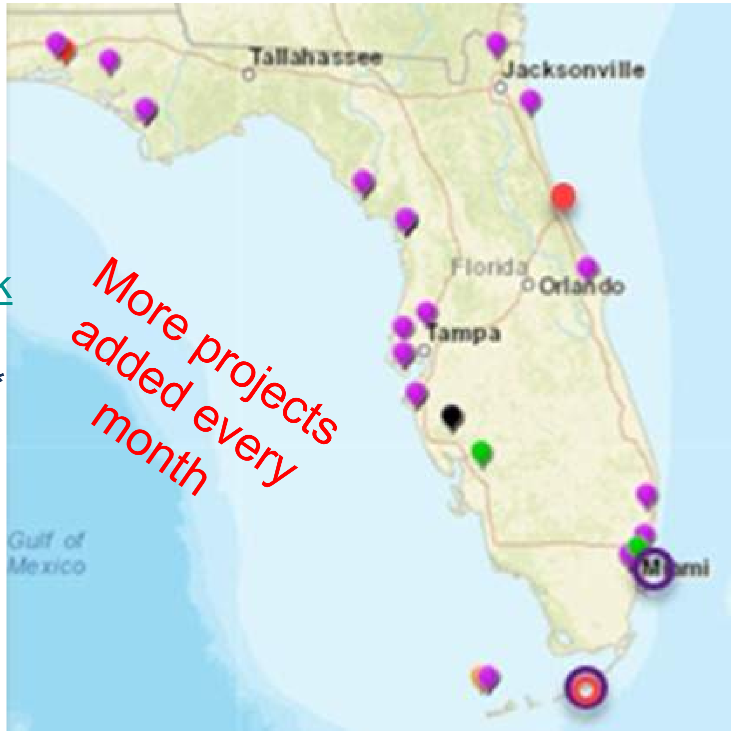
* bulkhead/seawall only
** piling/substructure only
*** complete bridge

Recent Completed Projects

Arthur Drive over Lynn Haven Bayou **
Bakers Haulover Cut Bulkhead Replacement *
Cedar Key Bulkhead Rehab *
Key West Bight Ferry Terminal Extension **
Halls River Bridge ***
PortMiami Tunnel Retaining Walls
South Maydell Dr over Palm River *
SR-A1A Flagler Beach Seawall (Segment 3) *
SR-5 (US-17) over Trout River Rehab **
SR-5 (US 41)/Morning Star and Sunset link-slabs
SR-45 (US 41) over North Creek ***
SR-312 over Matanzas River Rehab **
SR-520 over Indian River Bulkhead Rehab *
Sunshine Skyway Seawall Rehab & Extension*
UM Innovation Bridge ***
UM Fate Bridge superstructure
UM i-Dock ***
US-1 over Cow Key Channel FSB's

Current Projects

4th St at Big Island Gap **
40th Ave NE over Placido Bayou ***
Barracuda Blvd over Canal Bradano **
Bayway Structure-E Seawall Cap *
Bimini Dr over Duck Key Canal *
CR30A over Western Lake ***
Jupiter Federal Observation Platform ***
NE 23rd Ave over Ibis Waterway ***
S. Maydell Dr/Palm River Bulkhead *
SR-A1A over Myrtle Creek and Simpson Creek
SR-A1A N. Bridge Observation Platform ***
SR 404 & 528 Indian & Banana Rivers Rehab *
SR5 over Oyster Creek *
SR 5/US 1 over Earman River Canal ***
SR-30 over St Joe Inlet *
SR-112/I-195 Westshore waterway *
Village of North Bay Seawall *
West Wilson St over Turkey Creek **



FRP Structural Member (MS) systems used in Florida's Highway Bridges & Structures

Recent Completed Projects

Acosta Bridge fender replacement *
Bayway Structure-E fender *
US-331/Choctawhatchee Bay fender wales
Halls-River Bridge - Hybrid Composite Beams
Howard Frankland Bridge NB fender *
Ocala Water-Recharge Park Boardwalk ***
Skyplex Blvd - Composite Arch Bridge **
SR-A1A/Sisters Creek fender *
SR-A1A/Blue Heron fender replacement *
SR-3 over Barge Canal fender replacement *
SR-44 over Indian River fender replacement *
SR 714/South Fork St Lucie River *

Current & Future Projects

Bimini Dr over Duck Key Canal ? **
CR510 3-Sided Culvert-Bridge ? **
Marco Island Winter Berry Bridge
I-10/Apalachicola River Fender replace *
Jax. Main St Bridge Fender rehab *
SR-40 over Halifax River fender replacement *
SR-292 Perdido Key/ICWW fender replacement *
SR-520 over Indian River fender replacement *
US-192 over Indian River fender replacement *
SR-401 over Barge Canal fender replacement *
SR-518 over Indian River fender replacement *

https://www.fdot.gov/structures/innovation/frpms

complete fender system
** *FRP concrete filled arch*
*** *FRP pedestrian structure*


Halls River Bridge, FL (2017-19)


Ocala Water-Recharge Park, FL (2018-19)


Typical Fender System


Skyplex Blvd, FL (2018-19)

FRP Maintenance Repairs & Rehabilitation (MR&R) used on Florida's Highway Bridges & Structures

Recent Completed Projects

- Numerous since 1990's.
- We do not actively track

Current & Future Projects

- Identified during the biennial bridge inspection program – typically corrosion related.
- Emergency repairs from over-height vehicle impacts

(a)

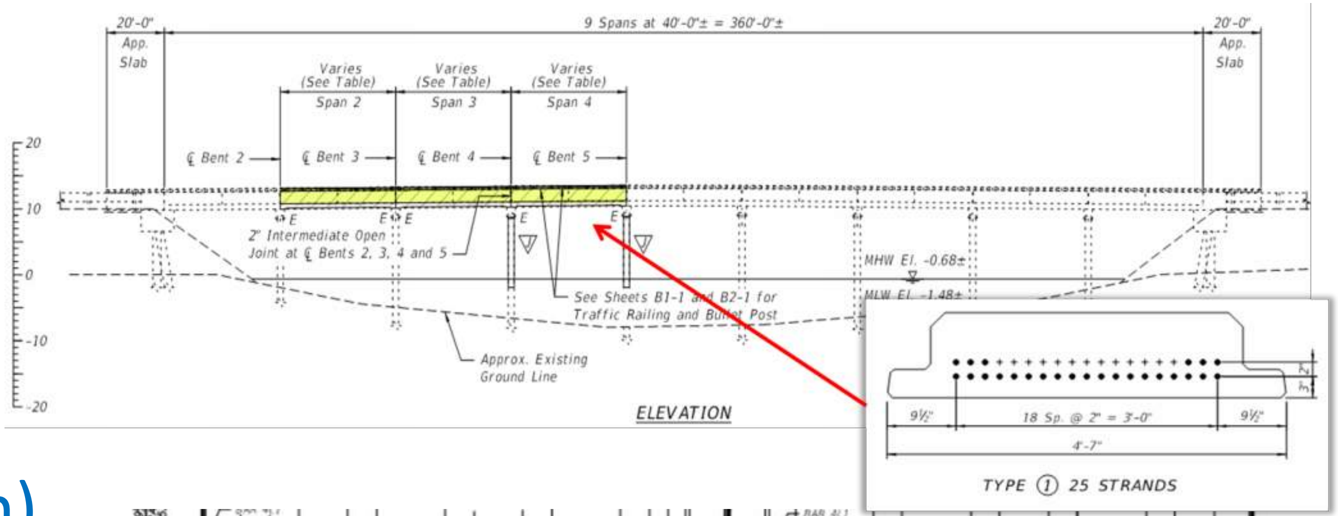
Figure 136—High tide inundation of (a) spans

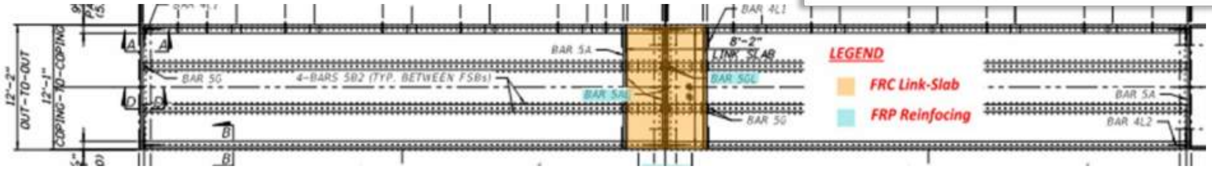
Figure 220—Corroded steel reinforcement in the north end of Girder 3-1

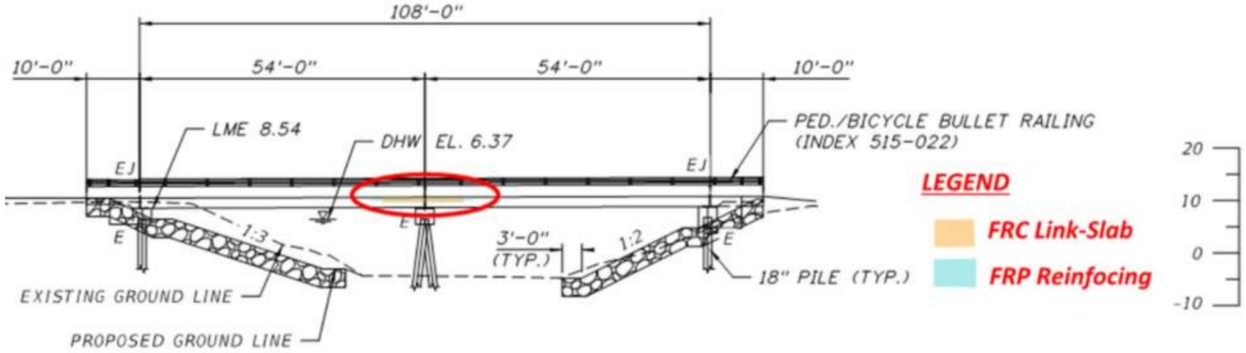
Figure 227—Girder damage from vehicle impact in July of 2001

Recently Completed Projects (RC/PC)

i. Bridge Superstructures (US-1/ Cow Key, US-41 Link-Slabs)
ii. Bridge Foundations (NE23rd Ave/Ibis)
iii. Seawalls (SR-A1A@Flagler Beach, Sunshine Skyway South)





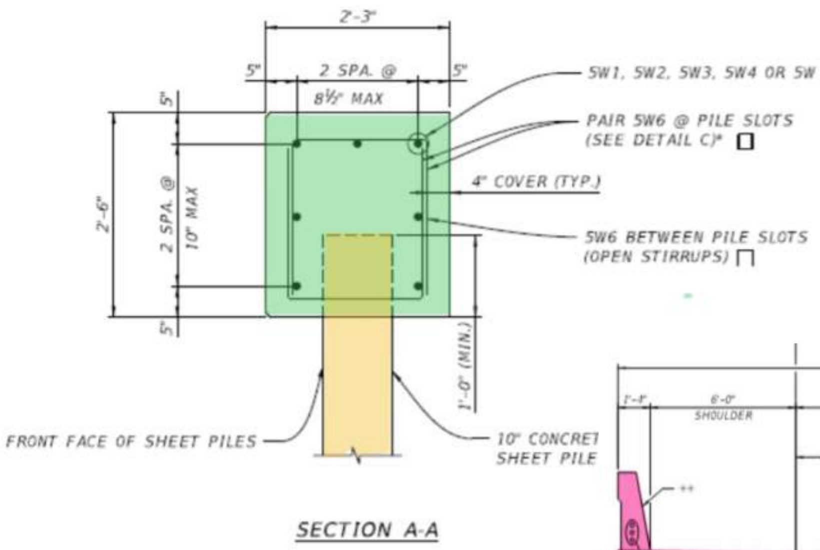


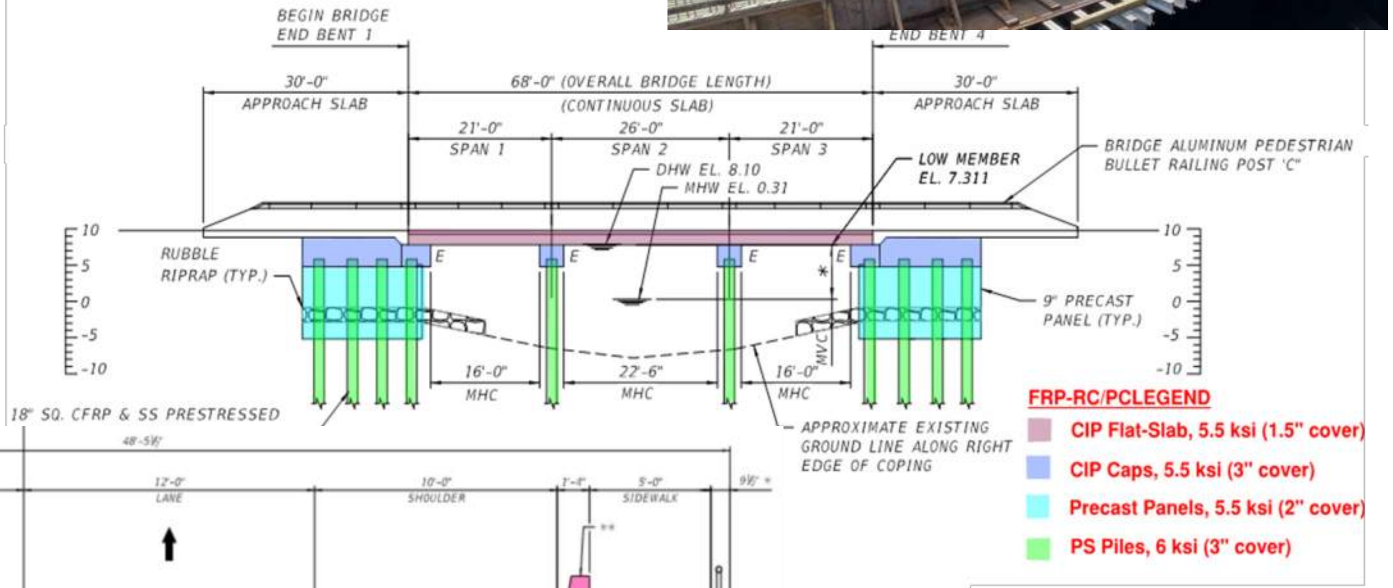

SR-A1A Flagler Beach (2019)

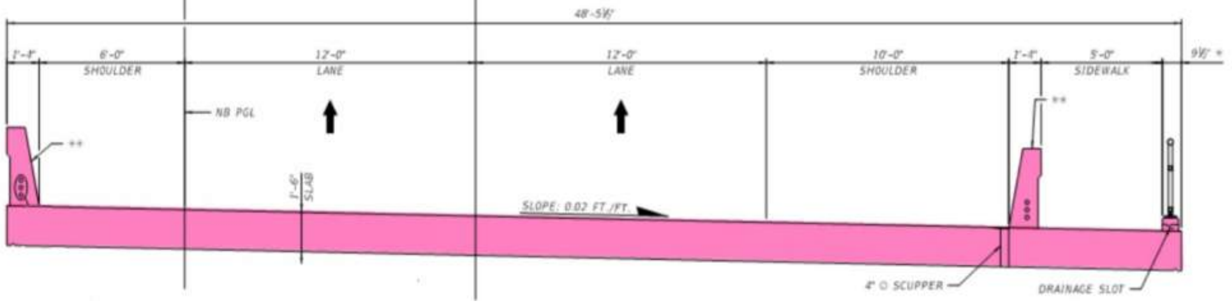

SR-A1A Flagler Beach (2019)

Projects Under Construction (RC/PC)

i. Bridge Superstructures (US41/North Creek, SR-105 Link-Slabs, 40th Ave NE/Placido Bayou)
ii. Bridge Foundations (NE23rd Ave, Maydell Dr.)
iii. Seawalls (SR30/St Joe Bay Inlet, Pinellas Bayway E)

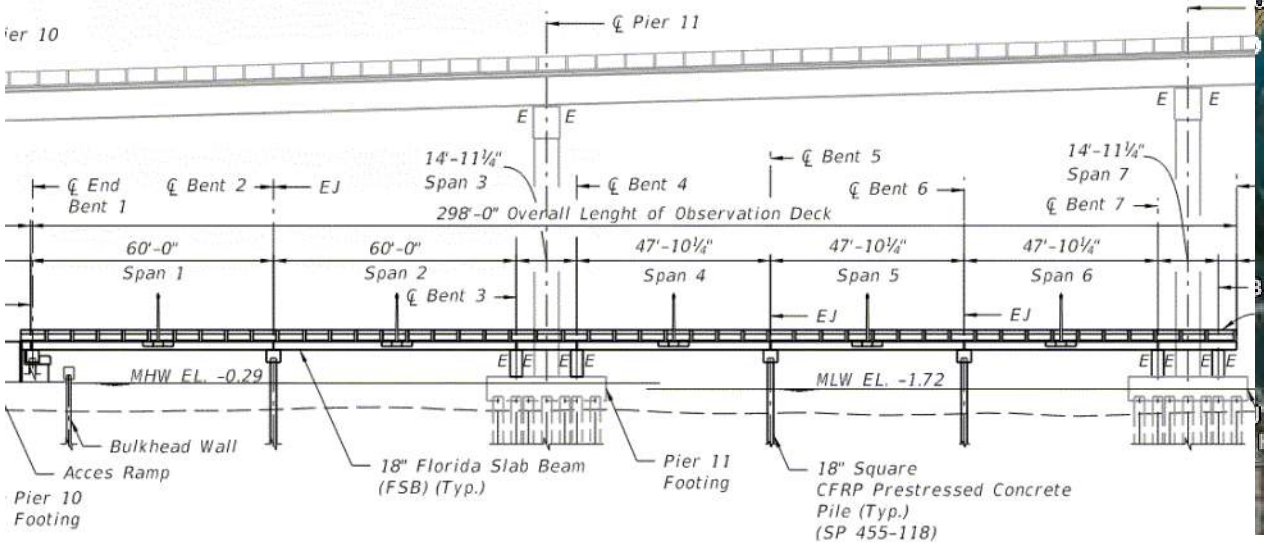


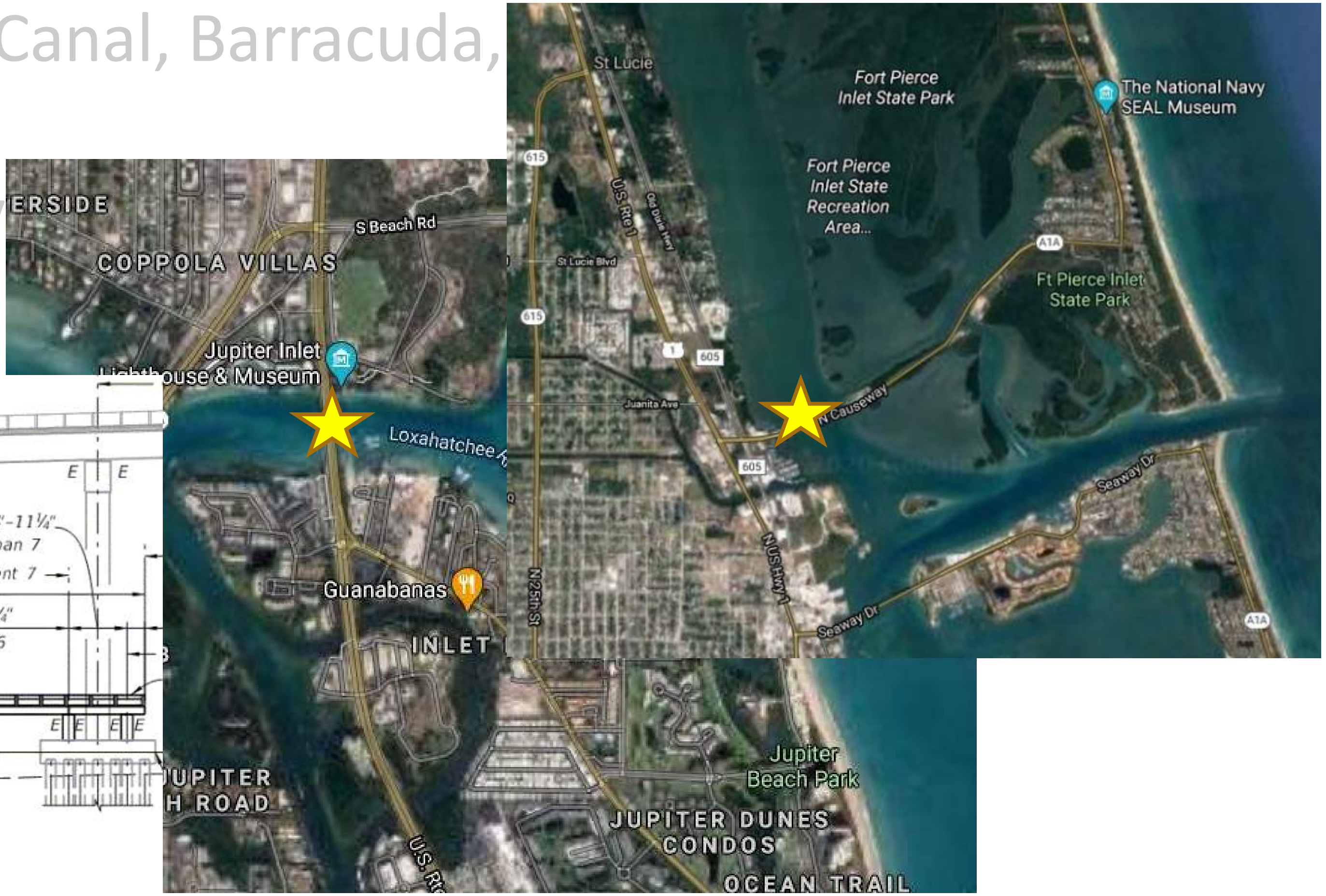




New Projects in Design (RC/PC & MS)

i. Pedestrian Piers & Fenders (North Bridge, Jupiter Beach)
ii. Prestressed Bridges (Earman Canal, Barracuda,
iii. CIP Bridges (Turkey Creek)
iv. Bridge Foundations (4th St ov





New Projects in Design (RC/PC)

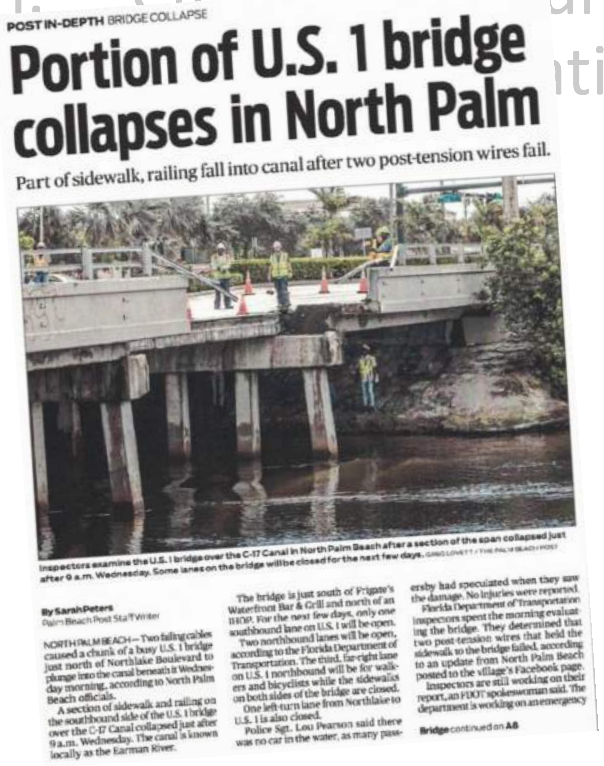
i. Pedestrian Piers & Fenders (North B

ii. Prestressed Bridges

(Earman Canal, Barracuda, 30A)

i. CIP Bridges (Turkey

tions



POST IN-DEPTH BRIDGE COLLAPSE

Portion of U.S. 1 bridge collapses in North Palm

Part of sidewalk, railing fall into canal after two post-tension wires fail.

Inspectors examine the U.S. 1 bridge over the C-17 Canal in North Palm Beach after a section of the span collapsed just after 9 a.m. Wednesday. Some lanes on the bridge will be closed for the next few days.

By Sarah Peters
Palm Beach Post Staff Writer

NORTH PALM BEACH — Two failing cables caused a chunk of a busy U.S. 1 bridge just north of Northlake Boulevard to plunge into the canal beneath it Wednesday morning, according to North Palm Beach officials.

A section of sidewalk and railing on the southbound side of the U.S. 1 bridge over the C-17 Canal collapsed just after 9 a.m. Wednesday. The canal is known locally as the Earman River.

The bridge is just south of Frigate's Waterfront Bar & Grill and north of an IHOP. For the next few days, only one southbound lane on U.S. 1 will be open.

Two northbound lanes will be open, according to the Florida Department of Transportation. The third, far-right lane on U.S. 1 northbound will be for walkers and bicyclists while the sidewalks on both sides of the bridge are closed.

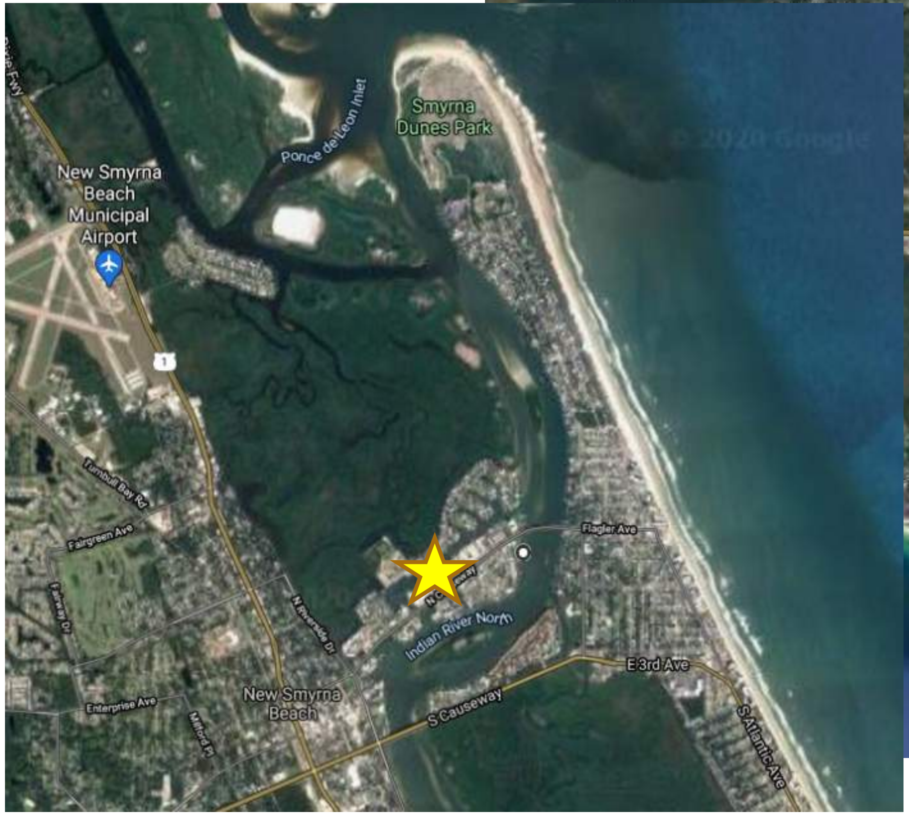
One left-turn lane from Northlake to U.S. 1 is also closed.

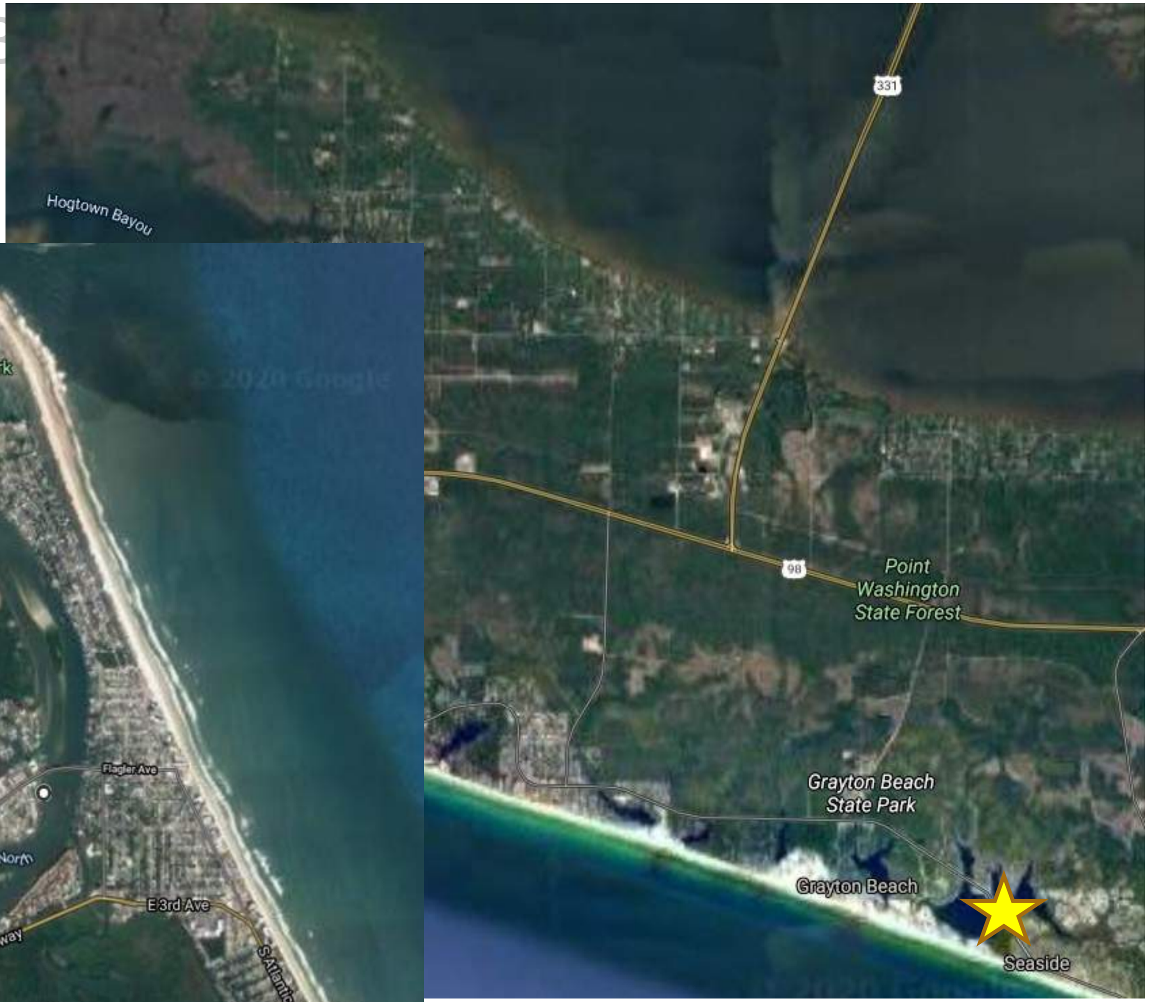
Police Sgt. Lou Pearson said there was no car in the water, as many passersby had speculated when they saw the damage. No injuries were reported.

Florida Department of Transportation inspectors spent the morning evaluating the bridge. They determined that two post-tension wires that held the sidewalk to the bridge failed, according to an update from North Palm Beach posted to the village's Facebook page.

Inspectors are still working on their report, an FDOT spokeswoman said. The department is working on an emergency

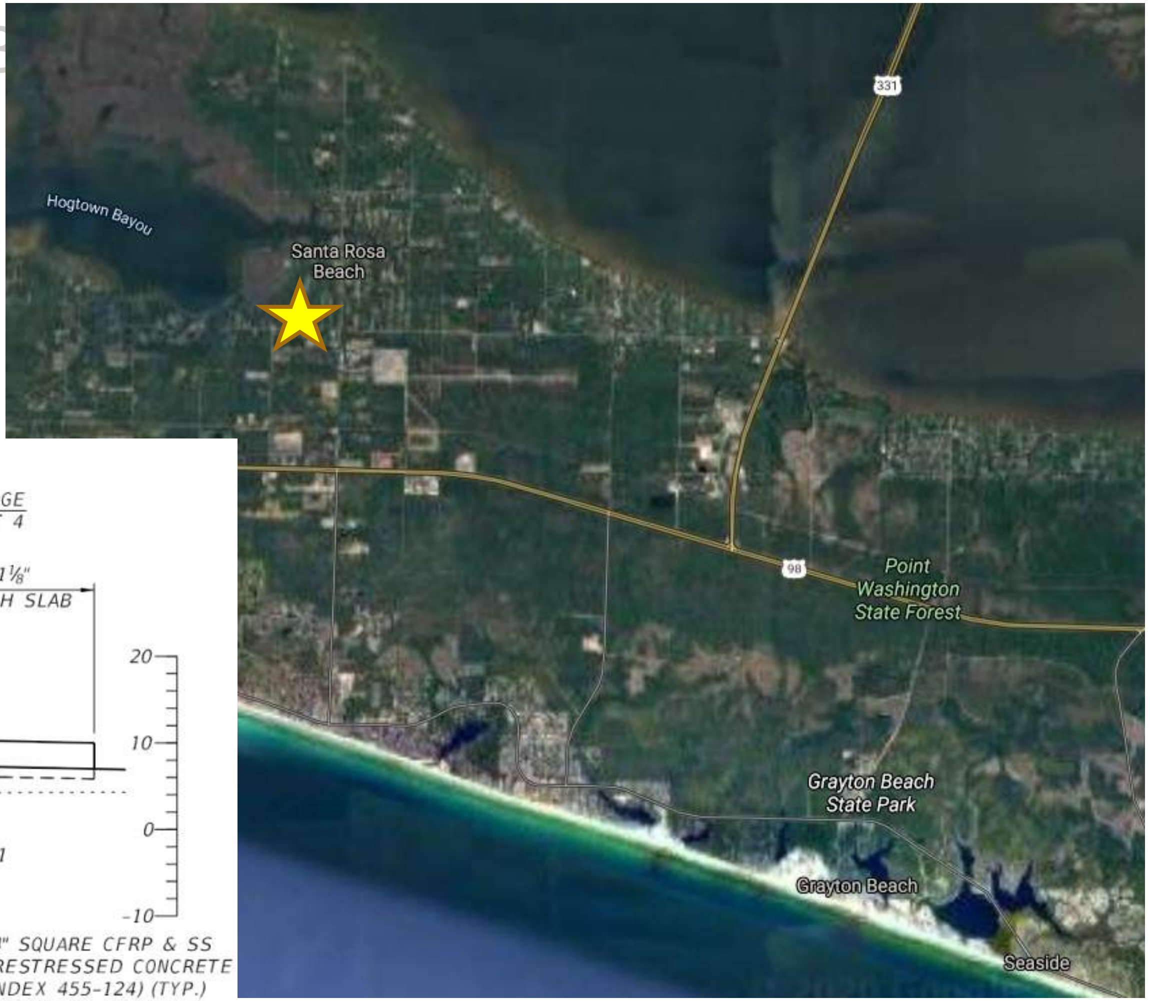
Bridge continued on A8

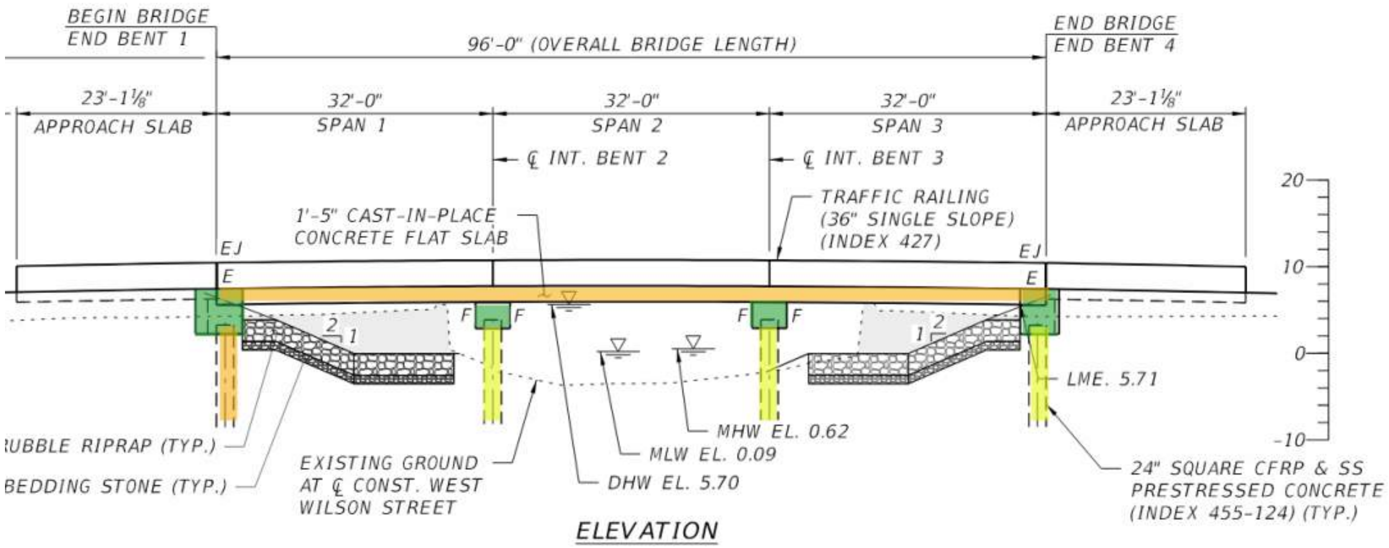




New Projects in Design (RC/PC)

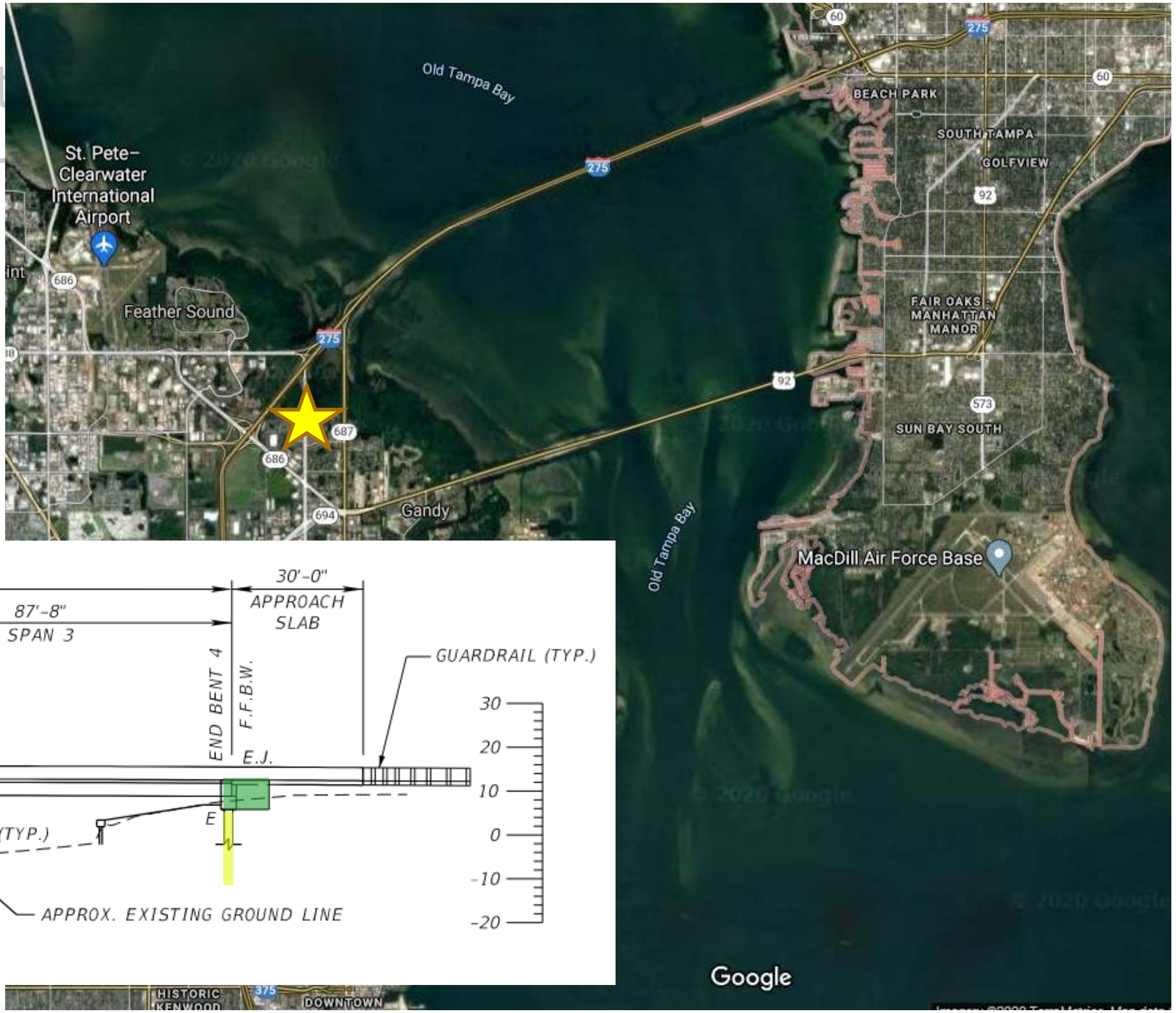
i. Pedestrian Piers & Fenders (North E
ii. Prestressed Bridges (Earman Canal,
iii. CIP Bridges (Turkey Creek)
iv. Bridge Foundations (4th St over Big

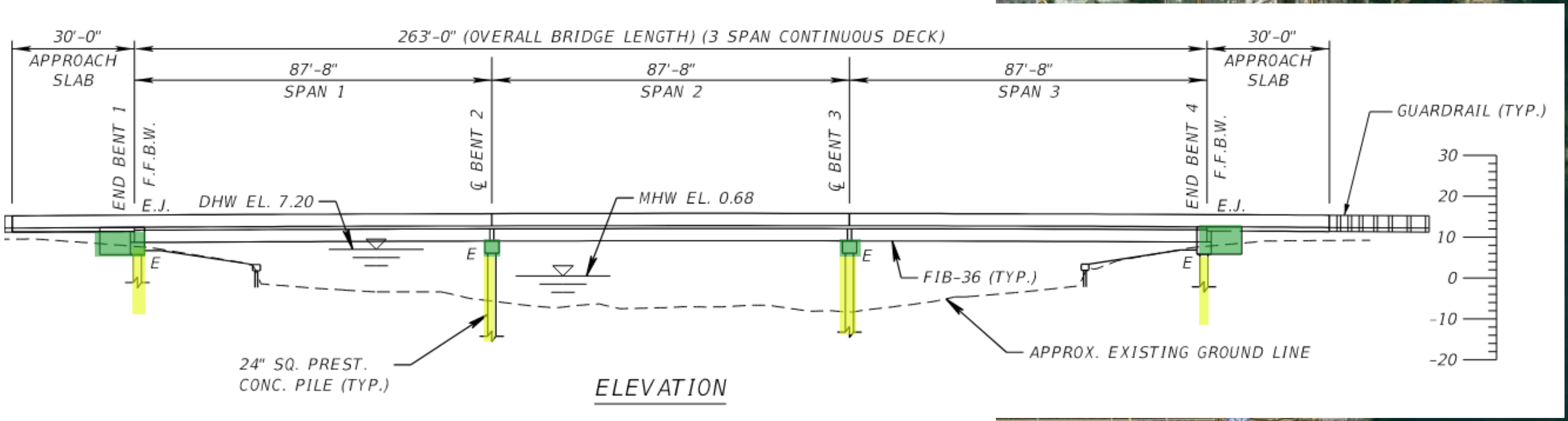




New Projects in Design (RC/PC)

i. Pedestrian Piers & Fenders (Nort
ii. Prestressed Bridges (Earman Car
iii. CIP Bridges (Turkey Creek)
iv. Bridge Foundations
(4th St over Big Island Gap)



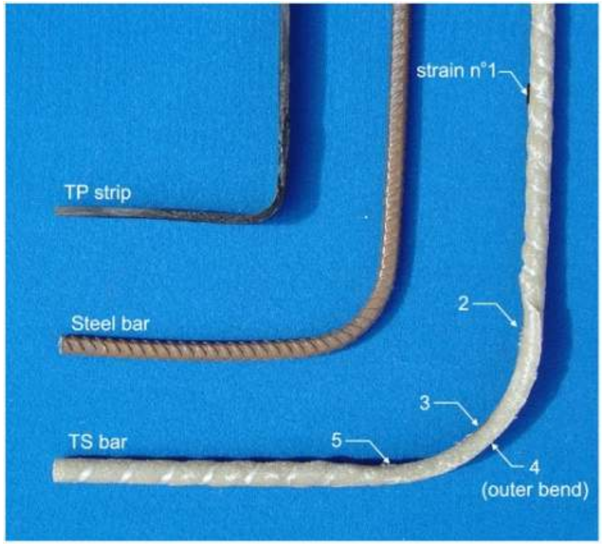


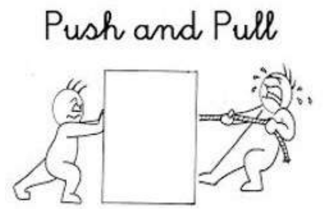
Lessons Learned from the Real World

i. Designer Issues
- Lack of designer training, software tools, and national consensus design codes.

ii. Material & Testing Issues
- Costs for FRP rebar supply to public agencies are typically higher since no centralized certification standards for manufacturers, so additional testing and approvals are invoked by individual agencies.

iii. Constructability Issue
1. Unit costs for FRP rebar are very high for small quantities due to the project testing requirements.
2. Many construction contractors do not understand the lead times involved for FRP rebar.
3. Higher modulus of elasticity can improve competitiveness of GFRP vs. other corrosion-resistant solutions.
4. Stirrup bends and closed shapes or multiple bends still not standardized.
5. Tie-wire (plastic ties are slower, more expensive, and less secure)
6. Coupling of bars for phased construction is essential for broader deployment or will rely on SS solutions.
7. Adhesive anchors are often needed, but not codified for FRP rebar. Field proof testing/gripping is a challenge, especially for bent bars.
8. Shear reinforcing requires much closer spacings and often multiple legs overlapping causing rebar congestion
9. Non-metallic lifting devices for heavy civil components are not available
10. Replacement of easily damaged bars in the field is a common need





BIDEN-HARRIS
TRANSITION

Forecasting the Future ???

President-Elect Vice President-Elect Nominees and Appointees

- new Federal "Push Factor"

https://buildbackbetter.gov/priorities/

46

President-elect Biden is working to make far-reaching investments in:

- **Infrastructure:** Create millions of good, union jobs rebuilding America's crumbling infrastructure – from roads and bridges to green spaces and water systems to electricity grids and universal broadband – to lay a new foundation for sustainable growth, compete in the global economy, withstand the impacts of climate change, and improve public health, including access to clean air and clean water.
- **Innovation:** Drive dramatic cost reductions in critical clean energy technologies, including battery storage, negative emissions technologies, the next generation of building materials, renewable hydrogen, and advanced nuclear – and rapidly commercialize them, ensuring that those new technologies are made in America.

- Industry "Push Factors"
  - **Closing the infrastructure Gap**: Shared goal of reducing infrastructure life cycle costs by 50% by 2025
  - **Sustainability**

SEI ASCE STRUCTURAL ENGINEERING INSTITUTE

SE2050 COMMITTING TO ZERO

- State/Owner "Pull Factors"
  - **Reducing Asset Management Risk:** limit need for corrosion related repairs, MOT, etc.
  - **Benefits from Enlarging the Market:** increase supply chain security, regional manufacturing opportunity, etc.

QUESTIONS ?

PUT IT DOWN
IT'S THE LAW

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Website: https://www.fdot.gov/design/Innovation/

FDOT