FDOT Activities and Experiences Using FRP Composites

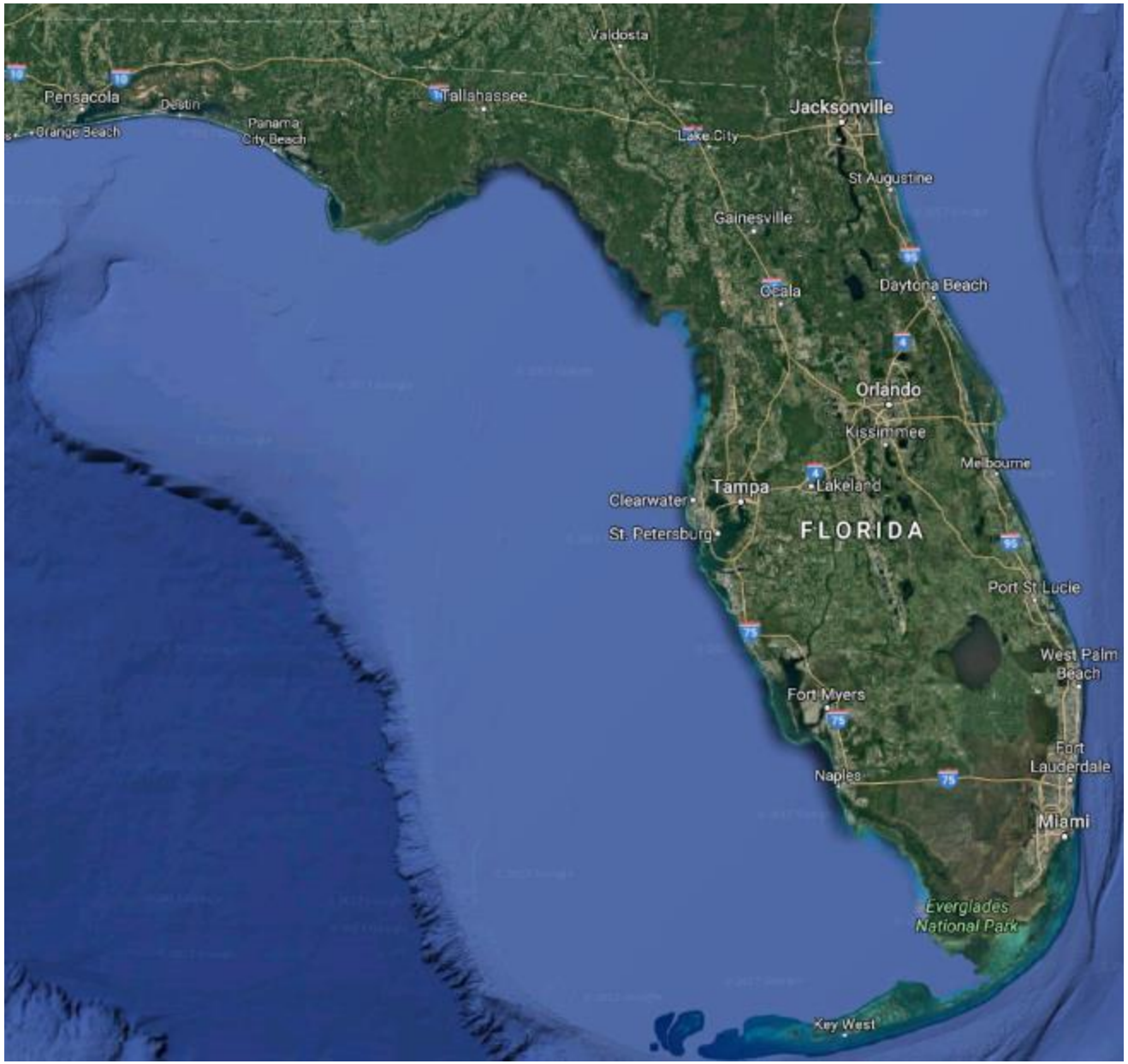
Will Potter

Florida Department of Transportation

Outline

- The Need – Why FRP Composites?
- Florida's FRP History and Implementation Efforts
- FRP Guidance Documents
- Project Examples
- Looking Forward…

-The Need-
Why FRP Composites?



Avoiding Corrosion

- Durability/Service Life
- Cost/Benefit Analysis
- Mitigating Risks


US 1 (Jupiter)


US 1 (Jupiter)


Gandy Blvd. seawall, (Tampa Bay)

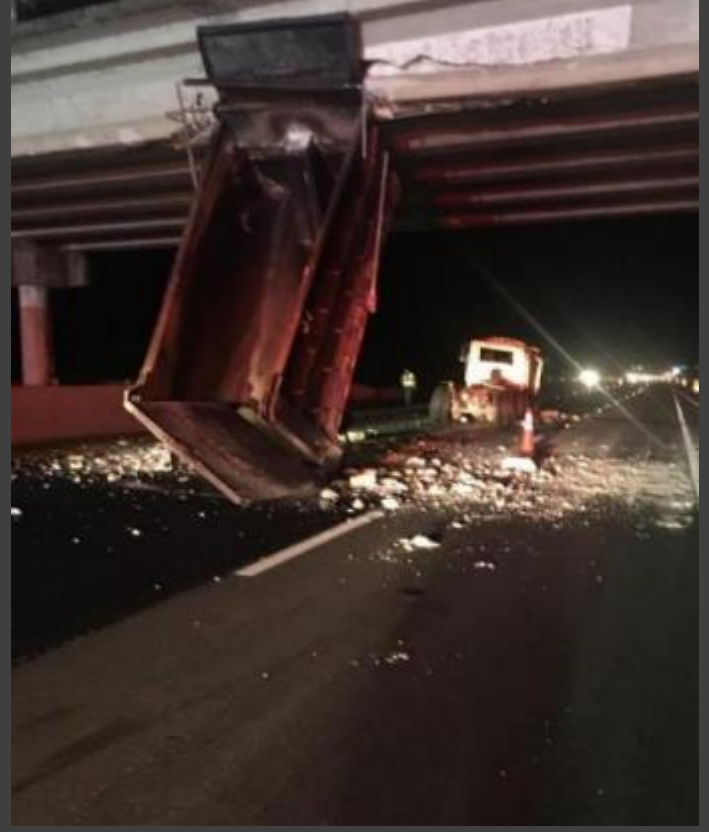

Old St. George Island Bridge Piling

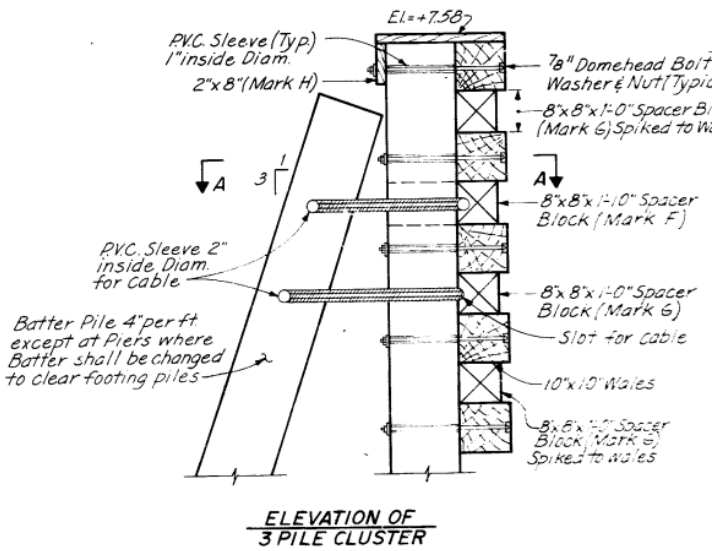

New and Old Seven-Mile-Bridge, (Florida Keys)


Courtney Campbell Causeway, seawall (Tampa Bay)

Repair and Strengthening Operations

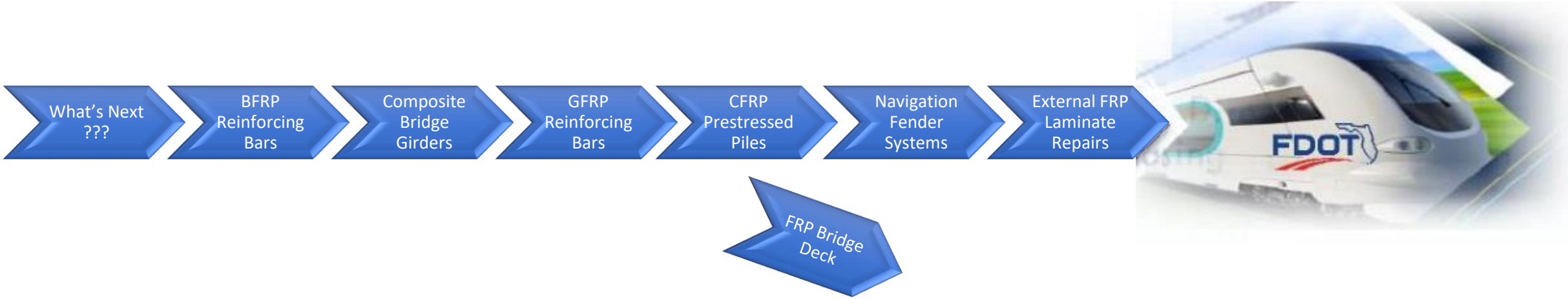
- Impact Damage
- Corrosion Damage
- Load Changes
- Defects





Bridge Fender Systems

Florida's FRP History



FDOT Research Efforts

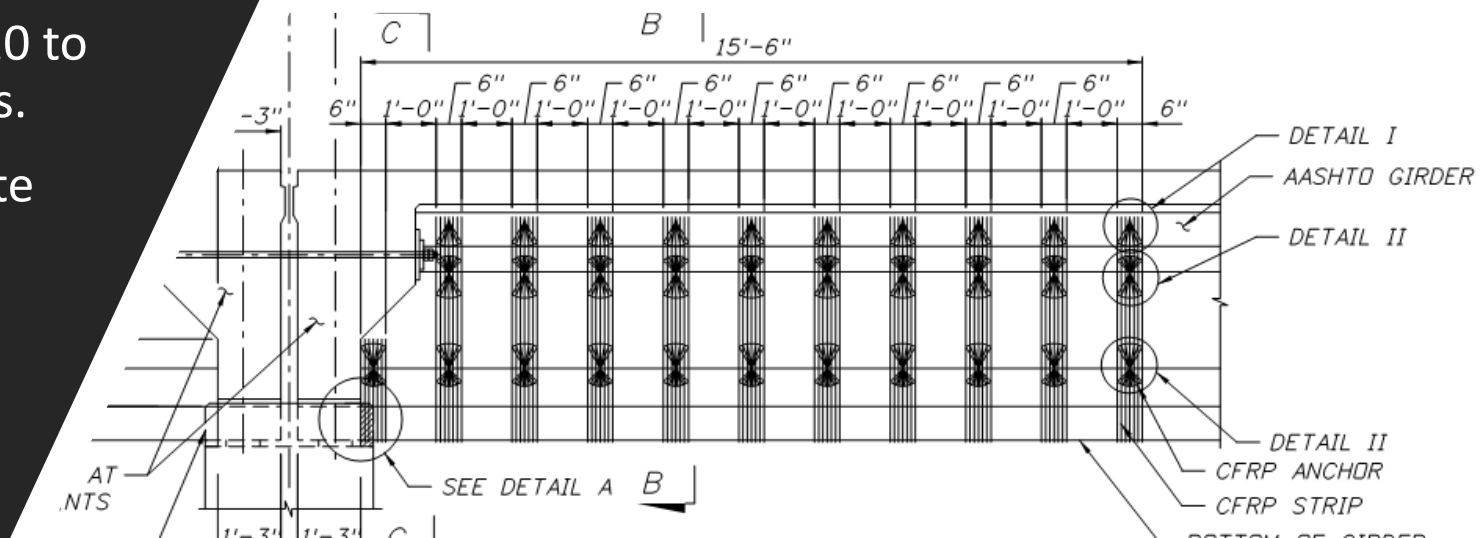
1992	Feasibility of Fiberglass Pretensioned Piles in a Marine Environment	Sen, R.	USF
1995	Active Deformation Control of Bridges with AFRP Cables	Arockiasamy, M.	FAU
1995	Durability of CFRP Pretensioned Piles in a Marine Environment – Phase II	Sen, R.	USF
1997	Mechanical and Microscopy Analysis of CFRP Matrix Composite Materials	Garmestani, H.	FAMU/ FSU
1997	FRP Composite Column and Pile Jacket Splicing	Mirmiran, A.	UCF
1997	An Analytical and Experimental Investigation of Concrete Filled FRP Tubes	Mirmiran, A.	UCF
1997	Flexural Reliability of RC Bridge Girders Strengthened with CFRP Laminates	Okeil, A.	UCF
1998	Studies of CFRP Prestressed Concrete Bridge Columns and Piles in Marine Environment	Arockiasamy, M.	FAU
1999	LRFD Flexural Provisions for PSC Bridge Girders Strengthened with CFRP Laminates	El-Tawil, S.	UCF
2000	Investigation of Fender Systems for Vessel Impact	Yazdani, N.	FAMU/ FSU
2001	Design of Concrete Bridge Girders Strengthened with CFRP Laminates	El-Tawil, S.	UCF
2003	Hybrid FRP-Concrete Column	Mirmiran, A.	NC State
2004	CFRP Repair of Impact Damaged Bridge Girders	Hamilton, T	UF
2009	Thermo-Mechanical Durability of CFRP Strengthened RC Beams	Mackie, K	UCF
2011	Testing of Trelleborg Structural Plastics	Wagner, D.	FDOT

FDOT Research Efforts Continued…

2012	The Repair of Damaged Bridge Girders with CFRP Laminates	El-Safty, A.	UNF
2014	Investigation of CFCC in Prestressed Concrete Piles	Roddenberry, M.	FAMU/ FSU
2015	Repair of Impact Damaged Utility Poles with FRP, Phase II	Mackie, K.	UCF
2015	Use of CFRP Cable for Post-Tensioning Applications	Mirmiran, A.	FIU
2017	Durability Evaluation of Florida's FRP Composite Reinforcement for Concrete Structures	Hamilton, T.	UF
2018	Bridge Girder Alternatives for Extremely Aggressive Environments	Brown, J.	ERAU
2018	Degradation Mechanisms and Service Life Estimation of FRP Concrete Reinforcements	El-Safty, A.	UNF
2018	Testing, Evaluation, and Specification for Polymeric Materials used for Transportation Structures	El-Safty, A.	UNF
2018	Performance Evaluation of GFRP Reinforcing Bars Embedded in Concrete Under Aggressive Environments	Kampmann, R.	FAMU/ FSU
2019	Inspection and Monitoring of Fabrication and Construction for the West Halls River Road Bridge Replacement	Roddenberry, M.	FAMU/ FSU
2019	Performance Evaluation, Material and Specifications for Basalt FRP Reinforcing Bars Embedded in Concrete (STIC)	Kampmann, R. Roddenberry, M.	FAMU/ FSU
2021	Evaluation of GFRP Spirals in Corrosion Resistant Concrete Piles	Jung, S.	FAMU/ FSU
2021	Development of GFRP Reinforced Single Slope Bridge Rail	Consolazio, G.	UF
2021	Testing Protocol and Material Specifications for Basalt Fiber Reinforced Polymer Bars	Kampmann, R. Tang, Y	FAMU/ FSU

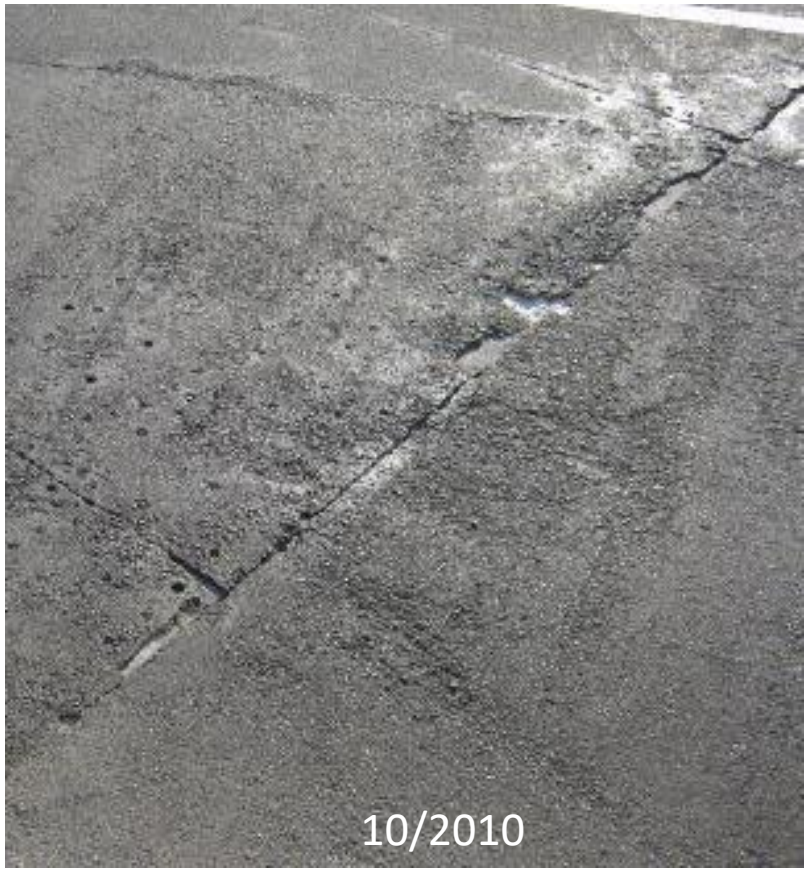
CFRP Repair and Strengthening

- Currently reference ACI 440.2R w/ modifications
  - Structures Design Manual – Volume 4 – Section 4
- Research and installations performed since the early 1990's
- Considered routine practice for given applications
- Repairs have been re-evaluated after 10 to 15 years of service with positive results.
- Detailing is critical to ensuring adequate performance and longevity.



Bridge Navigation Fender Systems

- 2006-2011 – Predesigned FRP Systems using Standard Plans
- 2011-2015 – Preset spacings under Standard Plans with Contractor/Vendor designs
- 2015+ - Customized Contractor/Vendor configuration and design



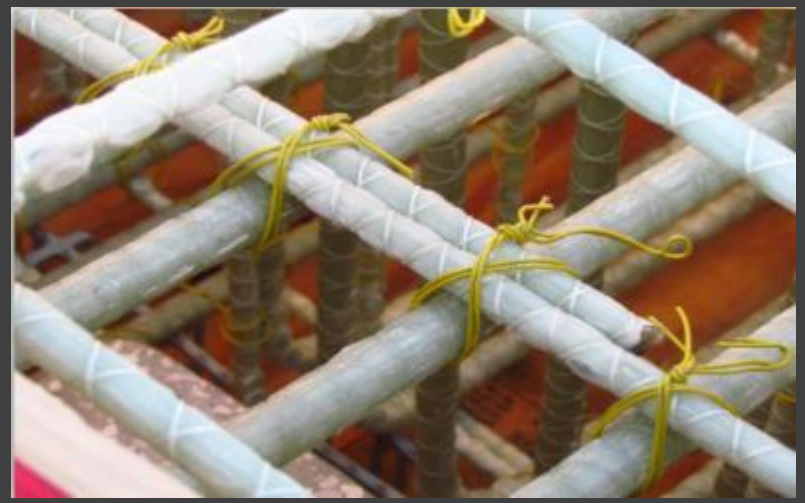
GFRP Bridge Deck

CFRP Prestressed Piling and Sheet Piling

- CFRP Pretensioned Piling
  - Standard Plans Index – 455-100 series
- CFRP Pretensioned Sheet Piling
  - Standard Plans Index – 455-440
- Continuing to learn and refine the detailing practices…

GFRP Reinforcing Bars

- Recent implementation effort
- Several projects under construction and more to come
- Initial low risk implementation effort with a broaden effort envisioned

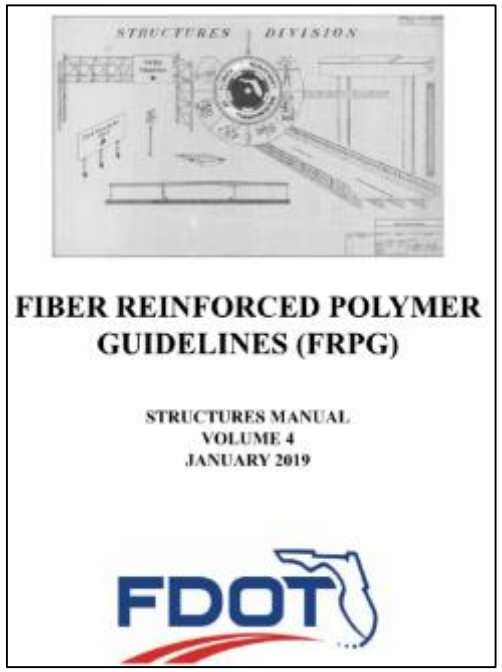


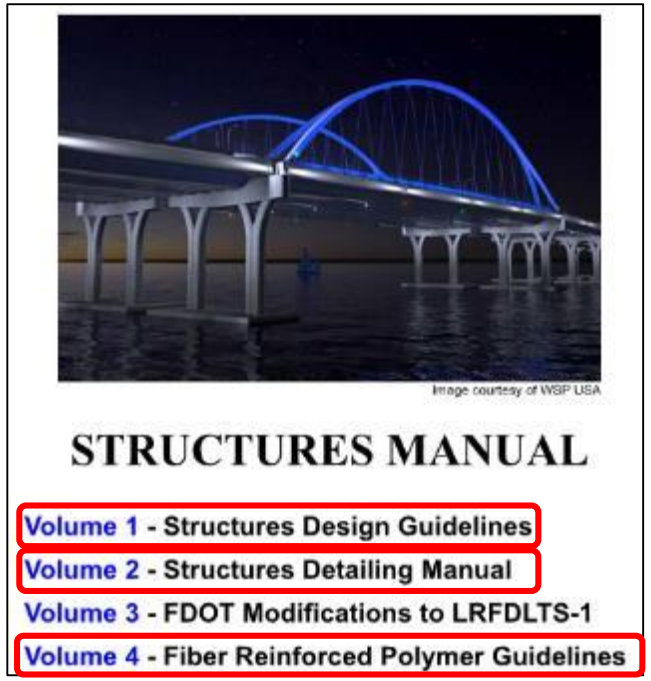
Composite Bridge Girders

- Continuing to evaluate the appropriate implementation methods…

Guidance Documents

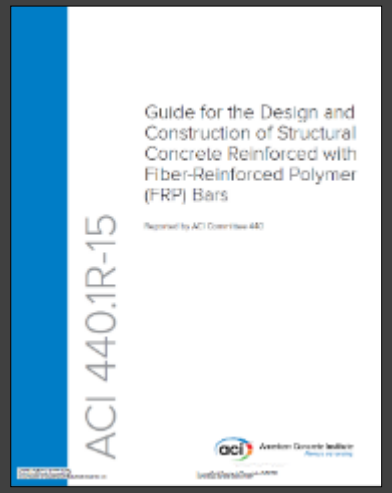
- Design Criteria
- Detailing Criteria
- Standard Plans
- Specifications
  - Material and Construction
- Materials Manual

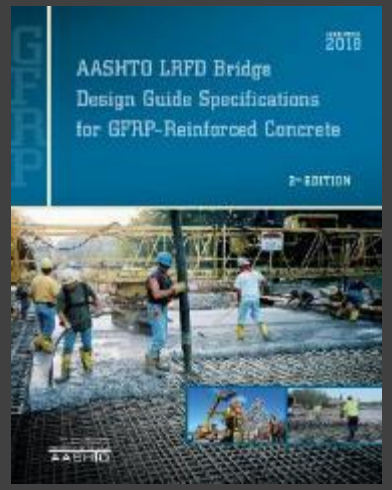


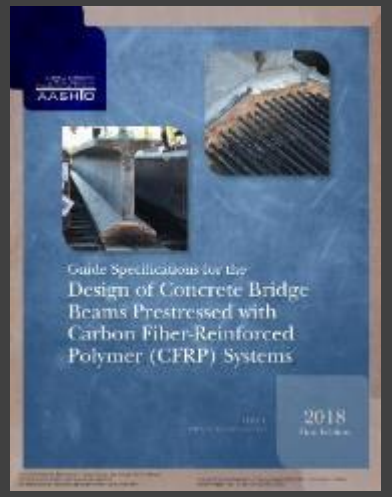


FDOT Structures Manual Design Criteria and Detailing Manual

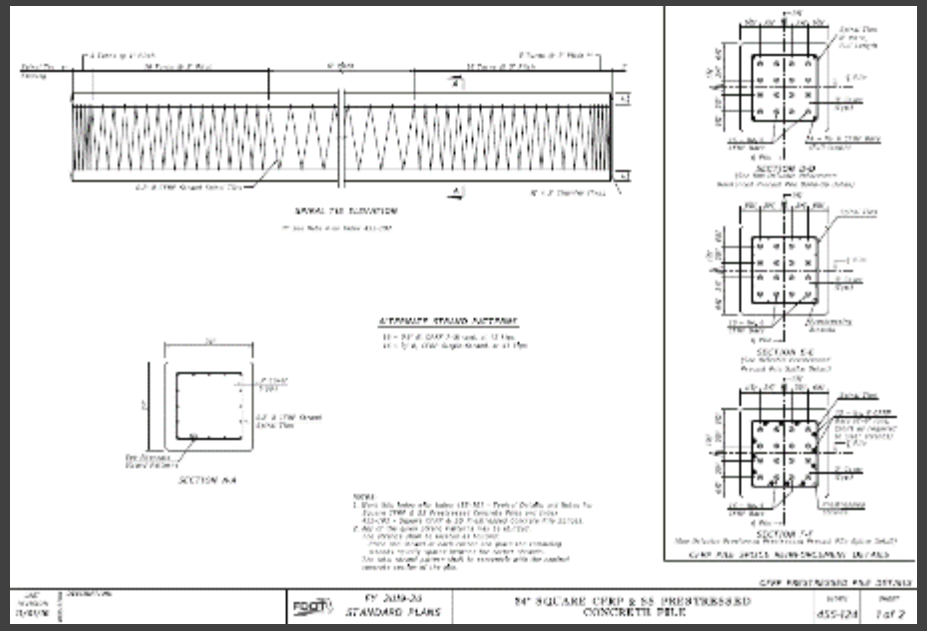
- Structures Design Guidelines
- Fiber Reinforced Polymer Guidelines
- Referenced Guides







Standard Plans



Structures Foundations	
455-101	Square CFRP and SS Prestressed Concrete Piles - Typical Details and Notes
455-102	Square CFRP and SS Prestressed Concrete Pile Splices
455-112	12" Square CFRP and SS Prestressed Concrete Pile
455-114	14" Square CFRP and SS Prestressed Concrete Pile
455-118	18" Square CFRP and SS Prestressed Concrete Pile
455-124	24" Square CFRP and SS Prestressed Concrete Pile
455-130	30" Square CFRP and SS Prestressed Concrete Pile
455-154	54" Precast/Post-Tensioned CFRP and SS Concrete Cylinder Pile
455-160	60" Prestressed CFRP and SS Concrete Cylinder Pile
Fiber Reinforced Polymer Fender Systems	
471-030	Fender System - Prestressed Concrete Piles and FRP Wales
Structures Foundations - Sheet Pile Wall	
455-400	Precast Concrete Sheet Pile Wall (Conventional)
455-440	Precast Concrete Sheet Pile Wall (CFRP/GFRP & HSSS/GFRP)

https://www.fdot.gov/design/standardplans/SPRBC.shtm

Developmental Standards (Plans)

Developmental Standard Plans

- Issued to implement new technologies in a limited trial fashion on an as-needed or an as-available basis.

WALL SYSTEMS		
D6011c	**Gravity Wall - Option C (GFRP Reinforced)**	
Certification Statement	Permitted Projects FPID No(s): 430021-1	
FIBER REINFORCED POLYMER BAR BENDING DETAILS		
D21310	**FRP Bar Bending Details**	
Certification Statement	Permitted Projects FPID No(s):	
	430021-1	433550-3
	432194-1	435815-1
	434359-1	
FRP REINFORCED TRAFFIC RAILINGS RAILINGS		
D22420	**Traffic Railing (32" F Shape - GFRP Reinforced)**	
Certification Statement	Permitted Projects FPID No(s): 430021-1	
FRP REINFORCED APPROACH SLABS		
D22900	**Approach Slab - GFRP Reinforced (Flexible Pavement Approach)**	
Certification Statement	Permitted Projects FPID No(s): 430021-1	

437635-1 438528-1

437973-1 441740-1

https://www.fdot.gov/roadway/DS/Dev.shtm

Construction and Material Specifications

- Construction
  - **105** – Contractor Quality Control (FRP Producers)
  - **400** – Concrete (FRP Bar)
  - **415** – Reinforcing for Concrete (FRP Bar)
  - **450** – Precast Prestressed Concrete Construction (FRP Bars/ Strand)
  - **471** – FRP Fender Systems (Design criteria and construction considerations)
- Materials
  - **932** – Nonmetallic Accessory Materials for Concrete Pavement and Concrete Structures (GFRP and CFRP Bars)
  - **933** – Prestressing Strand (CFRP Strand material)
  - **973** – FRP Composite Structural Shapes (material and fabrication requirements)

State Materials Office (Gainesville, FL)

Material and Producer Requirements

- State Materials Office Oversight Role:
  - Material Specification
  - Sampling and Testing Requirements
  - Quality Control Program – Production Facility Approvals
  - Conduct and Facilitate Materials Research

CFRP Girder Bearing Repair

Halls River Bridge

Halls River Bridge


Phase I


HCB Arch Casting


GFRP Deck Reinforcement


Completed Phase I

Halls River Bridge

Divers placing GFRP rebar mat in forms

Light-weight for easy handling

Bulkhead wall cap GFRP reinforcement in place

Prestressed Sheet Pile System (rebuilt 1970's): Extensive corrosion damage in splash zone

Completed view of North Wall

Bakers Haulover Cut Bridge Rehab.

Skyway Rest Area Seawall (Cap Rehab.)

Bridge Substructure (Rehab)

Looking Forward… New Projects in 2019

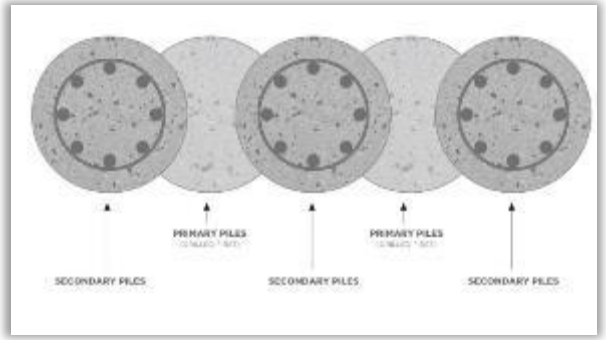
- SR A1A Secant-Pile Seawall – *11/6/18 contractor awarded*
- NE 23rd Ave/Ibis Waterway – *2/27/19 letting*
- US 41 over Morning Star & Sunset Canal – *2/27/19 letting*
- US 41 over North Creek – *7/31/19 letting*
- US 1 over Cow Key channel, 6 Span Replacement – *10/21/19 letting*
- Pensacola Beach Pedestrian Tunnels (3) – *Design 100% (city project)*

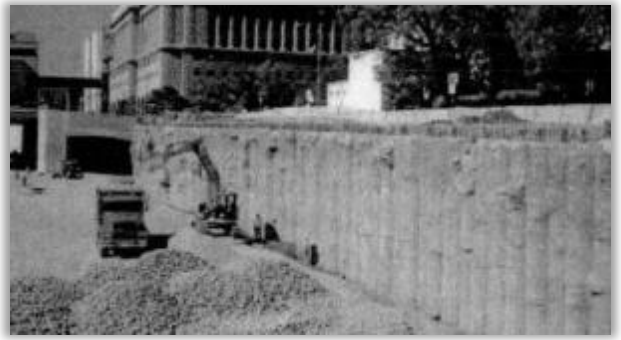
Looking Forward… New Projects in 2019

- SR A1A Secant-Pile Seawall – *11/6/18 contractor awarded*

Proposed Secant Wall Concept Rendering

SR A1A damage after Hurricane Matthew (2016)





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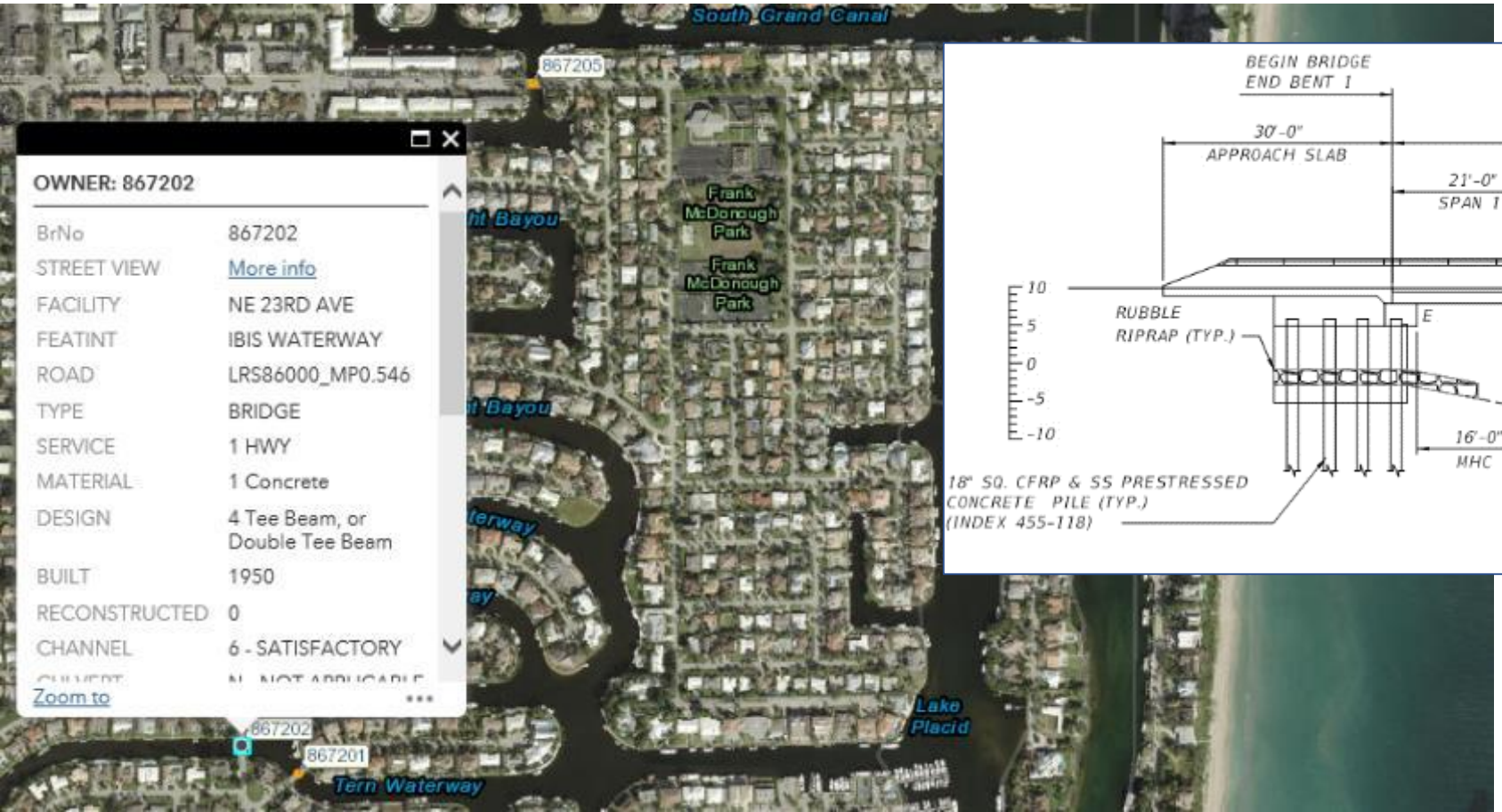
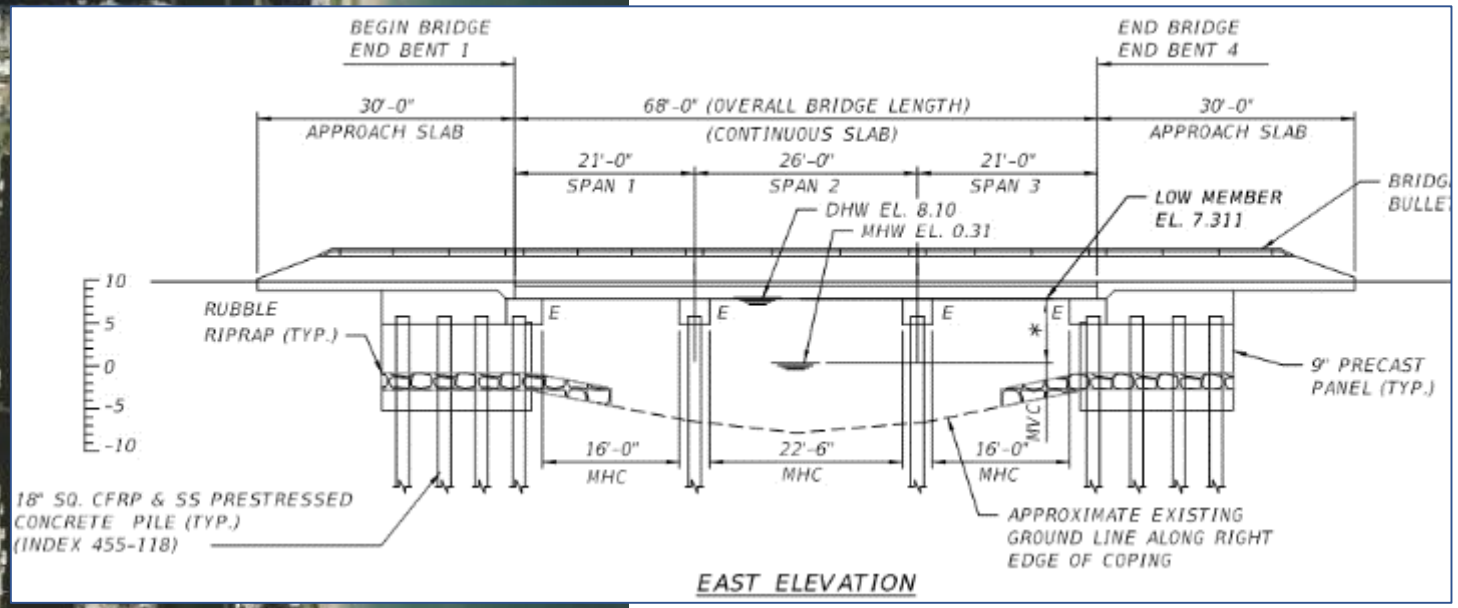
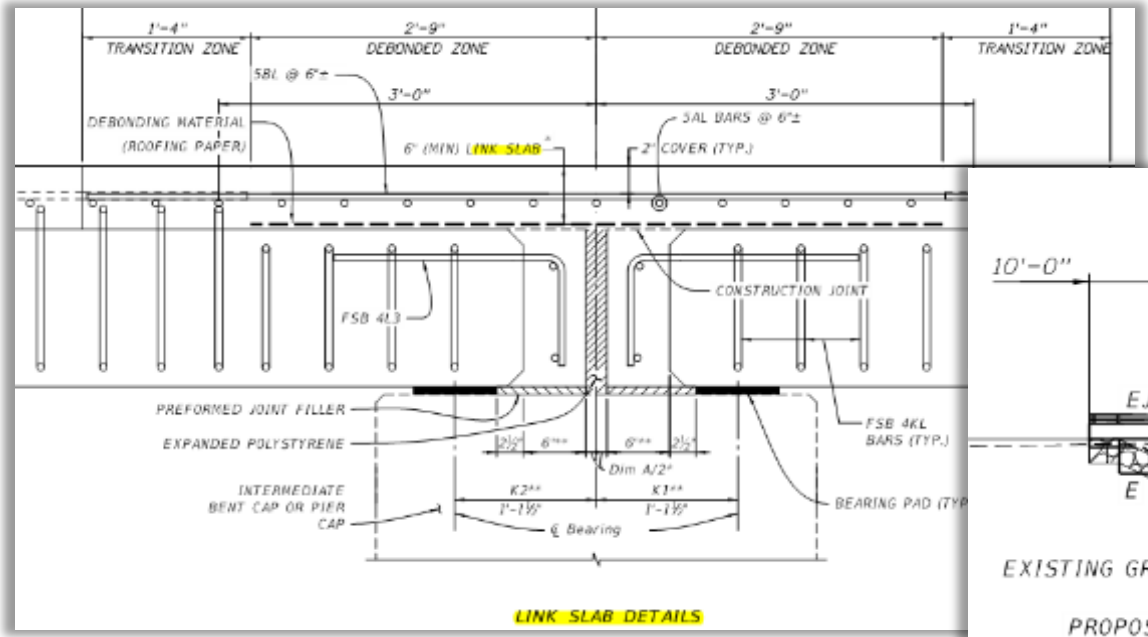
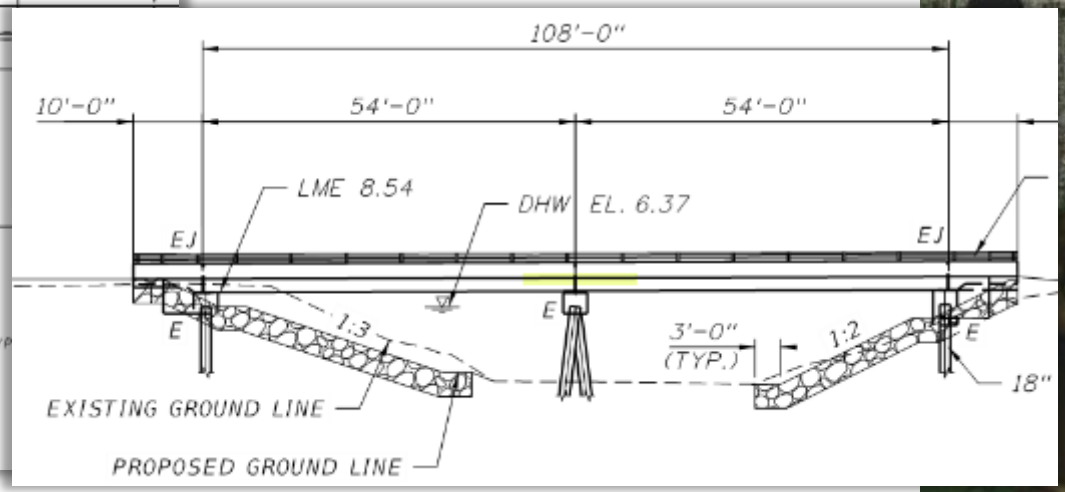


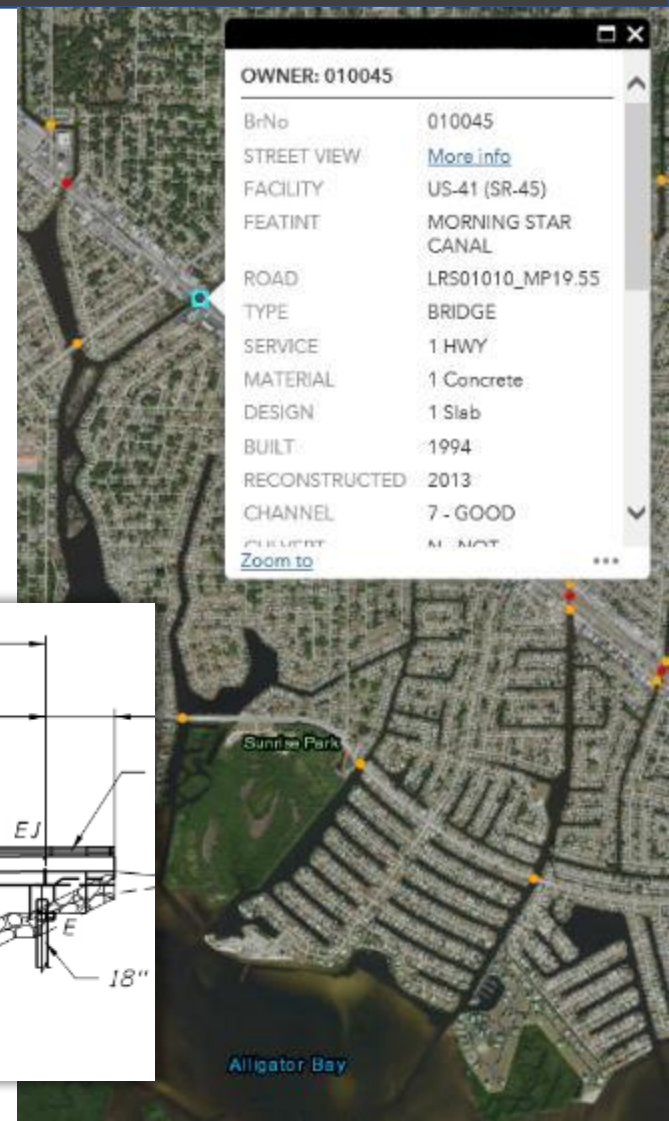


Looking Forward… New Projects in 2019

- US 41 over Morning Star & Sunset Canal – *2/27/19 letting*
  - *GFRP-RC link-slab (shown)*
  - *GFRP-UHPC link-slab (similar)*

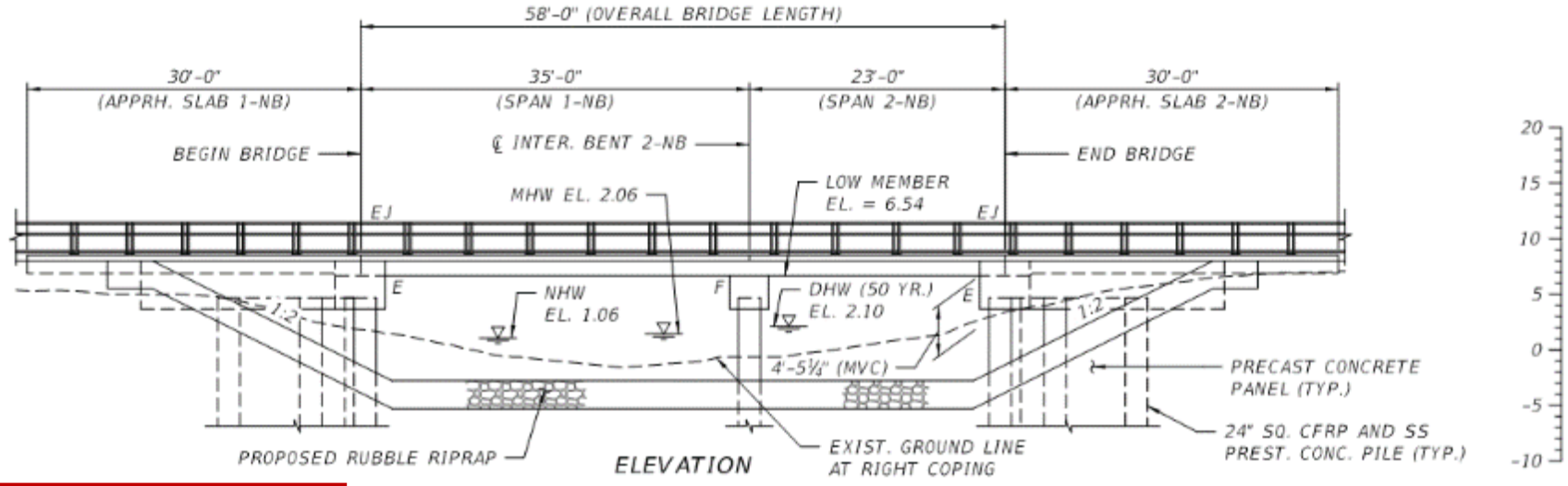




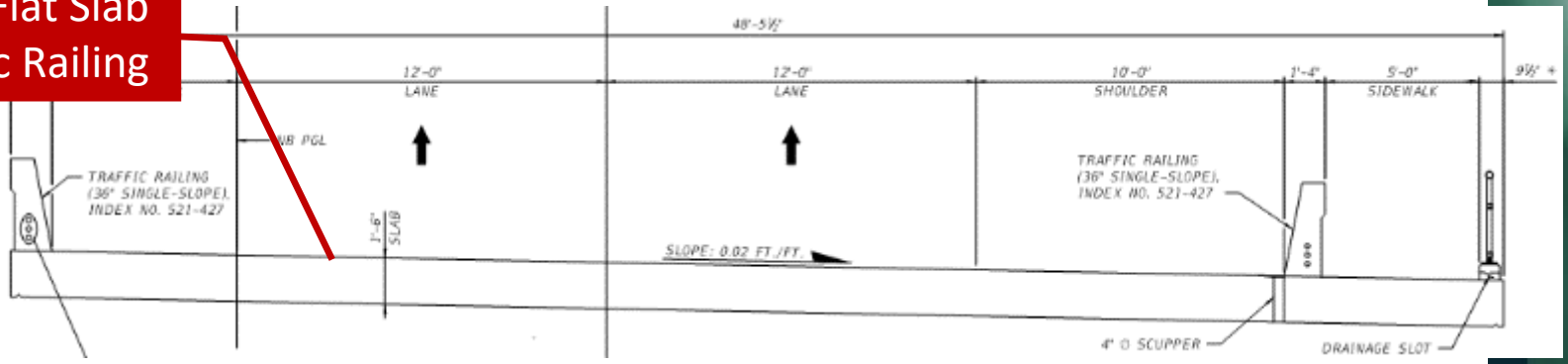


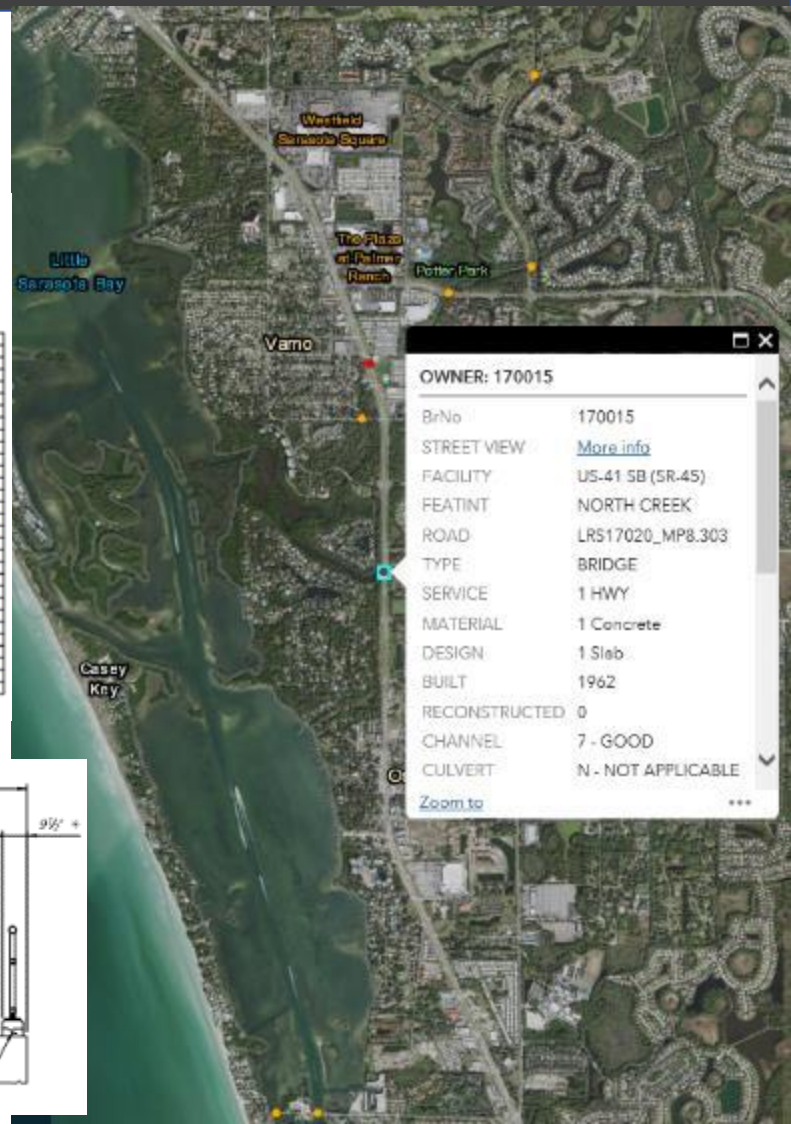
Looking Forward… New Projects in 2019

- US 41 over North Creek – *7/31/19 letting*



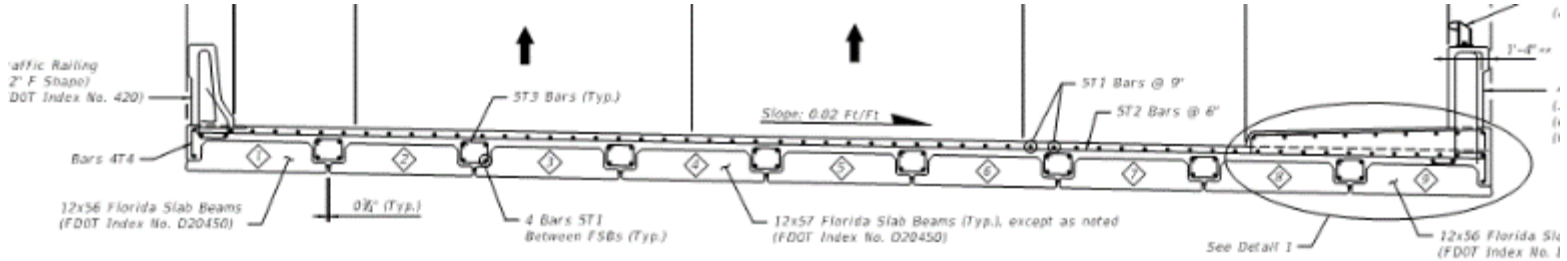
GFRP-RC Flat Slab and Traffic Railing

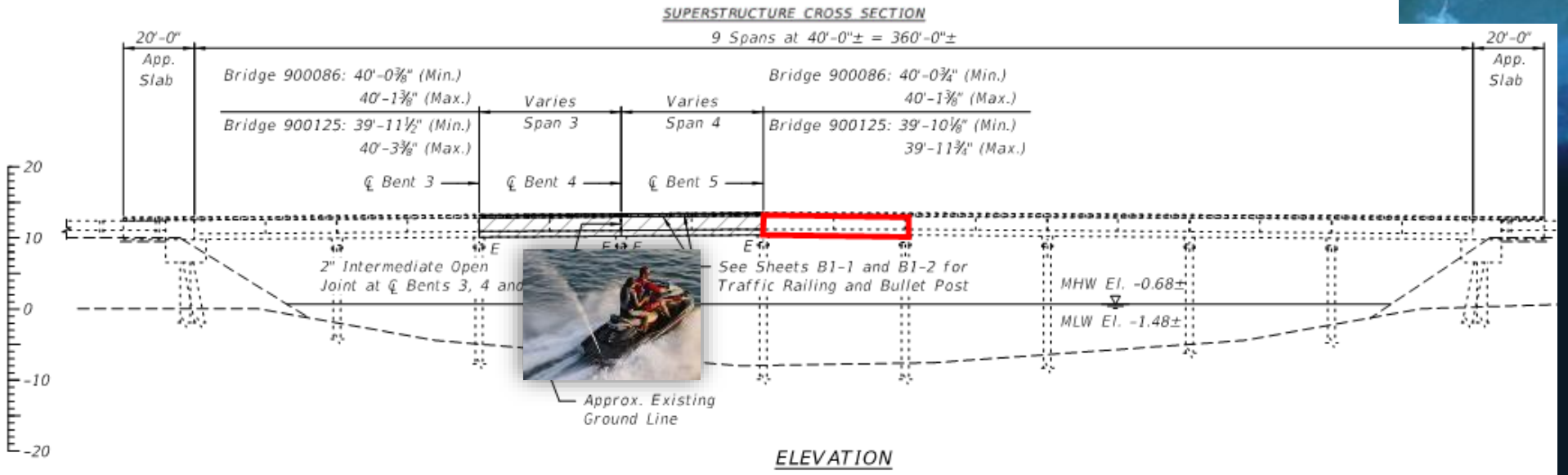


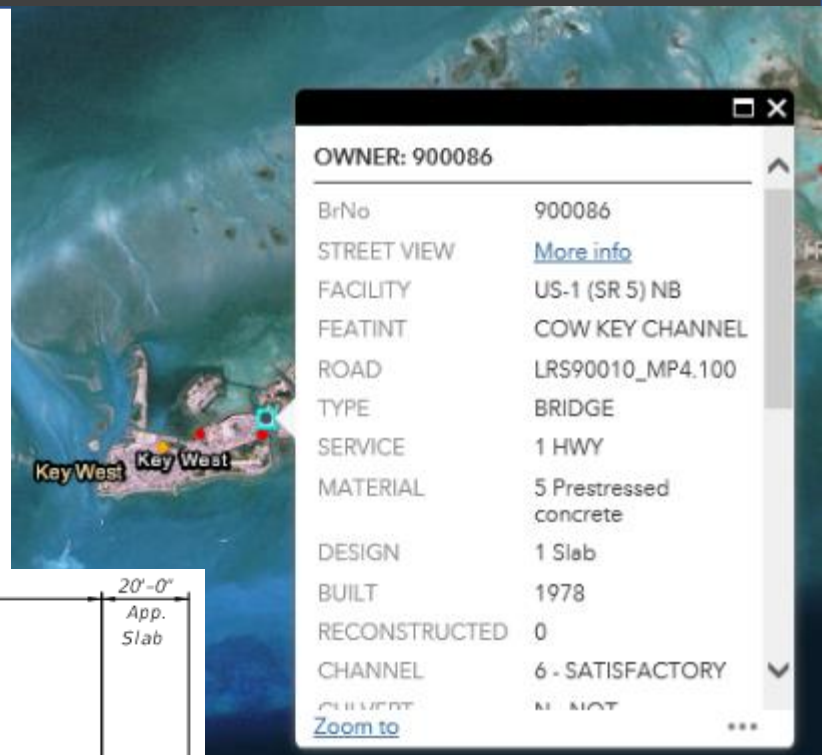


Looking Forward… New Projects in 2019

- US 1 over Cow Key channel, 6~span replacement – *10/21/19 letting*

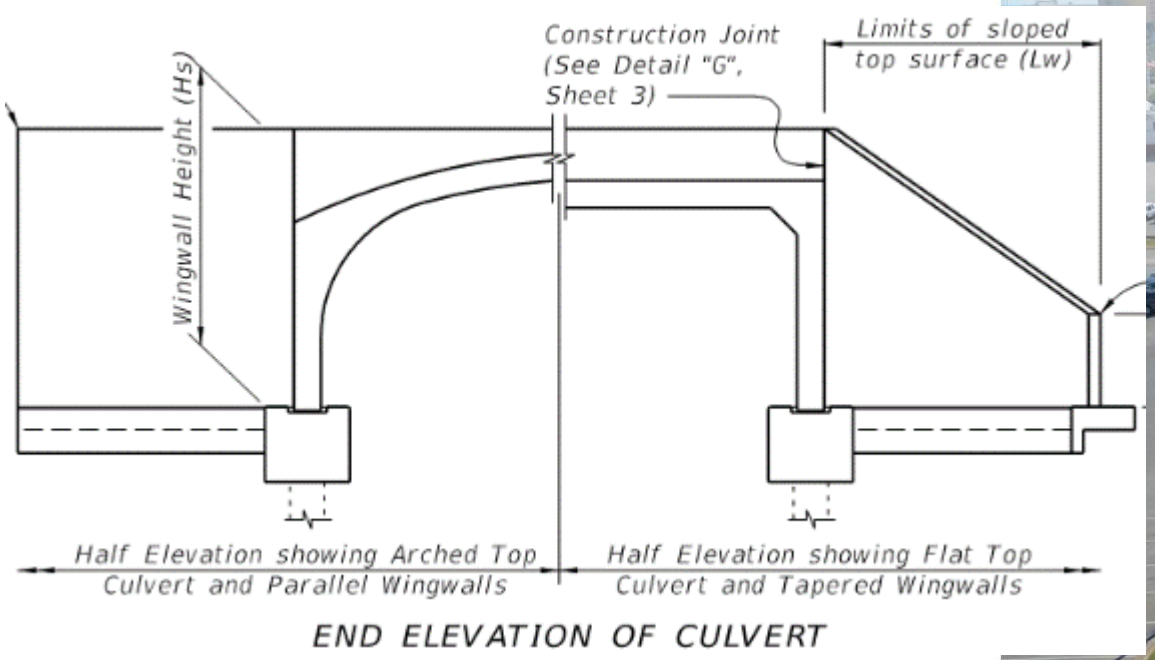






Looking Forward… New Projects in 2019

- Pensacola Beach Pedestrian Tunnels (3) – *Design 100% (city project)*



Looking Forward…

- **Priority Focus Areas:**
  - Continue efforts to improve design and construction guidance
  - Investigate new concepts for efficiencies and competition
  - Construction & Maintenance guidance for inspection and repair for FRP systems
  - Continue coordination with AASHTO and ACMA to develop design codes and test protocols. FDOT is very active in the future development of FRP.
- **Promote: Confidence, Competency, Consistency & Codification****
  - *Use it where you need it!*

*** 2018 FDOT-FRP Industry Workshop Strategic Goals*

FDOT

ACMA
American Composites Manufacturers Association

Questions

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