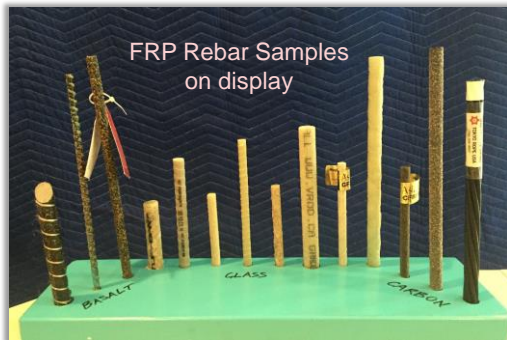


FDOT Executive Workshop
January 15, 2020

Fiber-Reinforced Polymer Deployment for Corrosion-Free Bridges



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State Structures Design Office

1

Why use FRP rebar for Bridges and other Structures?

- Failure of structures exposed to aggressive environments is often corrosion of the steel reinforcement;
- Chlorides from air-borne salt or seawater penetrate concrete and reach steel rebar:
 - ✓ Via concrete porosity
 - ✓ Via cracks
- Corrosion is also accelerated by carbonation of concrete that lowers the pH;

- + Low electro-magnetic interference;
- + Lower ownership costs.



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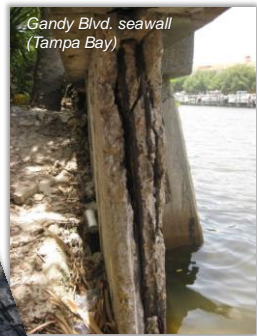
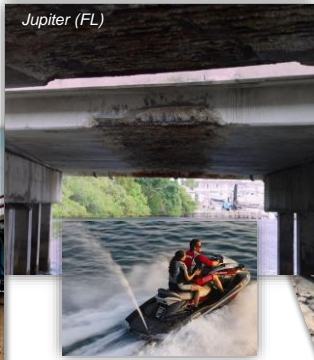
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Why use FRP rebar for Bridges and other structures

- Florida maintains more than 150 million sq.ft. of bridge area (7007 FDOT bridges²);
- Florida has more than 4,000 miles seawall-bulkheads³.

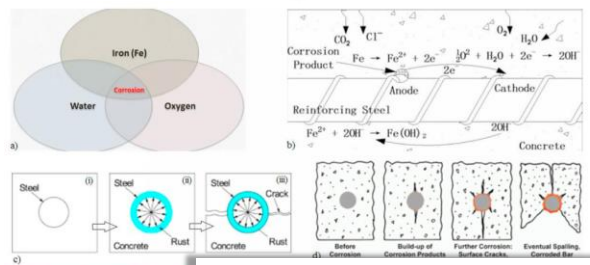
WebTable 3. Shoreline hardening and population statistics by state (1)

	Hard sheltered shore (km)	Sheltered shore (km)	Hard sheltered shore (%)	Hard open shore (km)	Open shore (km)	Hard open shore (%)	Total shore (km)	Hard shore (%)	
Atlantic									
Connecticut	477	1907	25	0	0	477	1907	25	
Delaware	267	2163	13	5	45	11	292	13	
DC	29	54	53	0	0	29	54	53	
Florida	2694	11,365	24	58	628	9	2752	11,992	23
Georgia	22	6362	1	14	158	3	109	638	2
Gulf									
Alabama						356	2606	14	
Florida						4422	26,383	17	



(1) Gittman et al. (2015) <https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/150065>
 (2) FDOT Bridge Inventory - 2019 Annual Report
 (3) Estimates from Gittman et al. (2015)

Why? ...Inevitability of Corrosion



Bridge Inventory — 2019 Annual Report (2)

(2) https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/maintenance/str/bi/florida_bridge_inventory_2019_annual_report.pdf

Conclusion

Figure 1 from: Corrosion Mechanism in Reinforced Concrete (from Maia & Alves, 2017)

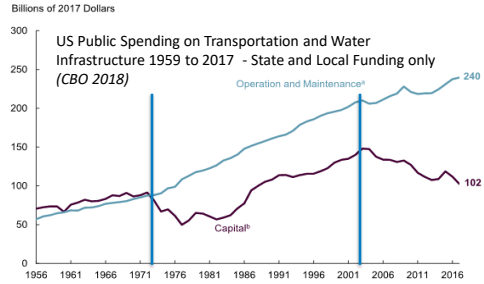
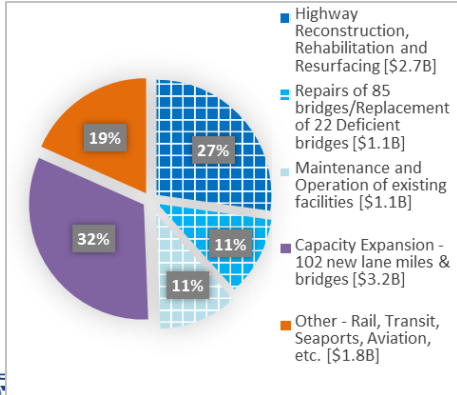
Florida's bridges are generally in good condition, with those maintained by the FDOT in better condition than those maintained by local governments or others. The most serious threat to bridges in Florida is the corrosion of steel reinforced concrete substructures in coastal regions. Much has been learned in recent years about corrosion in marine environments, affecting material specifications and design practices that helps new bridges built today. However, the older bridges in the coastal regions are beginning to require careful evaluation and extensive corrective actions. On-going re-



Why? ...some Infrastructure Facts

Florida DOT Transportation Budget FY 2019/2020

➤ 49% for combined Maintenance, Operations, Repair, Rehabilitation and Deficient Bridge Replacement (hatched areas).



"Reduce the life cycle cost of infrastructure by 50% by 2025 and foster the optimization of infrastructure investments for society"



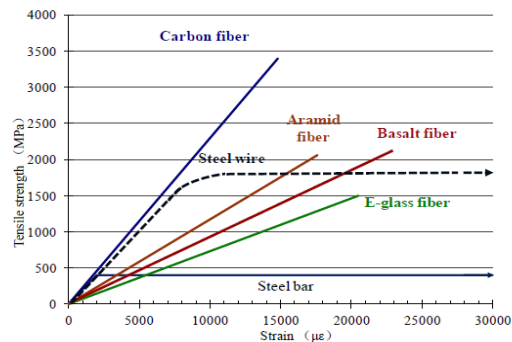
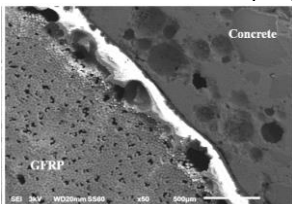
www.ASCEgrandchallenge.com

Why? ...Drastic Consequences → Different Solutions

FRP composites have been utilized for durable bridge applications for more 30+ years, demonstrating their ability to provide reduced maintenance cost, extended service life, and significantly increase design durability.

FRP materials of most interest to FDOT (currently):

- **Carbon FRP strands and laminates** (PAN fiber with epoxy resin systems)
- **Glass FRP reinforcing Bars** (E-CR fiber with vinyl ester resin systems);
- **Basalt FRP reinforcing bars** (melt-rock fiber with epoxy or vinyl ester resin)

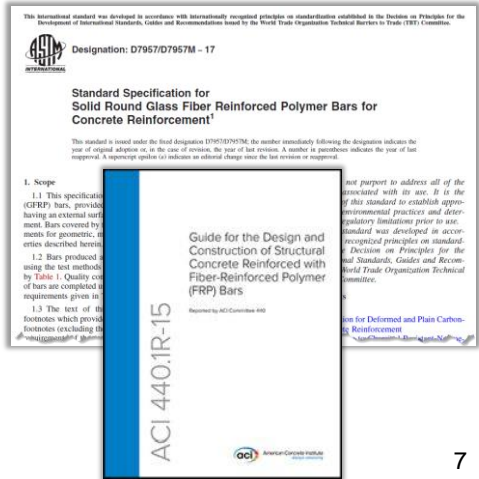
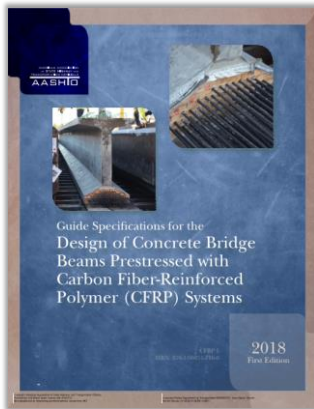
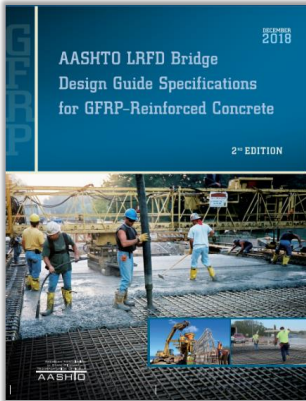


FDOT's Fiber-Reinforced Polymer Deployment Train



Availability of Design Guidance & Tools

- **Design and Construction Specifications**
 - Now available for rebar & strand (also shapes - tubes, beams & plates for Pedestrian Bridges etc.)

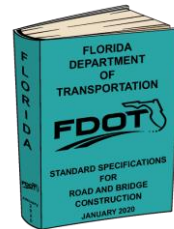


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Availability of Design Guidance & Tools

- **FDOT Guidance, Specs and Approval Lists:**



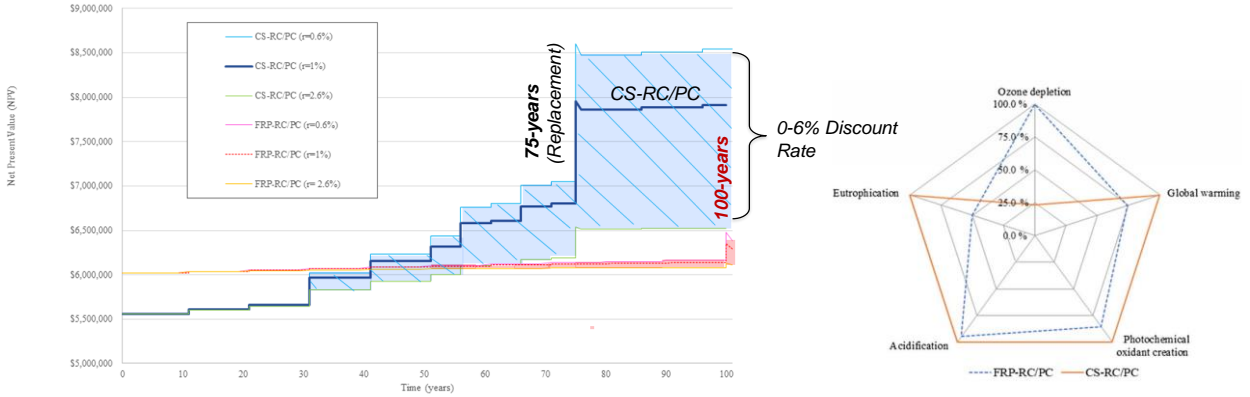
<https://www.fdot.gov/structures/innovation/FRP.shtm>

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Cost Justification (Service Life, LCC, etc.)

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 versus FRP-RC/PC bridge (adapted from Cadenazzi et al. 2019)



Project Examples & Fast-Facts





Extra Slides, if needed for later follow up.



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Project Fast Facts

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.shtml>

Project Name: SR 24 over Nublar Three Channel Bridge No. 140001

Project Description: Rehabilitation of three bridges in Cedar Key

Project Purpose & Need: Bridge Inspectors reported identified deterioration, including evidence of corroded steel reinforcement in the reinforced concrete bridge deck. Work activities included removal of the existing reinforced concrete and installation of a new reinforced concrete FRP reinforcement.

Project Location: FDOT District Three, Bay County, Lynn Haven, Florida

Agency: Florida Department of Transportation

URL: <http://www.fdot.gov/structures/innovation/FRP.shtml>

Project Name: Archer Drive over Lynn Haven Bypass Bridge No. 466143

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

Project Purpose & Need: Three FRP reinforced precast concrete and driven to test performance. One pile was processed with CFRP treatment and two piles were also processed with GFRP wrap.



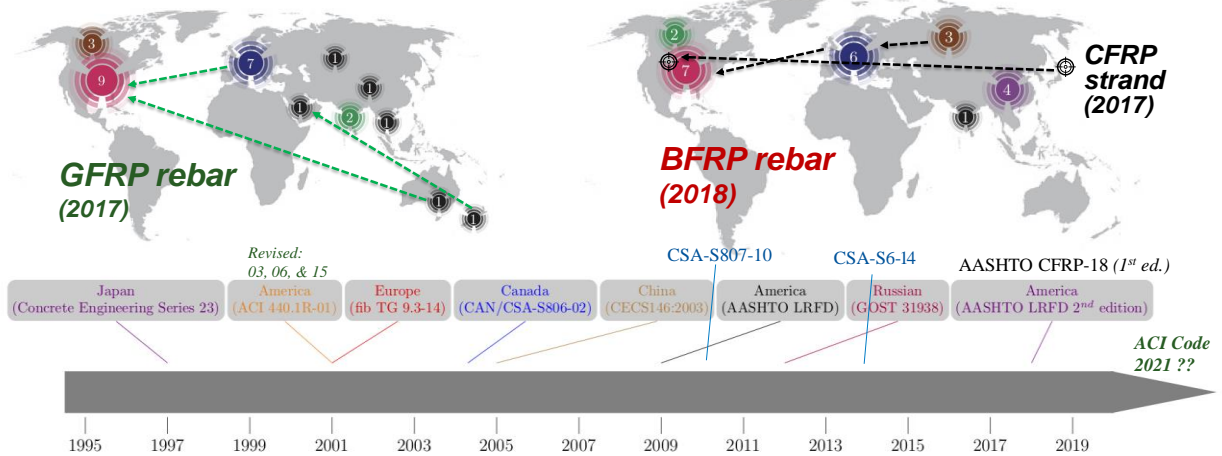
Fast-Facts: <https://www.fdot.gov/structures/innovation/FRP.shtml#link9>

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Availability of Design Guidance & Tools

Development of worldwide Manufacturing and FRP-RC/PC Guidelines



From FDOT Research Projects **BDV30 977-18 (GFRP)** and **BDV30 986-01 (BFRP)** - FAMU-FSU/UM

Availability of Design Guidance & Tools

- **Uniform Approval Processes**
 - Producer Approval vs Product Approval (APL)

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

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FDOT Fiber Reinforced Polymer Production Facility Listing

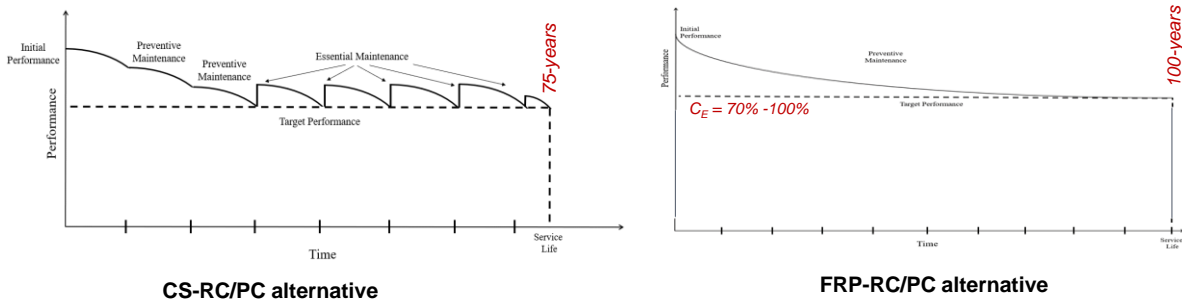
MAC

FRP ID	Company	Contact	Phone	Physical Address	OC Plan Status
FRP-02	OWENS CORNING (BLYTHEWOOD, SC)	John Amoretti	(419) 819-7229	1021 Jenkins Drive, Blythewood, SC 29008	Quality Control Plan ACCEPTED 3/19/2019
FRP-05	PULTRALL	Roxanne Fortier	(416) 291-0000	10000 Highway 7, Markham, ON L3R 9V7	Quality Control Plan ACCEPTED 3/19/2019
FRP-07	PULTRON (DUBAI)	Bogdan Patrascu	(714) 880-9533	S404 Street, Building 10, Jebel Ali Free Zone South, UNITED ARAB EMIRATES	Quality Control Plan ACCEPTED 12/11/2017
FRP-08	ATP	Aniello Giamundo	(811) 948-7131	via Campa 34, ITALY	Quality Control Plan ACCEPTED 12/11/2017
FRP-12	TUF-BAR INC (EDMONTON CANADA)	Nathan Sim	(780) 448-9338	5715-76 Avenue, CANADA	Quality Control Plan ACCEPTED 12/11/2017
FRP-14	TUF-BAR INC (ONTARIO CANADA)	Jay Christopher	(519) 833-5050	7 Erin Park Dr, CANADA	Quality Control Plan ACCEPTED 12/11/2017



Cost Justification (Service Life, LCC, etc.)

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



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*.

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