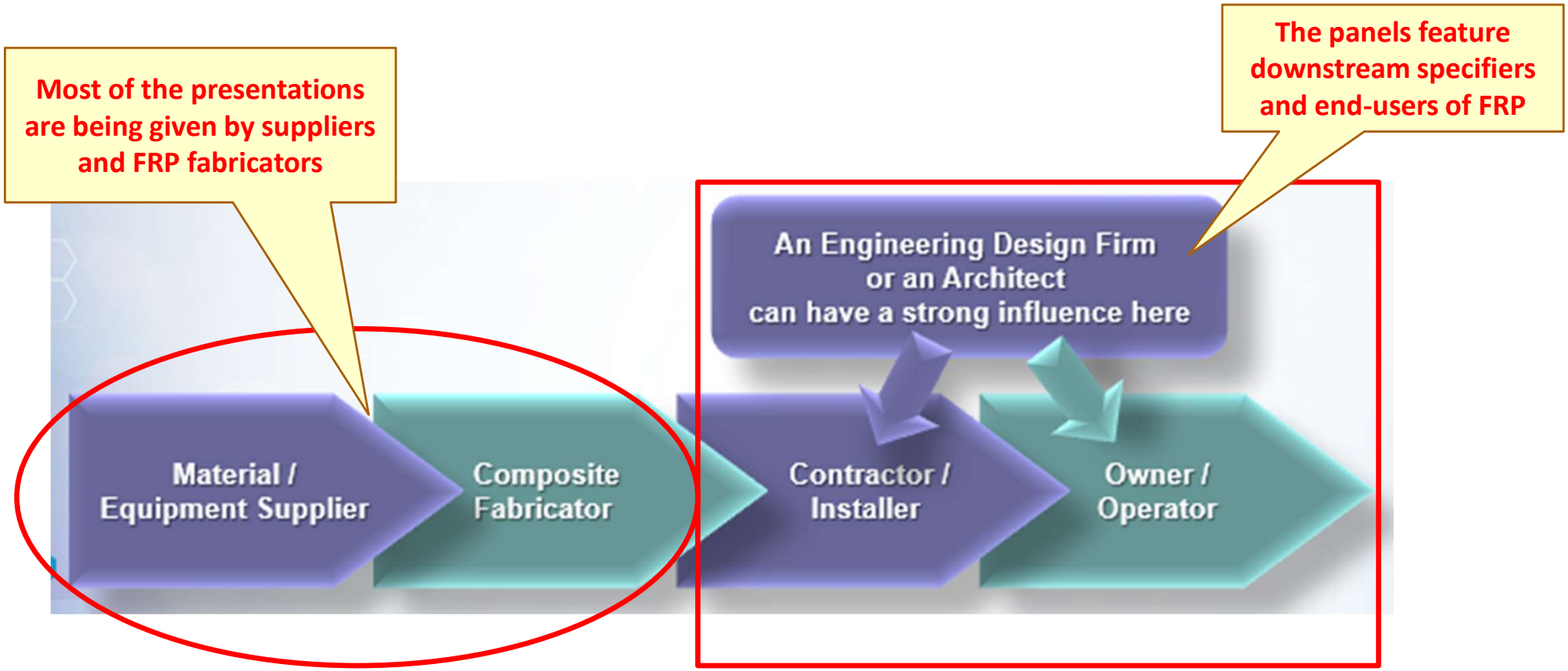
Constructing & Rehabilitating Bridges with FRP Composites

State DOT End-User Panel

March 7, 2023

End-User Panels

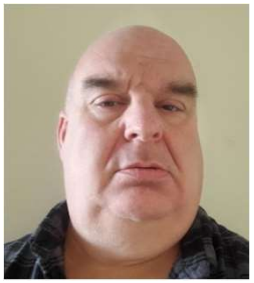


Today's Panelists

Steve Nolan Senior Structures Design Engineer

Tim Keller Administrator, Office of Structural Engineering

Cabell Garbee Manufactured Products Engineer



Q&A

- We will have about 10 minutes for Q&A at the end of the presentations
- Please enter your questions into the Chat

Our First Panelist

Steve Nolan

Senior Structures Design Engineer

- How have you used FRP?
- Motivation for using FRP. Why did you choose it?
- What was the biggest challenge you overcame?
- What were the most important benefits you've seen?

Why use FRP materials for Bridges & Structures

- Florida maintains more than 150 million sq.ft. of bridge area *(7152 FDOT bridges [2]);*
- Florida has more than 4,000 miles seawall-bulkheads [3].

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 (%)
Atlantic									
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
Florida	2694	11 365	24	58	628	9	2752	11 992	23
Georgia	92	6340	1	14	158	9	106	6498	2
Gulf									
Alabama							356	2606	14
Florida							4427	26 383	17

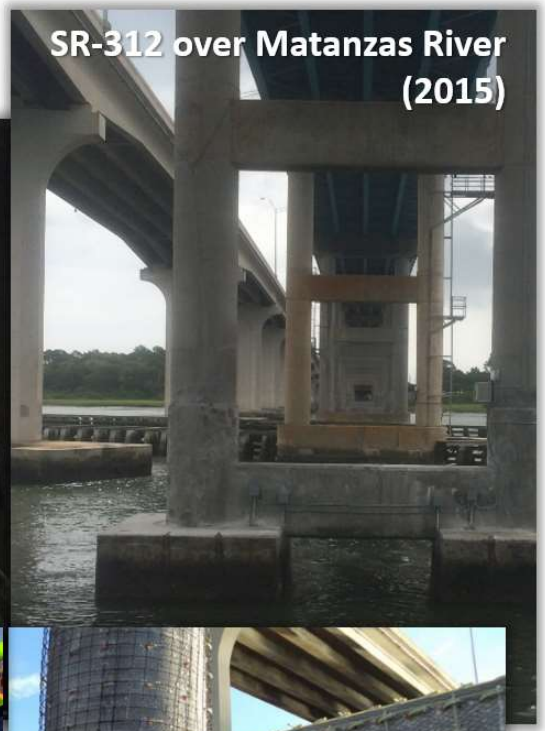
(1) Gittman et al. (2015) https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/150065
(2) FDOT Bridge Inventory – 2022 Annual Report
(3) Estimates from Gittman et al. (2015)

How are FRP materials used for Strengthening & Repair of Bridges

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

How is FRP rebar used for Restoring Corroded Bridge Foundations

- Pier Repairs & Cathodic Protection with FRP reinforcing:



How is FRP rebar for New and Replacing Bulkhead Walls protecting Bridge Abutments

- Bulkhead & Seawall Cap Replacements:

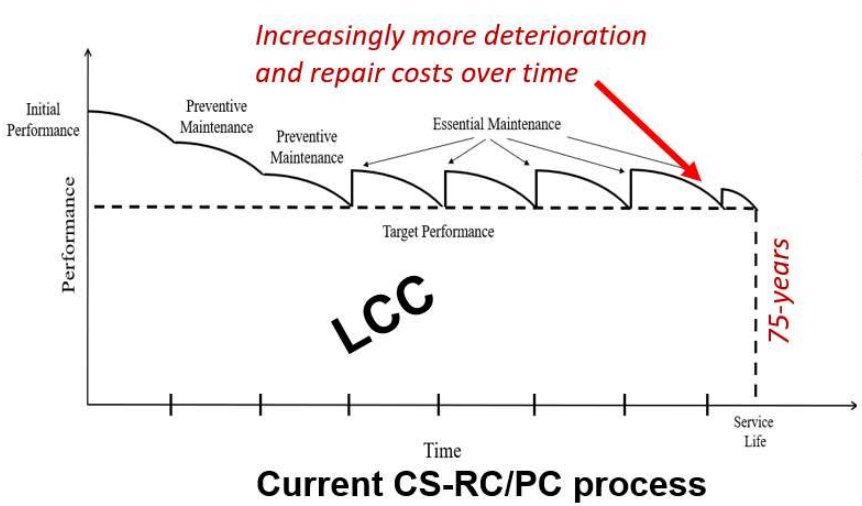
How are FRP materials used for New Bridges and Structures

- Halls River Bridge: https://www.fdot.gov/structures/innovation/hallsriverbridgeworkshop/default.shtm
- 40th Ave NE over Placido Bayou: http://www.40thavenuebridge.com/

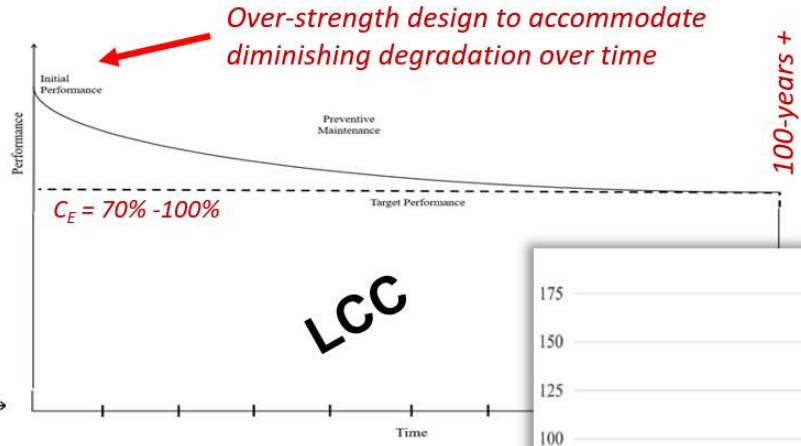
Benefits of FRP based on Cost & Sustainability

(Life-Cycle Cost & Assessment)

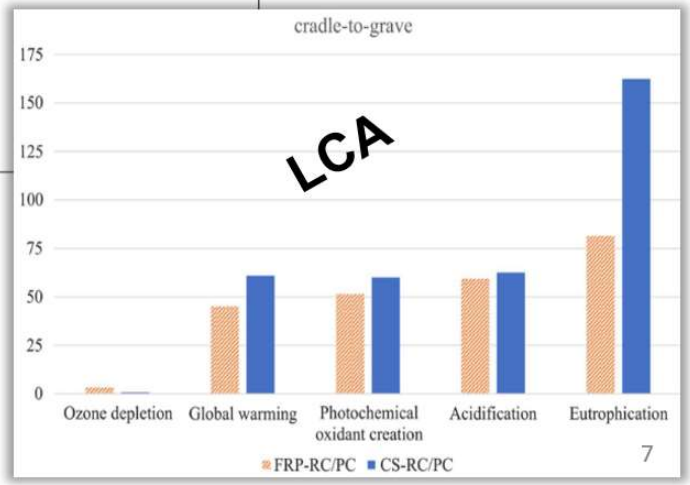
LCC & LCA can show the sustainable (economic and environmental) advantage of composite structures in the coastal environment:



Current CS-RC/PC process

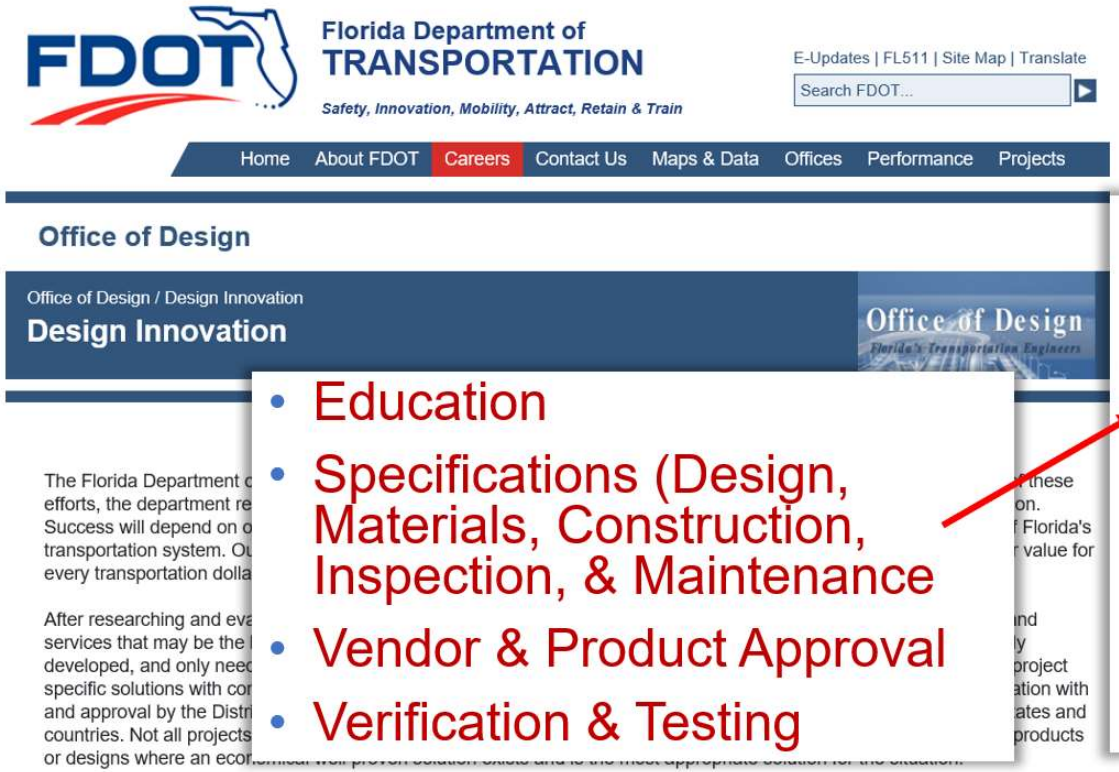


FRP alternatives



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.

Challenges for Implementing of FRP Products



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

- Education
- Specifications (Design, Materials, Construction, Inspection, & Maintenance
- Vendor & Product Approval
- Verification & Testing

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)

FRP Products Approval (SMO & MAC):

https://www.fdot.gov/materials/quality/programs/materialsacceptance/documentation/frp.shtm

ODOT EXPERIENCE WITH GFRP

OHIO DEPARTMENT OF TRANSPORTATION

Tim Keller, State Bridge Engineer

ODOT Summary
GFRP

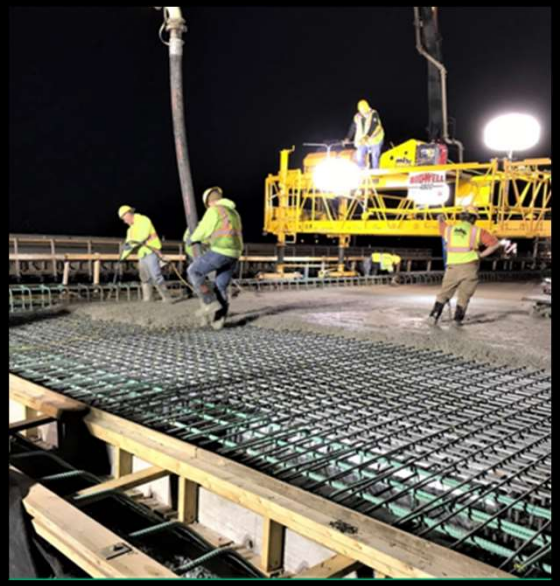
- 9 bridge decks in service with GFRP Reinforcing
- Used a total 1.5 million LF of GFRP Reinforcement – all in decks
- GFRP is included in our standard specifications
- We have approved the use of deck reinforcement design aides developed by Owens Corning

LUC-25-0792

- Bridge replacement of SR 25 (Anthony Wayne Trail) Bridge over Norfolk Southern Railroad in Toledo, OH
- First bridge at ODOT with GFRP Reinforcing in the deck
- 343,250 LF of GFRP Reinforcement (#4 & #5)

LUC-475-0648 & LUC-475-0753

- Bridge superstructure widening and replacements of four mainline I-475 Bridges in Lucas County, OH
- Project sold Fall 2019
- Completed in Summer 2021
- 466,430 LF of GFRP Reinforcement (#4, #5 & #6)



HEN-Liberty Bridge

- New 8 span bridge crossing the Maumee River in Napoleon, OH
- Project sold Fall 2019
- Completed in Fall 2021
- 470,554 LF of GFRP Reinforcement (#4, #5 & #6)

WOO-75-1333 & WOO-75-1535

- Re-deck 2 structures over I-75 in Bowling Green, OH
- Project sold Spring 2021
- Completed in Summer 2021
- 187,900 LF of GFRP Reinforcement (#4, #5 & #6)

Hydrodemolition

- Common practice for ODOT to use hydro-demolition to prepare concrete decks prior to placement of rigid overlays
- On average, ODOT spends approximately $15 million per year on rigid overlays
- Wanted to know if hydro-demolition on a bridge deck with GFRP bars was possible

Hydrodemolition

Test Slab

Hydrodemolition

Test Slab

Hydrodemolition
Test Slab

Hydrodemolition
Results

- Hydrodemolition on a bridge deck with GFRP reinforcing is possible **with care**
  - Most likely will damage some bars during the operation

NORTH CAROLINA
Department of Transportation

Fiber-Reinforced Polymer Technology: NCDOT Producer Requirements

W. Cabell Garbee, II, PE
NCDOT Manufactured Products Engineer
March 7, 2023

History in North Carolina

- 2005 – Glass Fiber Reinforced Polymer (GFRP) Bridge Deck
- 2014 – NCDOT/NCSU Research Project 2014-09: *CFRP Strands in Prestressed Cored Slab Units*
- 2017 – Transportation Pooled Fund Research Project – 5(363): *Evaluation of 0.7 inch Carbon Fiber Reinforced Polymer Pretensioning Strands in Prestressed Beams*
- *2021 Harkers Island Replacement Bridge [Under Construction]*
  - *3000 ft long, No Structural Steel Reinforcement, Uses GFRP bars and CFRP strands*
- *2023 Brunswick County NC 179B over Calabash River*
  - *FRP Reinforced 20" Square Concrete Piles*
- *2024 Tyrrell/Dare County (Alligator River), ~3 miles long*
  - *FRP Reinforced Square Concrete Pipe or Drilled Shafts (Contractor Option)*

Significance of the Harkers Island Bridge Replacement Project

Project Utilizing Innovative Technology:

- Carbon Fiber Reinforced Polymer (CFRP) Strands
- Glass Fiber Reinforced Polymer (GFRP) Bars

- "NO" Steel Reinforcement
  - Steel ONLY in the Railing (MASH compliance)

Availability: August 30, 2021

Completion: October 28, 2025 (Includes removal of existing swing bridge and remediation of site

Moratorium:

No in-water, seabottom disturbance, work allowed from April 1 through September 30

Bridge No. 96

- Built 1970
- Superstructure Replacement 2013
- Functionally Obsolete

Bridge No. 73

- Built 1969
- Posted SV 24, TTST 37
- Structurally Deficient

Product and Material Approvals:

1. NCDOT Product Evaluation Program (Approved Product List)
2. *NCDOT Production Facility Approval (HiCAMS Vendor List)*
   - Producer Facility Audit
   - Brand Registration
   - Materials Sampling and Process/Product Inspection

3. Project Acceptance (Job Site)
   - Certification
   - Visual Inspection
   - Materials Sampling and Inspection

Product and Material Approvals:

NCDOT Product Evaluation Program (Approved Product List)

- Single Point of Entry to NCDOT for Product Evaluation
- Comprehensive evaluation of products
- Review of product specifications, technical data, and test results
- Monitor installations durability and performance.

Products evaluated

- Not previously evaluated by NCDOT
- NCDOT Standard Specification does not exist
- Required Placement on Approved Products List (APL).

https://connect.ncdot.gov/resources/Products/Pages/default.aspx

NCDOT Production Facility Approval (HiCAMS Vendor List)

- Producer Facility Audit
- Brand Registration
- Materials Sampling and Process/Product Inspection

Products

- NCDOT Standard Specification exists
- Fabricated Items

Project Acceptance (Job Site)

- Certification
- Visual Inspection
- Materials Sampling and Inspection

At the point of delivery (concrete producer's yard), the Engineer will select a minimum of two discrete samples from each coil of material. Each discrete sample shall be a minimum of 7 feet in length. At least six discrete samples will be obtained from each production Lot

At the point of delivery, the Engineer will select a minimum of six straight bars with minimum lengths of 7 feet each and a minimum of five bent bars from each shipment, representing a random production Lot, per bar size of GFRP r

Material Approvals:

1. NCDOT Product Evaluation (Approved Product List)
2. *NCDOT Vendor Approval (Tokyo Rope, Owens Corning-Mateenbar)*
   Producer Facility Audit (FRP Institute for Civil Infrastructure)

3. Project Acceptance Testing (NCSU)

Q&A

You can type your questions into the Chat

The Next End-User Panel

Selecting & Using FRP Composites in Buildings

Specifier and End-User Panel

Emily Guglielmo	Brett McMahon
Principal	CEO
Martin/Martin	Miller & Long

Tuesday, March 21 2:35 to 3:05 pm ET

Thank you for attending !!