Part 1 - Reports

a. FDOT FRP-RC implementation status

b. FDOT Materials Office update on durability focused research projects

c. Update on AASHTO LRFD Guide Specification for GFRP-RC *(Antonio Nanni & Will Potter)*

d. Canadian Standards Association update

e. ACMA FRP-RMC update

f. Action Item Status from last year

2018 FDOT-FRP Industry 2nd Winter Workshop

February 9, 2018

Orlando, FL

AASHTO Specifications for GFRP-RC Bridges 2nd Ed.

(under consideration)

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UNIVERSITY OF MIAMI

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   - ACI & CSA
5. **Examples of outcomes**
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   - Expansions

1. Task Force for AASHTO Guide 2nd Ed.

Universities

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University of Miami

Fabio Matta
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University of Miami

Transp. Agencies/Industry

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Texas DOT

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Jim Gutierrez
Cal Trans

Mark Henderson
CT Cons.

Steven Nolan
FDOT

Will Potter
FDOT / T6

2. Approach and Relevance

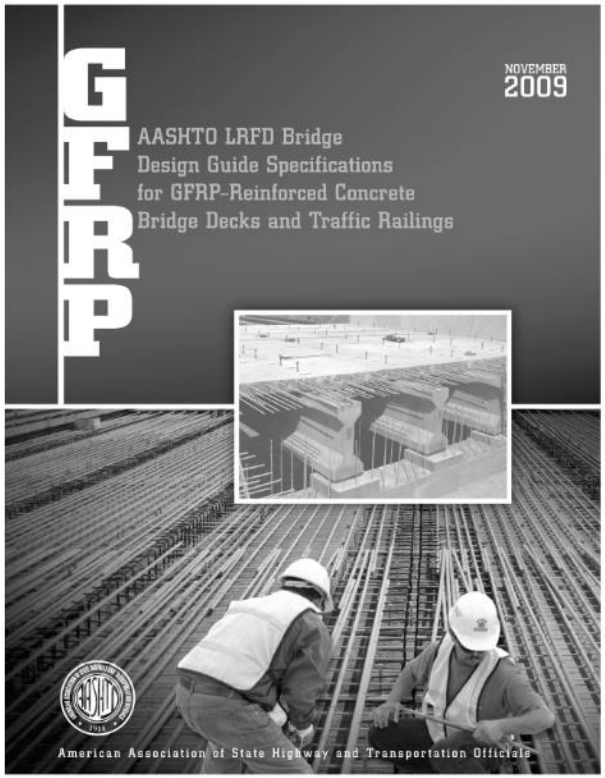
- **Harmonize** with national (ACI, ASTM and AASHTO-BDS) and international (CSA) specifications. **Outcomes**: ease material certification, enlarge market and ease design/deployment

- **Update** existing provisions of 1st Ed. to reflect better materials and manufacturing. **Outcome**: make design more efficient and economical

- **Expand** previous edition to include all elements of a bridge. **Outcome**: allow the design of a bridge entirely reinforced with GFRP

3. Deliverable

- From 1st Ed. on decks and railings to complete **Bridge Design Specifications** (GFRP-**BDS**)
- Submitted (**01/16/2018**) to AASHTO Committee T6 for ballot



2018

AASHTO LRFD BRIDGE DESIGN GUIDE SPECIFICATIONS FOR GFRP REINFORCED CONCRETE – 2ND EDITION

TABLE OF CONTENTS

2nd Ed. Table of Content (comparison)

Chapter/Section	AASHTO-18 Ed. 2	AASHTO-09 Ed. 1	ACI 440-15	CSA-14
2. Concrete Structures				
• Flexural elements	x	x	x	x
• **Compression elements**	**X**			
• Shear	x	x	x	x
• **Torsion**	**X**			
3. Decks	x	x		x
4. Substructures	**X**			
5. Railings	x	x		x
6. Material & Construction	x	x	x	x

Critical Design Parameters

	AASHTO -18 2nd Ed.	AASHTO -09 1st Ed.	ACI 440. 1R-15	CSA-14	
f_{fu}^*	99.73	99.73	99.73	**95.0**	Percentile grntd. strength
Φ_C	**0.75**	**0.65**	0.65	0.75	Res. Fact. concr. failure
Φ_T	0.55	0.55	0.55	0.55	Res. Fact. FRP. failure
Φ_S	0.75	0.75	0.75	0.75	Res. Fact. shear failure
C_E	0.70	0.70	0.70	**1.0**	*Env. knock-down*
C_C	**0.25**	**0.20**	0.20	0.25	*Creep knock-down*
C_f	**0.25**	**0.20**	0.20	0.25	*Fatigue knock-down*
k_b	**1.2**	**1.4**	1.4	**1.0**	*Bond coeff.*
w	**0.028**	**0.020**	0.028	0.020	Crack width
$c_{c,stirrups}$ [in.]	1.5	1.5	2.0*	1.5	*Clear cover*
$c_{c,primary}$ [in.]	2.0	2.0	2.5*	1.5	*Clear cover*
$c_{c,slab}$ [in.]	1.0	0.75	2.0*	1.5	*Clear cover*

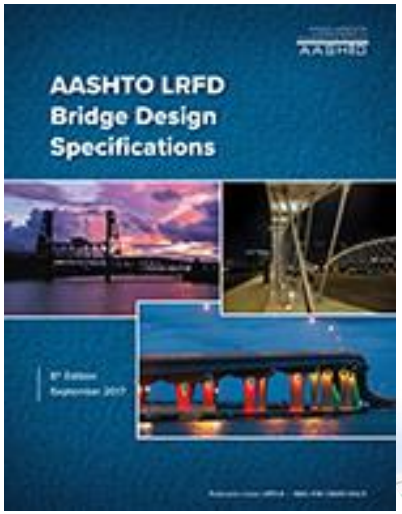
* ACI 440.5-08 Table 3.1

4. Harmonize: ASTM & BDS Docs

- Material specification as per **ASTM D7957-17.** Only vinyl ester/epoxy glass FRP round bars allowed
- Design of GFRP-RC bridge elements follows structure of **AASHTO BDS-17 (8th).** Same language used and integration
  - Chapter 2 "GFRP-RC Structures" in 2nd Ed. mimics AASHTO BDS-17 (8th) **Chapter 5 "Concrete Structures"**


Designation: D7957/D7957M – 17

Standard Specification for
Solid Round Glass Fiber Reinforced Polymer Bars for
Concrete Reinforcement[1]



Harmonize: ACI & CSA docs

- ***Inputs from existing guidelines/codes:***
  - **ACI 440.1R-15** *"Guide for the Design and Construction of Structural Concrete Reinforced with Fiber Reinforced Polymer Bars"*
  - **CSA S6-14 Section 16***"Canadian Highway Bridge Design Code: Fibre-Reinforced Structures"*
- ***Coordination with next-edition codes*** (where possible):
  - **ACI 440-19** *"Building Code Requirements for Structural Concrete Reinforced with Glass Fiber Reinforced Polymer Bars"* (under dev.)
  - **CSA S6-19 Section 16***"Canadian Highway Bridge Design Code: Fibre Reinforced Structures"* (for pub.)

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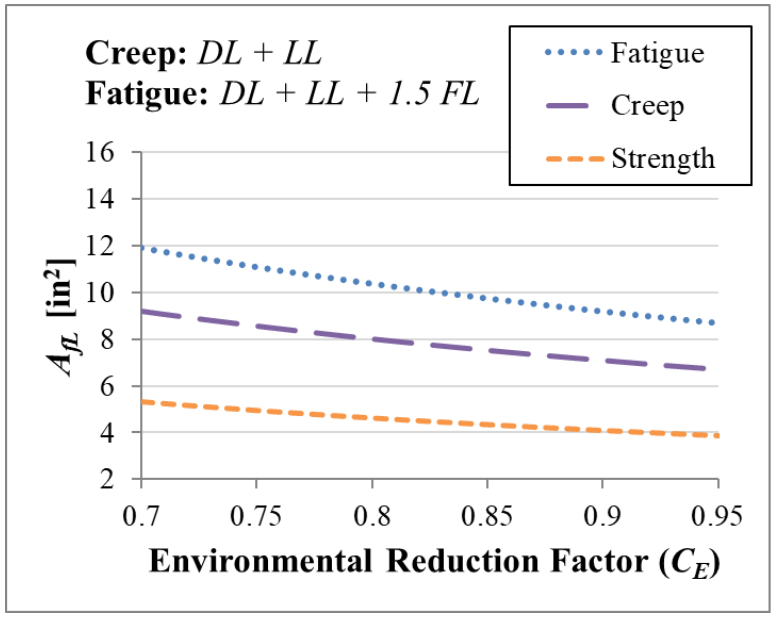
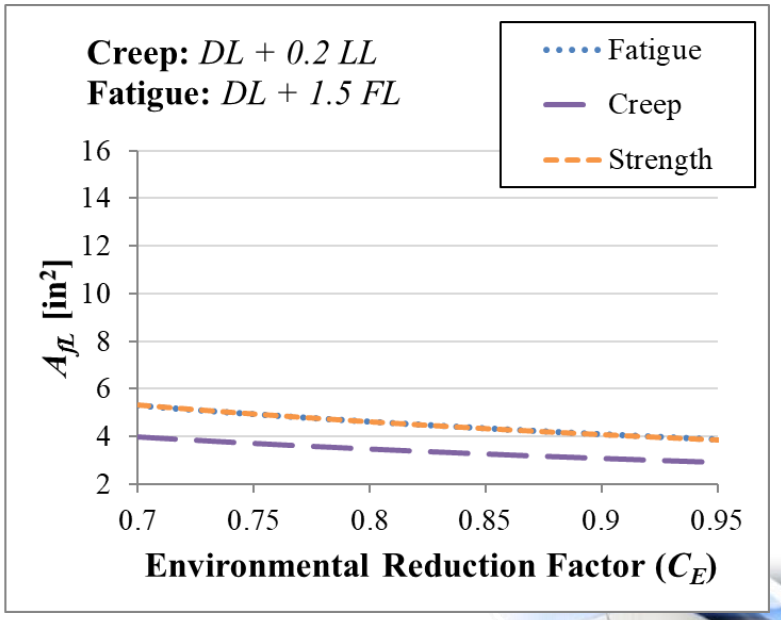
Update: Creep Rupture & Fatigue (Demand)

- Rationally defined creep rupture and fatigue load demands
- Only a portion of the **Service I live** component considered ***sustained load for creep rupture*** calculations
- **Service I dead** load added to ***fatigue load for cyclic fatigue*** *calculations*. Accounts for static/cyclic fatigue coupling

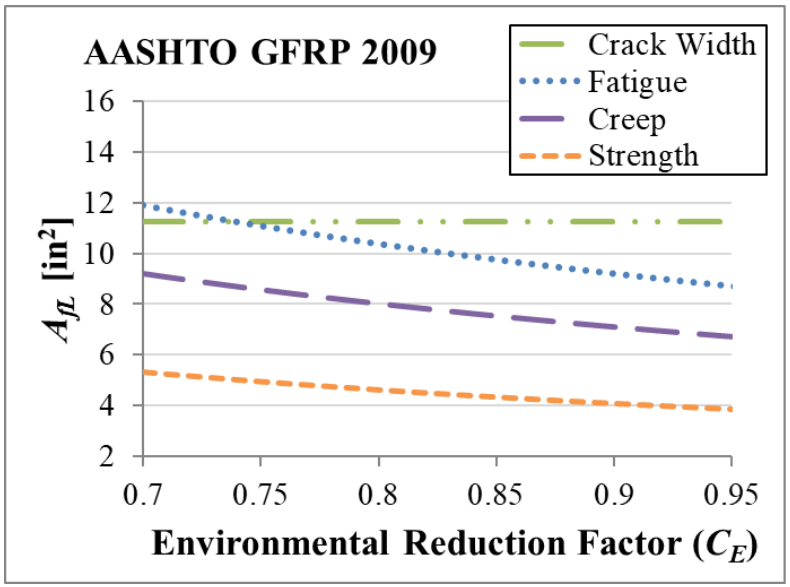


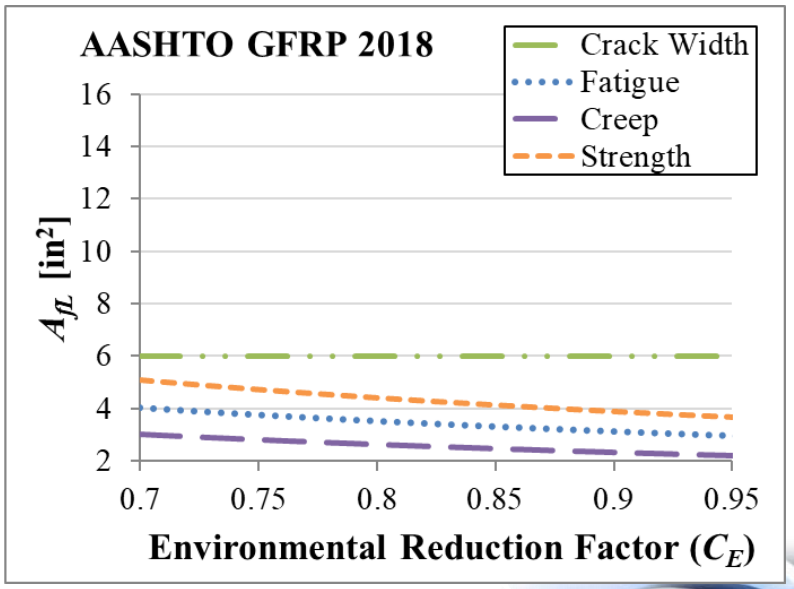


Adapted from Rossini et al. (2017)

Update: Flexural Parameters (Resistance)

- Updates reflect performances of ASTM-certified materials
- Φ_c factor aligned to AASHTO value (0.65 to **0.75**)
- **Creep and fatigue C_c** and **C_f** factors separated and aligned with CSA (0.20 to **0.25**)
- **Crack width** limit relaxed (0.020 to **0.028 in.**) and aligned with ACI

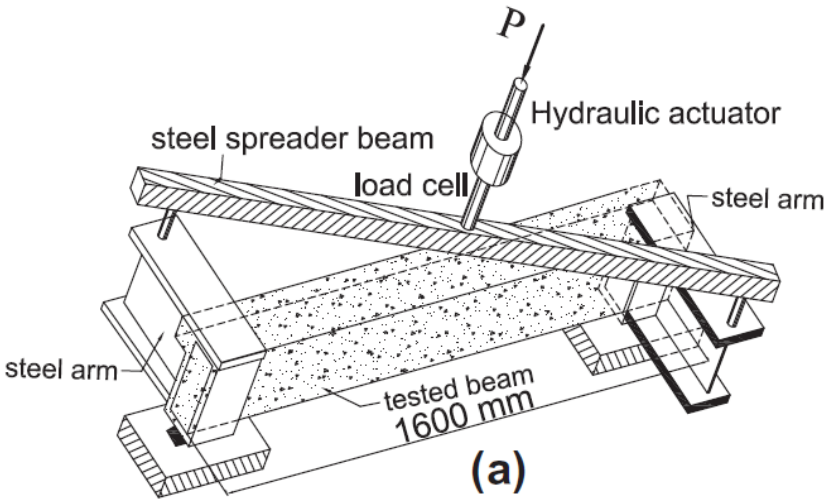




Adapted from Rossini et al. (2017)

Update: Compression, Shear and Torsion

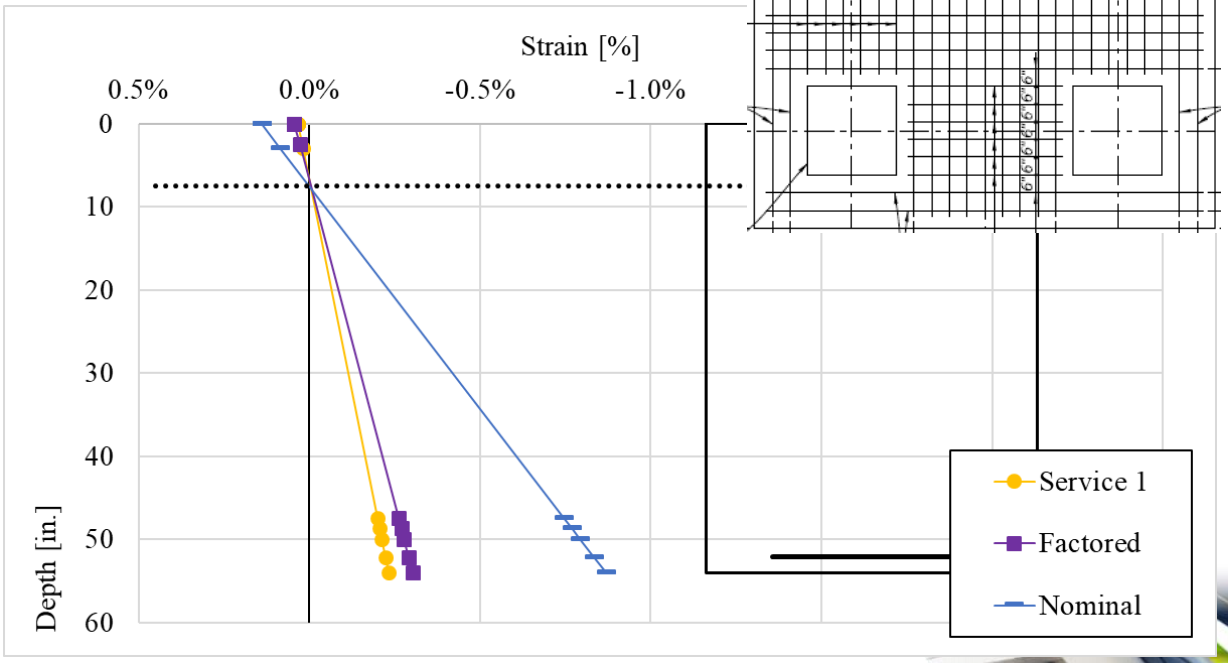
- Include **compression** and **torsion** for GFRP-RC
- Design procedures **aligned to BDS-17 (8th) new chapter 5.** Variations limited to material properties and related parameters
- Include all superstructure and substructure elements
- Harmonized with ACI 440-**19** Building Code under development



from Deifalla et al. (2013), Tobbi et al. (2012), Naqvi et al. (2017)

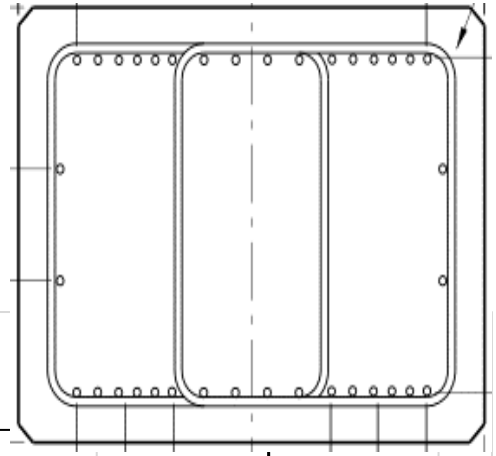
Expand: GFRP-RC Footings

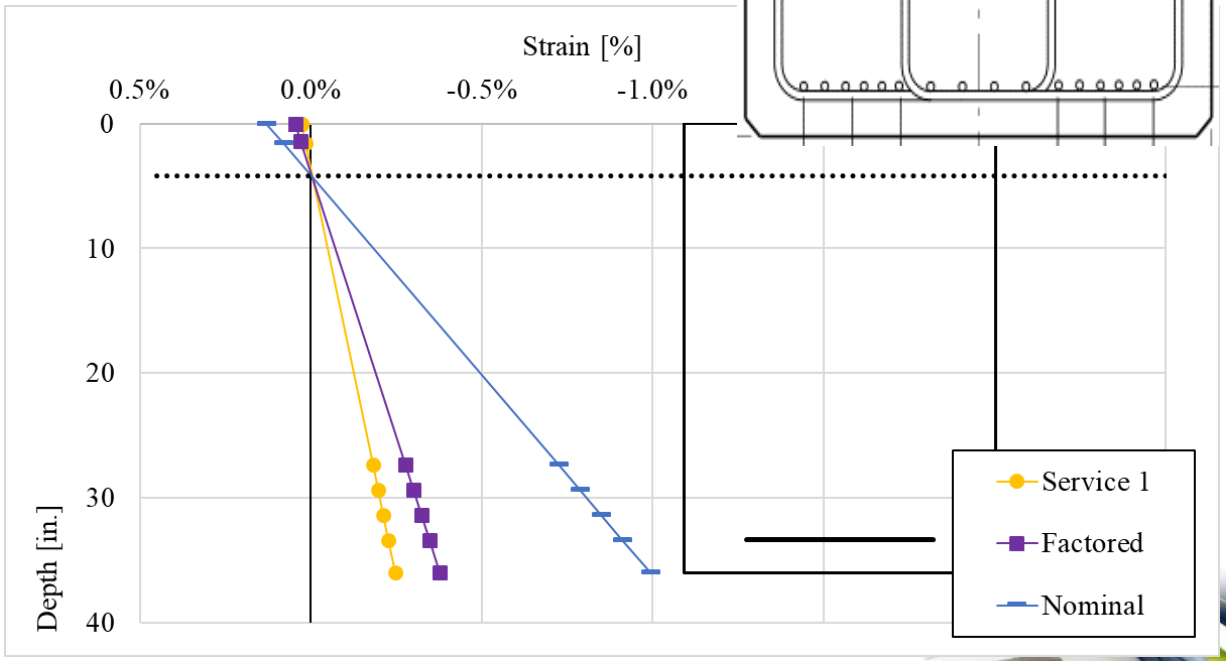
- Reference Project: ***SR 388 over Burnt Mill Creek Bridge***
- Steel-RC 13 #10
- GFRP-RC-09 26 #10 **(+ 100%)** not covered in 1st Ed.
- **GFRP-RC-18 19 #10 (+ 45%)**



Expand: GFRP-RC Bent Caps

- Reference Project: ***Halls River Bridge Replacement***
- Steel-RC 6 #8
- GFRP-RC-09 16 #8 **(+ 166%)** not covered in 1st Ed.
- **GFRP-RC-18 9 #8 (+ 50%)**

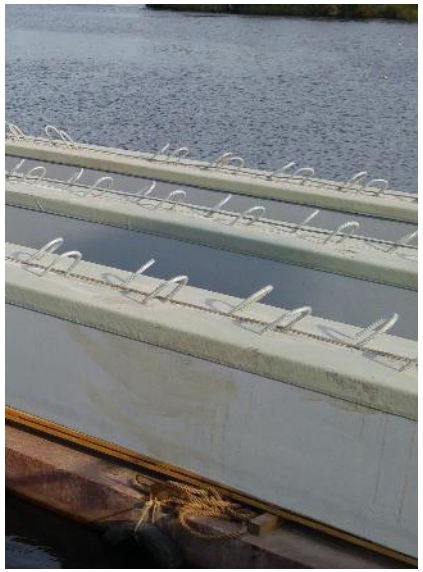


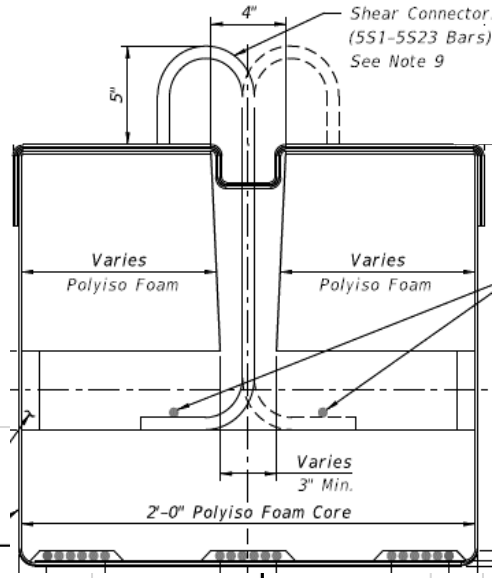


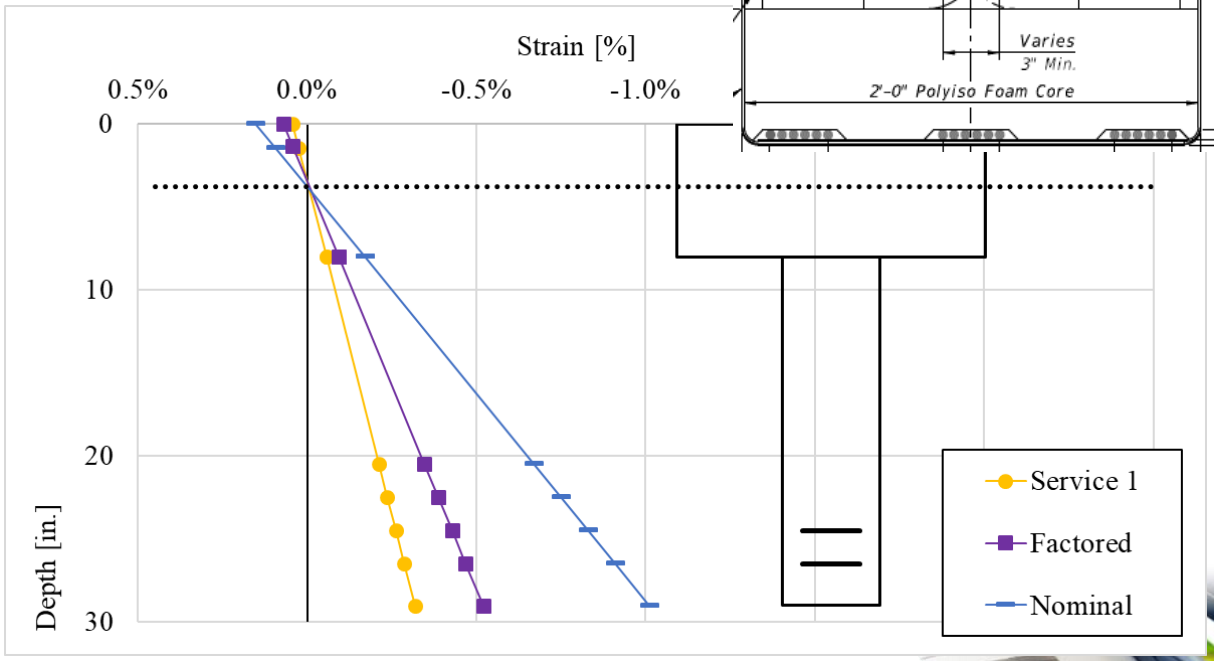
FDOT FRP Deployment Train

Expand: GFRP-RC Girders

- Reference Project: ***Halls River Bridge Replacement***
- Steel-RC 12 #8
- GFRP-RC-09 32 #8 **(+ 166%)** not covered in 1st Ed.
- **GFRP-RC-18 18 #8 (+ 50%)**



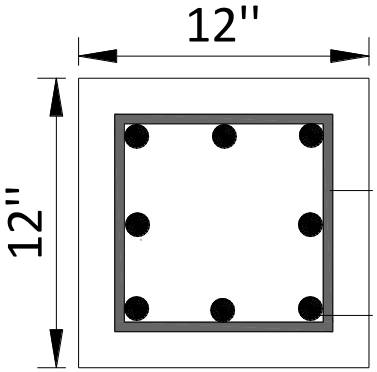


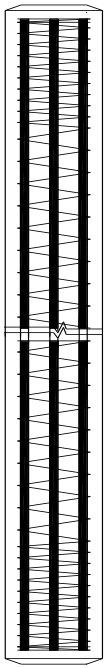


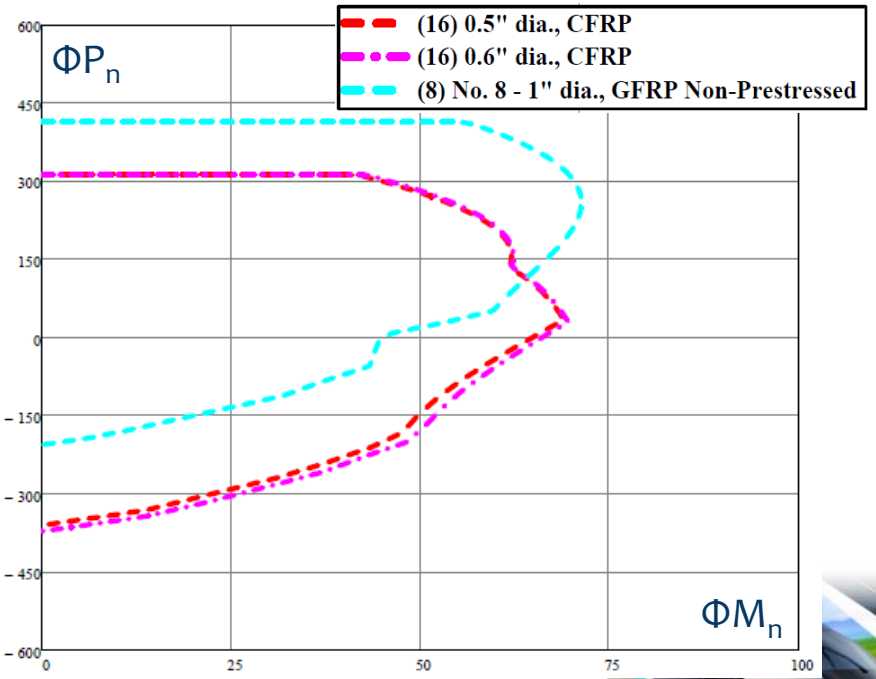
FDOT FRP Deployment Train

Expand: GFRP-RC Piles

- Reference Project: ***iDock with Seacrete™***
- Steel-RC 8 #6
- GFRP-RC-09 NA **not covered in 1st Ed.**
- **GFRP-RC-18 8 #8** **(+ 77%)**



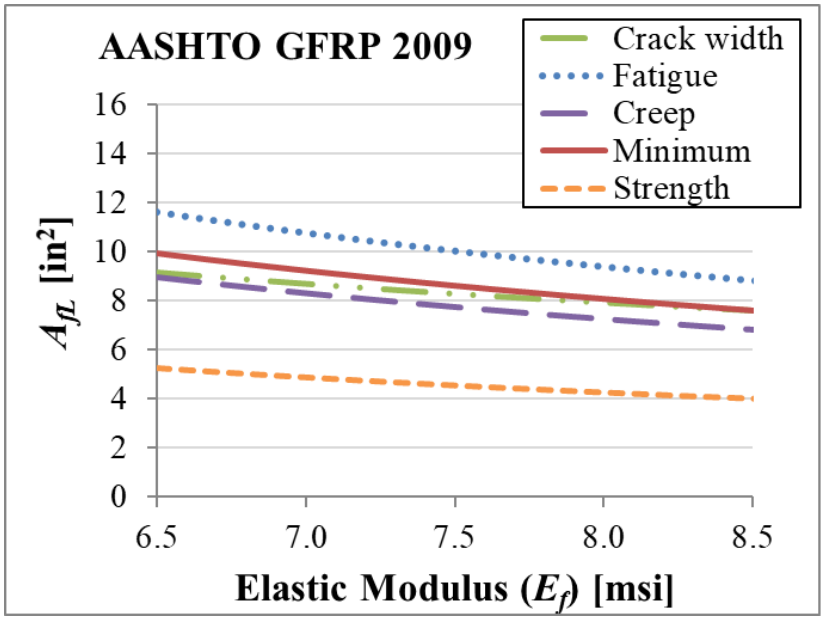


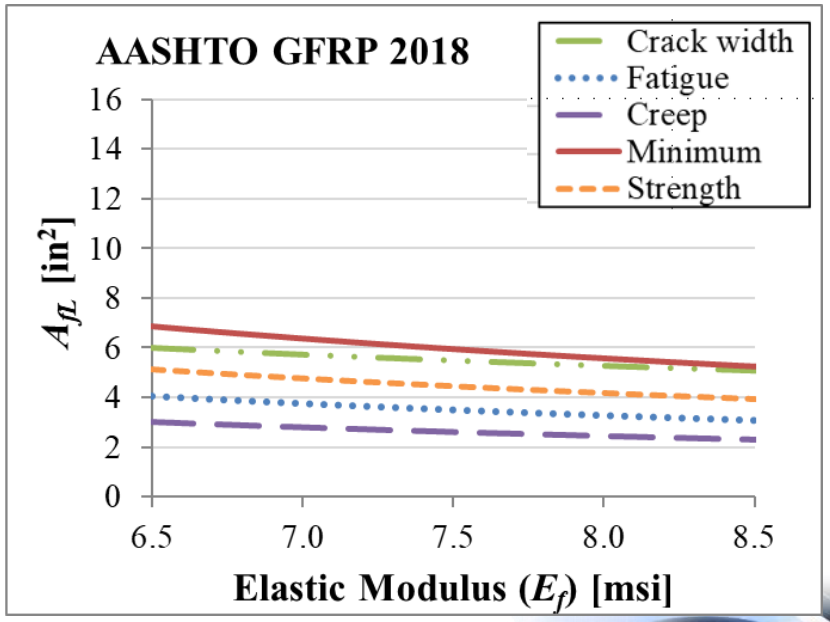


Courtesy of Dr. Brahim Benmokrane and FDOT

Challenge to Industry: Elastic Modulus

- Elastic modulus is a **game-changer**
- Increment cannot come from sectional area enlargement
- Compliance with **ASTM D7957-17** and possible revision
- Improve **quality of constituents and manufacturing** process

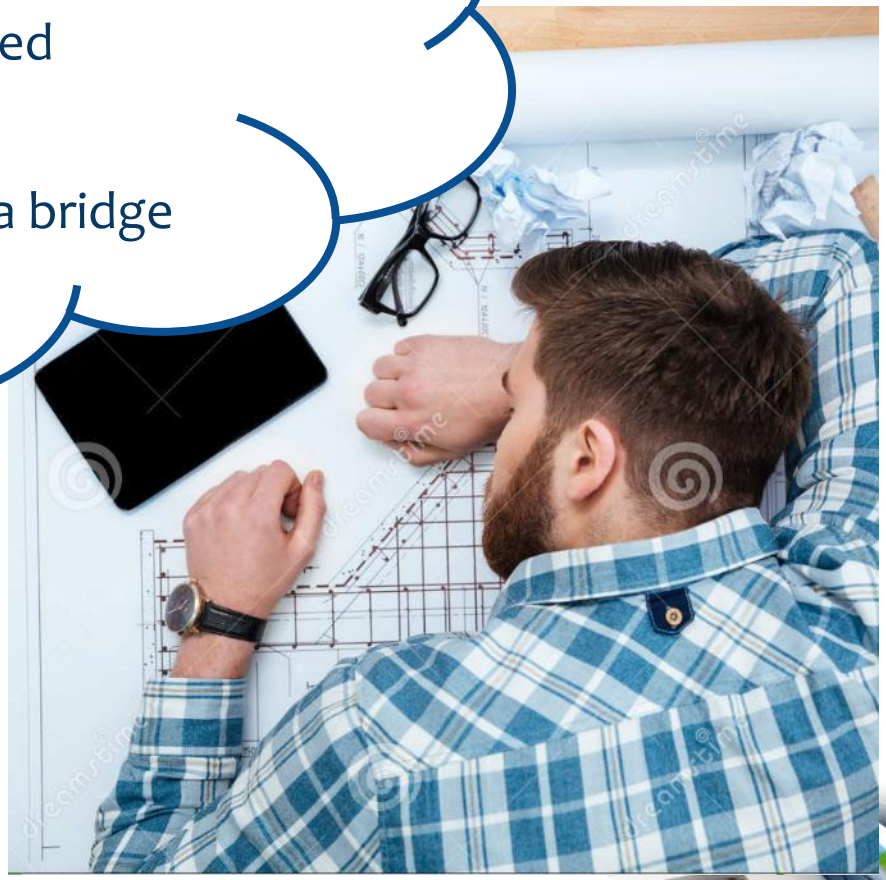




Adapted from Rossini et al. (2017)

Conclusions

- New generation of FRP spec
- Less reinforcement required
- Fully integrated with BDS
- Covers all RC elements in a bridge



Dreaming is nice, but…

We need adoption to make it real!!!

2018 FDOT-FRP Industry 2nd Winter Workshop

February 9, 2018

Orlando, FL

AASHTO Committee on Bridges and Structures – T-6 (FRP Composites) update

William Potter william.potter@dot.state.fl.us

AASHTO CBS-T-6 update

- Active/Working Agenda Items
  - AASHTO Specifications for GFRP-RC Bridges, 2nd Ed.
    - Planned 2018 Ballot Item
  - AASHTO Specifications for CFRP Prestressing, 1st Ed.
    - NCHRP 12-97 final report should be released soon
    - Tentative 2018?

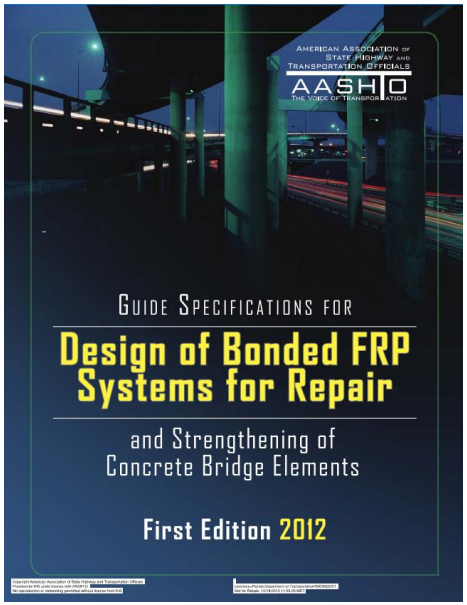
AASHTO CBS-T-6 update

- Ballot Items Timeline – 2018

		Duration	Deadline
Draft Ballot Items Submitted by Technical Committees (To Portal)	TC Chairs		February 16
M&M Post Revised Draft Ballot Items for Comment	M&M	4 weeks	March 16
Comments from Members and Revisions from M&M Returned to Technical Committee chairs	Members M&M	4 weeks	April 13
Technical committee Post Final Ballots	TC Chairs	5 weeks	May 18
Ballot Book Posted	M&M	3 weeks	June 8
Annual Meeting		2 weeks	June 25

AASHTO CBS-T-6 update

- Future Work
  - Update the AASHTO Specification for FRP Repair and Strengthening
    - Design concerns/discrepancies
    - Addressing prestressed concrete
    - Address NSM Repair
    - Enhance design examples



AASHTO CBS-T-6 update

- Future Work/Research (cont'd)…
  - FRP mild reinforcement for prestressed applications
    - Shear and end-region reinforcement to compliment to the CFRP prestressing guide specification
- T-6 Strategic Plan
  - Assist both T-6, industry, and academia in providing the direction for FRP composites implementation and development

AASHTO CBS-T-6 update

2018 Committee on Bridges and Structures

Annual Meeting

June 25-28

Burlington, VT

T-6 Meeting (tentative)

June 26 (8:00-12:00)