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FRP Deployment for New Construction

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(Structures Standards Group)

Outline

- Fender Systems
- Internal Reinforcement
- FRP for Pretensioning
- Construction Specifications
- Design Standards
- Design Guidance
- Where are we heading…
- FDOT Current Projects Status

Leveraging the most benefit from FRP for FDOT

i. Why composites:
   - Avoiding corrosion -
     - GFRP rebar
     - CFRP prestressing strand
     - Polymeric piling durability & toughness

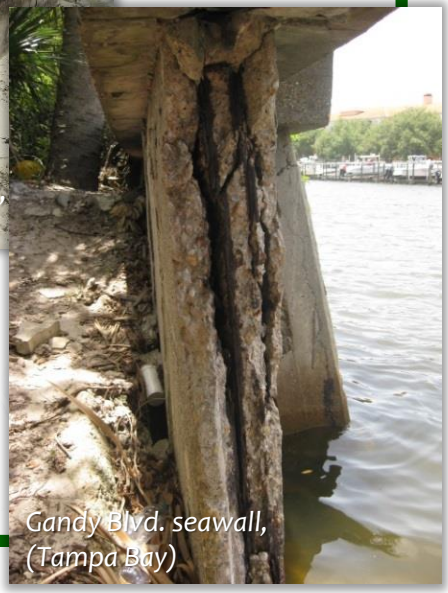
ii. Durability/Service Life;

iii. Cost-Benefit;

iv. Challenges - Mitigating Risks
   - New Material Systems;
   - Limited suppliers/competition;
   - Unfamiliar design criteria;
   - Unfamiliar construction practices.


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

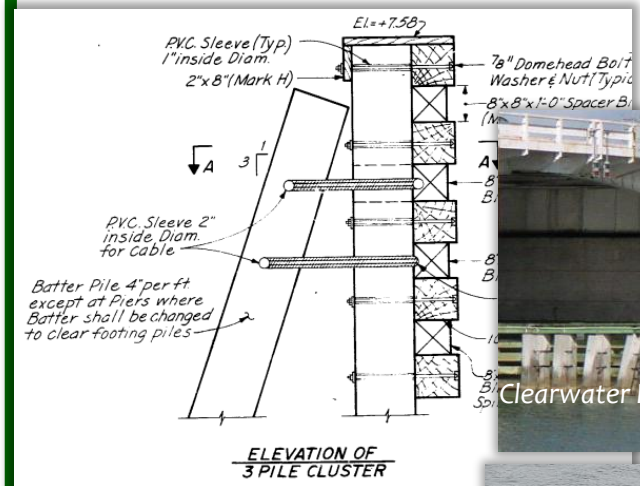

Courtney Campbell Causeway, seawall (Tampa Bay)

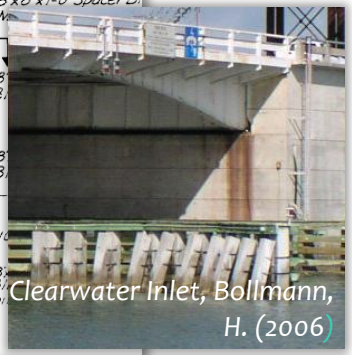

Gandy Blvd. seawall, (Tampa Bay)

Fender Systems

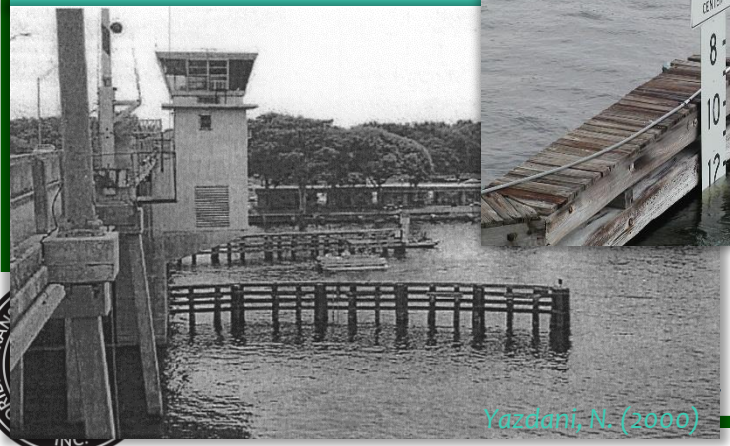
OLD:

Timber and/or Concrete



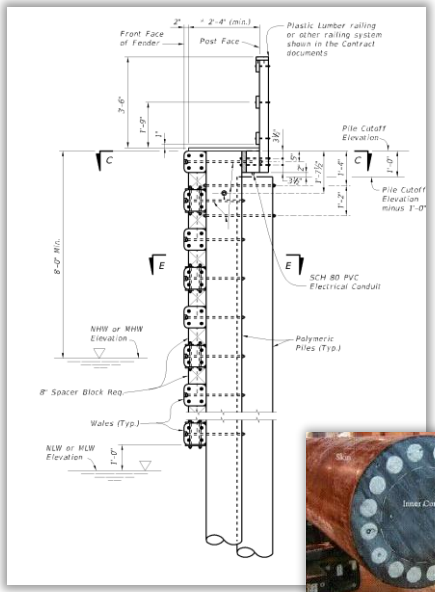

Clearwater Inlet, Bollmann, H. (2006)

I-95/I-595 Interchange (1984)

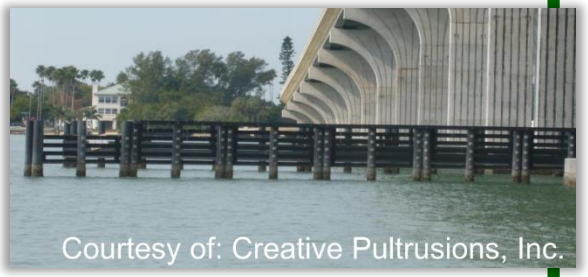

Yazdani, N. (2000)

NEW:

FRP Composite Systems




Courtesy of: Creative Pultrusions Inc. (2014)


Courtesy of: Creative Pultrusions, Inc.

Fender System Piles and Wales:

- FDOT ***Spec.* 471 & 973**
- New Approved Producers List (now FRP Production Facilities) requirements in ***MM 12.1*** *(Jan. 2015)*
- New ***Structures Detailing Manual*** - Chapter 24 *(Jan. 2015)*


Courtesy of : Garcia Bridge Engineers (2013)

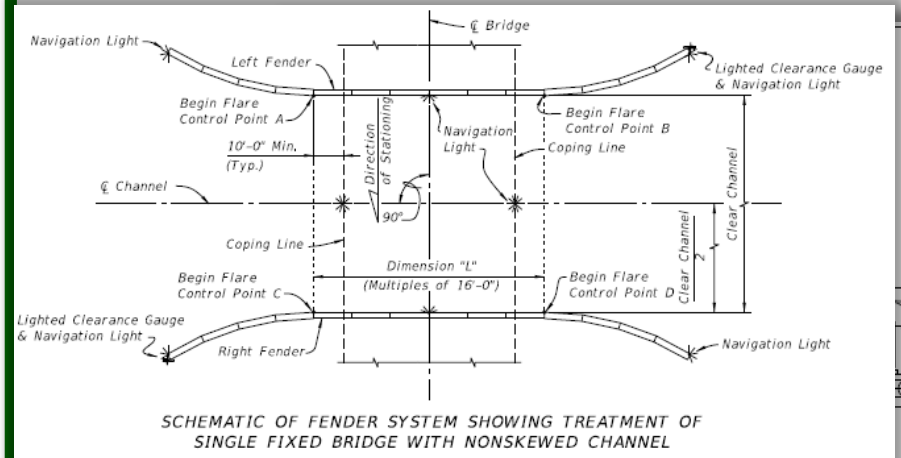
Fender Systems

Materials:

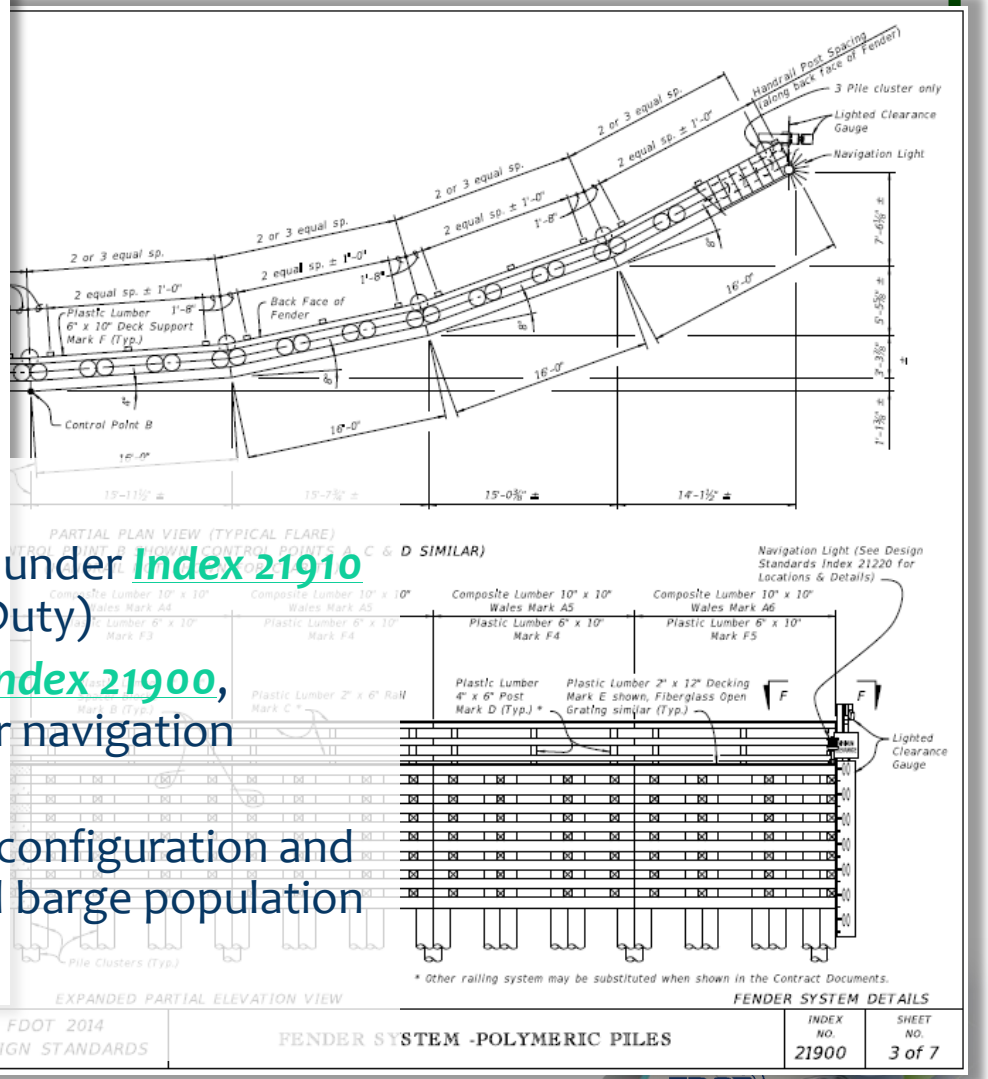
- Thermoset Pultruded & Thermoplastic Structural Shapes

(photographs) D. Troutman; Creative Pultrusions Inc., *Polymeric Bridge Fender Piles and Wales.*

Fender Systems



SCHEMATIC OF FENDER SYSTEM SHOWING TREATMENT OF SINGLE FIXED BRIDGE WITH NONSKEWED CHANNEL



Progressive Development:

- 2006 – 2011, Predesigned FRP Systems under ***Index 21910*** (Heavy Duty) & ***Index 21920*** (Medium Duty)
- 2011 – 2015: Preset pile spacing under ***Index 21900***, Contractor/ Vendor designs tailored for navigation channel barge population generic;
- 2015+: Customized Contractor/Vendor configuration and designs tailored for navigation channel barge population based on ***Structures Manual***.

Fender Systems

Resources:

i. Fender System "Polymeric" Piles and Wales (***Design Standards*** – *Index 21900 series*, since 2006);

ii. FDOT ***Specifications*** *471 & 973;*

iii. Approved Products List (***APL***) for Wales *(and Piles for projects bid prior to July 2015);*

iv. **Fiber Reinforced Polymer Production Facility Listing** via ***Materials Manual*** – *Section 12.1 (Piles for new projects bid since July 2015 lettings);*

v. Custom designed systems – ***Structures Design Guidelines (SDG)*** – *Section 3.14* design criteria *(new projects bid since July 2015 lettings);*

vi. ***Structures Detailing Manual*** ***(SDM)*** *- Chapter 24 (updated Jan 2015).*

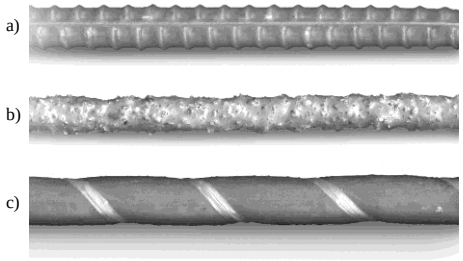
Internal Reinforcement for Concrete Structures

GFRP and CFRP Reinforcing Bars

Permitted use for:

- Approach Slabs;
- Bridge Decks and Bridge Deck overlays;
- Cast-in-Place Flat Slab Superstructures;
- Pile Bent Caps, Pier Columns and Caps not in direct contact with water;
- Traffic Railings;
- Pedestrian/Bicycle Railings;

(photographs) Hughes Bros. *GFRP Bars.*



Example bar-surface types:
a) Ribbed
b) Sand-coated
c) Helically wrapped and sand-coated

FRP Deployment Train

GFRP and CFRP Reinforcing Bars (cont.)

Permitted use for (cont.):

- Retaining Walls, Noise Walls and Perimeter Walls;
- MSE Wall Panels;
- MSE Wall Copings;
- Bulkhead Copings;
- Concrete Sheet Piles
- Drainage Structures.

(photograph) FDOT, 2015. *GFRP Bars in bulkhead cap – Cedar Key.*

(photograph) Hughes Bros. *GFRP Bars in retaining walls.*

Challenges with GFRP & CFRP Rebar *(Spec. Section 932):*

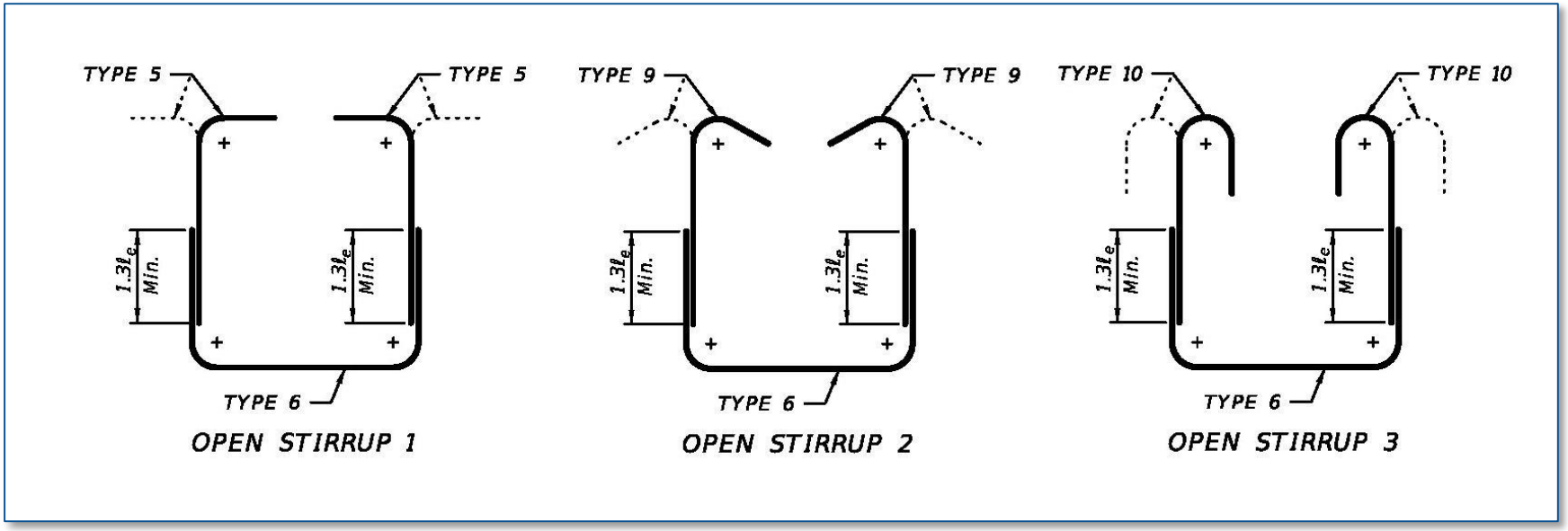
- No field of FRP bars;
- Fabricate bent FRP bars to the required shape;
- FRP bars must be shielded from prolonged exposure to UV light.
- No thermal or shear cutting of FRP bars;
- Tie using plastic coated wire or zip ties;
- No mechanical couplers;
- Paid for by the linear foot based on bar size (not weight).

(photograph) Hughes Bros. *FRP Protection.*

(photograph) Hughes Bros. *Coated tie wire.*

Challenges with FRP Bar Bending Details (cont.)

- Combinations of single bars for complex shapes

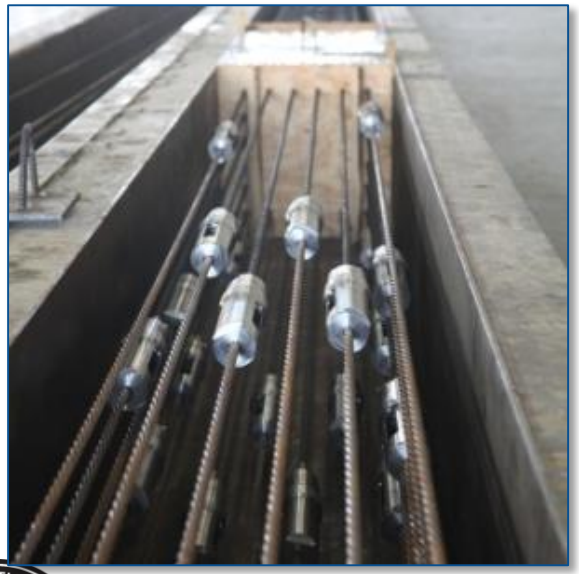


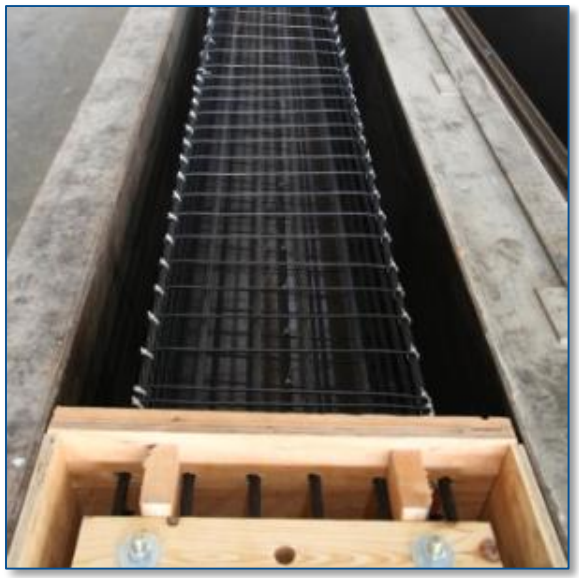
FRP for Pretensioned Concrete

CFRP Prestressing Strands

Permitted use for:

- Prestressed concrete piles;
- Concrete sheet piles



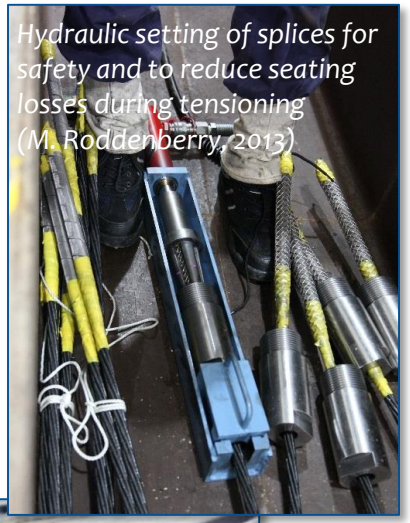


(photographs) FDOT. *CFRP Strands in Piles.*

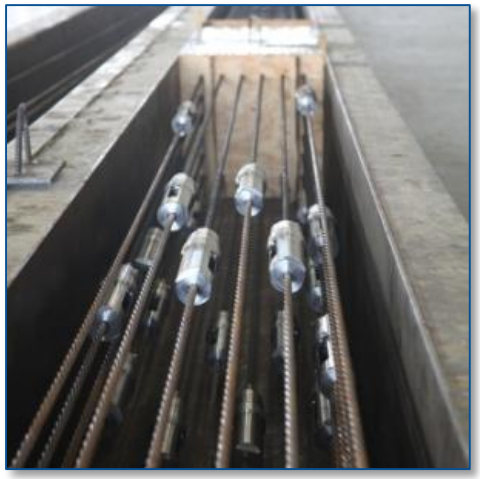
Challenges with CFRP Strands

(Spec. Section 933):

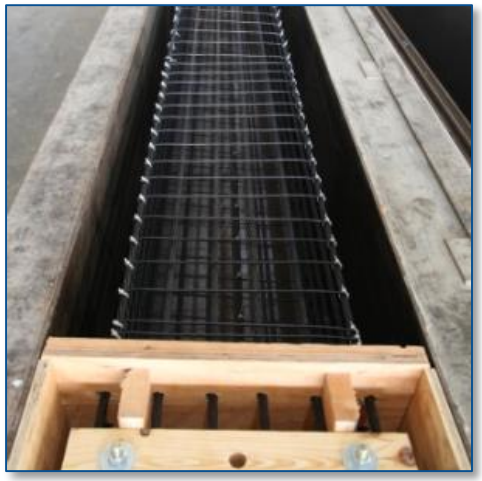
- Use self-consolidating concrete only;
- No flame or shear cutting of CFRP strand;
- Tie using plastic coated wire or zip ties;
- Spirals for CFRP reinforced piling must also be CFRP;
- Headers must be wood, or steel with rubber grommets.
- Coupling to steel strand tails for stressing



Hydraulic setting of splices for safety and to reduce seating losses during tensioning (M. Roddenberry, 2013)



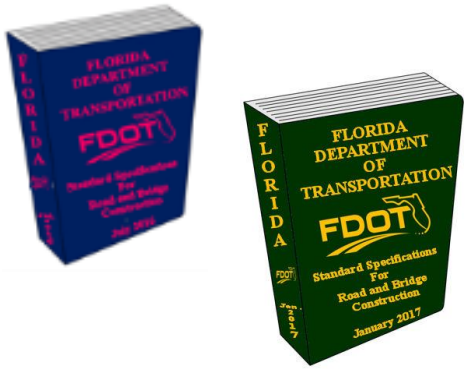
(photograph) FDOT. *Coupling CFRP Strands to Steel Strands.*



(photograph) FDOT. *Wooden Headers For CFRP Strands.*

(photograph) FDOT. *CFRP Pile Casting with SCC.*

Construction Specifications



Specifications:

a) Standard Specifications (effective July 2016):
- Implemented previous FRP ***Developmental Specifications.***
- ***400*** Concrete Structures – Fiber Reinforced Polymer Reinforcing;
- ***410*** Precast Concrete Box Culvert;
- ***415*** Reinforcing for Concrete;
- ***450*** Precast Prestressed Concrete Construction – Fiber Reinforced Polymer (FRP);
- ***932*** Nonmetallic Accessory Materials for Concrete Pavement and Concrete Structures;
- ***933*** Prestressing Strand;

b) Previous Developmental Specifications:
- ***Dev400FRP, Dev410FRP, Dev415FRP, Dev450FRP, Dev932FRP, Dev933FRP***

(Photograph) Hughes Bros.

Design Standards

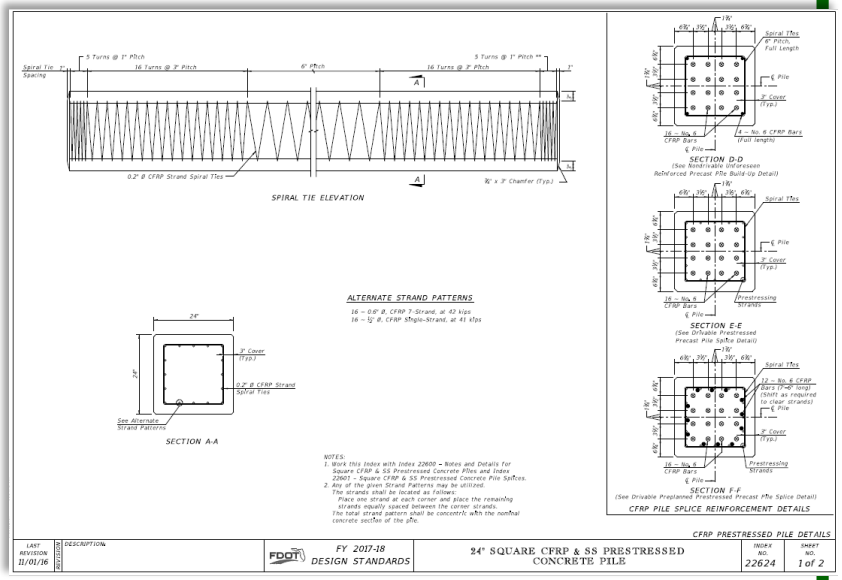
Design Standards:

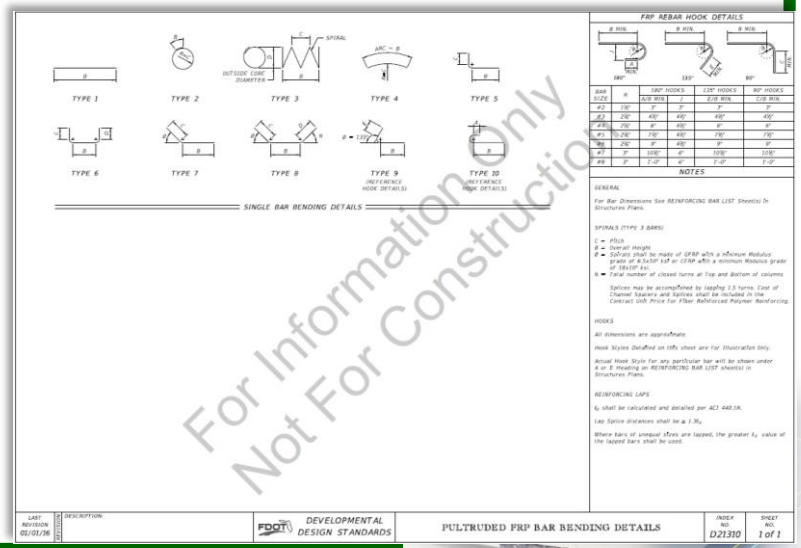
a) FY2017-18 Design Standards:

- ***Index 22600 series*** – Square CFRP & SS Prestressed Concrete Piles;
- ***Index 22440*** – Precast Concrete CFRP/GFRP & HSSS/GFRP Sheet Pile Wall

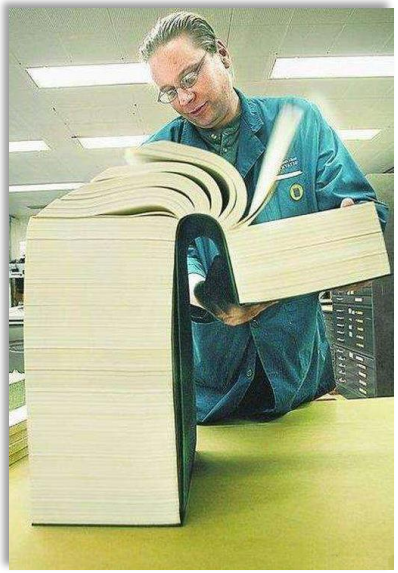
b) Developmental Design Standards:

- ***Index D6011c*** – Gravity Wall – Option C (GFRP reinforced);
- ***Index D21310*** – Pultruded FRP Bar Bending Details;
- ***Index D22420*** – GFRP reinforced 32" F-Shape Traffic Railing;
- ***Index D22900*** – GFRP reinforced Approach Slab;





Design Guidance

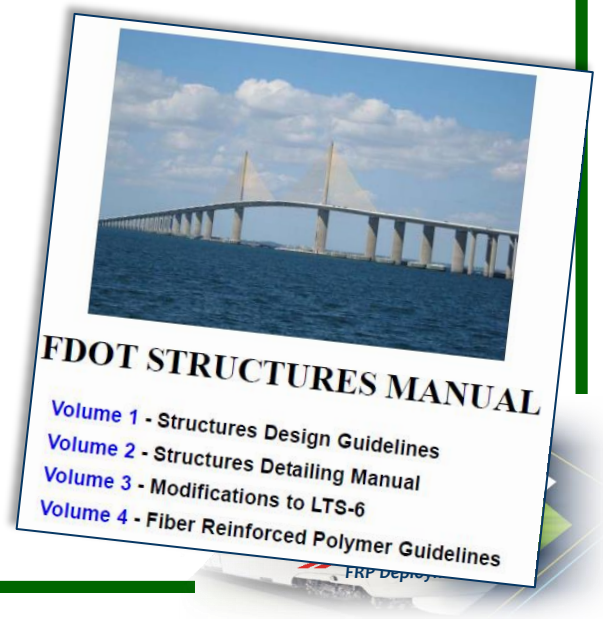


FDOT Structures Manual

1. Design criteria –
   - *a) Fiber Reinforced Polymer Guidelines (FRPG – Vol.3)*
   - *b) Structures Design Guidelines (SDG – Vol.1);*

2. Detailing criteria – ***Structures Detailing Manual (SDM-Vol.2);***

http://www.fdot.gov/structures/StructuresManual/CurrentRelease/StructuresManual.shtm



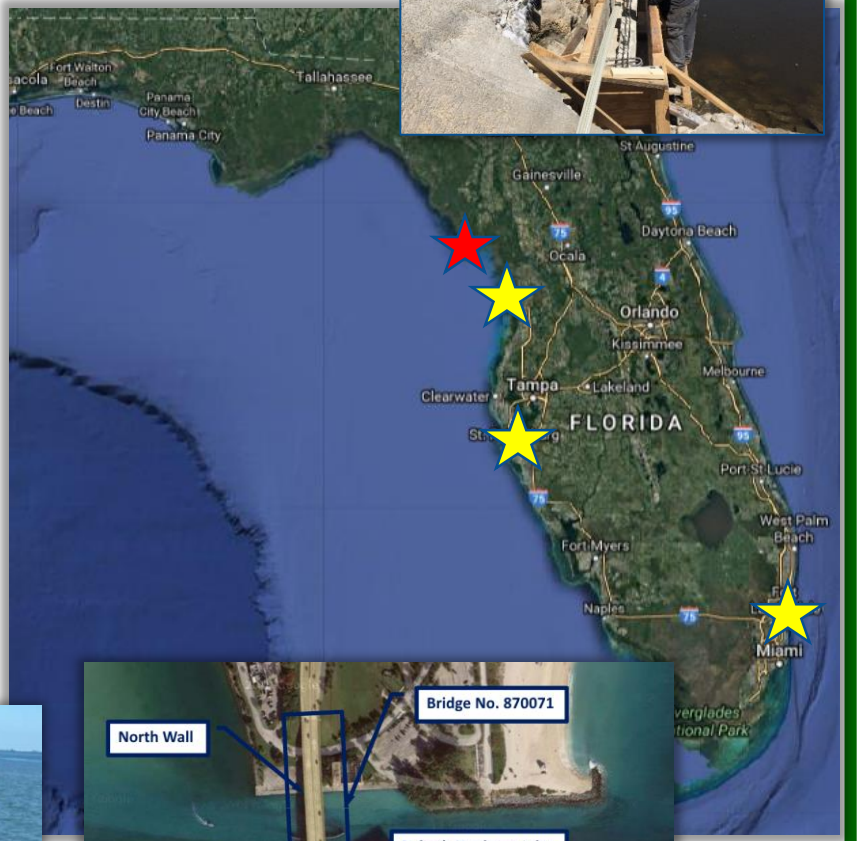
Where are we heading?

Possible expanded applications of FRP Internal Reinforcement:

- Initially Glass FRP (GFRP) reinforcement;
- Investigating Basalt FRP (BFRP) reinforcing;
- Investigation feasibility of CFRP Prestressing for low-level bridges over saltwater for beams/slabs;
- Development of GFRP closed stirrups (continuous – filament winding) for greater product efficiency.
- Resolution of GFRP durability in submerged applications for bridges.

FDOT Projects Status

1. ***Cedar Key Bulkhead Cap Rehab.***
   - FPID 432194-1 construction completed June 2006; SMO monitoring.
2. ***Halls River Bridge Replacement***
   - Construction started 1/9/17;
   - Astaldi Construction Corp.
3. ***Bakers Haulover Cut Bridge Rehab.***
   - Contractor started mobilizing to site;
   - Kiewit Infrastructure South Co.
4. ***Skyway South Rest Area Seawall Rehab.***
   - Design Build Procurement;
   - Anticipated Award Date 02/8/2017;



Questions ??

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