



# Design Innovation: Alternate Designs for Longer-lasting Bridges & Structures



GFRP rebar for deck & substructure of Halls River Bridge (2017-18)



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



UHPC-PC H-Pile for CR-339 demonstration (2020)



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

# Implementing Technology for Longer-Lasting Bridges & Structures

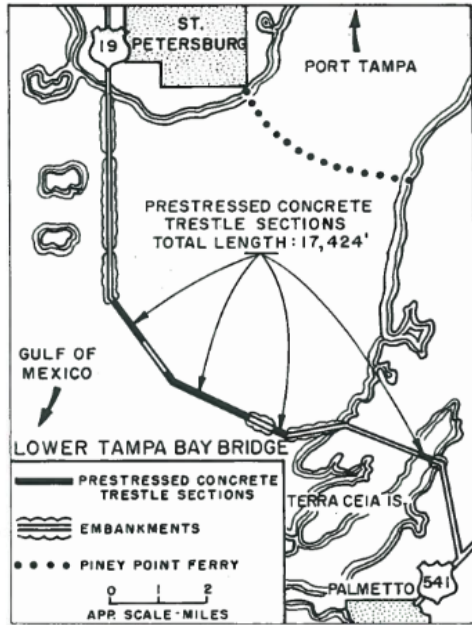
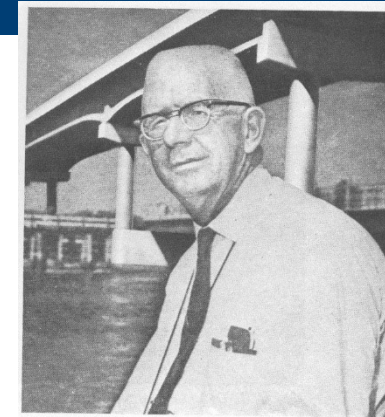


Fig. 21. Location map of Lower Tampa Bay Bridge.

## FDOT's History with Innovation and Structures Research...



William E. Dean. In background is the Sebastian Inlet Bridge for which Dean received a special PCI Award in 1964.

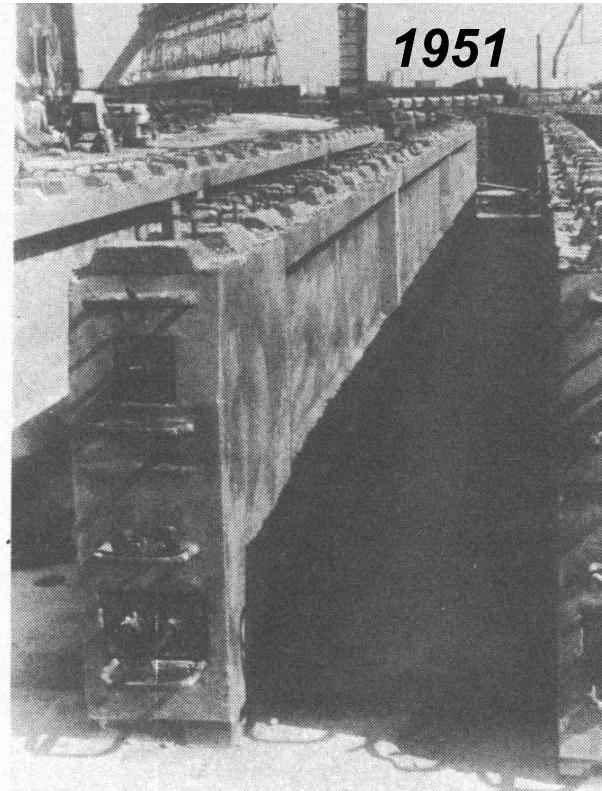


Fig. 26. Typical Tampa Bay beam



1950 (Ref : [PCI Journal, Nov-Dec 1978, Part 3, p22](#))

Fig. 25. Demonstration test of 100-ft (30.5 m) long prestressed channel slab at R. H. Wright & Son, Fort Lauderdale, Florida.

1951 (Ref: [PCI Journal, Jul-Aug 1978 Part 2, p51](#))

**William Dean's Influence**

During the early construction stages of

known as the Sunshine Skyway. This crossing connects the city of Brandon to St. Petersburg, Florida (Fig. 21).

This project had laid dormant for several years since bids taken around 1946 exceeded the allocated budget. The proposal was to construct a 17,500 ft (5334 m) trestle bridge calling for precast reinforced concrete units (Fig. 22) having spans of 36 ft (11 m) and a total width, out-to-out, of 37 ft 5 in. (11.4 m), including curbs (see next page).

Preload surmised that in using prestressed concrete, the 36 ft (11 m) span could, perhaps, be increased to 48 ft

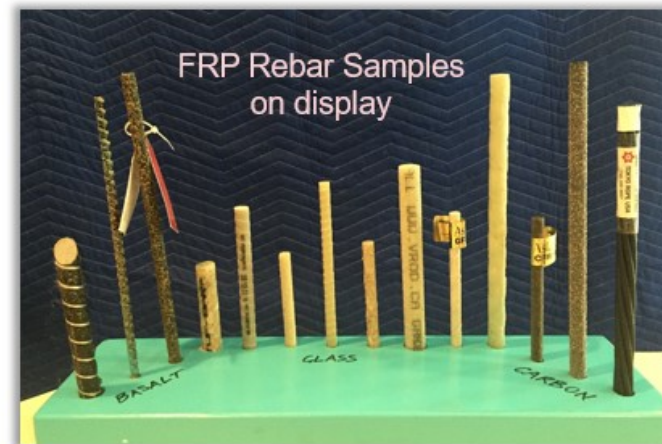


# Implementing Technology for Longer-Lasting Bridges & Structures

**Recall from 2020:**

FDOT Executive Workshop  
January 15, 2020

## Fiber-Reinforced Polymer Deployment for Corrosion-Free Bridges



Steven Nolan, P.E. ([Steven.Nolan@dot.state.fl.us](mailto:Steven.Nolan@dot.state.fl.us))



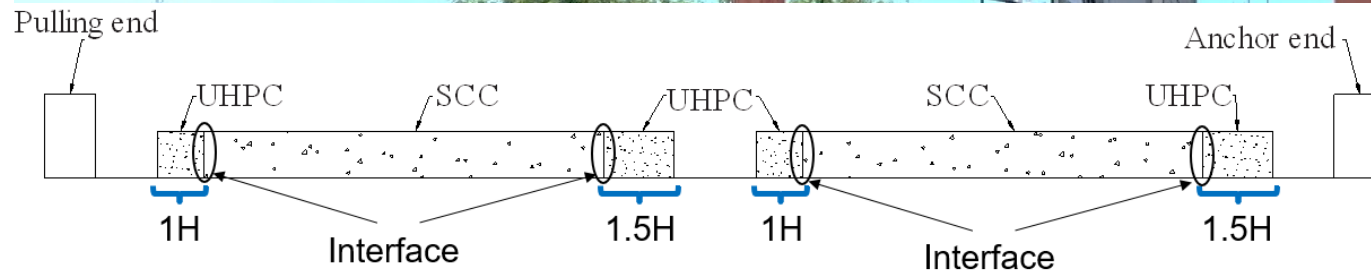
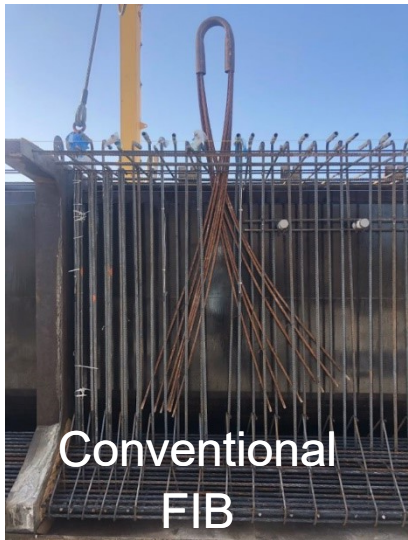
State Structures Design Office

<https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/structures/innovation/frp/fdot-exws-frp-nolan.pdf>

# Ultra-High-Performance Concrete (UHPC) Innovation

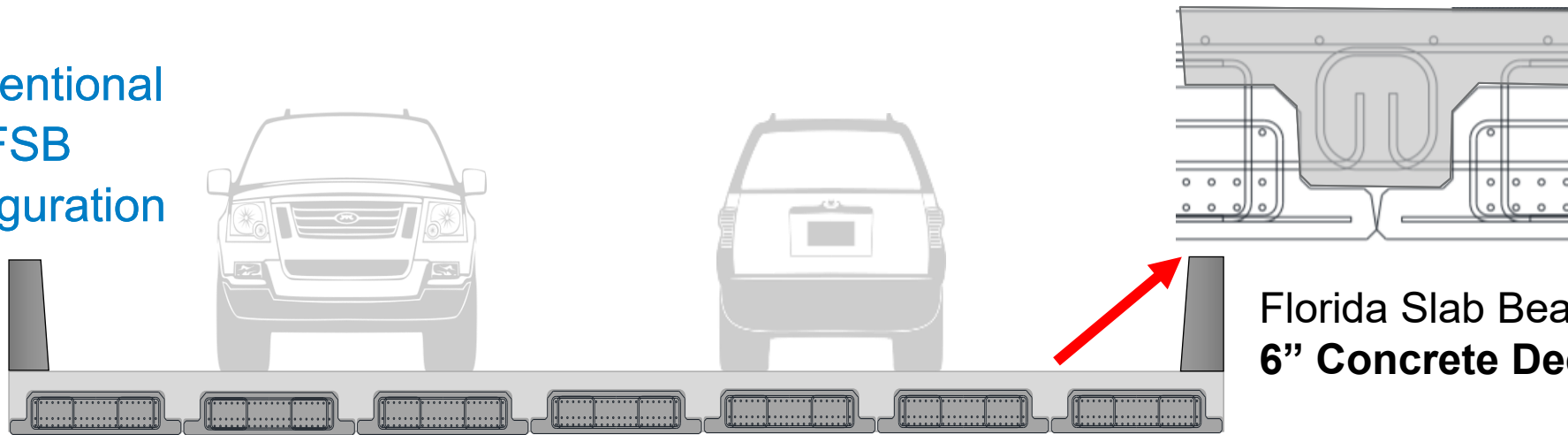
## Hybrid Prestressed Concrete Girder with UHPC

- Evaluated the effectiveness of UHPC to contribute to the structural performance of prestressed girders
- Reduce or eliminate visible end-region cracking
- This will help end girder span length and allow more prestressing force.

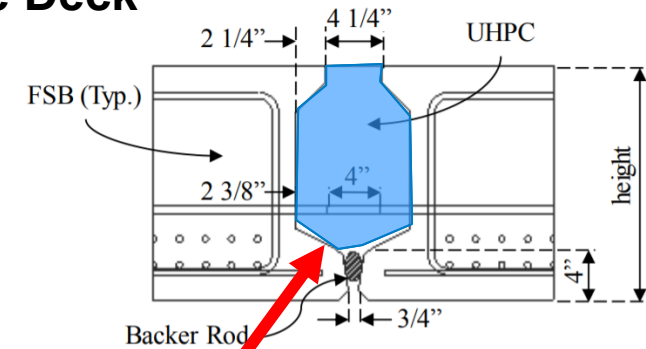


# Ultra-High-Performance Concrete (UHPC) Innovation

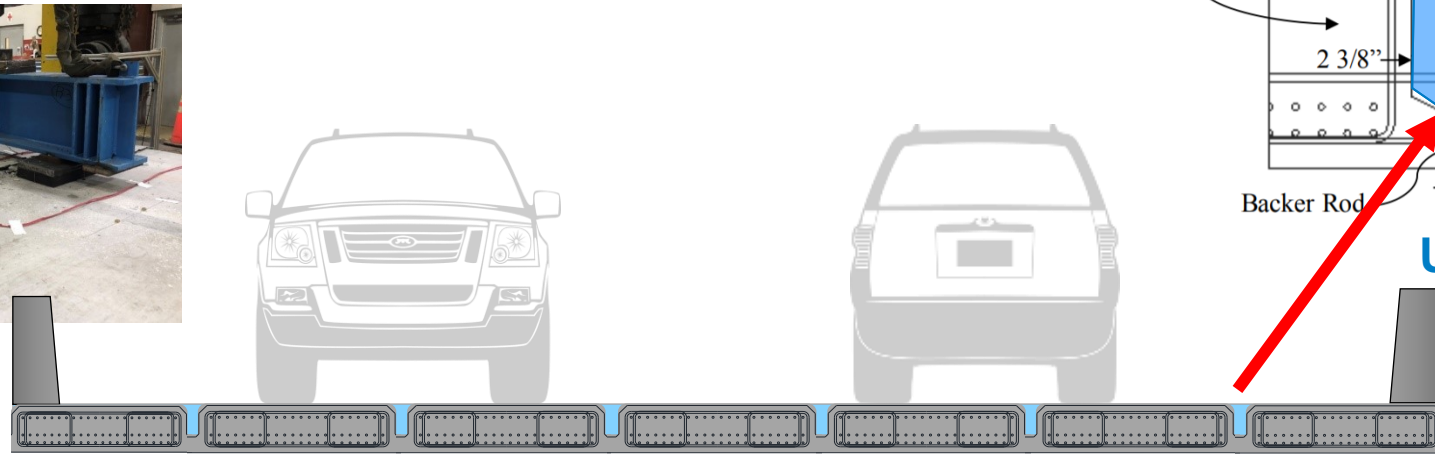
Conventional  
FSB  
Configuration



Florida Slab Beam with  
6" Concrete Deck



UHPC Closure  
Pour



Florida Slab Beam w/ UHPC Joints



# Corrosion-Resistant Strands (SS & FRP) Innovations



## High-Strength Stainless Steel (HSSS) Prestressing - Concrete Girders -



# Implementing Technology for Longer-Lasting Bridges & Structures



## How to encourage more District participation for implementation?

1. **Schedule** is always a challenge – *seems its always “too early” or “too late”.*
2. **Construction** is not the ideal time to propose innovative material alternates, but often that is what industry must default too thru the **CSI** process – *engineering cost and schedule risk is passed on to the contractor.*
3. **Implementation** at the beginning of the consultant’s Design Contract not working → *3-5 years before construction complete.*

→ *We need a more agile and equitable process!*

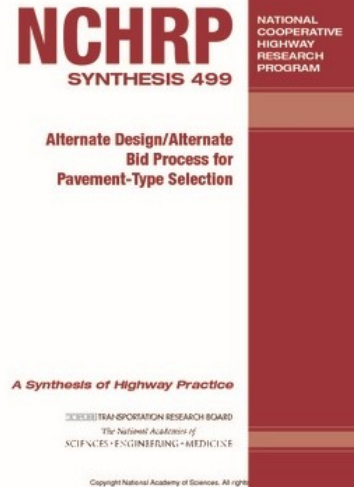


# Implementing Technology for Longer-Lasting Bridges & Structures



What would a more **agile** and **equitable** process look like?

- **Agile** – allow HCR alternate designs post-BDR & during procurement of contractor.
- **Equitable** – (1) Pay for the design of HCR alternate (**invitation-to-innovation**) in addition to conventional design (~**ADAB**) = “Low-Bid” (**A**);  
– (2) Bid alternates recognize the life-cycle cost benefits = “Best Value Bid” (**A+D**)
- **Incentivize** – **ATP\*\*** ≠ Cost Savings Initiative (**CSI**) proposals using select HCR materials (**invitation-to-innovation**) → give up cost share savings to FDOT.
- **Empower other Stakeholders** – cost adjustment and schedule extensions until institutionalized.



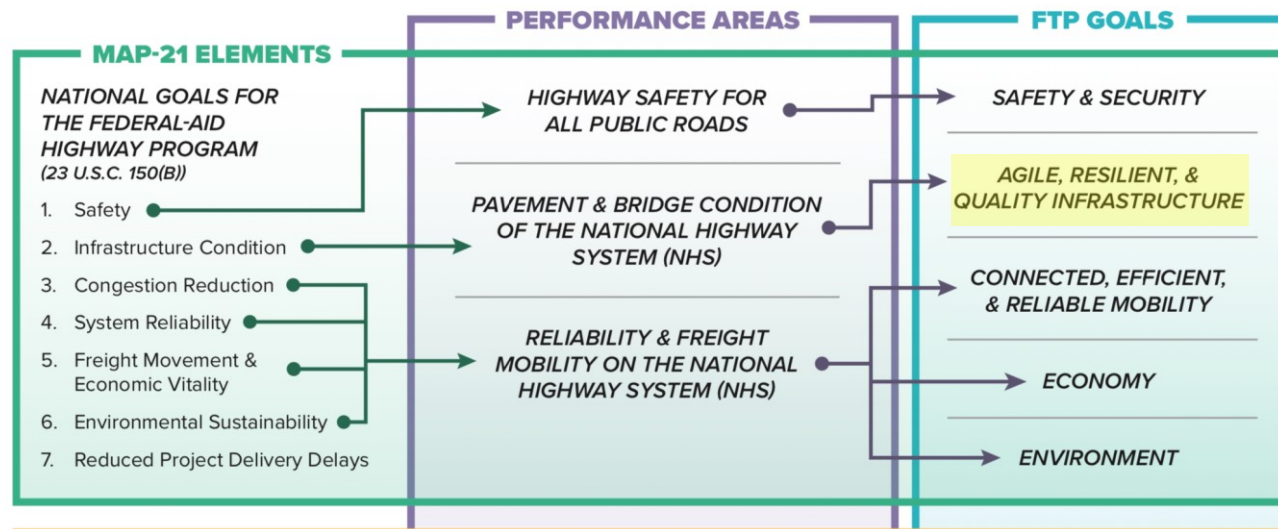


# Implementing Technology for Longer-Lasting Bridges & Structures



## How does a more agile and equitable process align with FTP goals?

### INTRODUCTION > NATIONAL GOALS, PERFORMANCE AREAS, & FTP GOALS



### PERFORMANCE > HIGHWAY INFRASTRUCTURE CONDITION

#### WHAT ARE OUR GOALS?



- FTP Goal:** Agile, resilient, and quality transportation infrastructure.
- National Goal:** To maintain the highway infrastructure asset system in a state of good repair.

#### WHY DOES THIS MATTER?

Maintaining the transportation system in good condition is one of Florida's basic commitments to its residents, visitors, and businesses. The physical condition of Florida's transportation system is important to meet customer expectations for safe and reliable travel and to support the state's quality of life and economic competitiveness.

#### WHAT ARE WE MEASURING?

Florida will continue to strive for a transportation system that is in good condition across every mode and every level of geography. These specific measures focus on the condition of roadway assets.

**Bridge condition** measures the physical characteristics of the bridge and its components. **Pavement condition** refers to the physical characteristics of roadway pavement, such as the degree of smoothness and evidence of cracking, rutting, or misalignment. A bridge or pavement in good condition has limited maintenance needs. A bridge or pavement in poor condition may be nearing a point where replacement or reconstruction is needed. This designation does not mean that a bridge or pavement is unsafe; rather, it needs frequent inspection and will become a priority for investment.

Florida law requires FDOT to ensure that 80 percent of the State Highway System pavement and 90 percent of FDOT-maintained bridges meet statewide standards. The federal transportation performance measures focus on the National Highway System (NHS), which comprises a subset of the State Highway System but also includes a small number of locally owned roads and bridges.

	FLORIDA'S STATEWIDE SYSTEM	NATIONAL HIGHWAY SYSTEM
<b>BRIDGES</b>	<b>12,529 BRIDGES</b> 7,044 maintained by FDOT	<b>5,584 BRIDGES</b> 5,430 owned by the state 151 owned by local governments
<b>PAVEMENT</b>	<b>275,922 LANE MILES</b> of all public roads 44,976 owned by the state	<b>37,309 LANE MILES</b> 8,630 on the Interstate 28,679 non-Interstate (26,207 state owned, 2,472 locally owned)

Source: FDOT Bridge Inventory Report, FHWA, National Bridge Inventory, FHWA, Highway Statistics, 2019 data.

Each bridge is inspected on a regular basis to evaluate components such as the deck, superstructure, substructure, and culverts. Individual components are rated on a numerical scale, and the bridge as a whole is classified as in good, fair, or poor condition based on the lowest rating for a single component. Performance is measured as the percentage of NHS bridges classified as in good or poor condition, based on deck area.

Pavement sections are assessed in a similar manner to evaluate the degree of roughness, cracking, rutting (longitudinal surface depressions), and faulting (vertical misalignment of two adjoining concrete slabs). The specific metrics and thresholds vary based on whether the pavement is asphalt, jointed concrete, or continually reinforced concrete. A section must be in good condition on all relevant metrics to be labeled good overall. Performance is measured as the percentage of NHS pavement classified as in good or poor condition, based on lane miles. This measure is reported for both the Interstate Highway System and the non-Interstate portion of the NHS.

# Why? Bridge Durability & Structural Advancement

- **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):



## WORK ZONES



Work zone fatalities make up approximately two percent of overall fatalities and two percent of serious injuries in Florida. Specifically, work zone crashes represented 385 fatalities and 2,414 serious injuries from 2015 to 2019, with the number trending upward over time. Work zone crashes compound the situation because of the risk they create to roadside workers who were present in the work zone in 35 percent of the fatal crashes and 44 percent of serious injury crashes. These crashes also can create tremendous disruption to roadways until they are cleared. Solutions include targeted enforcement in work zones, implementation of smart work zone applications, and efforts to educate drivers about work zone safety.

- HSSS-Prestressed Concrete (*2205 Duplex SS*)
- CFRP-Prestressed Concrete (*Carbon strands*)
- FRP-Reinforced Concrete (*Glass & Basalt*)
- Ultra-High Performance Concrete (*UHPC*)
- Light-weight Concrete or FRP (*Longer spans and/or less shipping cost*)

**Highly  
Corrosion-  
Resistant  
(HCR)**

**Structural  
Advancement**

42

**FLORIDA**  
Strategic Highway Safety Plan

**BUILDING FOR ETERNITY**

THE HISTORY AND TECHNOLOGY  
OF ROMAN CONCRETE ENGINEERING  
IN THE



By  
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Edited by  
J. B. OLESON

10

# What? Bridge Durability & Structural Advancement



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.

### 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](#)

*Previously: "invitation-to-innovation"*

## 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

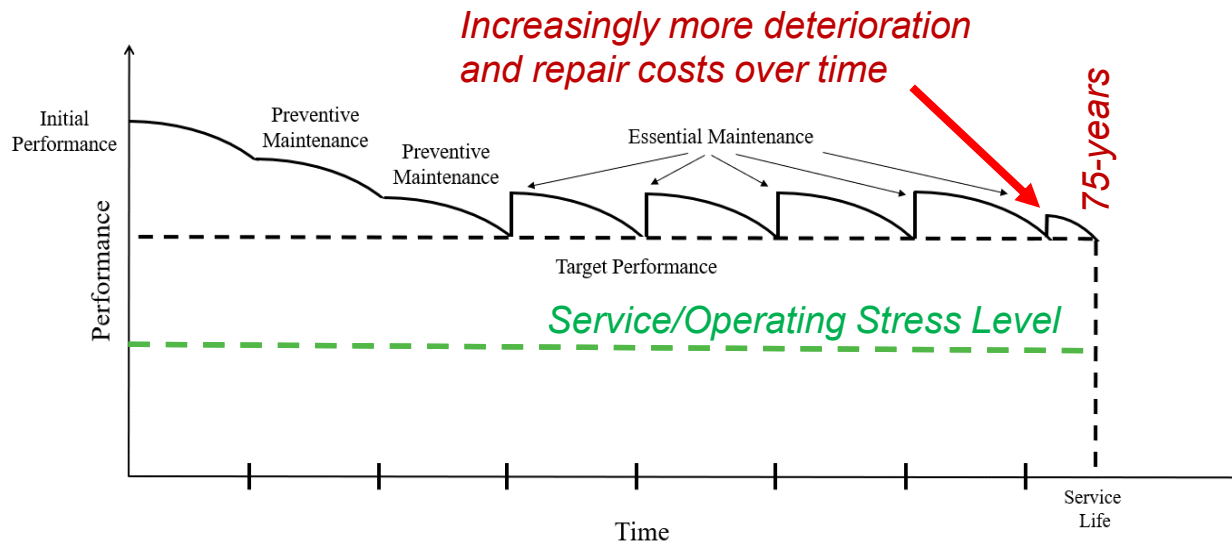
Ultra-High Performance Concrete (UHPC)

+ Stainless-Steel Prestressing Strand & Rebar

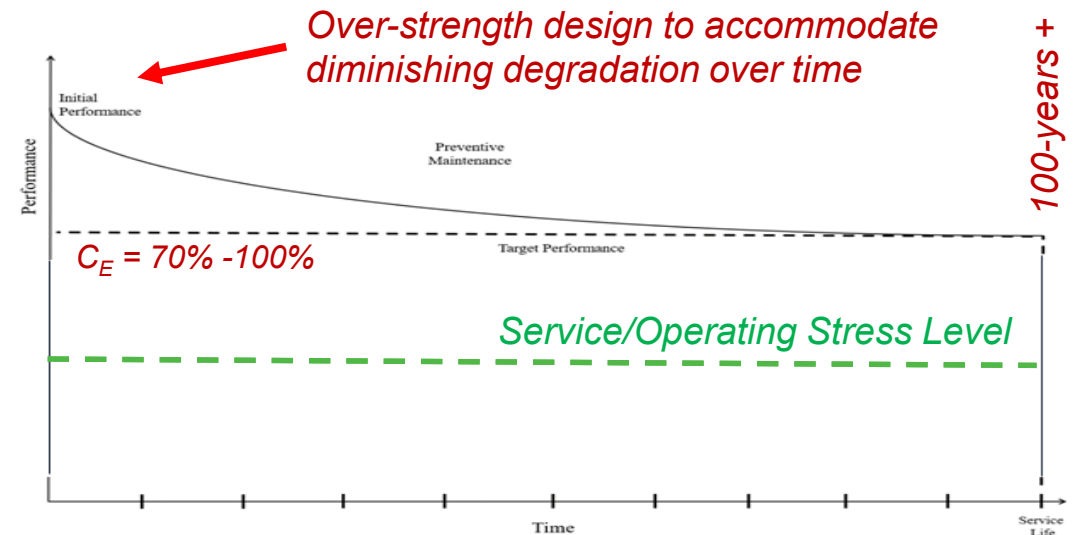


# How? Cost Justification (Life-Cycle Cost)

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



**Current CS-RC/PC process**

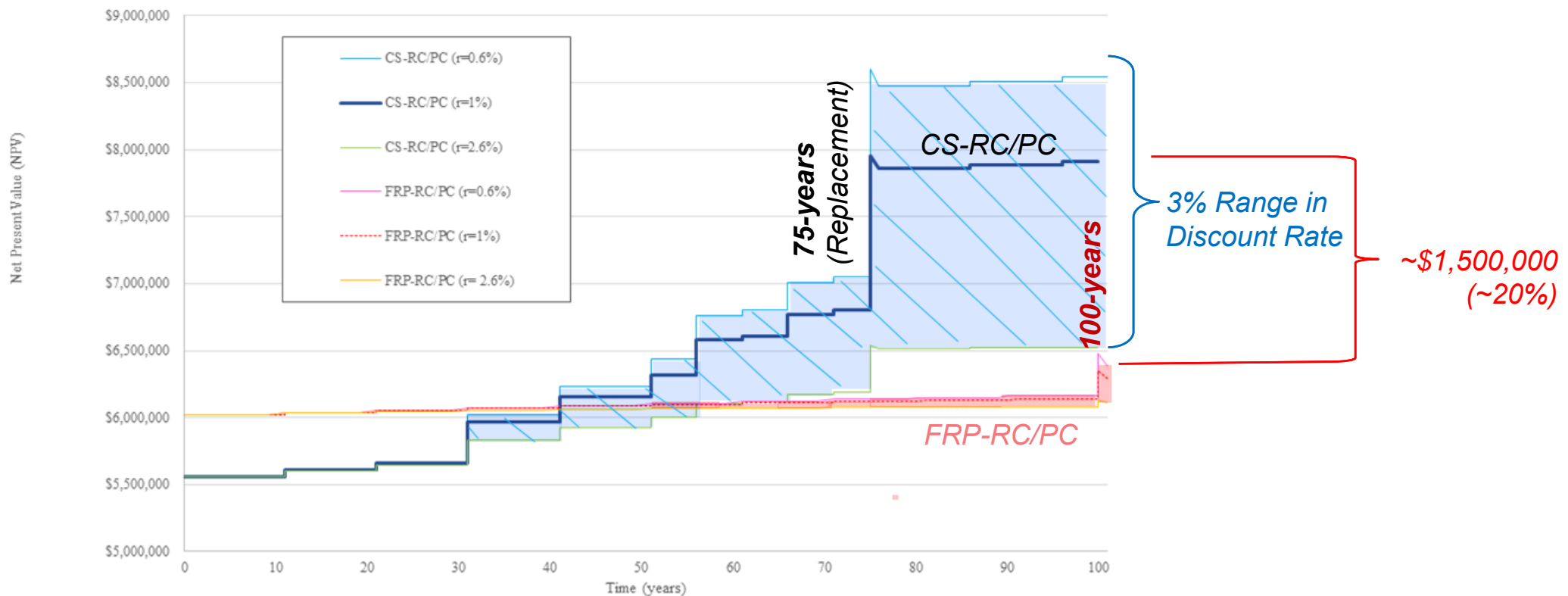


**HCR-RC/PC alternative**

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.

# How? Cost Justification (Life-Cycle Cost)

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



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

# How? Project Examples to build upon...

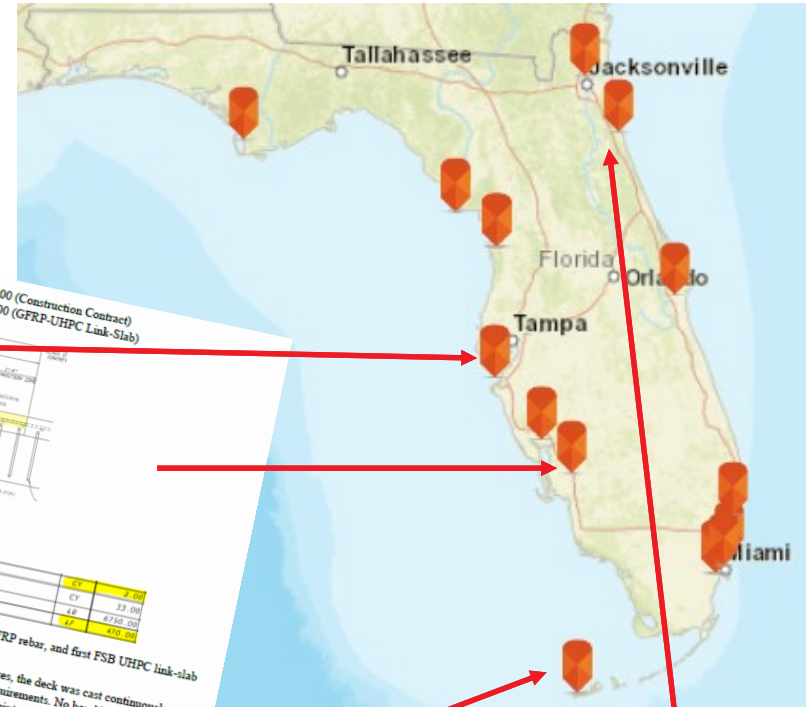
Structures Design - Transportation Innovation  
 Fiber Reinforced Polymer (FRP)  
 Reinforcing Bars and Strands

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



## Fast-Facts:

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



### FRP – Design Innovation

**Innovation Initiative:**

new vehicular bridge to use CFRP prestressed slabs using GFRP-RC. Abutments and embankment

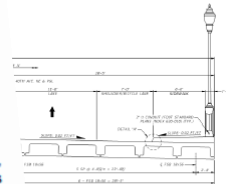
ted in the splash-zone require concrete using ternary trafine flyash or calcium nitrate additives. Also, ed to zero, and waterproofing sealants may be

using CFRP prestressing strands and GFRP rtion with no need for reduction in the AASHTO

strands (approx. 90,000 LF + 15,000 LF Strands SB (18"x56" and 18"x58") x 49' & 59' units, transverse reinforcement in FSBs

le bent caps and bulkhead caps and 7,000 #6's) stressed concrete piles (approx. 4350 LF) 800 SF)

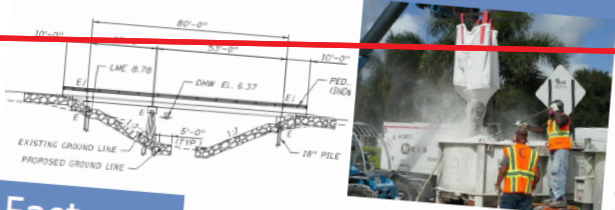
eliminates the need for additional concrete r corrosion protection. Lightweight equipment costs because of the handling. Other costs for the owner.



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 Mohammad, P.E.

Page

### FDOT Transportation Innovation Initiative: UHPC – Design Innovation



### Fast Facts: Ultra-High Performance Concrete

**Project Location:** FDOT District One Port Charlotte Charlotte County, Florida  
**Agency:** Florida Department of Transportation  
**URL:** <http://www.fdot.gov/structures/innovation/UHPC.shtm>  
**Project Name:** US 41 Pedestrian Bridge over Sunset Waterway Bridge No. 019004 FPID: 435390-1

Structures Design / Design Innovation  
**Ultra-High Performance Conc**

Structures Design - Transportation Innovation  
 Ultra-High Performance Concrete (UHPC)

Overview  
 Usage Restrictions / Parameters  
 Design Criteria  
 Specifications  
 Approved Products  
**Projects**  
 FDOT Research  
 Technology Transfer (T<sup>2</sup>)  
 Contact

100,000 (Construction Contract)	10,000 (GFRP-UHPC Link-Slab)
CF	33.00
CE	4.25
CF	4730.00
CE	270.00

PSU bridges, the deck was cast continuously over expansion joints at each support, due to significant differences in the use of a link-slab



US-1/Cow Key Channel



SR-A1A Flagler Beach

### 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:** 40th 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)



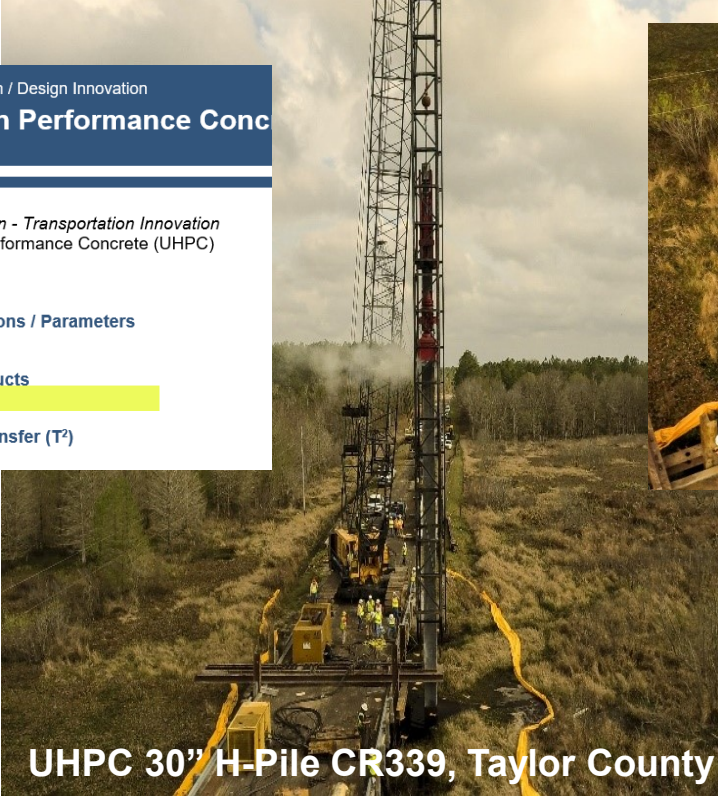
# How? Project Examples to build upon...

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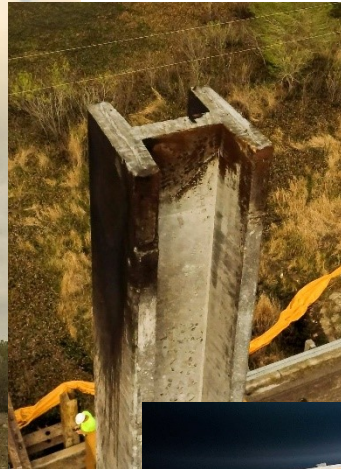
Structures Design / Design Innovation  
**Ultra-High Performance Conc**

Structures Design - Transportation Innovation  
 Ultra-High Performance Concrete (UHPC)

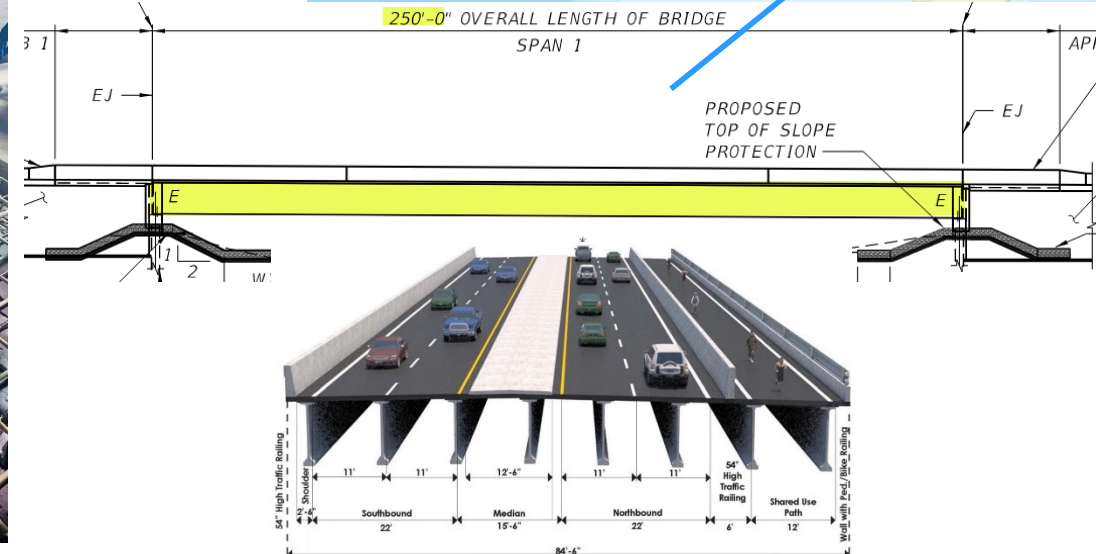
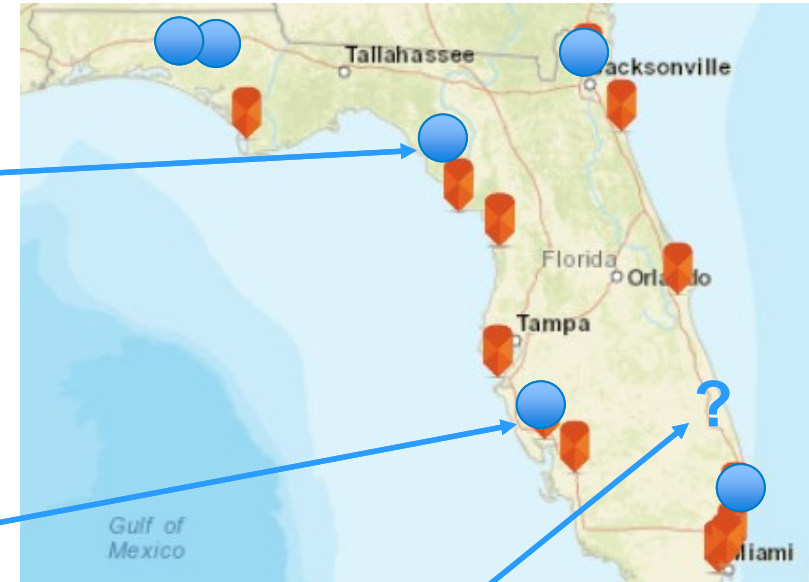
- Overview
- Usage Restrictions / Parameters
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- Projects**
- FDOT Research
- Technology Transfer (T<sup>2</sup>)
- Contact



UHPC 30" H-Pile CR339, Taylor County



UHPC Link-Slab,  
 US-41/Sunset Canal



# Implementing ATP's and ADAB for Longer-Lasting Bridges & Structures



## **Negative effects** of a more agile and equitable process?

- **Agile** – *mistakes due to new procedures & doing more with the same or less.*
- **Equitable** – *cost & time for design and/or construction.*
  
- **Incentives** – ATP's = *no cost sharing with the Department,*  
– ADAB = *additional design fees.*
- **Empowering other Stakeholders** – ATP's = *loss of control,*  
– ADAB = *more bid effort for Contractors.*



# Implementing ATP's & ADAB for Longer-Lasting Bridges & Structures



## Negative effects of a more agile and equitable process?

- Agile – mistakes due to new procedures same or less
- Equitable – cost & time for design at
- Incentives – How much will it cost?  
Alt. Design/Alt. Bid (ADAB) →
- Empowering other Stakeholders –



### WORK PROGRAM OVERVIEW \$3B NEW LETTINGS BREAKDOWN (FY21/22)

Program Plan	Program Plan Amount	Construction Budget	Construction Amount	New Lettings	New Lettings Amount
Construction	\$4,149.6	New Lettings	\$3,341.9	Roadway	\$1,478.5
				Roadway Resurfacing	\$909.3
				Bridge Replacement	\$345.6
				Other Lettings	\$333.3
				Safety	\$166.0
				Bridge Repair	\$66.8
				Traffic Operations	\$42.4
				<b>Total</b>	<b>\$3,341.9</b>
				Contingency	\$485.2
				P3 Payments	\$172.6
				LAP Lettings	\$120.2
				Bonus Payments	\$29.7
<b>Total</b>	<b>\$4,149.6</b>				
Operations and Maintenance	\$1,539.7				
Public Transportation	\$1,288.7				
Preliminary Engineering	\$1,034.0				
Right of Way	\$708.7				
CEI	\$567.6				
Administration and Other	\$560.3				
Other Product and Product Support	\$514.1				
<b>Total</b>	<b>\$10,362.7</b>				

20 Alt. Bridge Designs/yr.  
@ 100 hrs. (average)/project  
~ \$200K ~ 0.06% BR Const.  
< 0.25% BR Design



# Implementing ATP's & ADAB for Longer-Lasting Bridges & Structures



## Positive outcomes of a more agile and equitable process?

- **Agile** – *more responsive to innovation and scalable deployment*
  - *could bring new business to Florida if market is seen as more open than other states.*
- **Equitable** – *all solutions are evaluated based on value.*
- **Incentives** – *Technology Transfer and Skills building,*
  - *makes FDOT look even more progressive!*
- **Empowerment of other Stakeholders** – *more buy-in or “ownership” of the implementation challenges*

# Implementing ATP's & ADAB for Longer-Lasting Bridges & Structures



## Options to move forward:

1. Have **SDO's** prepare all the alternate designs, but:
  - *Not enough in-house staff/resources (~ 20 projects/year)*
  - *Perhaps limited to tools development & technical support*
2. Have **Design Consultant** contracts allowed negotiable additional hours, for alternate designs:
  - *Superstructure designs & retaining walls only;*
  - *Keep same span configuration & depth for simplicity;*
  - *Improve knowledge transfer, skill and confidence building.*
  - *Keep low-bid construction procurement for now.*



# Questions

## PERFORMANCE > HIGHWAY INFRASTRUCTURE CONDITION

### HOW DOES THE FTP ADDRESS THESE TARGETS?

Florida has a long-established and highly effective approach to preservation and maintenance of its bridge and pavement assets. The current practices for asset management are rooted in statutory requirements and implemented by FDOT's strong commitment to maintain the existing infrastructure before implementing capacity projects.

The FTP reinforces this legislative commitment by identifying "agile, quality, and resilient infrastructure" as a long-range goal for all of Florida's transportation system. The current FTP identifies strategies to support this goal, with greater emphasis on identifying and mitigating risks related to extreme weather, climate, and other trends.

Florida's **Transportation Asset Management Plan (TAMP)** describes FDOT's objectives, measures, and processes for improving or preserving the condition and performance of NHS bridge and pavement assets. The TAMP is consistent with the FTP and identifies actions needed to meet the two- and four-year targets. Example strategies documented in the TAMP include:

- > **Program the replacement or repair** of all structurally deficient FDOT-maintained bridges and those bridges posted for weight restriction within six years of deficiency identification and program the replacement of all other FDOT-maintained bridges designated for economy replacement within nine years of identification.
- > **Balance the programming** of resurfacing projects in relation to needs and optimize the timing of projects through the pavement management system.



In addition, as required by 23 CFR Part 667, FDOT has conducted two statewide evaluations of facilities repeatedly requiring repair and reconstruction due to emergency events. The first evaluation, completed in 2018, focused on NHS roads and bridges. The second evaluation, completed in 2020, included non-NHS roads and bridges that had previously undergone emergency repairs using federal funds. These reports identified a small number of facilities in Escambia, Franklin, Leon, Monroe, and Pinellas counties where emergency repairs had occurred on more than one occasion following an emergency event between 1997 and 2019. Per federal rule, FDOT will determine if there are reasonable alternatives prior to including projects on these facilities in future updates to the Work Program. FDOT will coordinate with MPOs on these priorities identified by the MPOs on these facilities for potential inclusion in the Work Program, and also consider this information in updates to the TAMP. FDOT will update the evaluation following every emergency event, as well as on a regular four-year cycle.



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