TRB Annual Meeting, (Washington DC.) January, 2018

Session 679 - Wednesday 1/9/2018, 3:45-5:30pm

Halls River Bridge

- Composites Replace Steel Reinforcement

Steven Nolan, P.E.

FDOT State Structures Design Office

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University of Miami, College of Engineering

FDOT

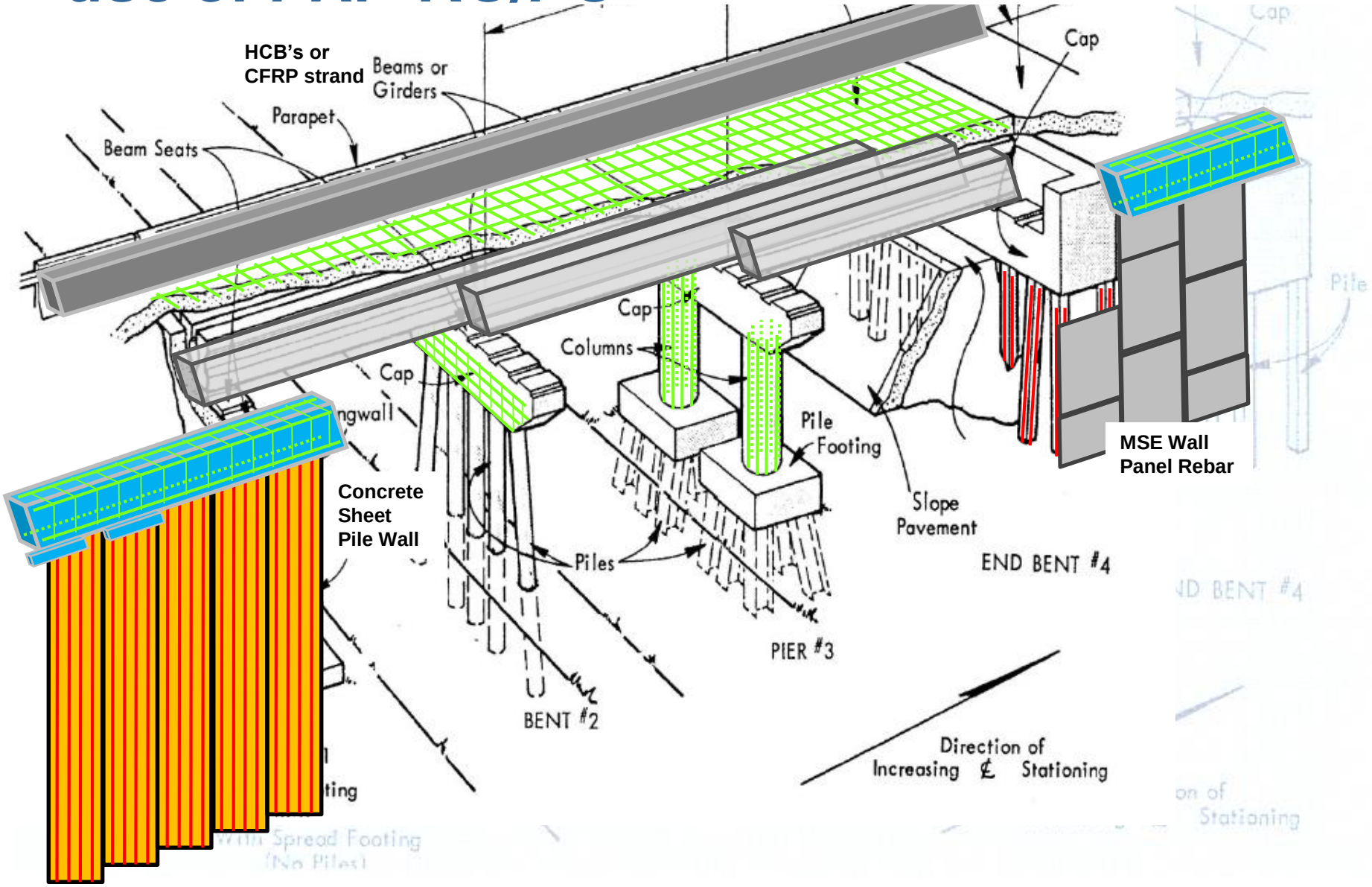
UNIVERSITY OF MIAMI

Outline:

- Halls River Bridge Replacement Project Overview
  1. SEACON Concrete Types
  2. Gravity Wall
  3. Cantilever Sheet Pile Walls (Bulkhead/Seawall)
  4. Bridge Substructure (Bent Cap & Bearing Piles)
  5. Hybrid Composite Beams
  6. GFRP-RC Decks, Diaphragms and Approach Slabs
  7. Traffic Railings
- Beyond Halls River Bridge
- Technology Transfer (T^2)

"Some contributions to the project were made possible with the financial support received from the Infravation Program under Grant Agreement No. 31109806.005-SEACON. The opinions in this presentation are those of the authors and not necessarily those of the sponsors or collaborators."

Typical Bridge Components with potential use of FRP-RC/PC



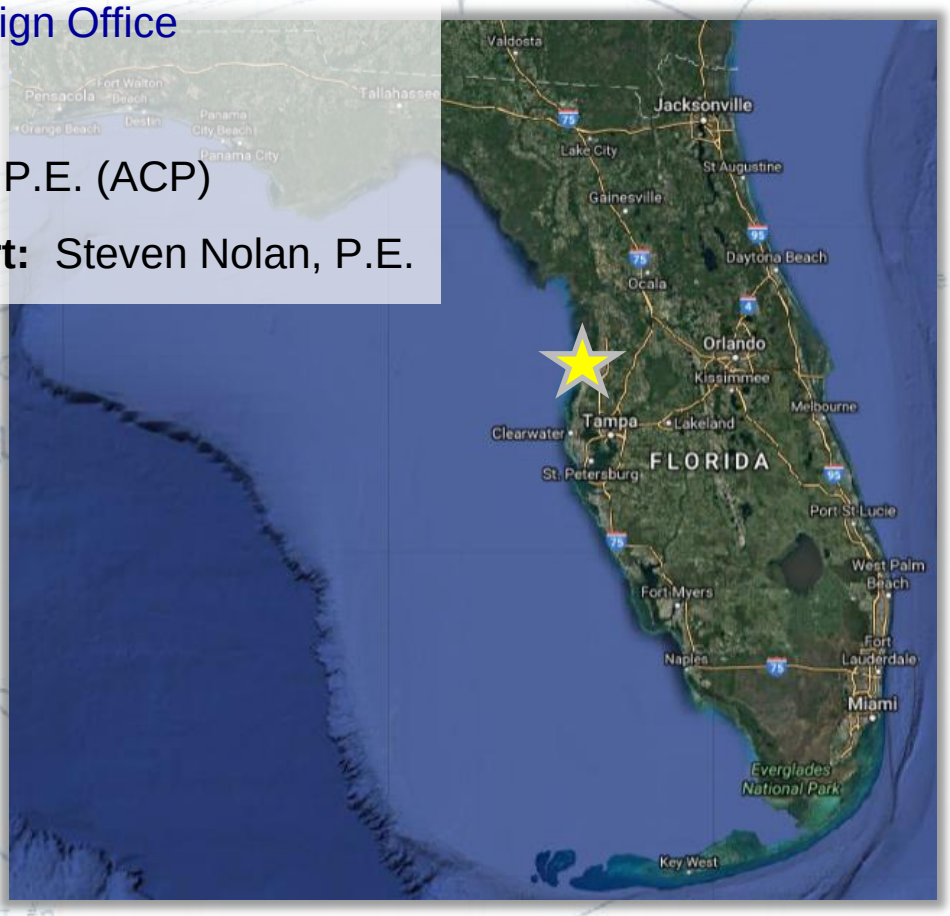
Project Overview – Halls River Bridge Replacement

Designer: FDOT District 7 Structures Design Office

Bridge EOR: Mamunur Siddiqui, P.E.

Bulkhead/Seawall EOR: Richard Hunter, P.E. (ACP)

FDOT Developmental Standards Support: Steven Nolan, P.E.



Owner & Maintaining Agency

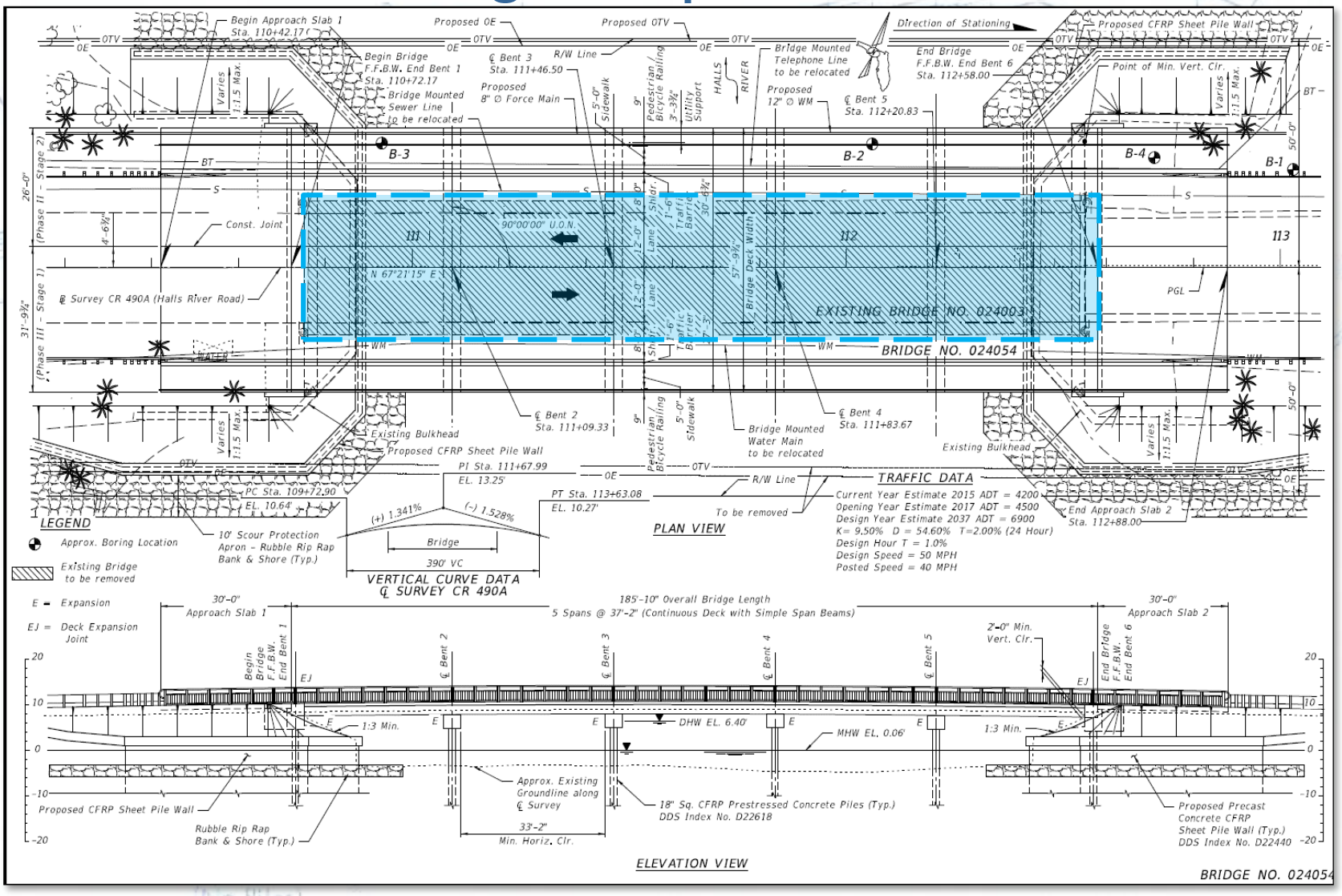
Design & Bi-Annual Inspection

Funding & Oversight

Collaboration Research

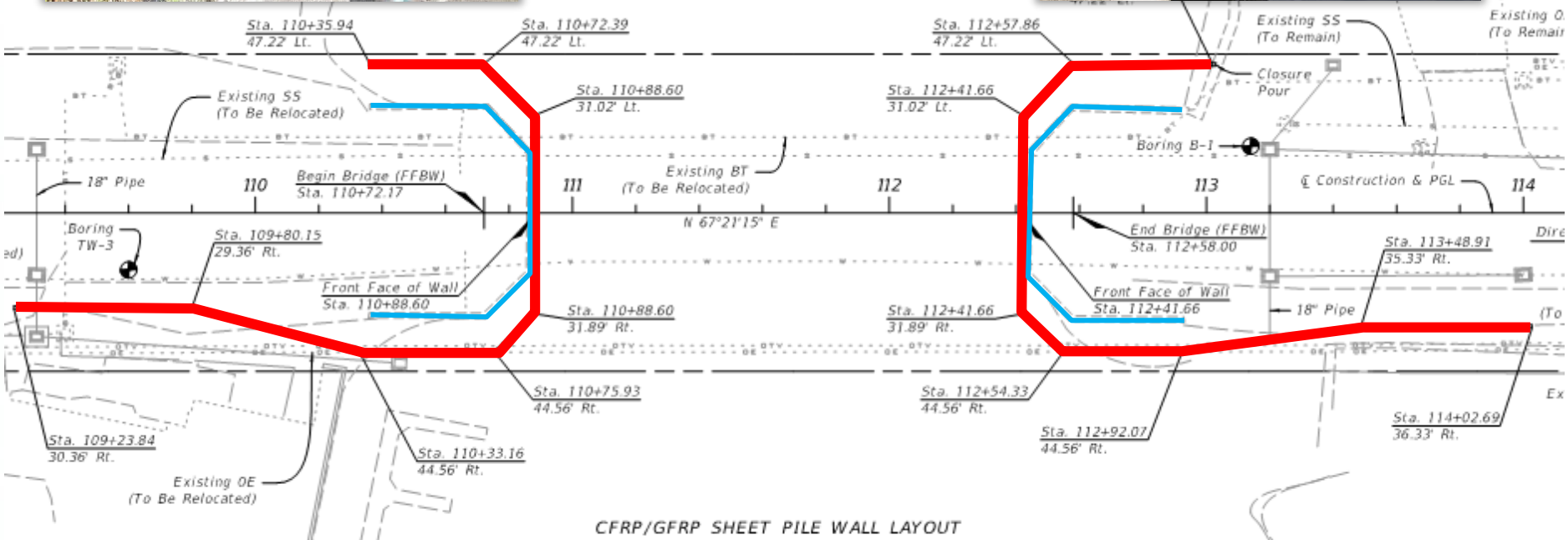
Research Testing and Monitoring

Project Overview – Halls River Bridge Replacement



Existing (blue) and Proposed Layout

Project Overview – Halls River Bridge Replacement



Existing (blue) and Proposed Bulkhead (Red) Layout

HRB Project Demonstrator – *SEACON* Concrete Types

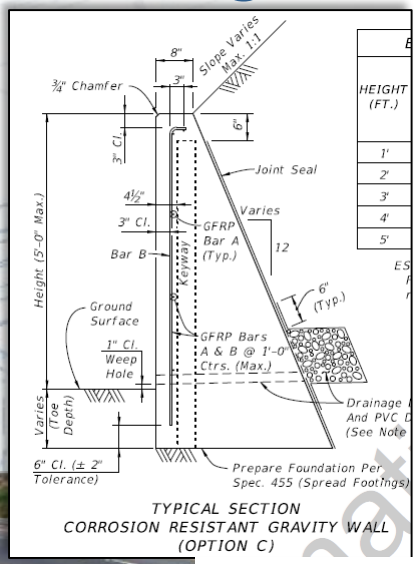
A. Concrete Types (FDOT Class):
   i. Recycled Concrete Aggregate (RCA – Class NS)
   ii. Recycled Asphalt Pavement (RAP – Class NS)
   iii. “Green” (Class IV)
   iv. White Cement (Class II)
   v. Slag Cement-60/40 (Class II)
B. Component Use of SEACON concretes:
   i. Gravity Walls
   ii. Bulkhead/Seawall Cap
   iii. Test Blocks
C. Design Criteria – see SEACON-WP1 & 2 for more details;
D. FDOT Concrete Material Specifications affected
   i. ***347*** (Non-Structural Class) - RAP & RCA
   ii. ***346*** (Structural Class); Modified Special Provision




HRB Project Demonstrator – Retaining Walls (with GFRP & RAP or RCA)

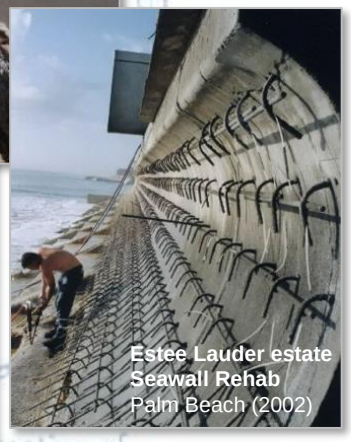
A. Components
   i. RAP concrete
   ii. RCA concrete
B. Structural System
   i. ***Index D6011c*** *– Gravity Wall*
   ii. GFRP temperature and shrinkage reinforcing design
C. Other example retaining wall projects
   i. Maui C-I-P seawall with GFRP rebar (2012)
   ii. Estee Lauder estate seawall (2002)
   iii. Pearl Harbor Dry Dock Rehab (2001)

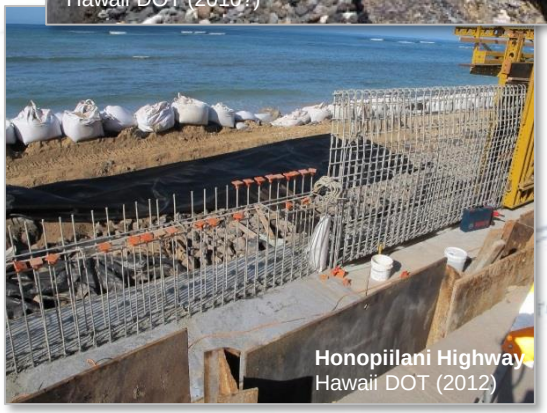

Pearl Harbor Dry Dock
Hawaii (2001)



Index D6011c
Florida DOT (2016)


Honopiilani Highway
Hawaii DOT (2010?)

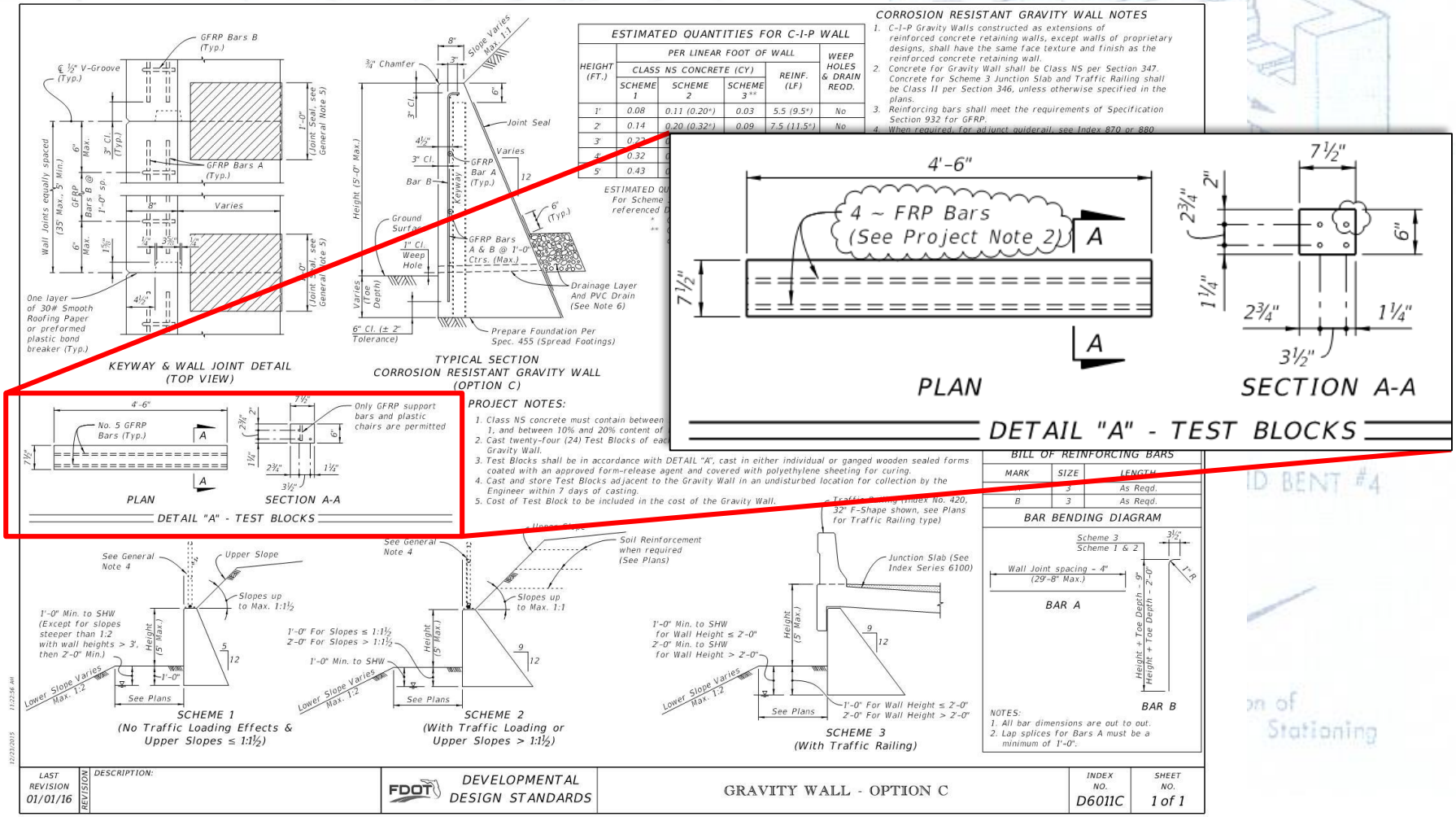

Estee Lauder estate Seawall Rehab
Palm Beach (2002)


Honopiilani Highway
Hawaii DOT (2012)

(Photographs) Hughes Bros.

HRB Project Demonstrator – Retaining Walls (with GFRP & RAP or RCA)

FDOT Index D6011c *(project version)*:



HRB Project Demonstrator – Cantilever Concrete Sheet Pile Walls (with CFRP/GFRP)

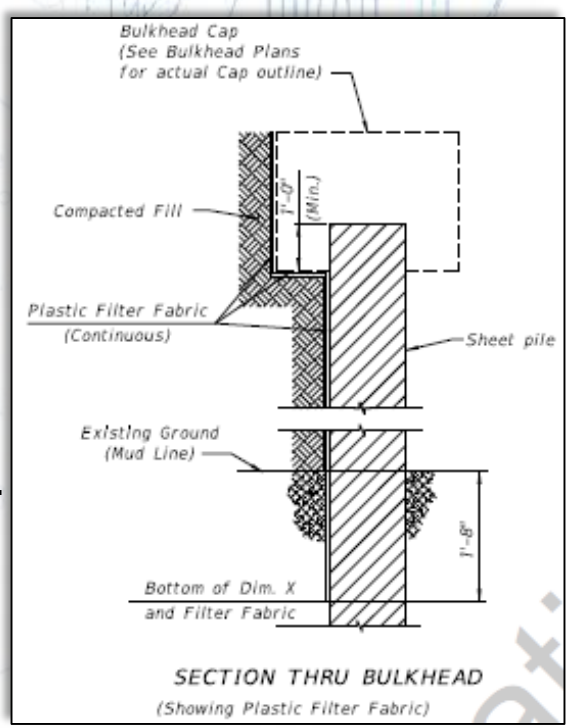
A. Components
   i. CFRP/GFRP Prestressed Concrete Sheet Piles (FDOT ***Index D22440***)
   ii. GFRP-RC Bulkhead Cap (***Structures Manual****-Vol.4...*)

B. Structural Systems
   i. Cantilevered
   ii. Anchored/Tied-Back Wall (Not use on HRB)

C. Other FDOT projects
   i. **Cedar Key SR 24 over Channel 5** bulkhead cap rehab.
   ii. **Bakers Haulover Cut** bulkhead cap & wall fascia
   iii. **Sunshine Skyway South Rest Area** seawall rehab.

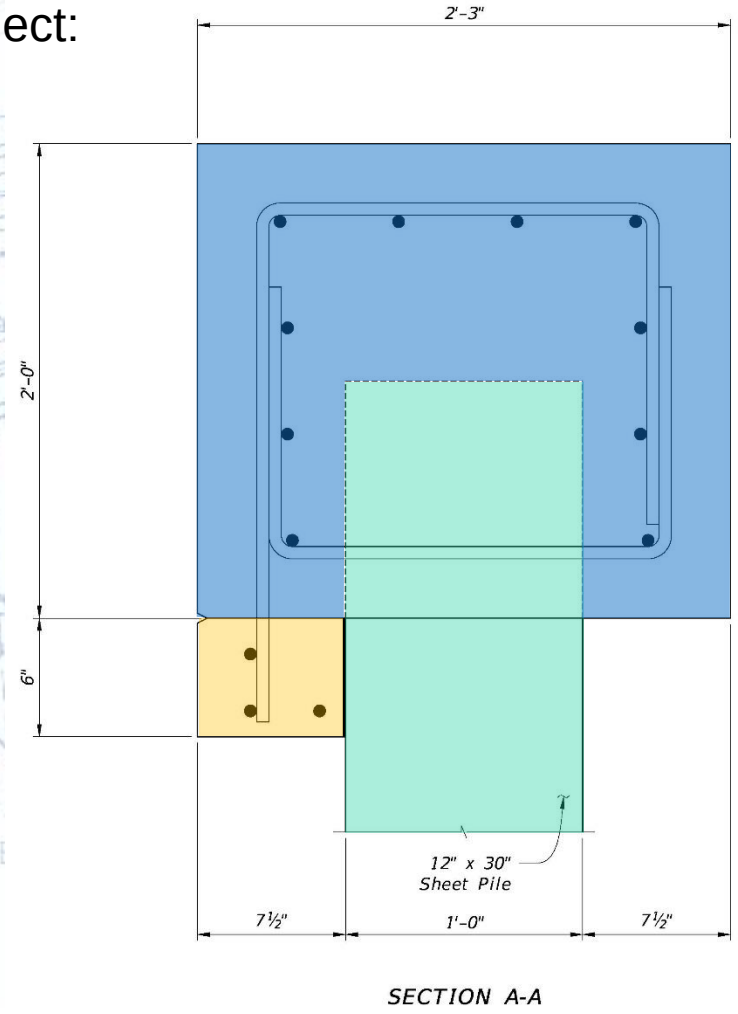
D. Design Criteria - ***ACI 440.1R*** & ***440.4R***

E. Material Specifications - ***Dev932*** & ***Dev933***



HRB/SR24 Project – Cantilever Concrete Sheet Pile Walls (with CFRP/GFRP)

Example from SR24/Cedar Key Project:



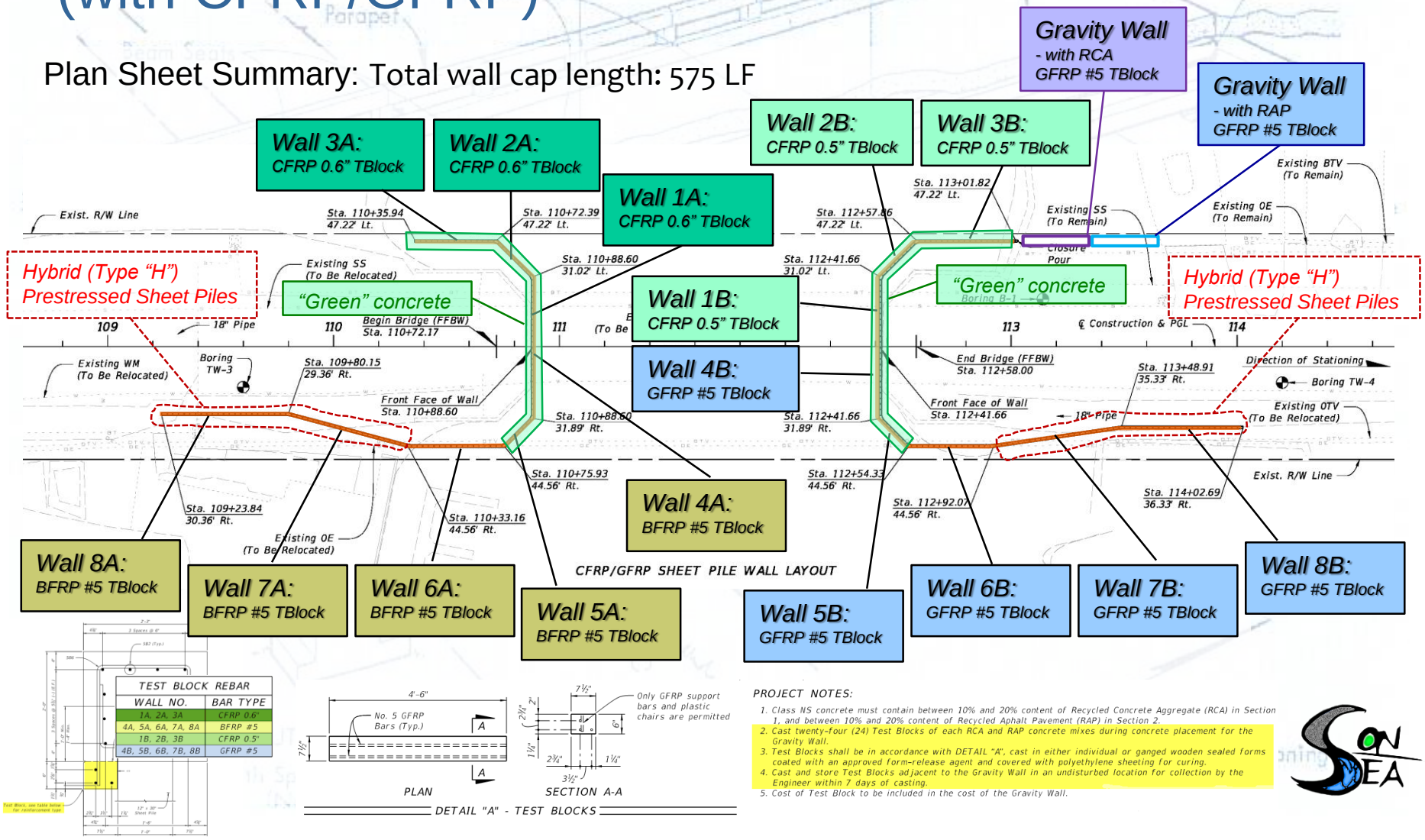
GFRP

CFRP/ GFRP

Test Block

HRB Project – Concrete Sheet Pile Walls (with CFRP/GFRP)

Plan Sheet Summary: Total wall cap length: 575 LF



PROJECT NOTES:

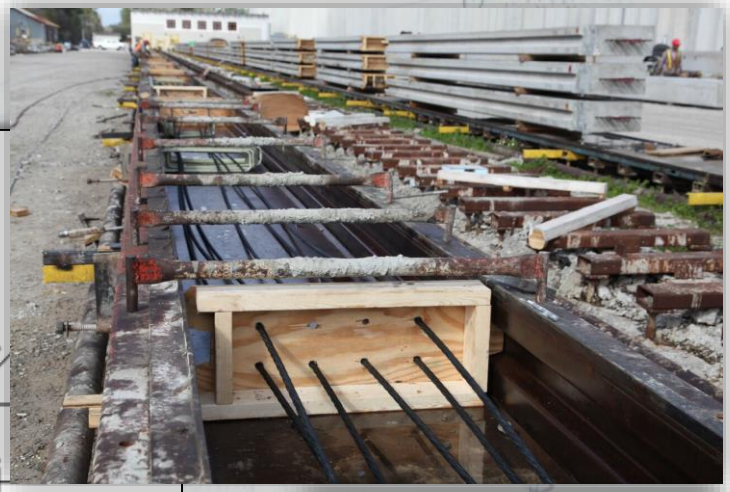
1. Class NS concrete must contain between 10% and 20% content of Recycled Concrete Aggregate (RCA) in Section 1, and between 10% and 20% content of Recycled Aphalt Pavement (RAP) in Section 2.
2. Cast twenty-four (24) Test Blocks of each RCA and RAP concrete mixes during concrete placement for the Gravity Wall.
3. Test Blocks shall be in accordance with DETAIL "A", cast in either individual or ganged wooden sealed forms coated with an approved form-release agent and covered with polyethylene sheeting for curing.
4. Cast and store Test Blocks adjacent to the Gravity Wall in an undisturbed location for collection by the Engineer within 7 days of casting.
5. Cost of Test Block to be included in the cost of the Gravity Wall.

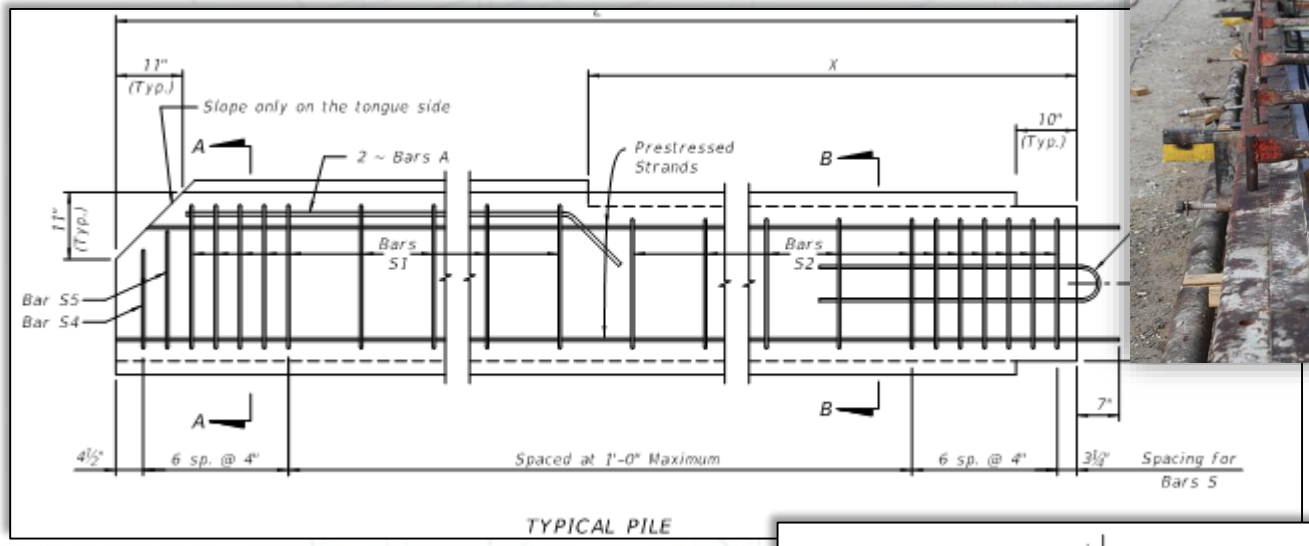
HRB Project – Anchored/Cantilever Concrete Sheet Pile Walls (with CFRP/GFRP & CFCC/SS Anchor Bars)

Example Plan Sheet Details:

HRB Project –
Cantilever Concrete Sheet Pile Walls
(with CFRP/GFRP – Type “A”)

Example Plan Sheet Details:



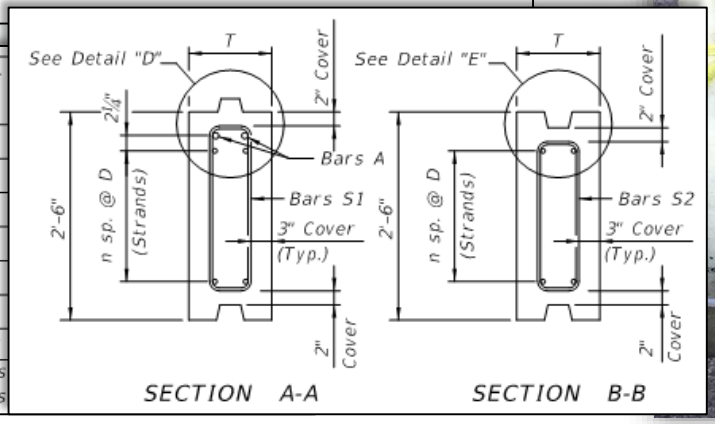


TYPICAL PILE

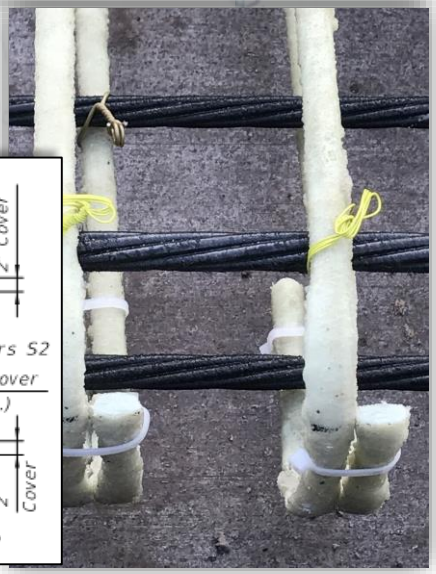
Wall Thickness	CFRP STRAND DIA. (in.)	MAXIMUM L **	n	D (in.)	TOTAL # OF STRANDS
T=10 in.	0.49 (12.5mm)	26'-0"	4	4	10
	0.5 (12.7mm)	27'-0"	3	5¼ (2)	8
	0.6 (15.2mm)	27'-0"	3	5¼ (2)	8
T=12 in.	0.49 (12.5mm)	31'-0"	5	3¼ (1)	12
	0.5 (12.7mm)	31'-0"	3	5¼ (2)	8
	0.6 (15.2mm)	31'-0"	3	5¼ (2)	8

* Unit Prestress after losses.
** Based on lifting using single point pick-up.

Alternate symmetrical
(1) 4 sp. @ 2" & 1 s
(2) 2 sp. @ 4" & 1 s

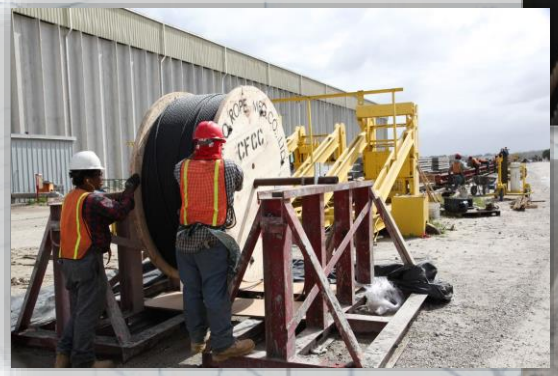


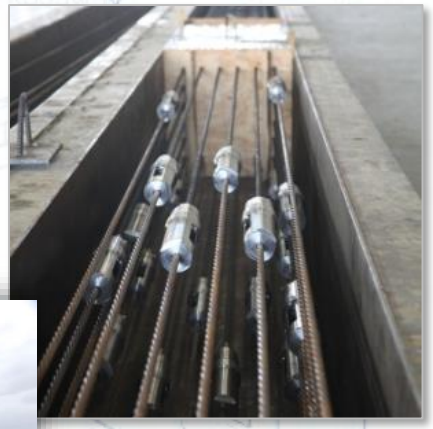
SECTION A-A SECTION B-B

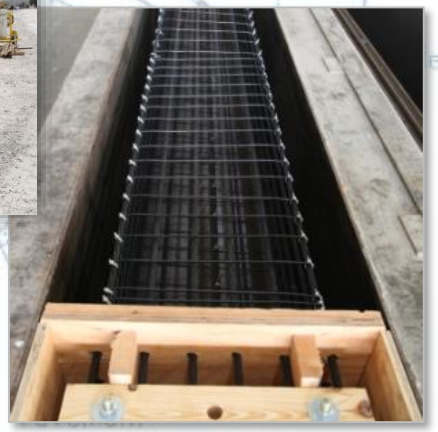


HRB Project – Pile Bent Substructure (with CFRP/GFRP-RC/PC)

A. Components
   i. Square CFRP Prestressed Bearing Piles
   ii. GFRP-RC Bent Cap
B. Structural System
   i. GRFP-RC Intermediate Bent Cap
   ii. GFRP-RC End Bent Cap.
C. Other projects
   i. Test Pile Research at FAMU/FSU
D. Design Criteria - ***ACI 440.1R*** & ***440.4R***
E. Material Specifications - ***Dev932*** & ***Dev933***

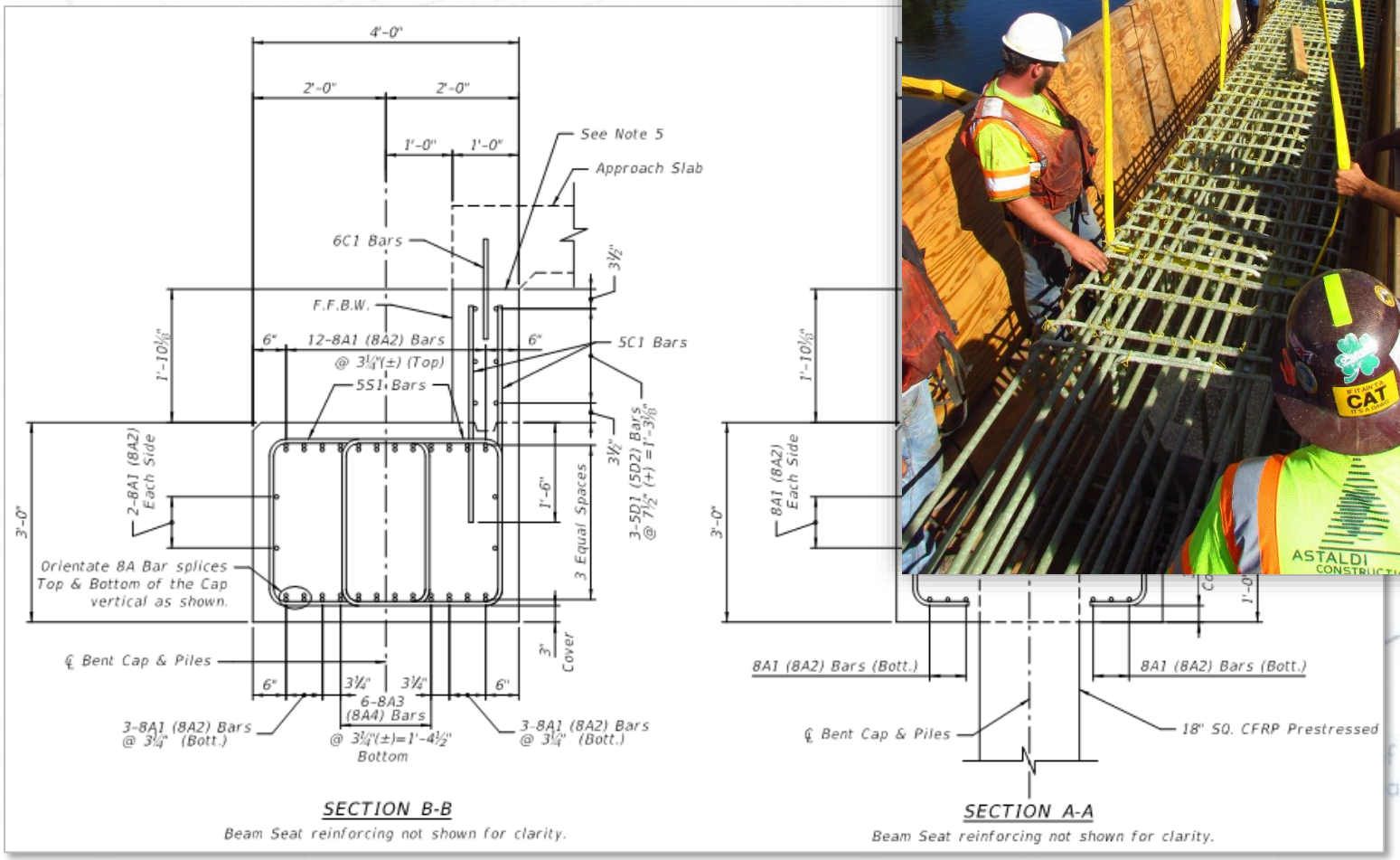






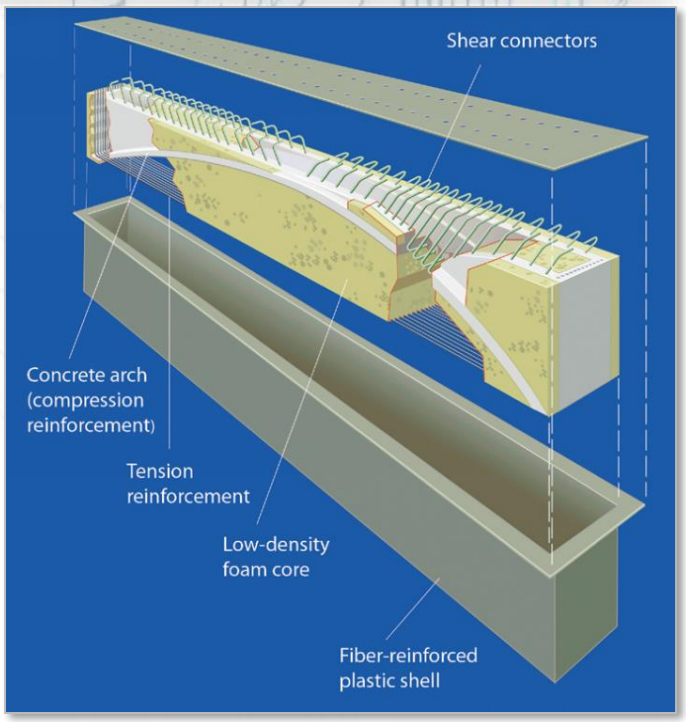
HRB Project – Pile Bent Substructure (with GFRP-RC)

Example Plan Sheet Details:



HRB Project – Hybrid Composite Bridge Beams

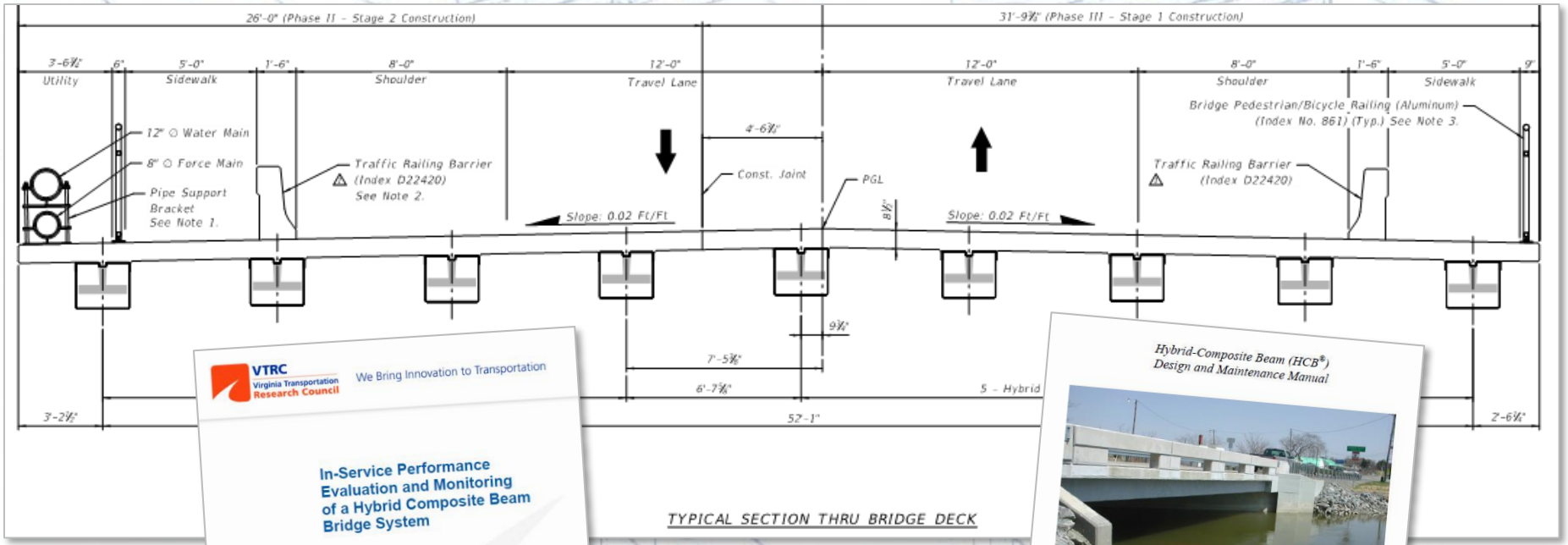
A. Components
   i. HCB Proprietary Product background (Hillman Composite Beam)
   ii. Wings/No wings, CIP compression arch, fabric selection for shell design
   iii. Strands, interface shear reinforcing
B. Structural System
   i. Customized design for project specific needs
C. Other projects
   i. DOT's (Maine, …)
   ii. Railroads …
D. Design Criteria - ***ACI 440.1R*** & ***440.4R***
E. Specifications – ***Technical Special Provisions (TSP)***

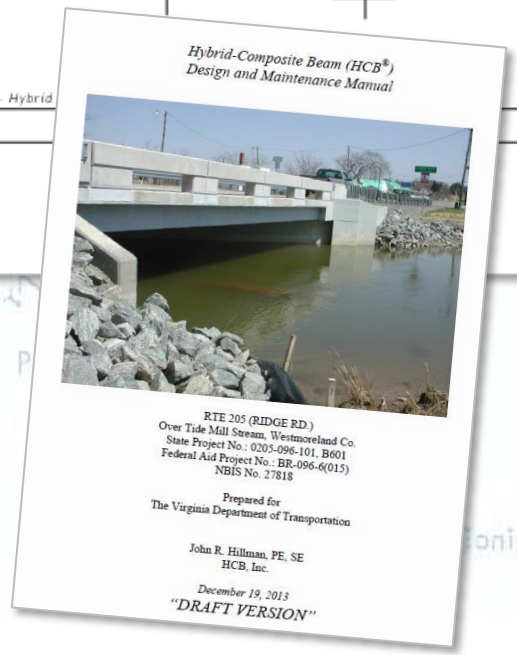


Schematic of HCB (John Hillman)

HRB Project – Hybrid Composite Bridge Beams

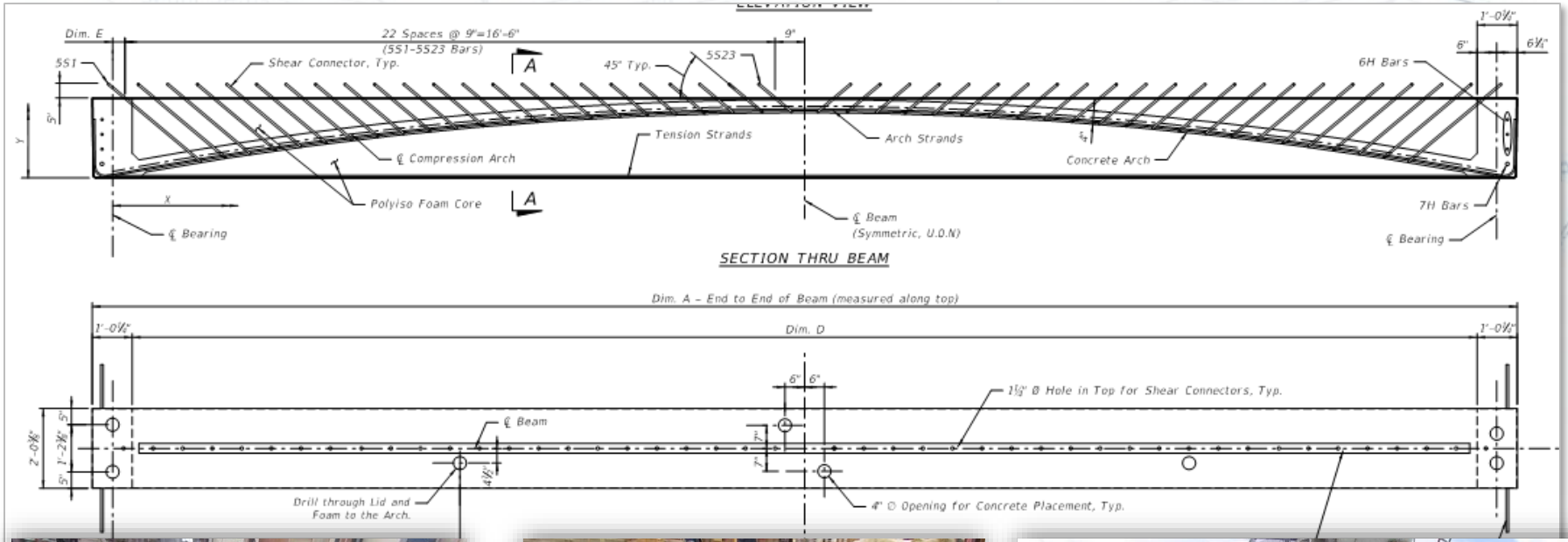
Example Plan Sheet Details:

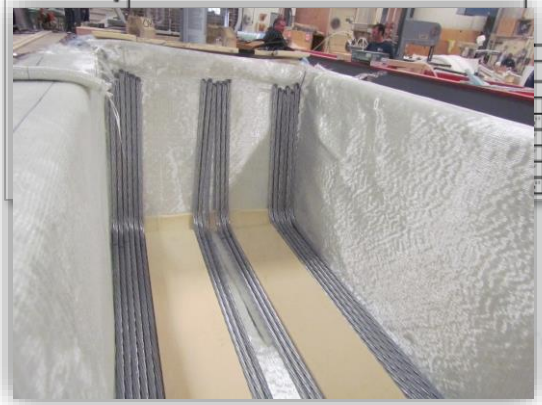




HRB Project – Hybrid Composite Bridge Beams

Example Plan Sheet Details (cont.):





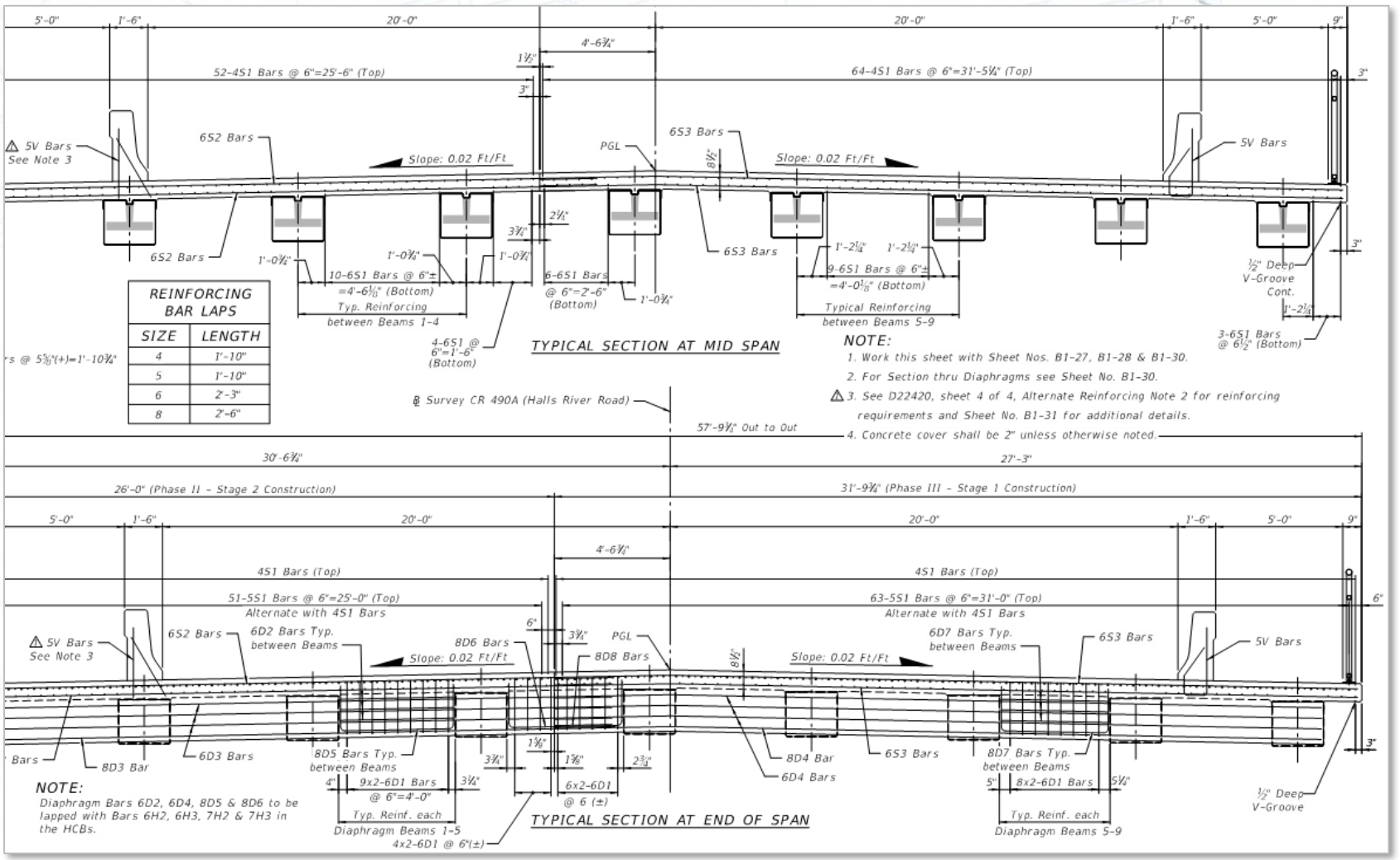
HRB Project – GFRP-RC Decks and Approach Slabs

A. Components
   i. Interior bay
   ii. Deck overhang
   iii. Adjacent to traffic railings
   iv. Approach Slab
B. Structural System
C. Other projects (from ACMA)
   i. 67+ USA
   ii. 400+ Canada
D. Design Criteria - ***AASHTO Guide Spec.***
E. Material Specifications - Dev932 & Dev933

(Photographs) Hughes Bros. *GFRP Bars*.

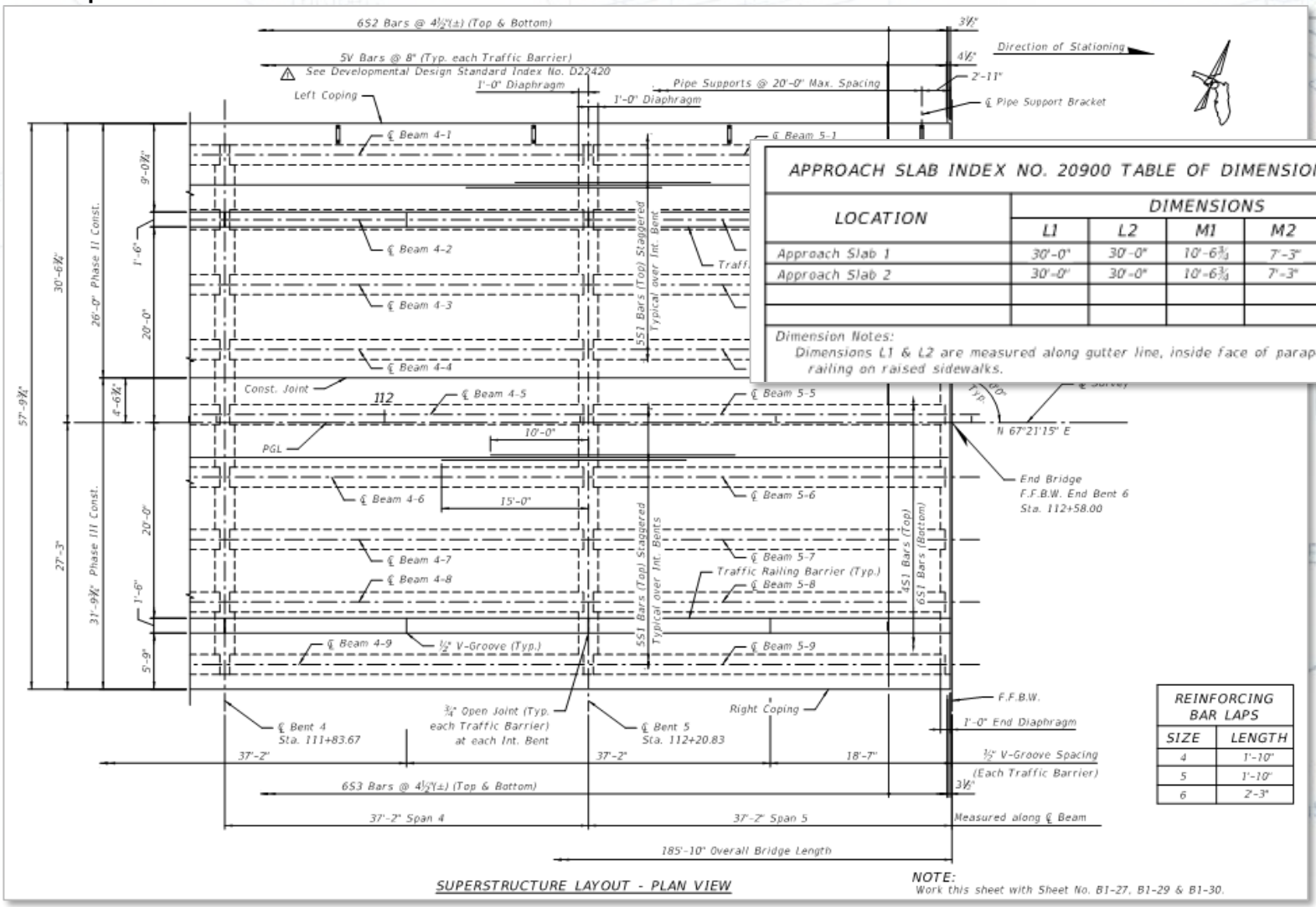
HRB Project – GFRP-RC Decks and Diaphragms

Example Plan Sheet Details:



HRB Project – GFRP-RC Approach Slabs

Example Plan Sheet Details:



APPROACH SLAB INDEX NO. 20900 TABLE OF DIMENSIONS						Table Date 07-01-13
LOCATION	DIMENSIONS					ANGLE Ø
	L1	L2	M1	M2	N	
Approach Slab 1	30'-0"	30'-0"	10'-6⅜"	7'-3"	40'-0"	00°00'00"
Approach Slab 2	30'-0"	30'-0"	10'-6⅜"	7'-3"	40'-0"	00°00'00"

Dimension Notes:
Dimensions L1 & L2 are measured along gutter line, inside face of parapet or inside face of railing on raised sidewalks.

REINFORCING BAR LAPS	
SIZE	LENGTH
4	1'-10"
5	1'-10"
6	2'-3"

SUPERSTRUCTURE LAYOUT - PLAN VIEW

NOTE:
Work this sheet with Sheet No. B1-27, B1-29 & B1-30.

HRB Project – GFRP-RC Traffic Railings

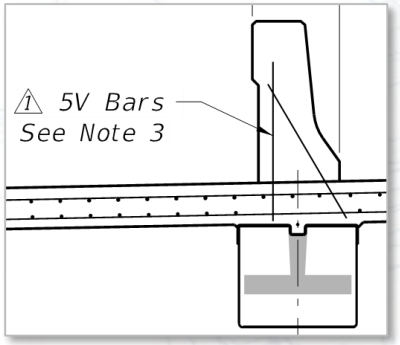
A. Components
   i. Inboard Section (Post Installed Anchorage – Phase III)
   ii. Edge Railing Section (Cast-in Anchorage)
B. Structural System
C. Similar crash tested designs
   i. V-Rod, Schloek, & Temcorp: MASH TL-5 42" F-Shape
   ii. GFRP Adhesive Anchor Tests by Hilti/Canadian Research Centre
D. Design Criteria
   i. AASHTO Guide Spec.
   ii. NCHRP 350/MASH
E. Material Specifications
   i. GFRP Rebar - Dev932;
   ii. White Cement & Slag Cement – Spec. 346

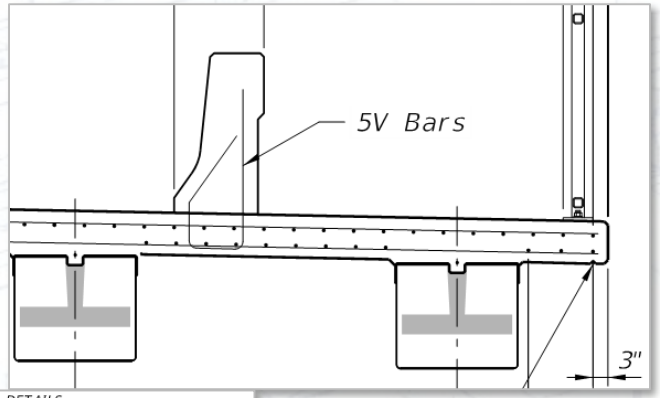
Photograph: *GFRP reinforced traffic railing from successful TL-5 crash test (Pultrall)*

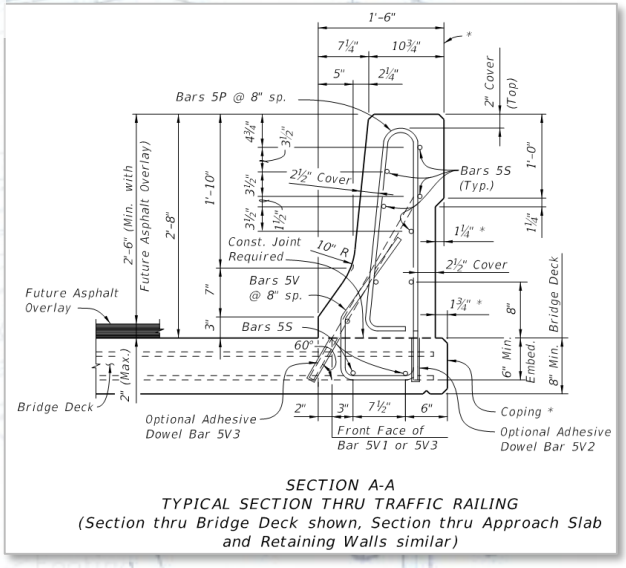
Photograph: *GFRP Bars in retaining walls & railings (*Hughes Bros.)

HRB Project – GFRP-RC Traffic Railings

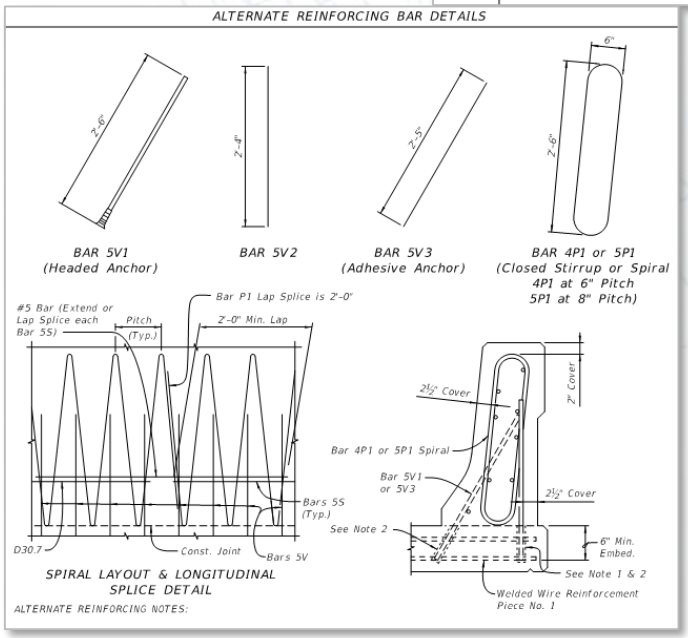
Example Plan Sheet Details:

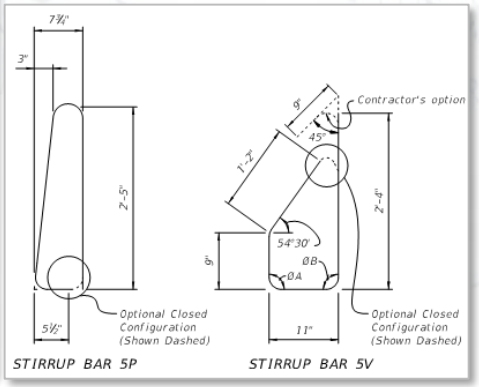


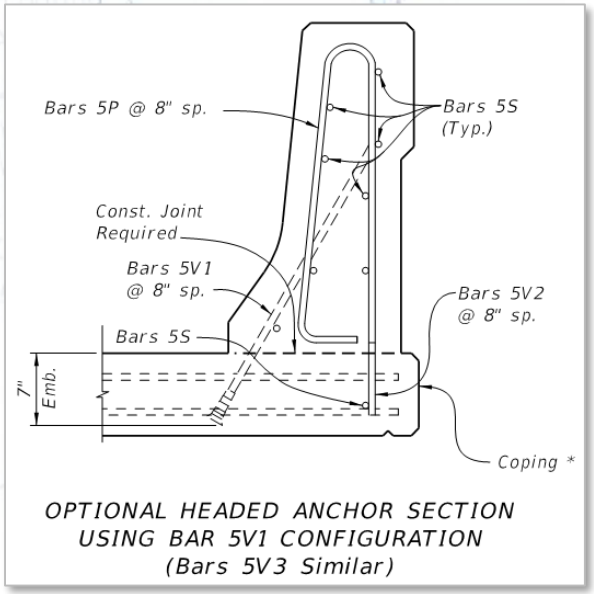




SECTION A-A
TYPICAL SECTION THRU TRAFFIC RAILING
(Section thru Bridge Deck shown, Section thru Approach Slab and Retaining Walls similar)







OPTIONAL HEADED ANCHOR SECTION
USING BAR 5V1 CONFIGURATION
(Bars 5V3 Similar)

HRB Project –
CAMX Award Finalist: "*Combined Strength*"

Mockups (December 2018):

Beyond Halls River Bridge

http://www.fdot.gov/structures/innovation/FRP.shtm

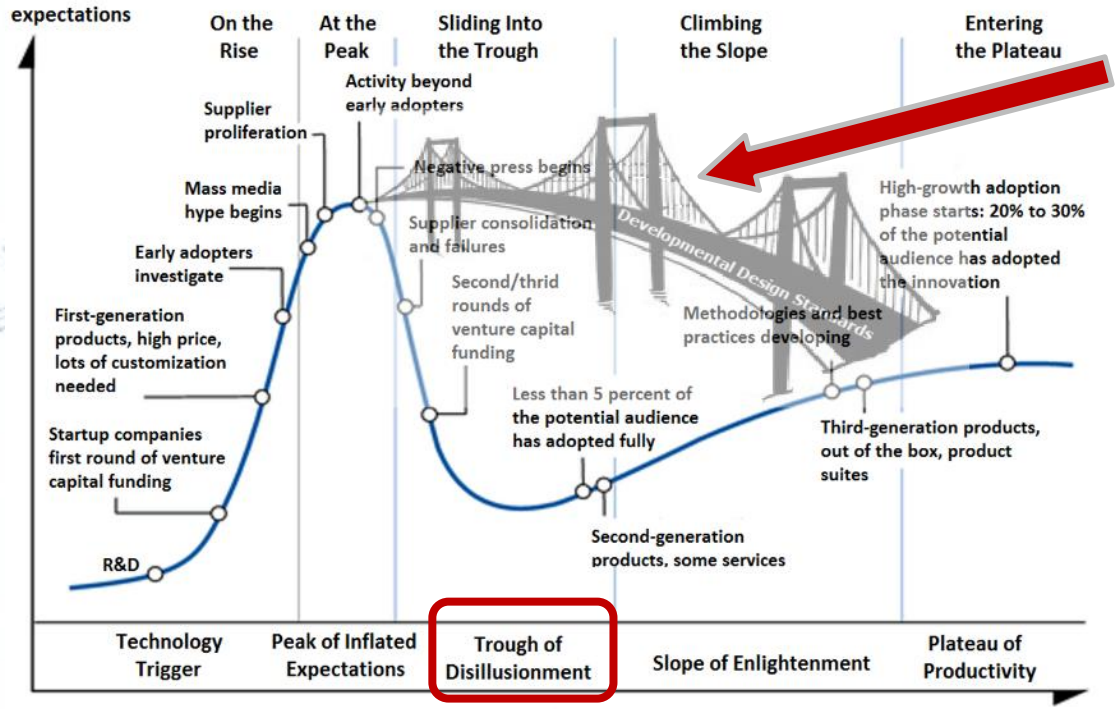
- ✓ Developing design criteria for:
  - *i.* ***Glass-FRP*** prestressing
  - *ii.* ***Basalt-FRP*** reinforcing
- ✓ FHWA's ***I****nnovations* ***D****eserving of* ***E****xploratory* ***A****nalysis* ***(IDEA)***
  - GFRP Prestressing - ***MILDGLASS*** *(University of Miami);*

IDEA
Innovations Deserving
Exploratory Analysis Programs

- ✓ FHWA's ***S****tate* ***T****ransportation* ***I****nnovation* ***C****ouncils* ***(STIC)*** Incentive Program
  - BFRP Reinforcing Standards Development -***MACTBr*** *(FDOT)*

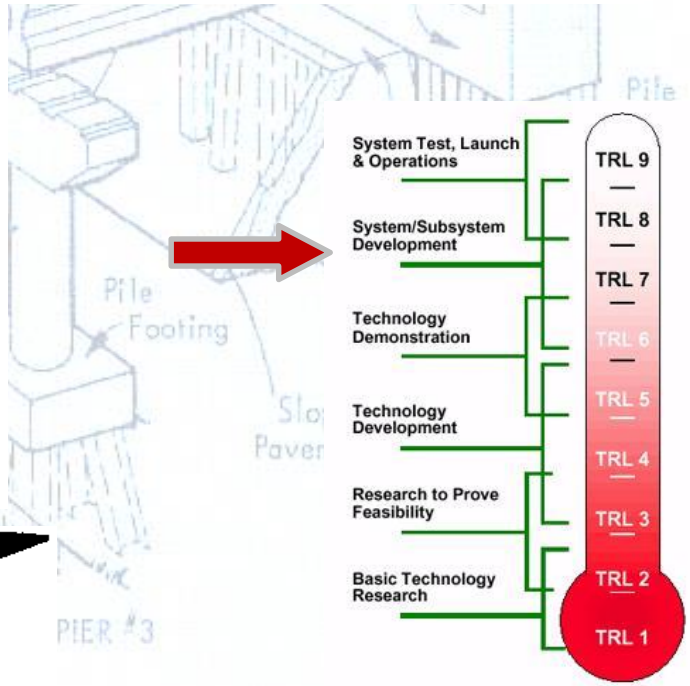
STIC
State Transportation Innovation Councils

Technology Transfer – Implementation, Nurturing & Tracking

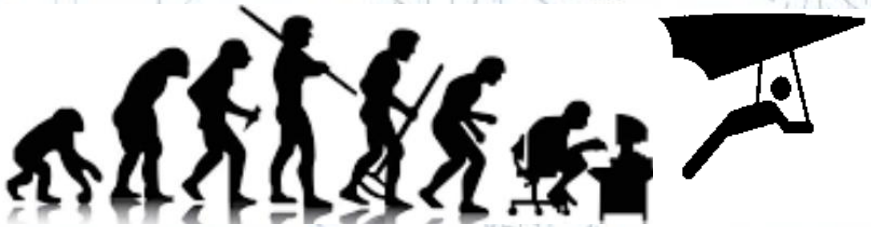


Source: Gartner Inc. Hype Cycle

Developmental Standards provide a bridge across the *"Trough of Disillusionment"* for effective implementation!



Source: NASA

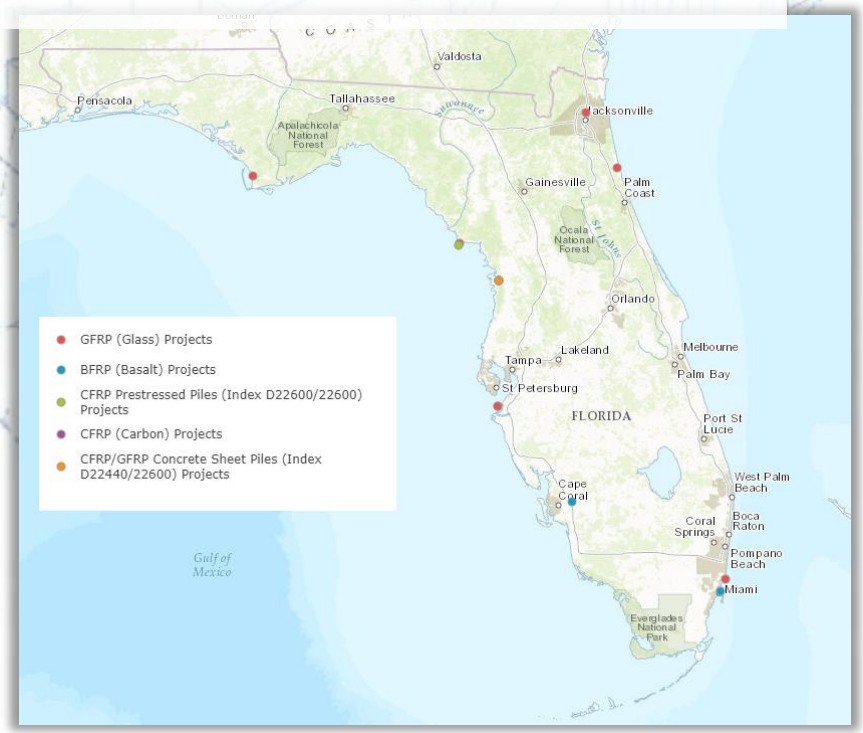


Research (TRL 1-3) → Demonstration Project (TRL 4-5) → Developmental (*DDS*) Index (TRL 6-8) → Design Standard Index (TRL 9)

Technology Transfer - Tools

Projects GIS-Mapping Tool:

- Active and Completed FRP-RC projects;
- Includes FRP-Fender Systems,
- Hope to add bridge beam repair/strengthening projects in future (20+ year history of wet-layup repairs)



http://www.fdot.gov/structures/innovation/FRP.shtm

Technology Transfer - Tools

- ✓ **Fast-Facts**
- ✓ **Presentations & Workshops**

Technology Transfer (T^2)

The following links to FDOT meetings, seminars and workshops are provide as background information for potential users and industry partners:

- FHWA/NCHRP 20-68A U.S. Domestic Scan 13-03 meeting with FDOT (June 4-5, 2015)
- FDOT-FRP Rebar Industry Workshop (June 15, 2016)
- Composites-Halls River Bridge Promotional Video for CAMX 2016 (September 26-29, 2016)
- CAMX 2016: FDOT-FRP Deployment for Structural Applications (for new construction) (September 29, 2016)
- ACMA-Transportation Structures Council (TSC) Meeting - FDOT Presentation (September 29, 2016)
- FDOT-CO Winter FRP-RC Workshop & FDOT/FTBA Construction Conference (February 3, 2017)
- Halls River Bridge Replacement FRP Demonstration Project Workshop (May 2-3, 2017)
- FDOT 2017 Design Training Expo - FRP Reinforced Concrete Design (June 6, 2017)
- International Workshop on GFRP Bars: FDOT GFRP Implementation - Current Status, Projects, and Challenges (July 18, 2017)
- FES/FICE 2017: The Halls River Bridge - Perspective of Owner/Designer, Contractor and Researcher (August 4, 2017)

Overview

The deterioration of reinforcing and prestressing steel within concrete is one of the

Projects:

FDOT and affiliated projects in Florida (completed and under construction) can be explored using the FRP-Projects GIS-Mapping Tool (pending). Please contact the coordinators at the bottom of the page to have your project included in the Map.

Fast-Facts sheets for selected projects are listed below:

- Halls River Bridge
- Sunshine Skyway Seawall Rehabilitation
- Bakers Haulover Cut Bulkhead Replacement
- Cedar Key Bulkhead Rehab
- PortMiami Tunnel Retaining Walls
- US-17 (SR-5) Over Trout River
- SR-312 Over Matanzas River
- Arthur Drive over Lynn Haven Bayou
- UM Innovation Bridge
- UM Fate Bridge

http://www.fdot.gov/structures/innovation/FRP.shtm

Technology Transfer - Tools

✓ Face-to-Face:

- FDOT Conferences, Workshops and coordination with AASHTO Subcommittee on Bridges and Structures: Task Group T-6 (FRP), and T-10 (Concrete)

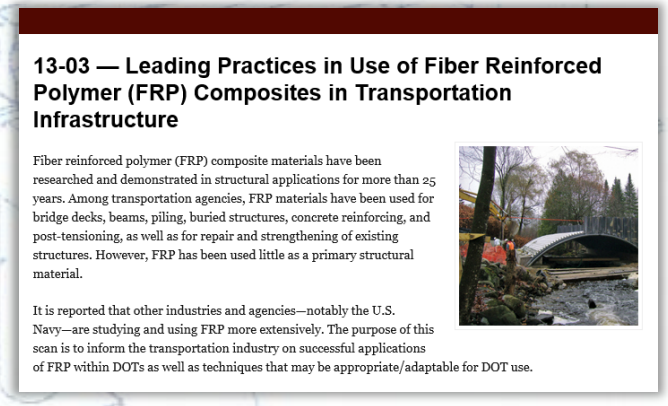
June 18-20th Orlando

FLORIDA innovative TRANSPORTATION SYMPOSIUM

2017 Design Training Expo

2016 Design Training Expo

2015 Design Training Expo



13-03 — Leading Practices in Use of Fiber Reinforced Polymer (FRP) Composites in Transportation Infrastructure

Fiber reinforced polymer (FRP) composite materials have been researched and demonstrated in structural applications for more than 25 years. Among transportation agencies, FRP materials have been used for bridge decks, beams, piling, buried structures, concrete reinforcing, and post-tensioning, as well as for repair and strengthening of existing structures. However, FRP has been used little as a primary structural material.

It is reported that other industries and agencies—notably the U.S. Navy—are studying and using FRP more extensively. The purpose of this scan is to inform the transportation industry on successful applications of FRP within DOTs as well as techniques that may be appropriate/adaptable for DOT use.

2017 FTBA Construction Conference – FRP Structures Session Outline

Date: Feb 2-3, 2017
Location: Hyatt Regency Orlando
9801 International Drive
Orlando, FL 32819
Telephone: (407) 284-1234

View the Tentative Schedule

Register Now

PRELIMINARY OUTLINE

Thursday (2/2/2017)

S1: FDOT FRP Deployment for New Construction – Steve Nolan (1:30-1:50pm)

S2: Halls River Bridge Replacement - Example FRP Project Application - Mamun Siddiqui, Cristina Suarez (2:00-2:20pm)

S3: FRP Constructability Issues and Contractor's Perspective – Antonio Nanni (University of Miami) & Astaldi (Contractor – Sergio Notarianni, Pietro Banov) (2:30-2:50pm)

Questions

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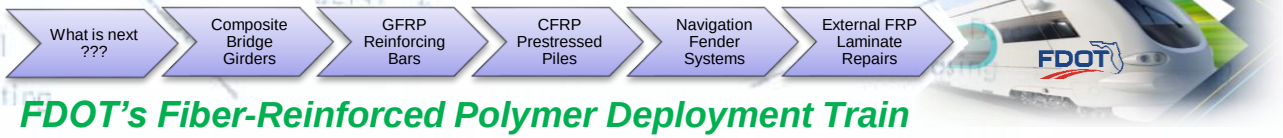

FDOT's Fiber-Reinforced Polymer Deployment Train