

GFRP Rebar Workshop

2016



Design Training

Post-Expo

6/15/2016, 1:00pm - 4:00pm

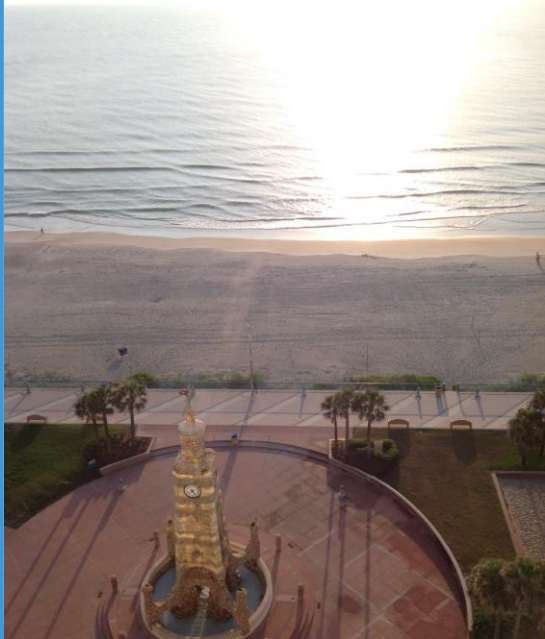
Hilton Daytona Beach Oceanfront Resort

St Johns Room

100 North Atlantic Avenue

Daytona Beach, Florida 32118, USA

Tel: 1-386-254-8200



Part 1 - Presentations

1. GFRP Industry perspective
 - i. ACMA-TSC (John Busel)
 - ii. Owens Corning (Chris Skinner)

2. ACI Committee 440 perspective (Antonio Nanni)

3. AASHTO-T6 perspective (Will Potter – FDOT rep.)

4. **FDOT perspective**
 - i. Materials (Chase C. Knight)
 - ii. Design (Steve Nolan)
 - iii. Construction (future workshops)
 - iv. Maintenance (future workshops)

FDOT Perspective - Materials

I. Overview

II. Material Requirements

III. Research



State Materials Office

FDOT Perspective - Materials

Overview

State Materials Office Roles:

- *Material Specifications*
- *Sampling and Testing Requirements*
- *Quality Control Program – Production Facility Approvals*
- *Conduct and Facilitate Research – Durability/Service Life*

FDOT Perspective - Materials

Material Requirements

1. Producer Quality Control
 - a) *Specifications Section 105*
 - b) *Materials Manual Chapter 12.1*
 - c) *Specifications Section 932*

2. Acceptance at the Project Level
 - a) *Certification*
 - b) *Sampling and Testing*

3. MAC

FDOT Perspective - Materials

Material Requirements

1. Producer Quality Control

a) Section 105 – Contractor Quality Control

- FRP producers must meet requirements of Materials Manual

b) Materials Manual Chapter 12.1

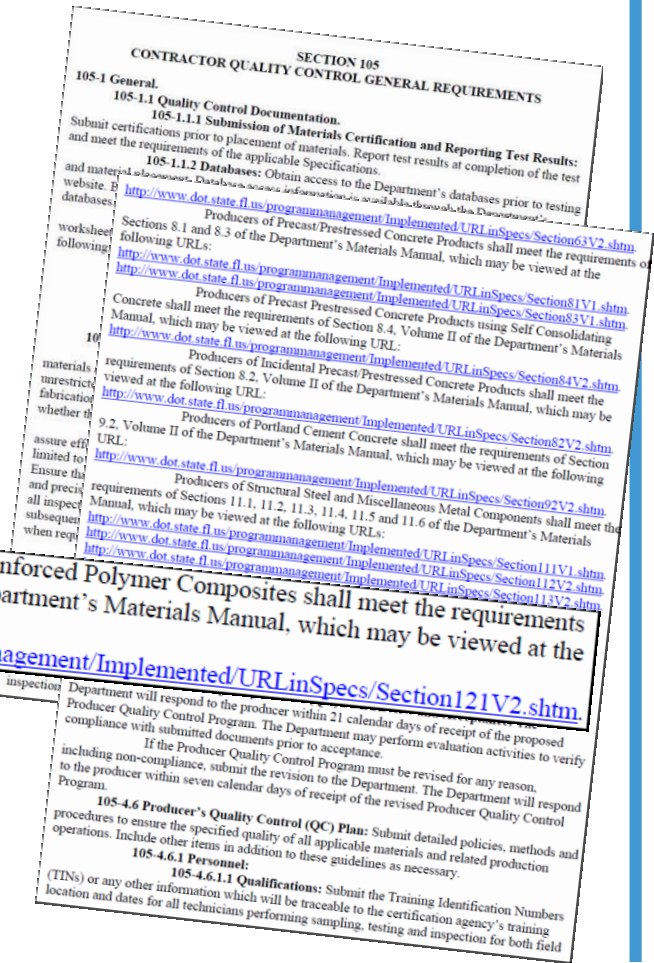
c) Specifications Section 932

2. Acceptance at the Project Level

a) Certification

b) Sampling and Testing

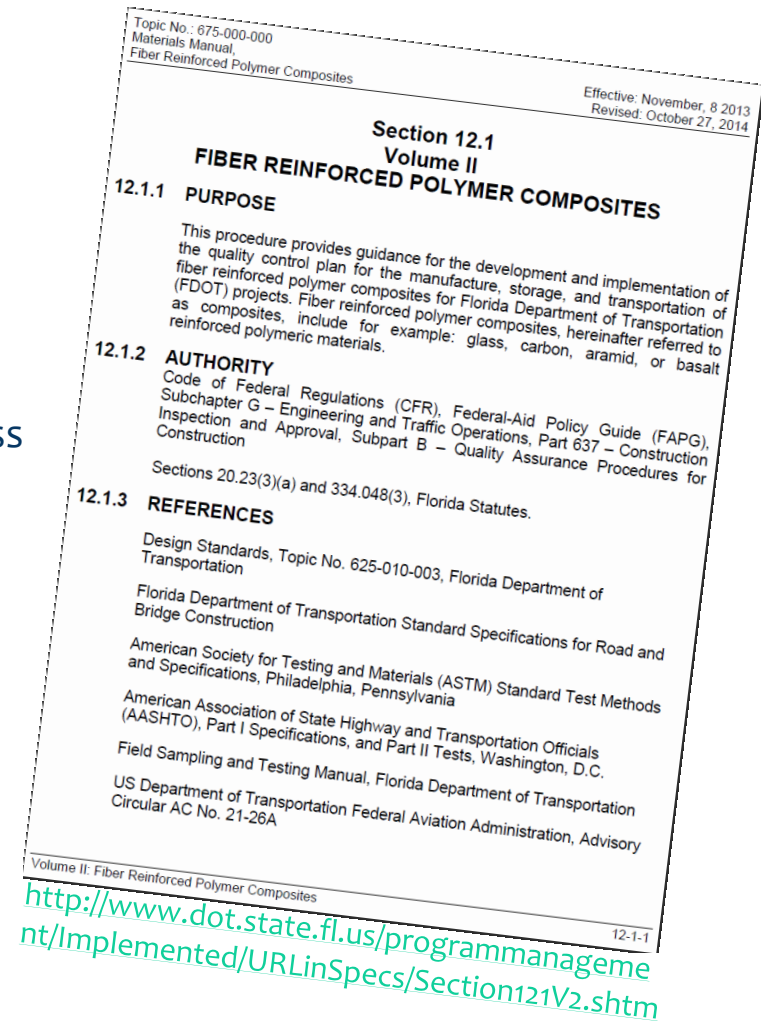
3. MAC



FDOT Perspective - Materials

Material Requirements

1. Producer Quality Control
 - a) *Specifications Section 105*
 - b) **Materials Manual Chapter 12.1**
 - Production Facility Qualification Process
 - Producer Responsibilities
 - Incoming raw material control
 - Manufacturing quality control
 - QC inspection
 - Handling, Storage, Shipment
 - Documentation and Record Retention
 - c) *Specifications Section 932*
2. Acceptance at the Project Level
 - a) *Certification*
 - b) *Sampling and Testing*
3. *MAC*

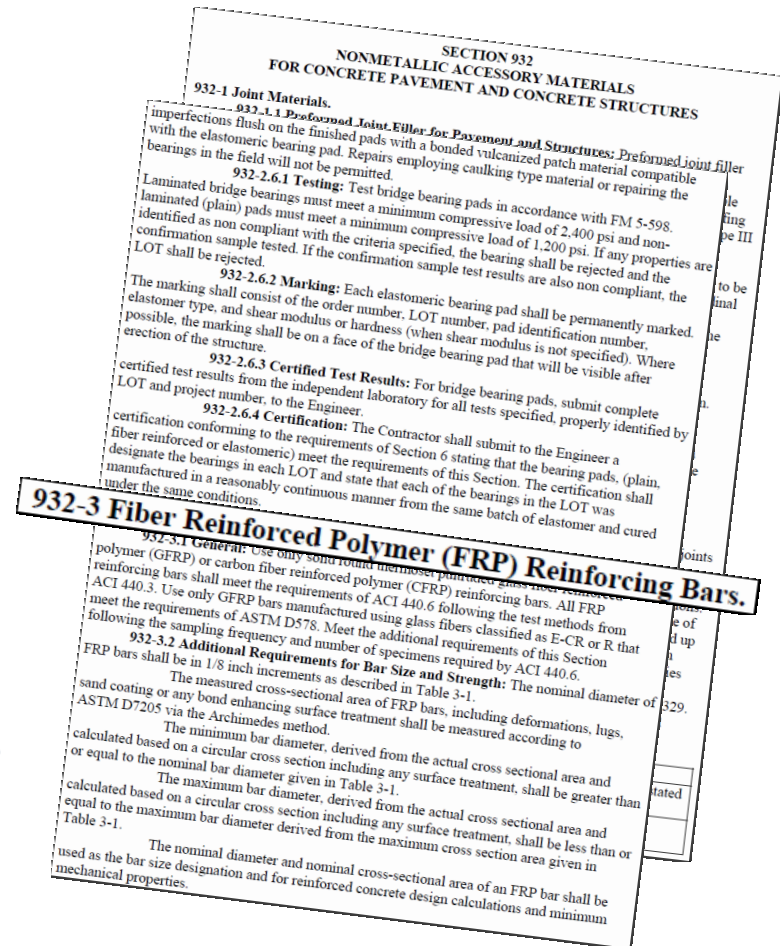


FDOT Perspective - Materials

Material Requirements

1. Producer Quality Control
 - a) Specifications Section 105
 - b) Materials Manual Chapter 12.1
 - c) Specifications Section 932
 - Developmental – pre July 2016
 - Standard – July 2016 forward
 - Sizes and Strengths
 - Physical Property Requirements for Producer Qualification
 - Requirements for Acceptance at the Project Level

2. Acceptance at the Project Level
 - a) Certification
 - b) Sampling and Testing



3. IMAC
 - <http://www.dot.state.fl.us/programmanagement/OtherFDOTLinks/Developmental/Default.shtm>
 - <http://www.dot.state.fl.us/programmanagement/Implemented/SpecBooks/default.shtm>

FDOT Perspective - Materials

Material Requirements

1. Producer Quality Control
 - a) Specifications Section 105
 - b) Materials Manual Chapter 12.1
 - c) Specifications Section 932

2. Acceptance at the Project Level
 - a) **Certification**
 - Notarized Statement from FRP Producer sent **prior to shipment**
 - Certificate of Analysis for each LOT sent with each shipment
 - b) Sampling and Testing

3. MAC

Blank Notarized Certification Statement Example
"USE ON PLANT'S LETTERHEAD"

MATERIAL CERTIFICATION
FLORIDA D.O.T.

Contractor: FIBER REINFORCED POLYMER PRODUCTS

F.D.O.T. Project Number:

F.D.O.T. Contract Number:

Project Location:

Description of Products:

We certify the described fiber reinforced polymer products will be manufactured by our plant in accordance with the requirements set forth in the Florida Department of Transportation Contract Documents and the plant's approved quality control plan. The plant's quality control manager or the inspectors under his/her direct supervision will inspect and review all QC records of the products prior to their shipment to the project site. Each shipment of the fiber reinforced polymer products to the project site will be accompanied with a signed or stamped delivery ticket. A certificate of analysis will also be attached for each LOT shipped.

Plant Company Officer or Designee: _____

Signature: _____

Date: _____

(Notarized)

FDOT Perspective - Materials

Material Requirements

1. Producer Quality Control
 - a) *Specifications Section 105*
 - b) *Materials Manual Chapter 12.1*
 - c) *Specifications Section 932*

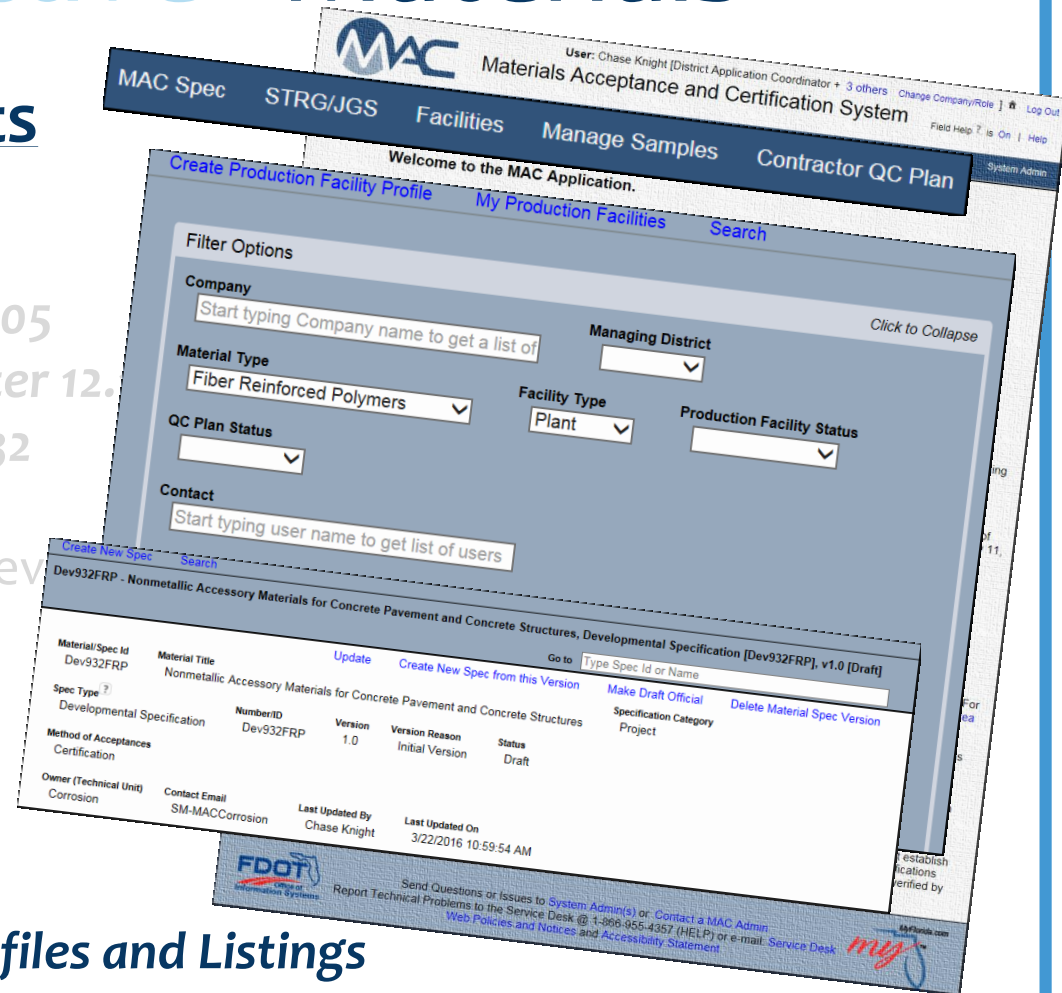
2. Acceptance at the Project Level
 - a) *Certification*
 - b) **Sampling and Testing**
 - Samples selected by Engineer after delivery to project
 - Contractor responsible for verification testing using independent ISO Lab

3. MAC

FDOT Perspective - Materials

Material Requirements

1. Producer Quality Control
 - a) Specifications Section 105
 - b) Materials Manual Chapter 12.
 - c) Specifications Section 932
2. Acceptance at the Project Level
 - a) Certification
 - b) Sampling and Testing
3. MAC
 - a) Specifications
 - b) Production Facility Profiles and Listings



FDOT Perspective - Materials

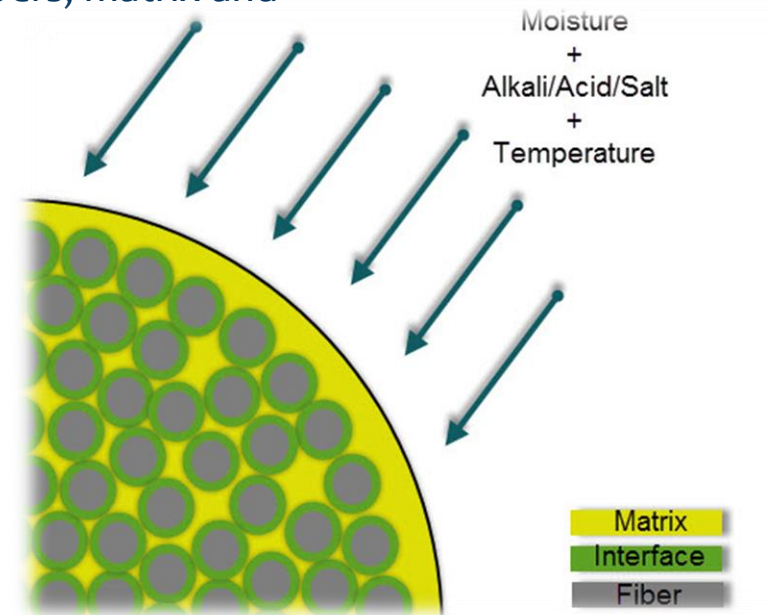
Research

1. Degradation mechanisms
2. Service life estimation
3. Performance of surface enhancements
4. Durability of bends
5. Field exposure

FDOT Perspective - Materials

Research

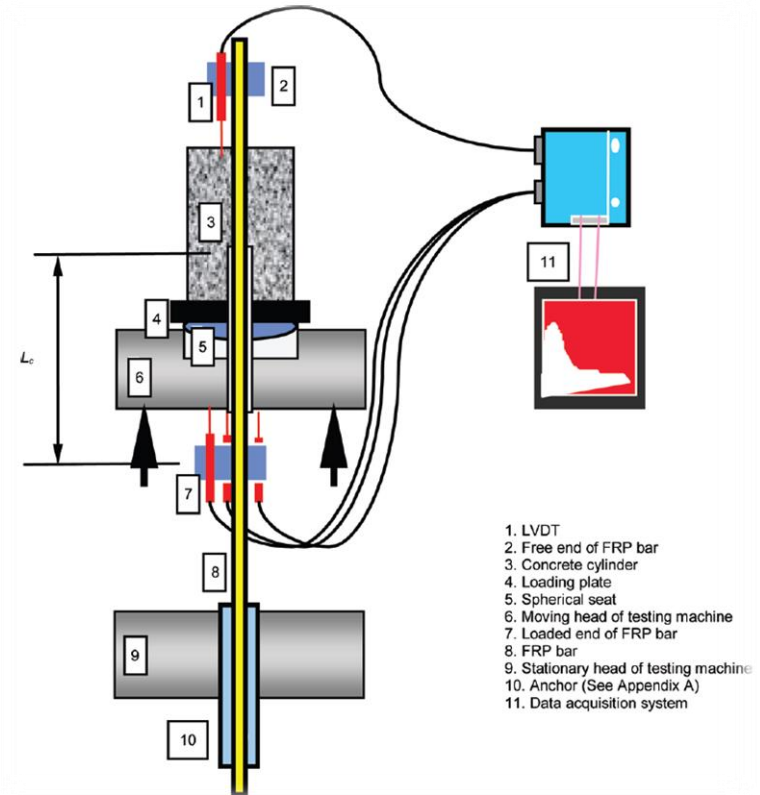
1. Degradation mechanisms
 - Model degradation of FRP in concrete based on synergistic effects of physical and chemical aging on fibers, matrix and interface
2. Service life estimation
 - Test protocol based on degradation model
3. Performance of surface enhancements
4. Durability of bends
5. Field Exposure



FDOT Perspective - Materials

Research

1. Degradation mechanisms
2. Service life estimation
3. Performance of surface enhancements
 - Durability of rebar-concrete bond
4. Durability of bends
5. Field Exposure



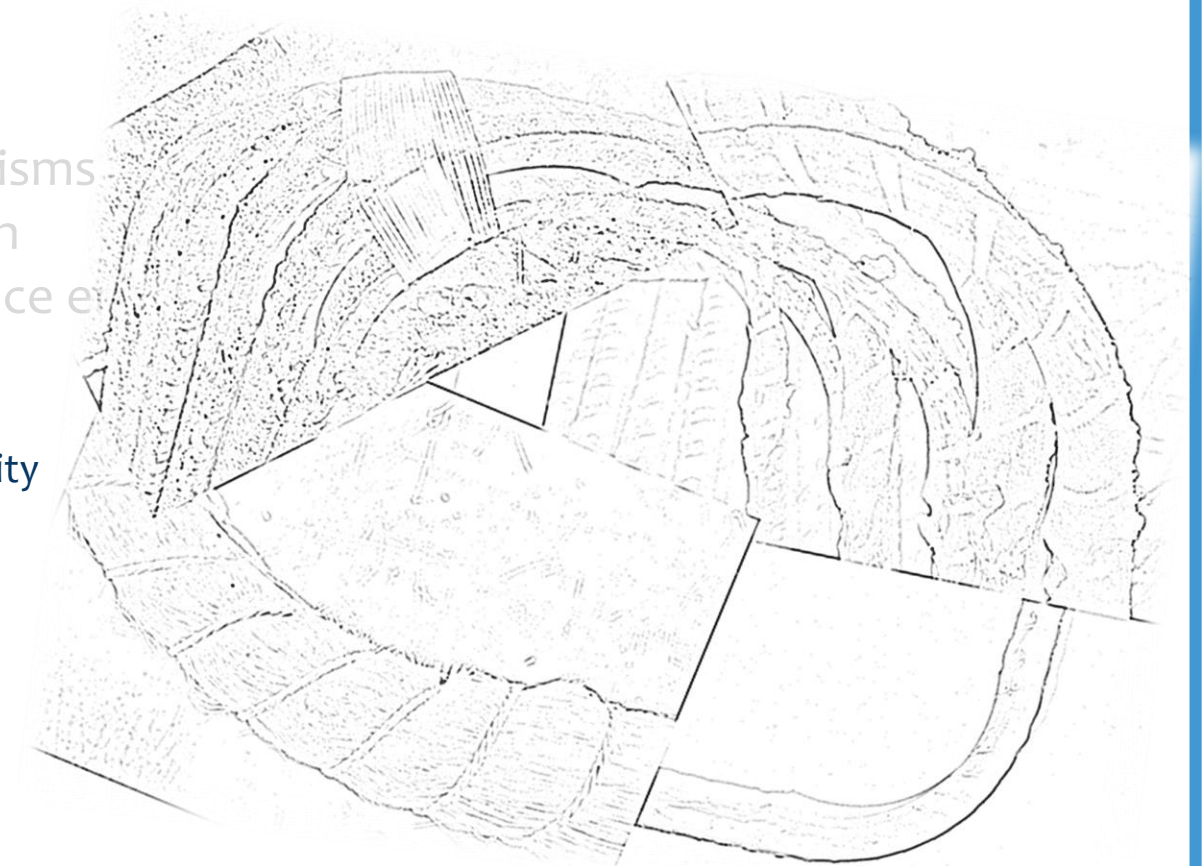
1. LVDT
2. Free end of FRP bar
3. Concrete cylinder
4. Loading plate
5. Spherical seat
6. Moving head of testing machine
7. Loaded end of FRP bar
8. FRP bar
9. Stationary head of testing machine
10. Anchor (See Appendix A)
11. Data acquisition system

ACI 440.3R

FDOT Perspective - Materials

Research

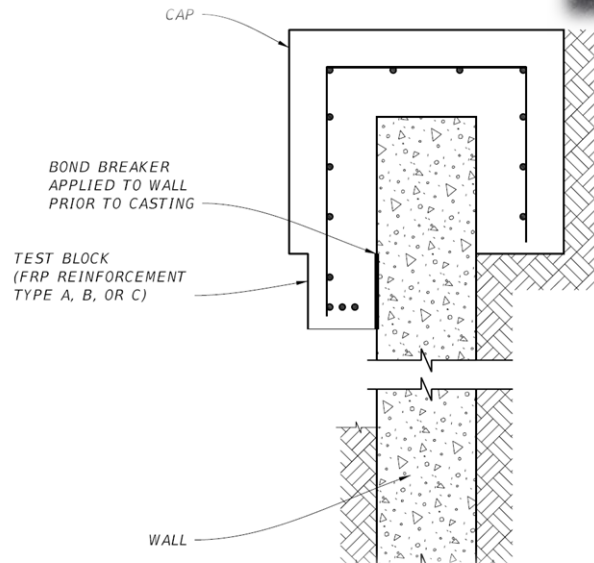
1. Degradation mechanisms
2. Service life estimation
3. Performance of surface e
4. Durability of bends
 - Effect of modified pultrusion on durability
5. Field Exposure



FDOT Perspective - Materials

Research

1. Degradation mechanisms
2. Service life estimation
3. Performance of surface enhancement
4. Durability of bends
5. Field exposure
 - Test blocks/beams

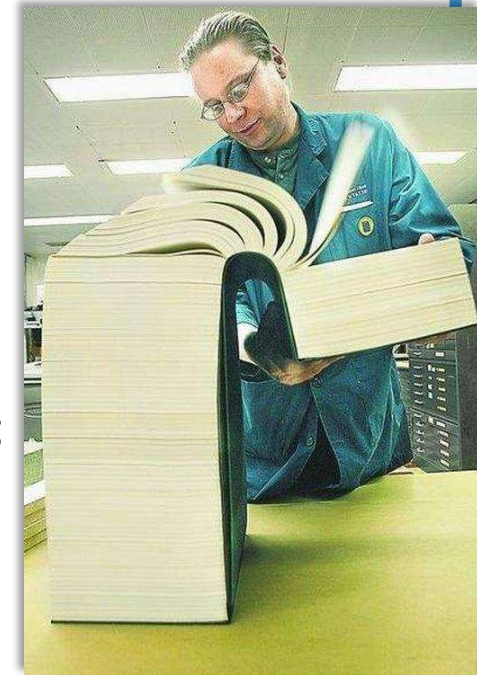


FDOT Perspective - Design

Design Documentation

What's available from FDOT?

1. Design criteria –
 - a) *Fiber Reinforced Polymer Guidelines (FRPG)*
 - b) *Structures Design Guidelines (SDG)*;
2. Detailing criteria – *Structures Detailing Manual (SDM)*;
3. *Design Standards*;
4. *Specifications (Construction and Materials)*.



FDOT's Fiber-Reinforced Polymer Deployment Train



FDOT Perspective - Design

Design Documentation

1. Design criteria –

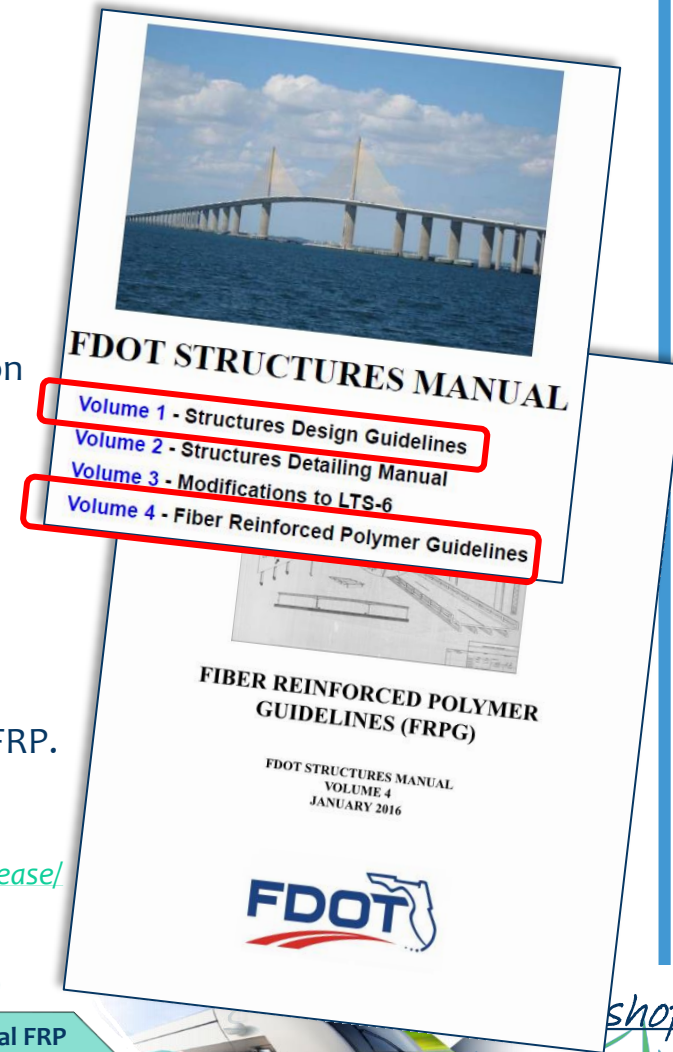
a) **Fiber Reinforced Polymer Guidelines (FRPG)**

- Overall commentary on FRP;
- Specific design criteria, plan content and Specification requirements;
- Design review requirements;
- Approval of use process;
- Permitted uses for each type of FRP.

b) **Structures Design Guidelines (SDG)**

- Overall design criteria;
- Revised and/or supplemented by **Fiber Reinforced Polymer Guidelines (FRPG)** for given applications of FRP.

<http://www.dot.state.fl.us/structures/StructuresManual/CurrentRelease/StructuresManual.shtm>



FDOT's Fiber-Reinforced Polymer Deployment Train

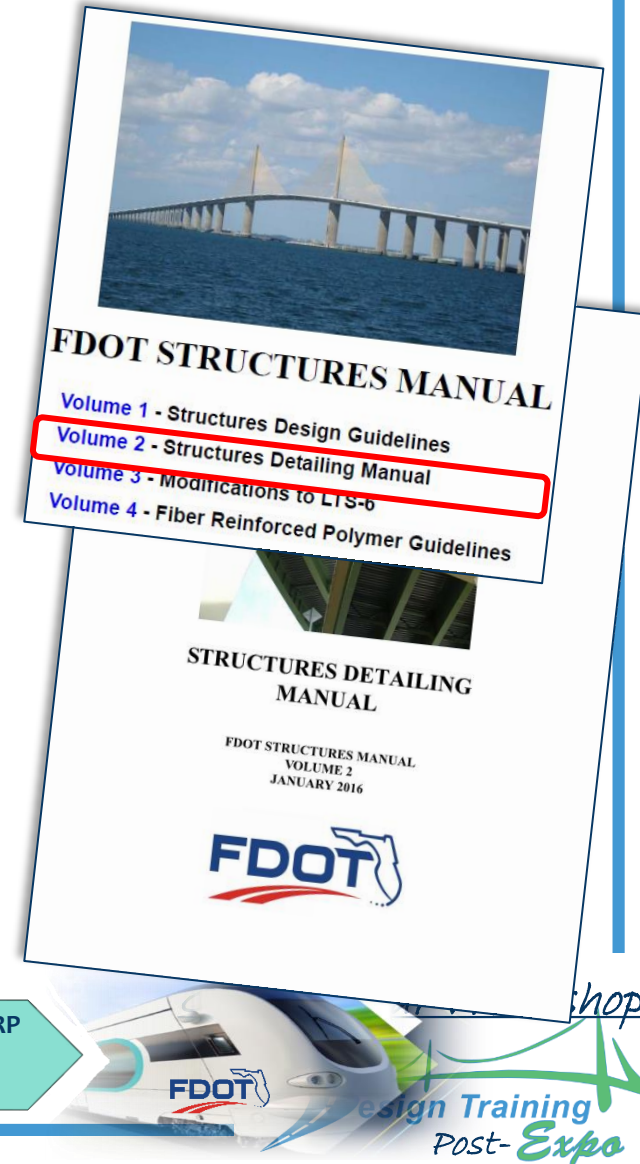


FDOT Perspective - Design

Design Documentation

2. Detailing criteria – **Structures Detailing Manual (SDM)**:
 - a) Overall detailing criteria;
 - b) Revised and/or supplemented by **Fiber Reinforced Polymer Guidelines (FRPG)** for given applications of FRP.

<http://www.dot.state.fl.us/structures/StructuresManual/CurrentRelease/Vol4FRPG.pdf>



FDOT's Fiber-Reinforced Polymer Deployment Train

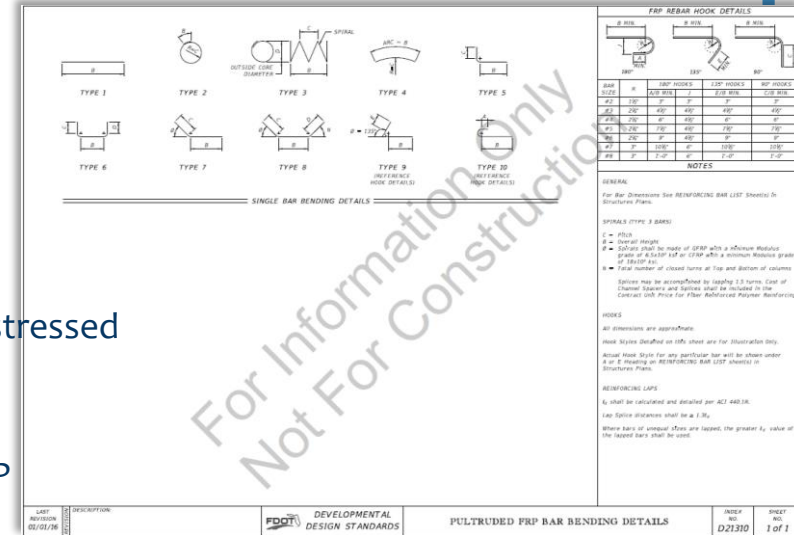


FDOT Perspective - Design

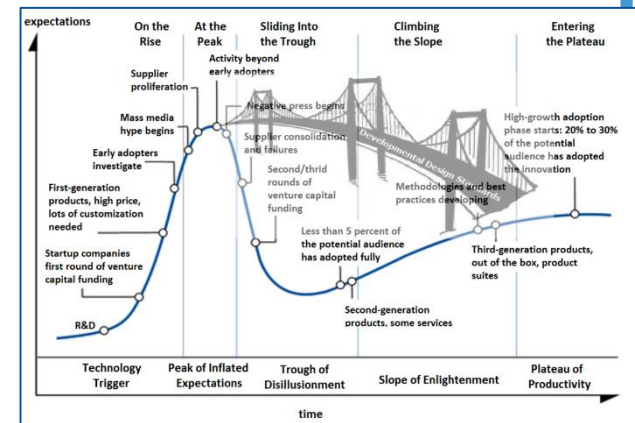
Design Documentation

3. Design Standards:

- a) FY2016-17 Design Standards:
 - **Index 22600 series** – Square CFRP & SS Prestressed Concrete Piles;
- 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 D22440 series** – Precast Concrete CFRP/GFRP Sheet Pile Wall
 - **Index D22900** – GFRP reinforced Approach Slab;



For Information Only
Not For Construction



FDOT's Fiber-Reinforced Polymer Deployment Train

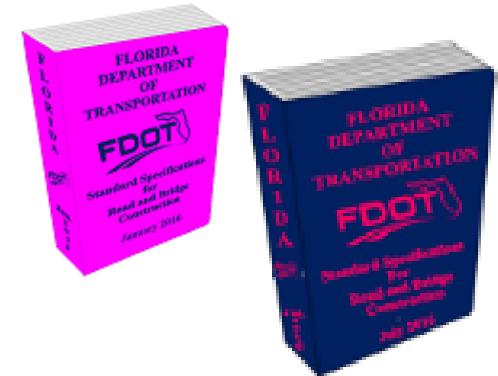


FDOT Perspective - Design

Design Documentation

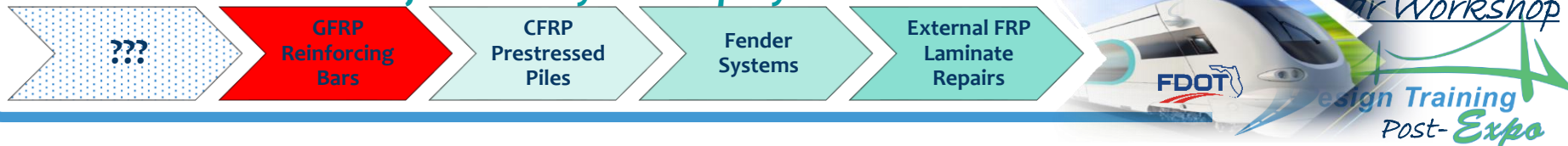
4. Specifications:

- a) Standard Specifications (effective July 2016):
 - Implemented previous FRP *Developmental Specifications*.
- b) Developmental Specifications:
 - **Dev400FRP** Concrete Structures – Fiber Reinforced Polymer Reinforcing;
 - **Dev410FRP** Precast Concrete Box Culvert;
 - **Dev415FRP** Reinforcing for Concrete;
 - **Dev450FRP** Precast Prestressed Concrete Construction – Fiber Reinforced Polymer (FRP);
 - **Dev932FRP** Nonmetallic Accessory Materials for Concrete Pavement and Concrete Structures;
 - **Dev933FRP** Prestressing Strand;



(Photograph) Hughes Bros. Coated tie wire.

FDOT's Fiber-Reinforced Polymer Deployment Train



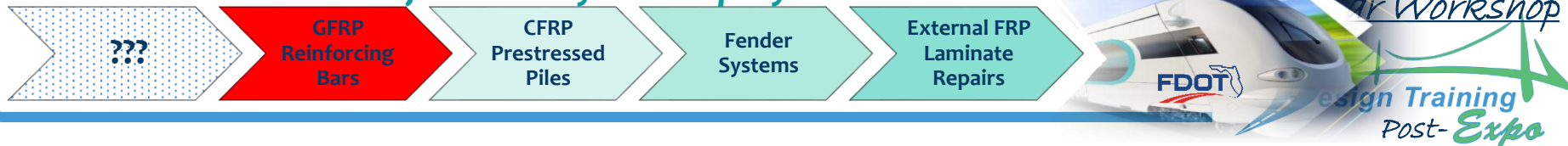
FDOT Perspective - Design

Roadmap to the safe deployment of GFRP reinforcement for concrete structures

- Barriers to expanded GFRP Implementation
- Potential Focus Areas



FDOT's Fiber-Reinforced Polymer Deployment Train



FDOT Perspective - Design

Barriers to expanded FRP Implementation:

1. First cost
2. Lack of confidence in durability for submerged environments (FDOT seeking 75 - 100 year service life)
3. Limitations on the strength due to degradation of properties over time (currently C_E factor = 0.7 for GFRP exterior environments) *[goes with item #2]*
4. Limitations on strength due to low design resistance factors (ϕ factors) related to lack of ductility and strength variability in the FRP materials (currently 0.55-0.65 for tensioned-control to compression-controlled flexural failure modes)
5. Restrictions in bar bending capabilities, and challenges with field modifications to bar shapes
6. Low Elastic Modulus, resulting in greater deflections and larger crack openings
7. Update AASHTO Guide Specification

FDOT's Fiber-Reinforced Polymer Deployment Train



FDOT Perspective - Design

Potential Focus Areas:

1. **Rationalization of Resistance Factors (phi factors)** used to address lack of ductility and variability in material strength properties;
2. **Refinement of Environmental Reduction factors (CE);**
3. **Resolution of durability question in submerged environments;**
4. **Advancement in bent bar fabrication;**
5. **Mitigation of lower elastic modulus effects** as related to member deflections and concrete crack widths;
6. **Investigate hybrid designs** – using FRC and/or Carbon-steel strand with GFRP rebar:
 - Concrete Sheet Piles;
7. **Improved FRP Industry coordination** especially between ACMA-TSC and AASHTO SCOBS-T6 (FRP) & T10 (Concrete);

FDOT's Fiber-Reinforced Polymer Deployment Train



FDOT Perspective - Design

Potential Focus Areas (cont.):

8. Continued Standardization
9. Accommodation of potential customization and optimization of FRP reinforcing and other products
10. Guidance on the use of Life Cycle Cost Analysis for FRP justification
11. Project Monitoring
12. Outreach and Technology Transfer
13. **Repair Methods** *[added]*
14. **Bridge Inspection** *[added]*

FDOT's Fiber-Reinforced Polymer Deployment Train



Questions ??

FDOT Contact Information:

Structures Design Office:

Rick Vallier, P.E. (FRP Coordinator)
(850) 414-4290

Rick.Vallier@dot.state.fl.us

Steven Nolan, P.E. (Standards Coordinator)
(850) 414-4272

Steven.Nolan@dot.state.fl.us



State Materials Office:

Chase C. Knight, PhD. (FRP Coordinator)
(352) 955-6642

Chase.Knight@dot.state.fl.us

Ivan Lasa, B.S.C.E. (Corrosion Lab.)
(352) 955-2901

Ivan.Lasa@dot.state.fl.us