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)

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Implementing Technology for Longer-Lasting Bridges & Structures

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


Fig. 26. Typical Tampa Bay beam

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

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

Florida Slab Beam w/ UHPC Joints

UHPC Closure Pour

Innovative Structural Research & Demonstration projects by the Florida DOT (2021)
Corrosion-Resistant Strands (SS & FRP) Innovations

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

Conventional Steel Strands

HSSS Strands

HSSS Strand Rupture

Innovative Structural Research & Demonstration projects by the Florida DOT (2021)
How to encourage more District participation for implementation?

1. **Schedule** is always a challenge – *seems it’s 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!**
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.*

**ATP** – Alternative Technical Proposal (similar to ATC for D-B)
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 AREAS**

- **HIGHWAY SAFETY FOR ALL PUBLIC ROADS**
- **FAVEMENT & BRIDGE CONDITION OF THE NATIONAL HIGHWAY SYSTEM (NHS)**
- **RELIABILITY & FREIGHT MOBILITY ON THE NATIONAL HIGHWAY SYSTEM (NHS)**

**FTP GOALS**

- **SAFETY & SECURITY**
- **AGILE, RESILIENT, & QUALITY INFRASTRUCTURE**
- **CONNECTED, EFFICIENT, & RELIABLE MOBILITY**
- **ECONOMY**
- **ENVIRONMENT**

**PERFORMANCE ELEMENT**

**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 drive 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; 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.

Each bridge is inspected on a regular basis to evaluate components such as the deck, superstructure, substructure, and subgrade. 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 bulging (vertical misalignment of two adjacent 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):
  - HSSS-Prestressed Concrete \(2205\) Duplex SS
  - CFRP-Prestressed Concrete \(\text{Carbon strands}\)
  - FRP-Reinforced Concrete \(\text{Glass & Basalt}\)
  - Ultra-High Performance Concrete \(\text{UHPC}\)
  - Light-weight Concrete or FRP \(\text{Longer spans and/or less shipping cost}\)

Highly Corroson-Resistant (HCR)

Structural Advancements
Non-Corrosive

What? Bridge Durability & Structural Advancement

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

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

**How? Cost Justification (Life-Cycle Cost)**

- **Current CS-RC/PC process**
- **HCR-RC/PC alternative**

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

3% Range in Discount Rate

~$1,500,000 (~20%)
How? Project Examples to build upon…

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

**Fast Facts:**
Carbon & Glass Fiber-Reinforced Polymer

**FRP - Design Innovation**

**Fast Facts:**
Ultra-High Performance Concrete

**UHPC - Design Innovation**

**Fast Facts:**
Ultra-High Performance Concrete

**Design Innovation: ADAB for Highly Corrosion-Resistant Bridges & Structures (2021)**
How? Project Examples to build upon…

Fast-Facts: [https://www.fdot.gov/structures/innovation/FRP.shtm#link9](https://www.fdot.gov/structures/innovation/FRP.shtm#link9)

Innovative Structural Research & Demonstration Project implementation by the Florida DOT (2021)

UHPC 30” H-Pile CR339, Taylor County

UHPC Link-Slab, US-41/Sunset Canal
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 and/or construction.
- **Incentives** – How much will it cost?

**Alt. Design/Alt. Bid (ADAB) →**

- Empowering other Stakeholders –

![Work Program Overview](image-url)

**$3B New Lettings Breakdown (FY21/22)**

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<th>Program Plan</th>
<th>Program Plan Amount</th>
<th>Construction Budget</th>
<th>Construction Amount</th>
<th>New Lettings</th>
<th>New Lettings Amount</th>
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**Contingency $485.3**

**P3 Payments $172.6**

**LAP Lettings $120.7**

**Bonus Payments $29.7**

**Total $4,149.6**

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*
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.*
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 “sustainable, 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 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 2018. 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 project 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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