A NEW CAMX
FOR A NEW TIME

COMBINED STRENGTH. UNSURPASSED INNOVATION

CAMX
THE COMPOSITES AND ADVANCED MATERIALS EXPO

SEPTEMBER 21-24

A VIRTUAL EXPERIENCE

2020

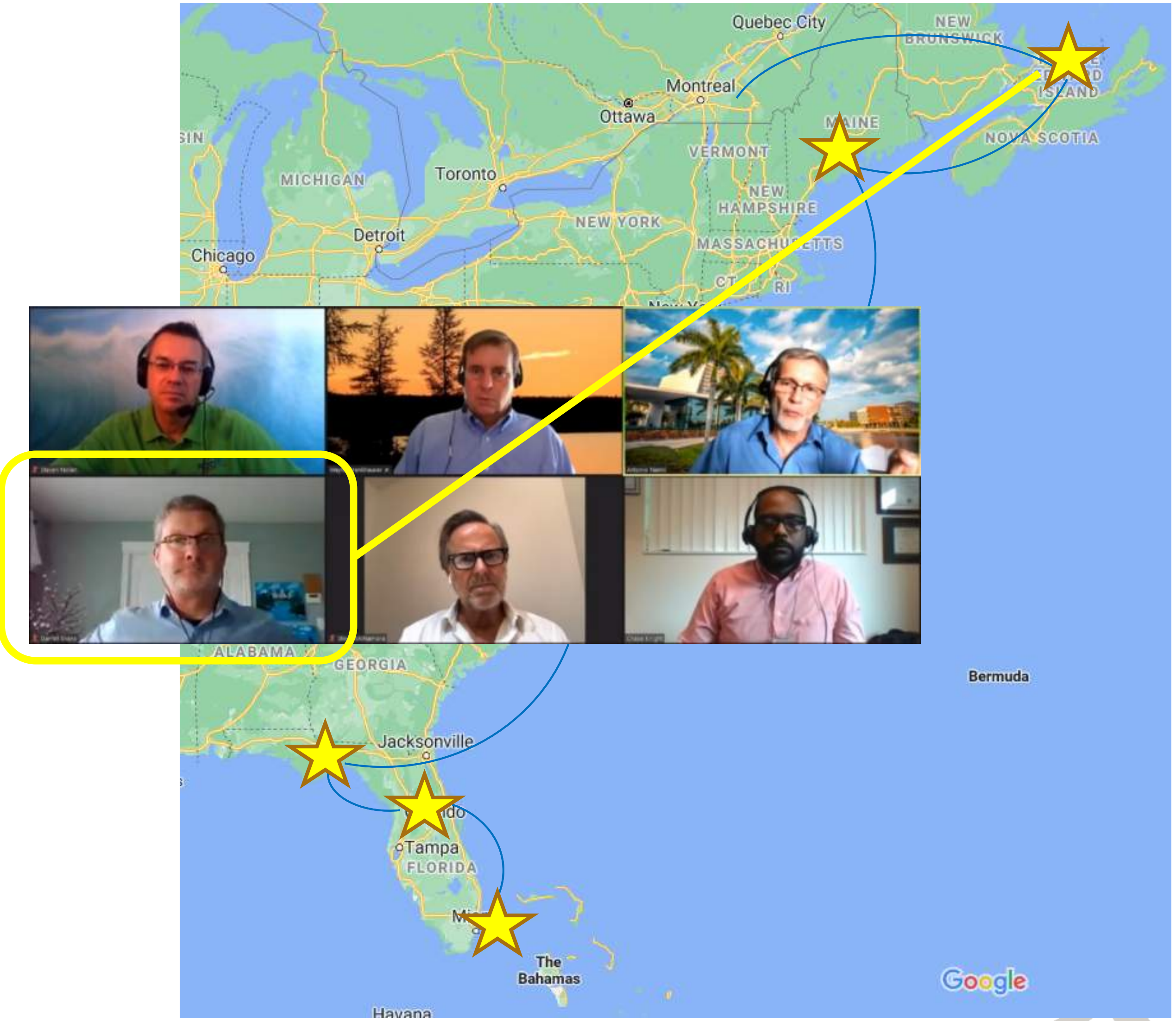
CAMX2020 Featured Panel – Infrastructure "Building Bridges Along the Atlantic"

Wednesday, September 23, 2020

Description: Recent bridge design and construction projects will be highlight showing the willingness of transportation agencies along the east coast of North America to embrace the use of FRP for more than just rehabilitation and strengthening. With a focus on improved Life Cycle Cost and reduced maintenance liability this panel will discuss the needs of the infrastructure community to integrate Composites reliably and economically into their business practices particularly for concrete structures.

OUTLINE

- Moderator: Antonio Nanni, PhD. PE. *(University of Miami)*
- Speaker 1: **Darrell Evans, PE. *(PEI Dept. of Transportation, Infrastructure & Energy)***
- Speaker 2: Wayne Frankhauser Jr., PE *(Maine Dept. of Transportation)*
- Speaker 3: Steven Nolan, PE. *(Florida Dept. of Transportation)*
- Speaker 4: Chase Knight, PhD. PE. *(Florida Dept. of Transportation)*
- Speaker 5: Steve McNamara, *(ANZAC CONTRACTORS, INC.)*



Building Bridges Along the Atlantic

Using ACM's for Internal Reinforcement in Prince Edward Island, Canada

Darrell Evans, P.Eng.
A/Asst. Director, Capital Projects
PEI Dept. of Transportation, Infrastructure & Energy

THE COMPOSITES AND ADVANCED MATERIALS EXPO
September 21-24, 2020 / www.theCAMX.org

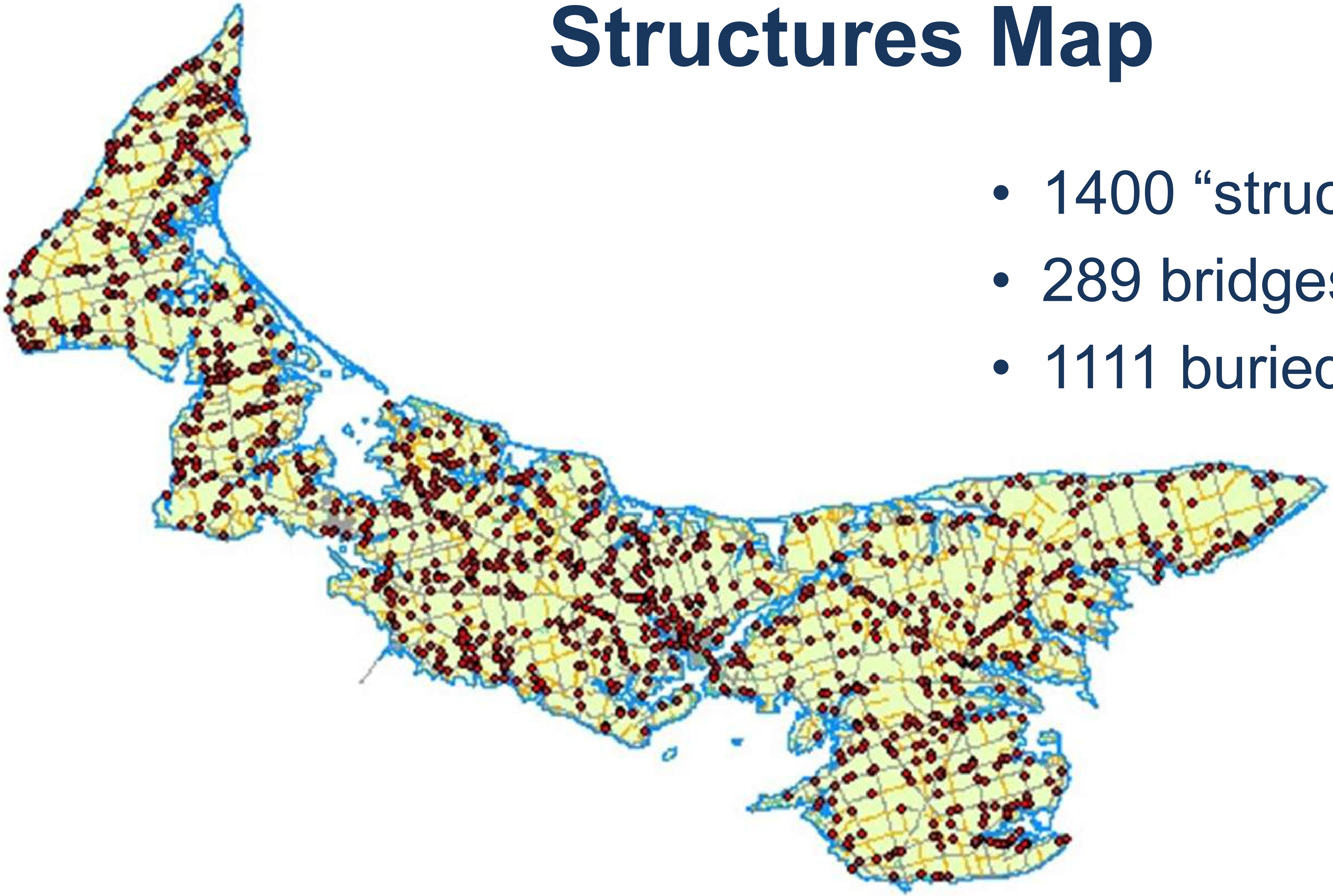
Darrell J. Evans, P.Eng.

- Graduate of the Technical University of Nova Scotia (TUNS) Class of ’95.
- Private Sector for 5 years (consulting).
- Public sector for 20 years.
- Transportation structures main focus.
- Instrumental in application of ACM’s for transportation infrastructure in PEI.
- Responsible for asset management within PEI.

Prince Edward Island, Canada

- Here we are on the east coast of Canada.
- Smallest Province.
- 5660 km^2 (2190 mi^2) of land area
- 5600 km (3480 mi) natural waterways
- 5600 km of roadway network.

Structures Map



- 1400 “structures”
- 289 bridges
- 1111 buried type.

Island Definition

- Surrounded by salt water (about 34 ppt)
- Florida hovers around 36 ppt

Creates some Issues

Seasonal variations

- Four Seasons
  - Almost Winter
  - Winter
  - Still Winter, and
  - Construction
- Or, in layman's speak:
  - Fall
  - Winter
  - Spring
  - Summer

Fantastic Summer (Construction) Season

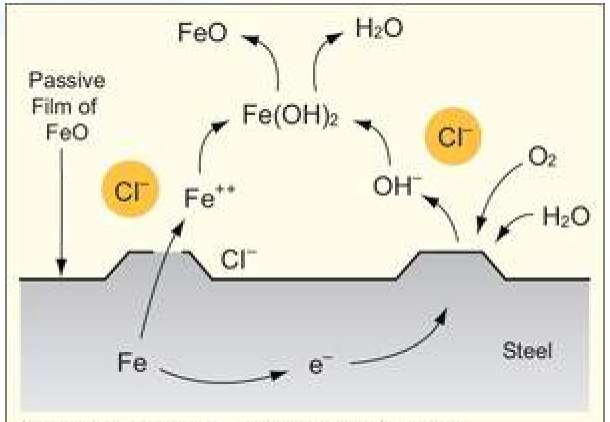
- Up to 30° C (86° F)
- Humidex up to 40° C (104 ° F)

Fantastic Winter Season too!

- This is 2015
- Total accumulation of 4.5 metres (≈ 15 ft.)
- Down to - 20° C (- 4° F)
- Wind chill down to - 40° C (° F)

Winter Maintenance

- Salt.
- Salt brine, salt pellets, salt/sand blend.
- Salt, salt, salt (NaCl).



Carbon steel with passive film failure allowing for corrosion.

Leads to more issues.

Use of GFRP in TIE's Infrastructure

- Began in 2002 using GFRP wraps on timber piles to extend the service life of our timber bridge infrastructure.
- To date, over 20 bridge rehabilitations conducted in this fashion.
- We will continue to use this method of repairs as half of our bridge inventory is timber.
- Also used in rehab of AASHTO PCC girder (shear strengthening).


2004 9 14


2004 10 12

Use of GFRP as Primary Reinforcement

- We were invited to sit on a national committee on ACM’s in 2004.
- During this exposure, we developed an interest in GFRP reinforcement.
- Test results seemed very positive based on samples taken from various locations across Canada, with differing applications.
- Initial costs appeared somewhat high; but, should be reviewed against life cycle costing.
- Philosophy was to try it, see how the design and construction community reacts to new methods and monitor over the long term.


GTL

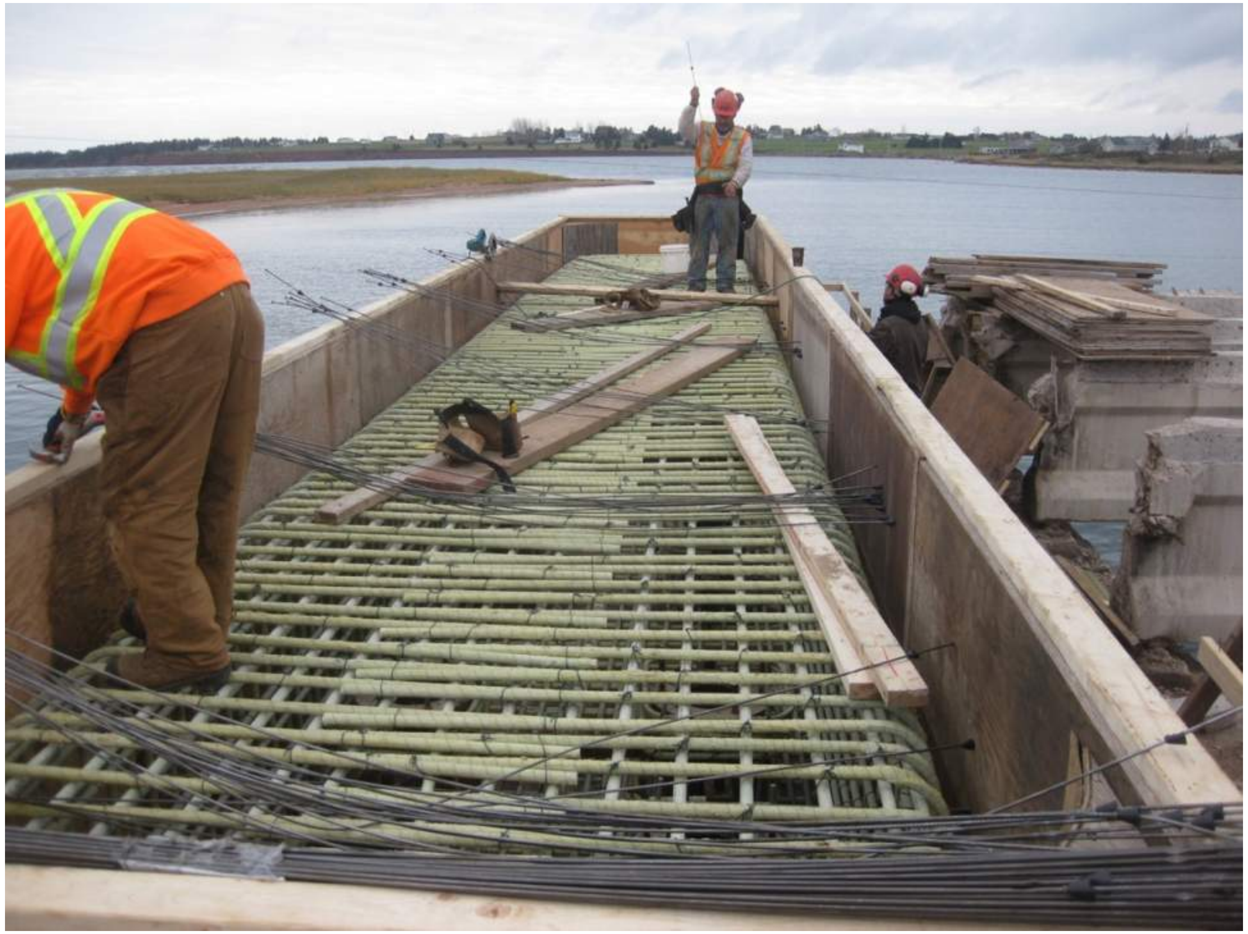

11/19/2009

Structures with GFRP as Primary Reinforcement

Bridge	No. of Spans	Super structure	Horiz. Align.	Total Length (m)	Ft.
Monatgue Bridge	2	Steel Plate Girder	Curved	60	197
Clarks Mill	1	Steel Plate Girder	Curved	43	141
Montrose Bridge	1	Steel Box Girder	Curved	52	171
Victoria Bridge	1	Steel Plate Girder	Straight	33	108
Kildare Bridge	3	PCC NEBT Girder	Straight	57	187
West River	1	Steel Plate Girder	Straight	48	157
Oak Drive O/P	4	AASHTO Type III	Straight	59	194
Darnley Bridge	4	PCC NEBT Girder	Straight	137	449
Ross' Corner	1	Steel Box Girder	Curved	47	154
St. Peter's	1	PCC NEBT Girder	Straight	28	92
Cardigan	1	Pre-Cast Box Girder	Straight	24	79
Marie	1	PCC NEBT Girder	Skewed	26	85
Huntley	1	PCC NEXT Girder	Skewed	20	66
North Lake	3	PCC NEBT Girder	Curved and Skewed	75	246
Souris	4	PCC NEBT Girder	Straight	128	420
Cornwall Rd O/P	1	PCC NEBT Girder	Skewed	33	108
Clyde River	2	Steel Box Girder	Straight	132	433
Bannockburn Rd. O/P	1	PCC NEBT Girder	Curved and Skewed	35	115
New Haven Interchange	1	PCC NEBT Girder	Skewed	35	115
Hunter River	1	PCC Voided Slab	Straight	15	49
		TOTAL DECK LENGTH		**1087**	**3566**

- Shaded areas represent deck and substructure.
- All others are just deck. T&B
- Represents about 7 % of bridge inventory.
- Plan on another 10 structures within the next 4 years.
- Green shaded is full-depth pre-cast deck post-tensioned together (albeit with steel).
- Orange is using GFRP ties for the formworks.

How much GFRP can we stuff into a bridge?



Can’t use it everywhere.

- Recognize that it doesn’t fit all scenarios.
- Pre-cast arches for example, use WWM which they can bend into any radius they require.
- Timber bridges (why bother)
- Retrofits or extensions.
- Also, where we require ductility (Diaphragms)

Issues

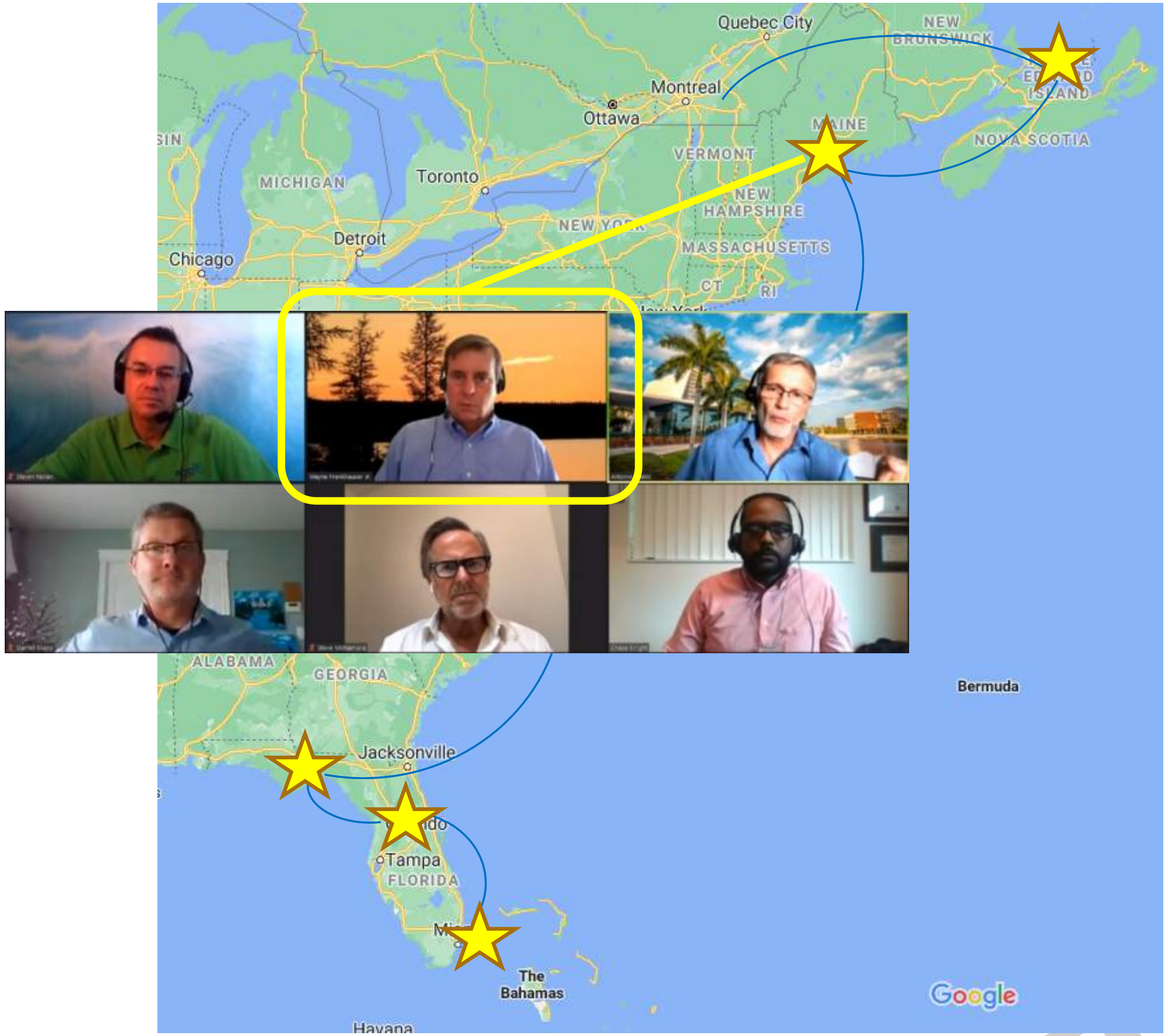
Issues

- Designer inexperience (know your material – detailing – code limitations).
- Contractor inexperience (know your limitations – placement and cutting- UV degradation).
- Supplier resources (engineering and technical support for the end user - competitiveness).
- Repairs due to external damage.
- End of life disposal (sustainability)
- These are all solvable.

Thank you!

OUTLINE

- Moderator: Antonio Nanni, PhD. PE. *(University of Miami)*
- Speaker 1: Darrell Evans, PE. *(PEI Dept. of Transportation, Infrastructure & Energy)*
- Speaker 2: **Wayne Frankhauser Jr., PE *(Maine Dept. of Transportation)***
- Speaker 3: Steven Nolan, PE. *(Florida Dept. of Transportation)*
- Speaker 4: Chase Knight, PhD. PE. *(Florida Dept. of Transportation)*
- Speaker 5: Steve McNamara, *(ANZAC CONTRACTORS, INC.)*



Building Bridges Along the Atlantic

Durable Bridges – An Owner's Perspective

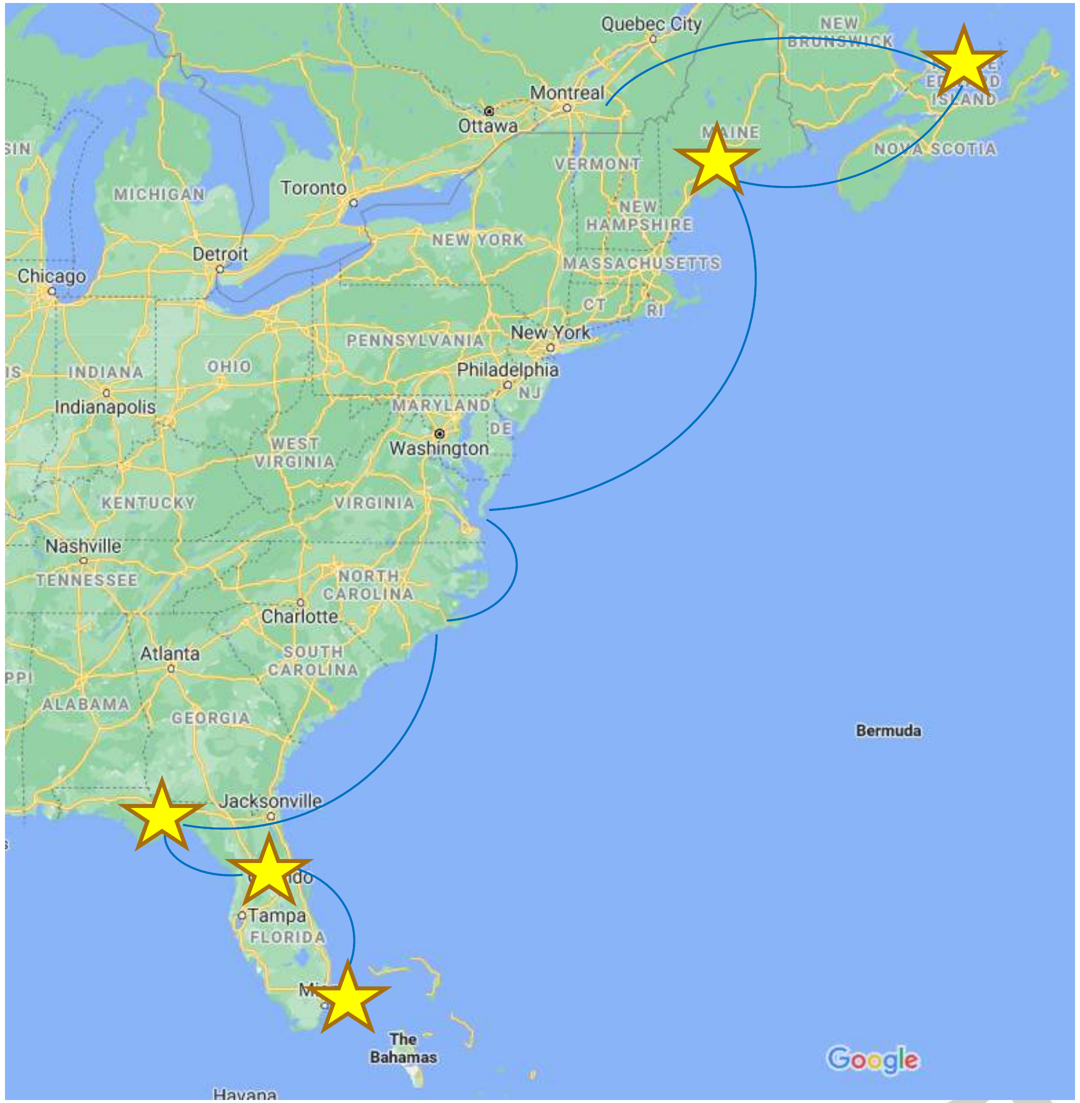
Wayne Frankhauser, PE

Bridge Program Manager

Maine Department of Transportation

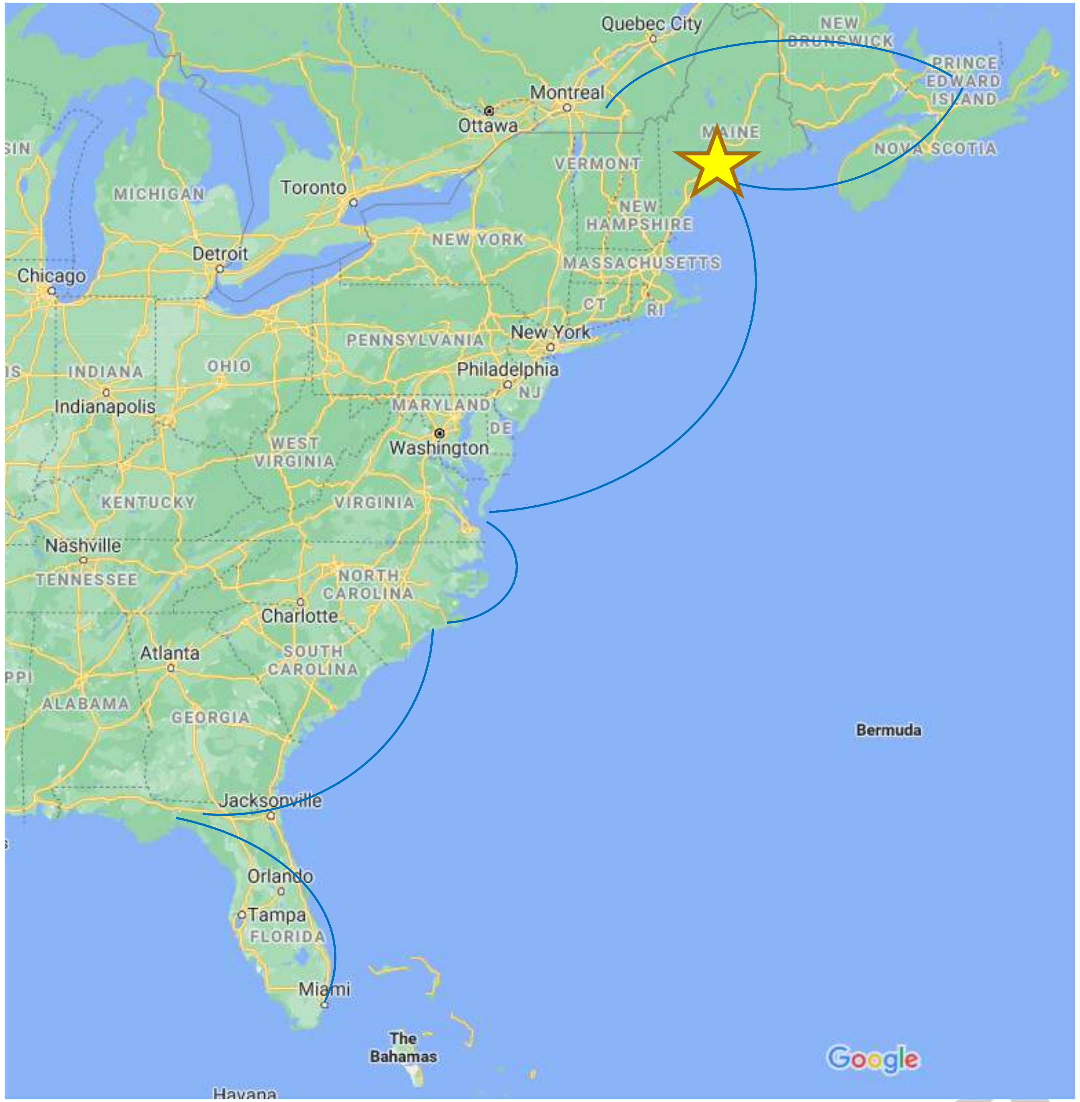
OUTLINE

1. Building better bridges
2. FRP solutions
3. Challenges to the widespread use of composites



Background

- MaineDOT owns and manages 2,750 bridges and minor spans
- 2020-21-22 Work Plan
  - 148 Bridge Projects – Estimated Cost: $545 million
  - Unmet need of $67 million per year to maintain bridges in good condition
- Can't build our way out – need to focus on preservation and building longer lasting bridges
- MaineDOT has been using composites for nearly 20 years
- Strong support from the UMaine Advanced Structures and Composites Center and the composite industry



Building Better Bridges

Harsh conditions cause reoccurring deterioration – Coastal environment, deicing chemicals, and freeze-thaw cycles.

- Piers deteriorate in splash zone and from leaky joints
- Decks deteriorate and spall
- Backwalls and bridge seats crumble
- Bridge bearings freeze up
- Bridge drains corrode
- Painted steel beams rust and are expensive to paint

Building Better Bridges

Can we do better?

- Better maintenance and preservation
- Better bridge detailing and construction practices
- Bridge type selection
- The use corrosion resistant materials

Some of these solutions will have a higher upfront costs

FRP Solutions

FRP Bridge Systems

- Composite Arch Bridge System
- HC Beams
- CT Girder System

Composite Arch System
on the Caribou Connector
(2011)
54’ 2” span x 12’ rise
Standard practice to include as an option on projects where appropriate

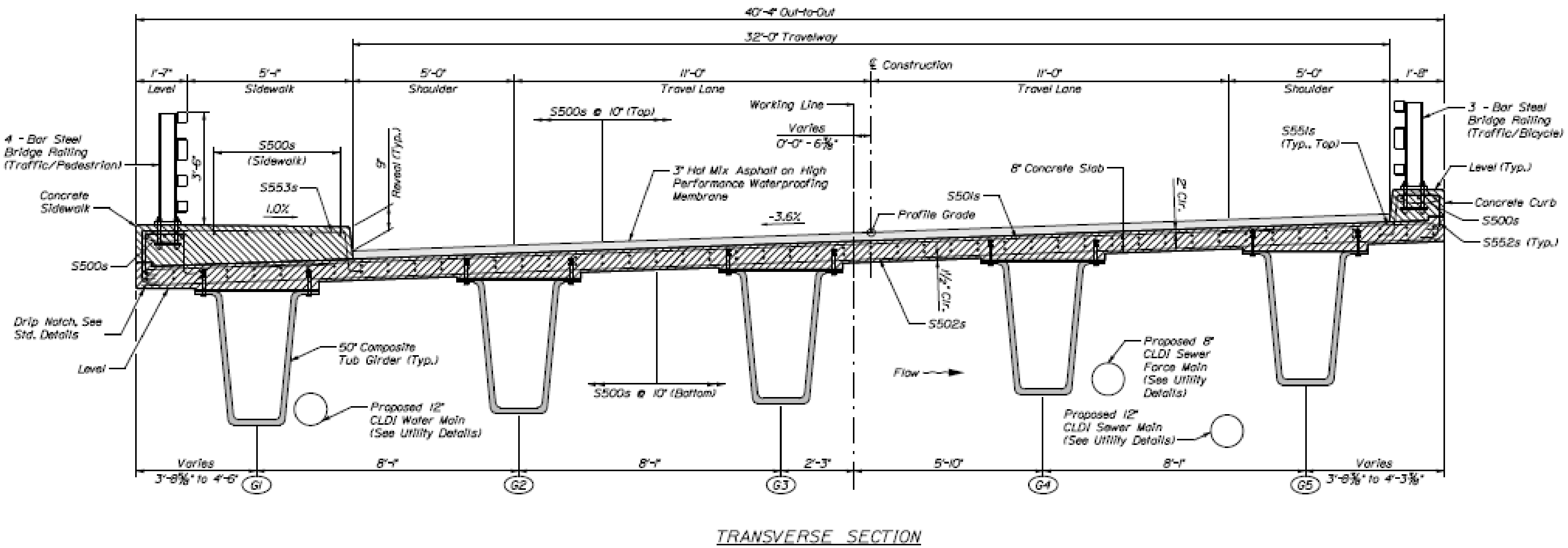
FRP Solutions

HC Beams

Boothbay, Barters Island Bridge (2012)

8 spans, 540’ long

FRP Solutions



CT Girder System
Hampden, Twin Bridge (2020)
75’ span

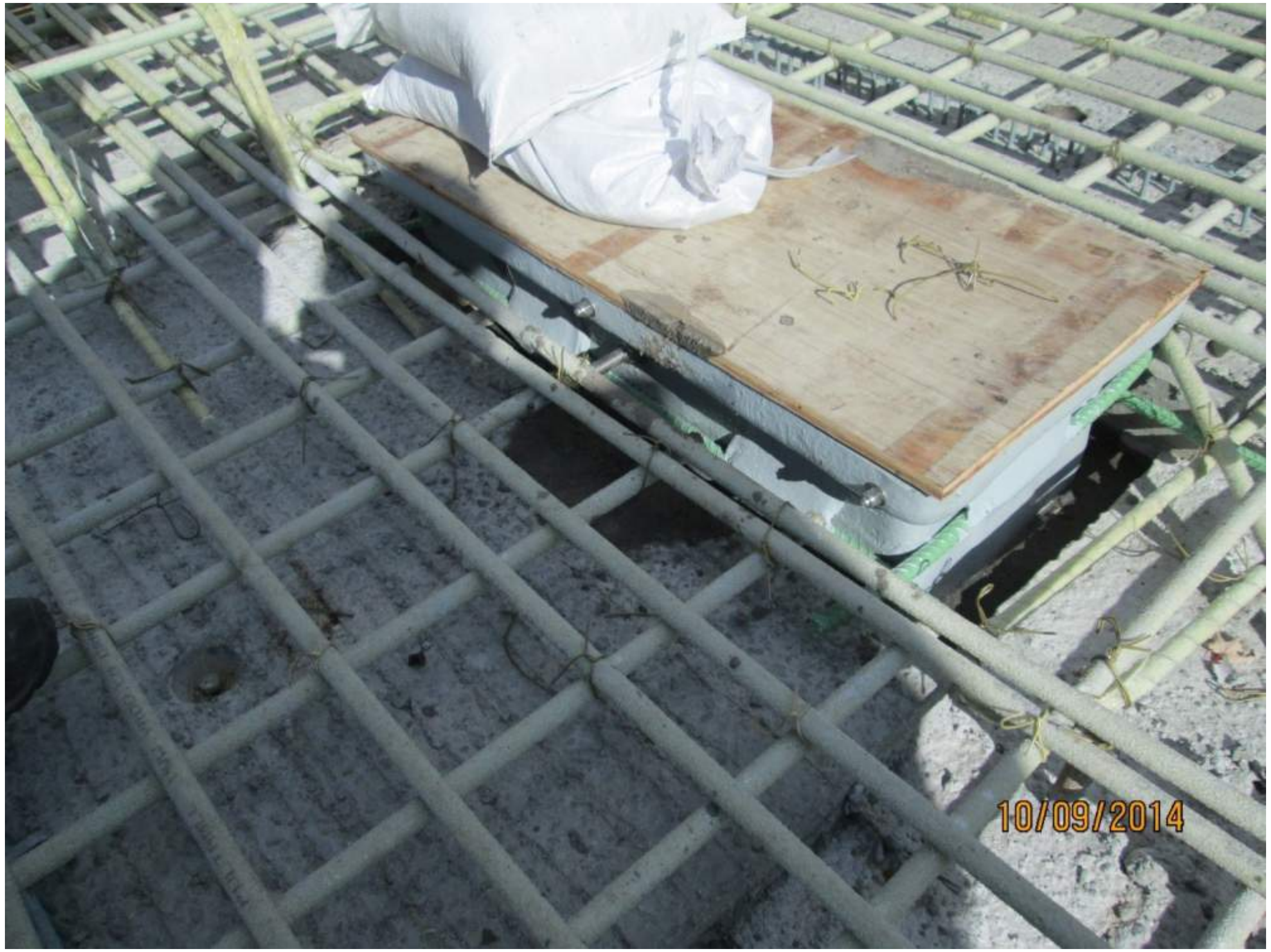
FRP Solutions

CT Girder System

FRP Solutions

GFRP Reinforcing

- MaineDOT has used nearly 500,000 LF of GFRP in the last 3 years
- Standard practice to use GFRP straight bars, and stainless bent bars, in our bridge decks
- Average cost for GFRP close to black bar



FRP Solutions

Composite Drains

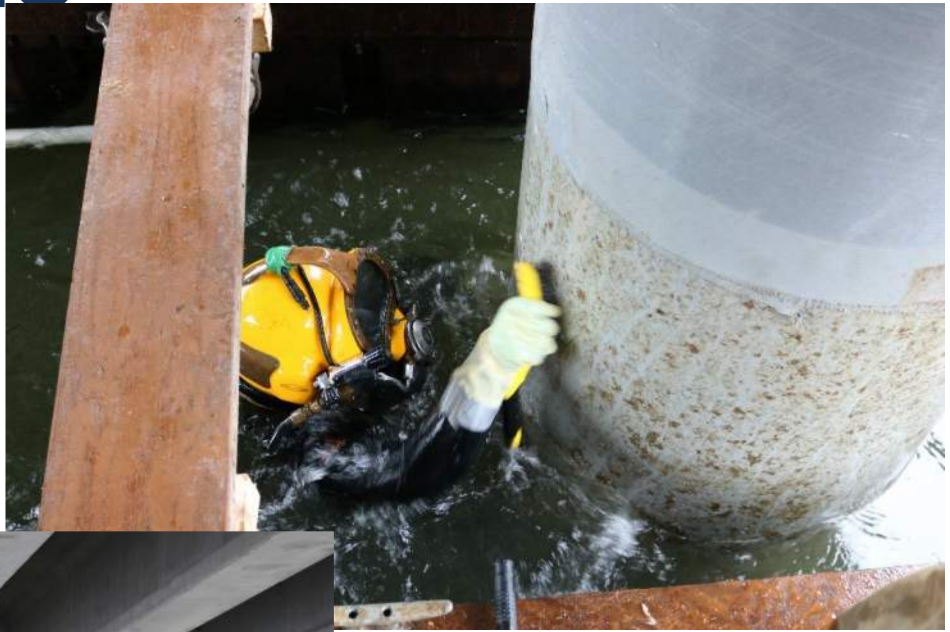
- Standard practice for new bridges

FRP Solutions

FRP Pile Wrap

York, Rices Bridge

Repair of the epoxy coated pipe pile bent piers built in 2005



Other FRP Applications

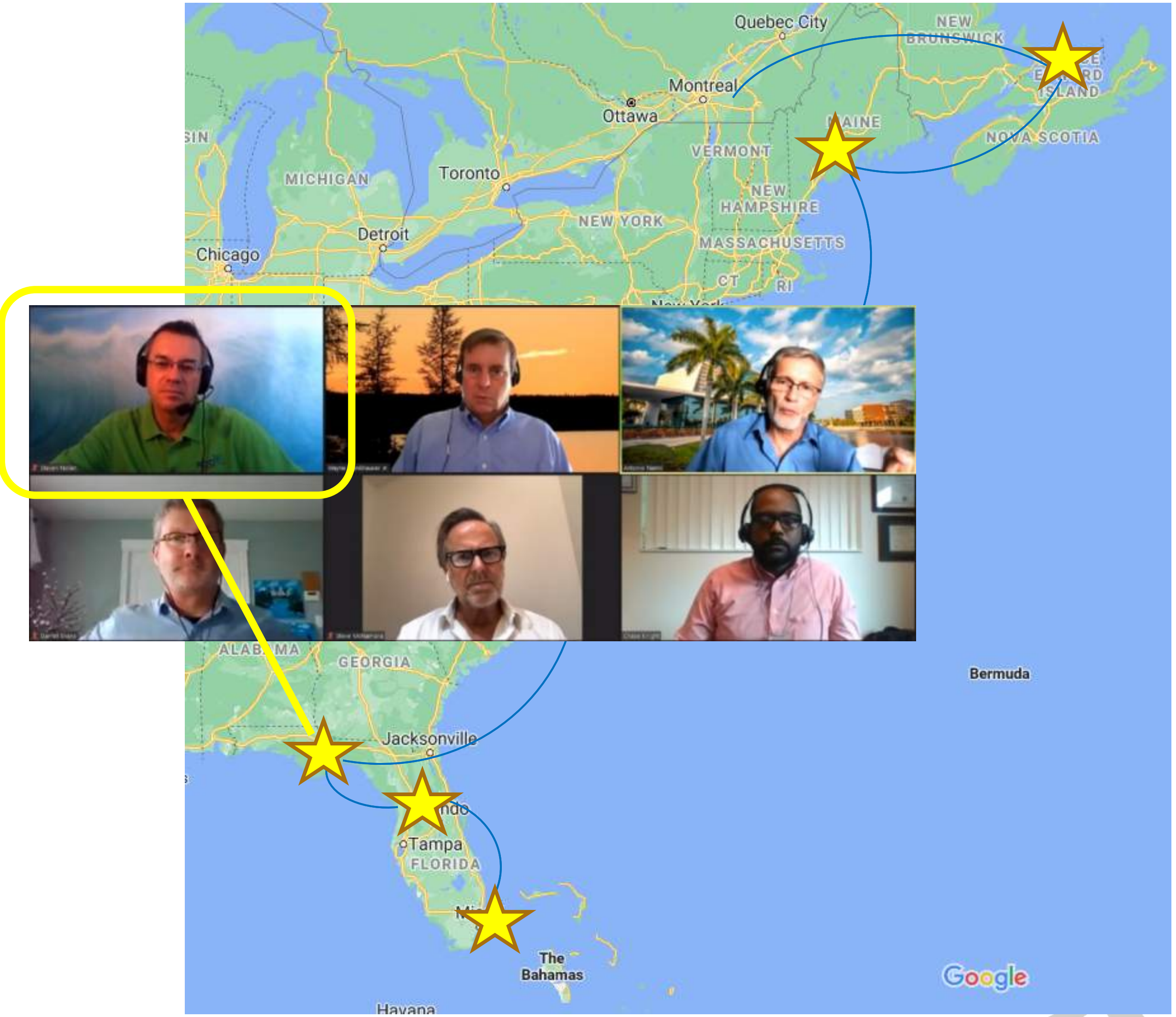
- FRP pile
- FRP culvert invert lining
- FRP fenders
- FRP fairing
- CFCC prestressing and post-tensioning
- Carbon fiber strand in cable stay

Challenges

- Education
- Specifications
- Industry support

OUTLINE

- Moderator: Antonio Nanni, PhD. PE. *(University of Miami)*
- Speaker 1: Darrell Evans, PE. *(PEI Dept. of Transportation, Infrastructure & Energy)*
- Speaker 2: Wayne Frankhauser Jr., PE *(Maine Dept. of Transportation)*
- Speaker 3: **Steven Nolan, PE. *(Florida Dept. of Transportation)***
- Speaker 4: Chase Knight, PhD. PE. *(Florida Dept. of Transportation)*
- Speaker 5: Steve McNamara, *(ANZAC CONTRACTORS, INC.)*



INFRASTRUCTURE FEATURED PANEL DISCUSSION

Wednesday, September 23, 2020

2:25 pm – 3:40 pm EDT

Building Bridges Along the Atlantic
- A Florida Structural Perspective

Steven Nolan, P.E.

Senior Structures Design Engineer

Lead: Advanced Materials for Structural Durability & Resiliency

FDOT

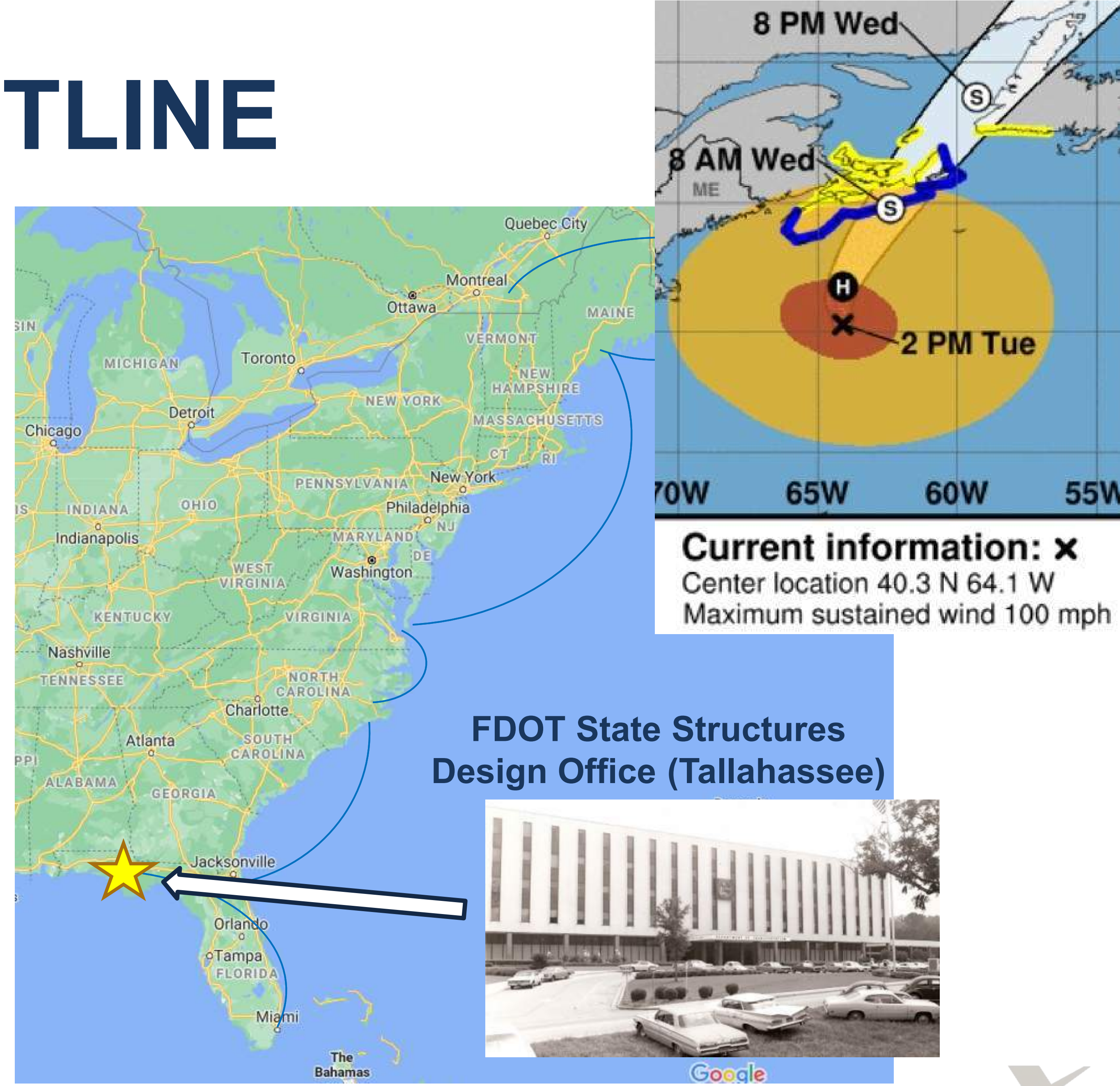
CAMX

THE COMPOSITES AND ADVANCED MATERIALS EXPO

September 21-24, 2020 / www.theCAMX.org

OUTLINE

1. **What are the Needs?**
2. **What are our Options?**
3. **What are the Benefits?**
4. **What are some Challenges that need Solving?**

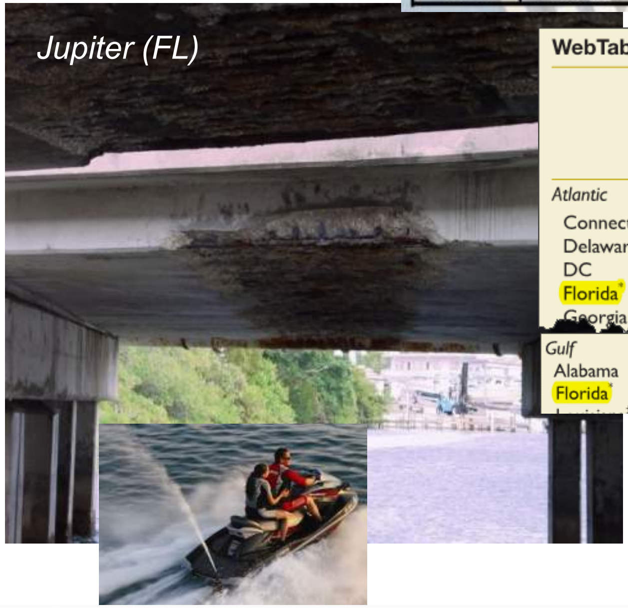


What Are the Needs ?

- Florida maintains over 166 million sq.ft. of bridge area [1]
- Florida has more than 4,000 miles seawall-bulkheads [2]

FDOT Bridge Deck Area (Square Feet)

	District								Total
	D1	D2	D3	D4	D5	D6	D7	Turnpike	
>1930's	59,278	343,697	288,979	92,308	77,762	258,464	153,377	0	1,273,865
1940's	171,558	334,093	165,977	18,231	20,248	98,057	27,114	0	835,279
1950's	879,478	1,807,266	765,387	435,327	567,212	1,496,850	1,357,430	597,192	7,906,141
1960's	1,143,661	5,412,125	1,095,280	1,089,510	3,335,514	4,024,420	1,924,386	749,843	18,774,739
1970's	2,525,123	6,050,066	4,349,136	4,223,189	1,382,828	2,116,673	3,849,713	2,055,573	26,552,302
1980's	3,705,331	2,427,726	2,593,652	6,797,929	1,099,028	4,754,463	5,849,264	1,038,778	28,266,170
1990's	1,872,971	2,708,191	5,284,785	3,201,458	2,338,915	1,518,442	3,287,262	2,926,232	23,138,256
2000's	2,934,733	5,338,688	4,884,453	3,619,007	3,303,165	1,347,235	4,196,084	1,802,460	27,425,825
2010's	766,709	3,027,594	2,873,274	0	2,828,151	1,442,905	2,935,326	619,216	14,493,176
Total	14,058,842	27,449,445	22,300,924	19,476,959	14,952,823	17,057,510	23,579,955	9,789,294	148,665,751



WebTable 3. Shoreline hardening and population statistics by state (3)

	Hard sheltered shore (km)	Sheltered shore (km)	Hard sheltered shore (%)	Hard open shore (km)	Open shore (km)	Hard open shore (km)	Hard shore (km)	Total shore (km)	Hard shore (%)
Atlantic									
Connecticut	477	1907	25	0	0		477	1907	25
Delaware	287	2163	13	5	45	11	292	2208	13
DC	29	54	53	0	0		29	54	53
Florida*	2694	11 365	24	58	628	9	2752	11 992	23
Georgia	92	6340	1	14	158	9	106	6498	2
Gulf									
Alabama							356	2606	14
Florida*							4427	26 383	17

Bridge Inventory — 2020 Annual Report

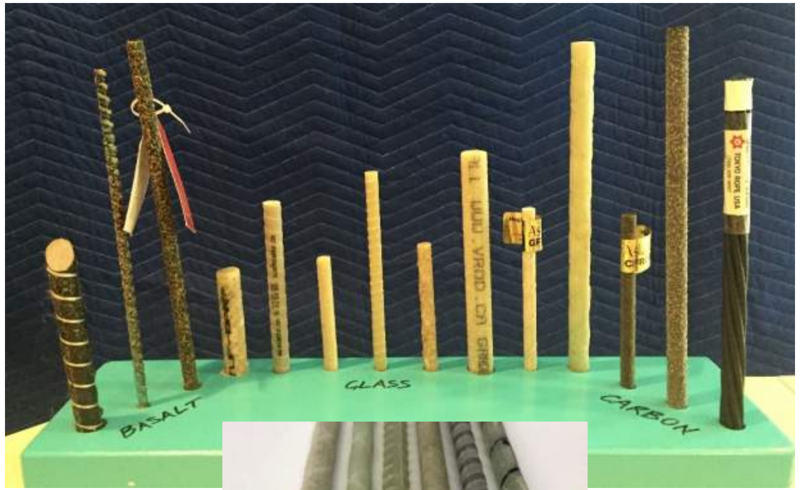
Conclusion

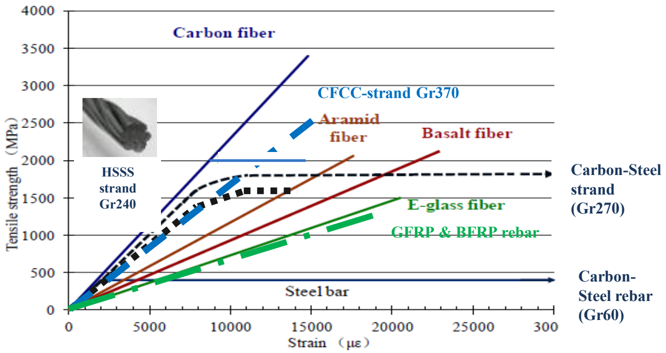
Florida's bridges are generally in good condition, with those maintained by the FDOT in better condition than those maintained by local governments or others. The most serious threat to bridges in Florida is the corrosion of steel reinforced concrete substructures in coastal regions. Much has been learned in recent years about corrosion in marine environments, affecting material specifications and design practices that helps new bridges built today. However, the older bridges in the coastal regions are beginning to require careful evaluation and extensive corrective actions. On-going re-

(1) FDOT Bridge Inventory - 2020 Annual Report
(2) Estimates from Gittman et al. (2015)
(3) Gittman et al. (2015) https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/150065

What are our Options ?

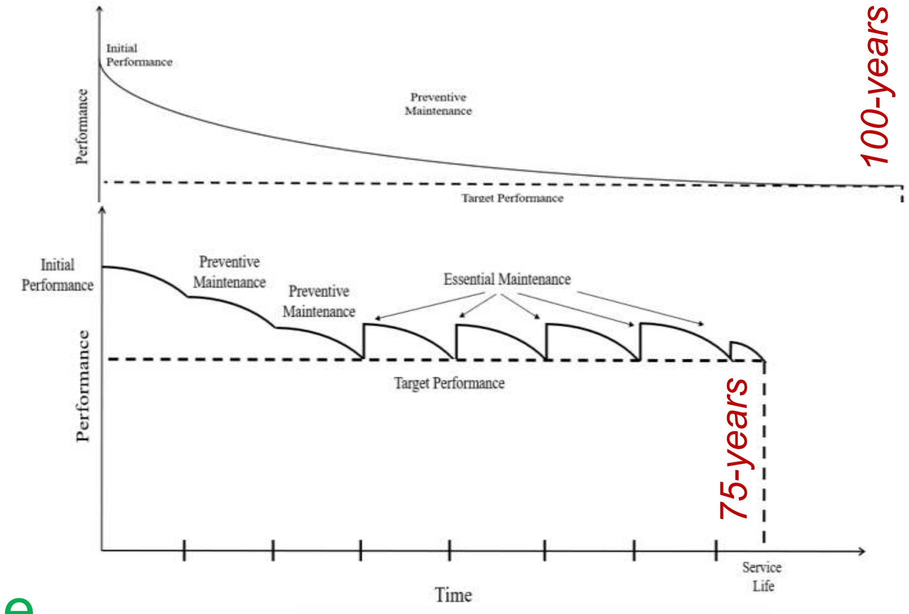
1. Glass & Basalt FRP rebar for concrete structures
2. Carbon FRP strand and spirals for prestressed members
3. Pultruded, Wound & Molded FRP Structural Components
4. FRP Laminates and Wraps for rehabilitation & strengthening

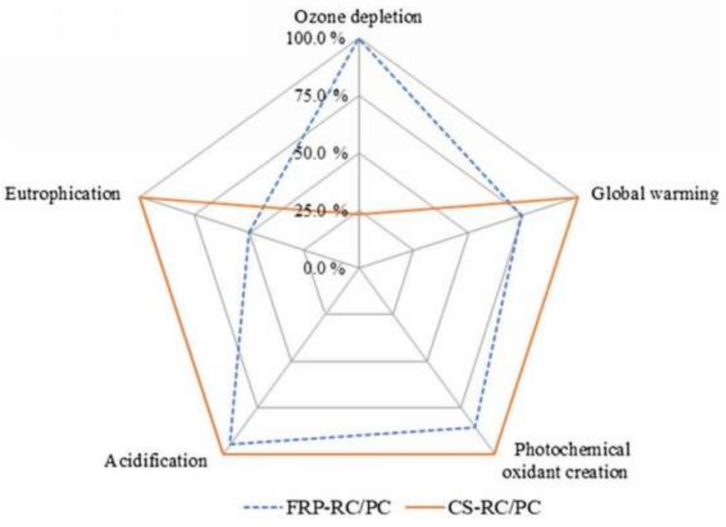




What Are the Benefits ?

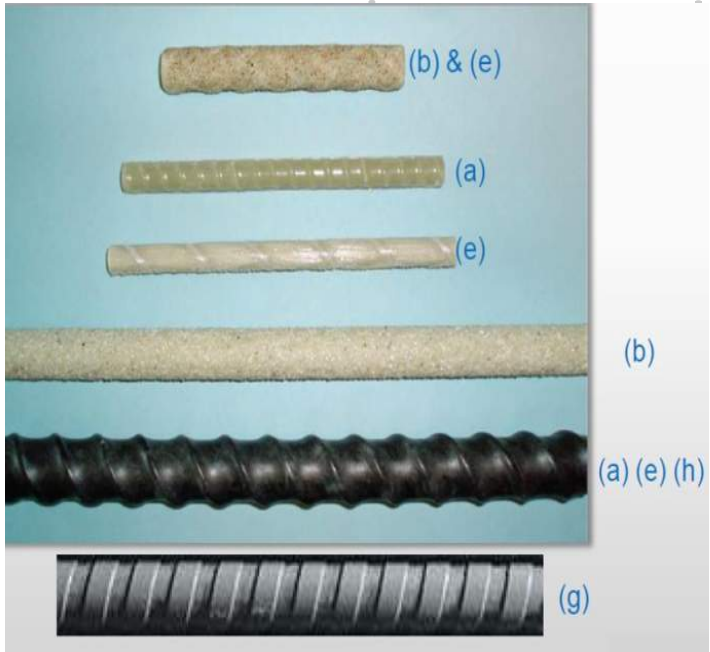
1. Reduced repair & rehabilitation
    - No corrosion
2. Longer asset life and replacement frequency
3. Potential reuse of foundations
4. Potential for widening in future.
5. Lighter weight materials
    - Worker safety
    - Strengthening of existing structures or decrease design loads
6. Sustainability benefits
    - Materials have improved LCA over conventional reinforcing
    - Reduce cement content needed or even geopolymer low alkalinity concretes





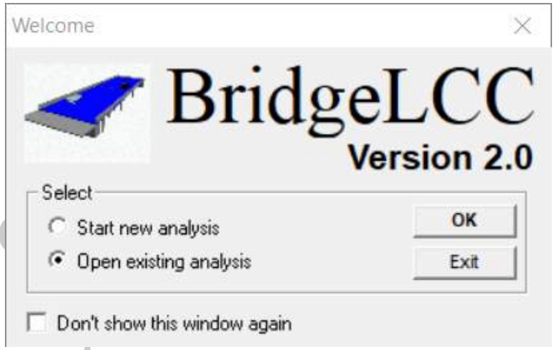
What Are the Challenges that need Solving ?

- Connections – Coupling, Anchoring, Lifting Devices
- Bent bars – Consistency, Scaling, & Performance
- Supply chain efficiency & Contractor expectations



What Are some Challenges that need Solving ?

- Connections – Coupling, Anchoring
- Bent bars – Consistency, Scaling, & P
- Supply chain efficiency & Contractor
- LCC Policy, Standards, & Design tools



Life-Cycle Design, Assessment, and Maintenance of Structures and Infrastructure Systems

Edited by
Fabio Biondini
Dan M. Frangopol

Dec. 2019

ASCE

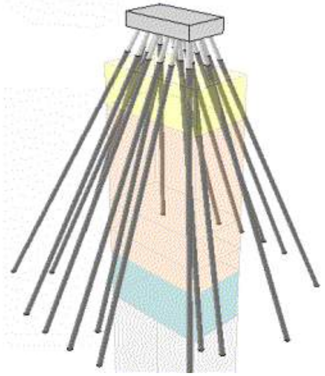
SEI STRUCTURAL ENGINEERING INSTITUTE

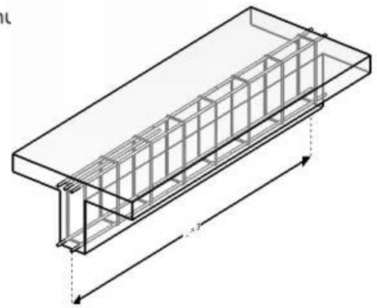
Published by the American Society of Civil Engineers

GUIDE SPECIFICATION FOR SERVICE LIFE DESIGN OF HIGHWAY BRIDGES, 1ST EDITION

Item Code: HBSLD-1

This guide specification is intended to offer design recommendations for agencies wishing to implement service life design principles and detailing recommendations. It was developed to incorporate quantitative approaches, along with proven deemed-to-satisfy provisions, into a single comprehensive design document for implementation on a national level. It also establishes … while providing opportunities for refinement and expansion, … become available.



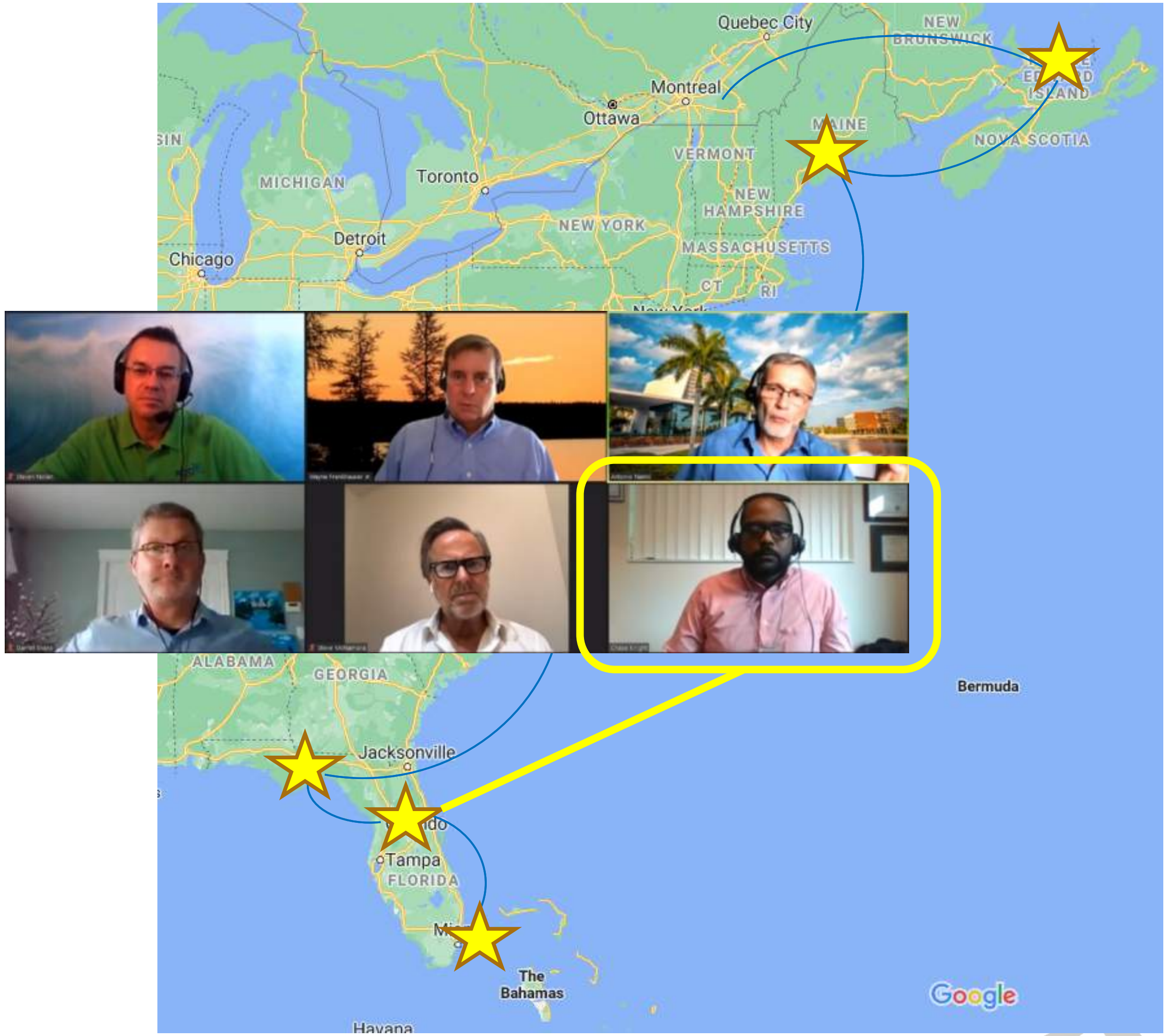


← *Published Sept. 2020*

performance indicators over the entire service life. ASCE strongly supports a change of design paradigm and proposed the use of Life-Cycle Cost Analysis in conjunction with the Grand Challenge of reducing life-cycle costs of civil infrastructure projects by 50% by 2025. Furthermore, research and implementa-

OUTLINE

- Moderator: Antonio Nanni, PhD. PE. *(University of Miami)*
- Speaker 1: Darrell Evans, PE. *(PEI Dept. of Transportation, Infrastructure & Energy)*
- Speaker 2: Wayne Frankhauser Jr., PE *(Maine Dept. of Transportation)*
- Speaker 3: Steven Nolan, PE. *(Florida Dept. of Transportation)*
- Speaker 4: **Chase Knight, PhD. PE. *(Florida Dept. of Transportation)***
- Speaker 5: Steve McNamara, *(ANZAC CONTRACTORS, INC.)*



INFRASTRUCTURE FEATURED PANEL DISCUSSION

Wednesday, September 23, 2020

2:25 pm – 3:40 pm EDT

Building Bridges Along the Atlantic
- A Florida Materials Perspective

Chase Knight, PhD, P.E.

State Corrosion & Composite Materials Engineer

FDOT

CAMX

THE COMPOSITES AND ADVANCED MATERIALS EXPO

September 21-24, 2020 / www.theCAMX.org

OUTLINE

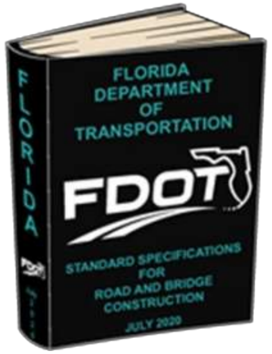
1. How does FDOT approve specified FRP materials for infrastructure?
2. What are our Quality Control expectations?
3. How can a new/novel FRP product or material get approved for use?
4. What do we worry about?

How does FDOT approve specified FRP materials for infrastructure?

– Uniform Approval Processes

- Limited U.S. consensus standards for FRP products and recognized manufacturer certification programs:
  1. Develop **FDOT Specifications** as an interim measure.
  2. Develop **FDOT Sampling and Test Methods** (**FSTM**s), if necessary.

- FRP Producer Approval or Product Approval (**APL**) ?
  1. "widgets" go on the **APL**.
  2. Most FRP products require more nuanced review, approval and monitoring = Producer QC Plan Approval by FDOT.
  3. Similar to Prestressed Concrete Plant approval, but no in-plant inspectors at this time - *Auditing is an option* - Industry or **AASHTO** certification program could be desirable.



Topic No.: 675-000-000
Materials Manual,
Fiber Reinforced Polymer Composites

Effective: November, 8 2013
Revised: ~~October 27, 2014~~May 17, 2019

Section 12.1
Volume II
FIBER REINFORCED POLYMER COMPOSITES

CHAPTER 10: Florida Test Methods

Section 10.1	Florida Sampling and Testing Methods	V1-Section 10.1 [PDF-123KB]	N/A

CHAPTER 11: Steel and Miscellaneous Metal Products

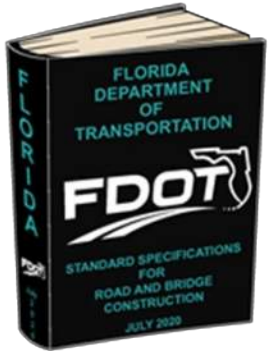
Section 11.1	Fabrication Inspection and Testing of Structural Metal Products	V1-Section 11.1	V2-Section 11.1
Section 11.2	Welding Procedure Specification Review and Approval Process	N/A	V2-Section 11.2
Section 11.3	Advanced Ultrasonic Testing	N/A	V2-Section 11.3
Section 11.4	Computed Radiography Procedures (Photostimulable Luminescence)	N/A	V2-Section 11.4
Section 11.5	Pre-Approved Repair Procedures for Structural Steel	N/A	V2-Section 11.5
Section 11.6	Pre-Approved Repair Procedures for Shop Applied Coatings	N/A	V2-Section 11.6

CHAPTER 12: Fiber Reinforced Polymer Composites

Section 12.1	Fiber Reinforced Polymer Composites	N/A	V2-Section 12.1

Uniform Approval Processes

- Limited U.S. consensus standards for FRP products and recognized manufacturer certification programs:
  i. Develop **FDOT Specifications** as an interim measure *or supplemental requirements, such as highlighted in the example below:*



932-3 Fiber Reinforced Polymer (FRP) Reinforcing Bars.

932-3.1 General: Obtain FRP reinforcing bars from producers currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

Use only solid, round, thermoset basalt fiber reinforced polymer (BFRP), glass fiber reinforced polymer (GFRP) or carbon fiber reinforced polymer (CFRP) reinforcing bars. Bars shall be manufactured using pultrusion, variations of pultrusion, or other suitable processes noted in the producer's Quality Control Plan, subject to the approval of the State Materials Office (SMO). For BFRP and CFRP bars only vinyl ester or epoxy resin systems are permitted. For GFRP, use only bars manufactured using vinyl ester resin systems and glass fibers classified as E-CR or R that meet the requirements of ASTM D578.

Measured Cross-Sectional Area	ASTM D7205	Within the range listed in Table 3-1	10[n]
Guaranteed Tensile Load[a]	ASTM D7205	≥ Value listed in Table 3-1	10[n]
Tensile Modulus	ASTM D7205	≥6,500 ksi for BFRP and GFRP ≥18,000 ksi for CRFP	10[n]
Alkali Resistance with Load	ASTM D7705; Procedure B, set sustained load to 30% of value in Table 3-1; 3 months test duration, followed by tensile strength per ASTM D7205	≥ 70% Tensile strength retention	5[m]
Transverse Shear Strength	ASTM D7617	>22 ksi	5[n]
Horizontal Shear Strength[p]	ASTM D4475	>5.5 ksi	5[n]
Bond Strength to Concrete, Block Pull-Out	ACI 440.3R, Method B.3 or ASTM D7913	>1.1 ksi	5[m]

a – Guaranteed tensile load shall be equal to the average test result from all three lots minus three standard deviations.
n – Tests shall be conducted for all bar sizes produced.
m – Tests shall be conducted for the smallest, median, and largest bar size produced.
p – Only required for BFRP bars.

Uniform Approval Processes

- FRP Producer Approval = Materials Acceptance & Certification

https://mac.fdot.gov/smoreports

FDOT

Generated: 5/28/2019 6:08:38 PM

Fiber Reinforced Polymer Production Facility Listing

ffice, 5007 N.E. 39th Avenue, Gainesvi

FRP-02 OWENS CORNING (BLYTHEWOOD, SC)

Company: Owens Corning Infrastructure Solutions
Contact: John Amonett **Email:** john.amonett@owenscorning.com
Phone: (419) 819-9739 **Fax:**
Physical Address:
1051 Jenkins Brothers Rd
Blythewood, SC 29016

QC Plan Status: Quality C

#04 GFRP BAR
#05 GFRP BAR
#06 GFRP BAR
#07 GFRP BAR
#08 GFRP BAR

FRP-06 PULTRALL

Company: Pultrall Inc
Contact: ROXANNE FORTIER **Email:** roxanne.fortier@pultrall.com
Phone: (418) 335-32(
Physical Address:
700 9eme rue Nord
Thetford Mines
CANADA

QC Plan Status: Quali

#03 GFRP BAR
#04 GFRP BAR
#05 GFRP BAR
#06 GFRP BAR
#08 GFRP BAR

FRP-12 TUF-BAR INC (EDMONTON CANADA)

Company: Tuf-Bar Inc.
Contact: Nathan Sim **Email:** nathan@tuf-bar.com
Phone: (780) 448-9338 **Fax:**
Physical Address: 5715-76 Avenue, CANADA
Mailing Address: 5715-76 Avenue, CANADA

QC Plan Status: Quality Control Plan ACCEPTED 3/19/2019

#03 GFRP BAR	Glass Fiber Reinforced Polymer Reinforcing for Concrete, #3
#04 GFRP BAR	Glass Fiber Reinforced Polymer Reinforcing for Concrete, #4
#05 GFRP BAR	Glass Fiber Reinforced Polymer Reinforcing for Concrete, #5
#06 GFRP BAR	Glass Fiber Reinforced Polymer Reinforcing for Concrete, #6
#07 GFRP BAR	Glass Fiber Reinforced Polymer Reinforcing for Concrete, #7
#08 GFRP BAR	Glass Fiber Reinforced Polymer Reinforcing for Concrete, #8

FRP-07 PULTRON (DUBAI)

Company: Pultron Composites Ltd
Contact: Bogdan Patrascu **Email:** bogdan@pultron.com
Phone: (714) 880-9533 **Fax:**
Physical Address:
S404 Street
Building 10 Jebel Ali Free Zone South
UNITED ARAB EMIRATES
Mailing Address:
S404 Street
Building 10 Jebel Ali Free Zone South

QC Plan Status: Quali

#04 GFRP BAR
#05 GFRP BAR
#06 GFRP BAR
#08 GFRP BAR

FRP-08 ATP

Company: ATP
Contact: Aniello Giamundo **Email:** a.giamundo@atp.sa.it
Phone: (811) 948-7131 **Fax:**
Physical Address: via Campa 34, ITALY
Mailing Address: via Campa 34, ITALY

QC Plan Status: Quality

#03 GFRP BAR
#04 GFRP BAR
#05 GFRP BAR
#06 GFRP BAR
#08 GFRP BAR

FRP-14 TUF-BAR INC (ONTARIO CANADA)

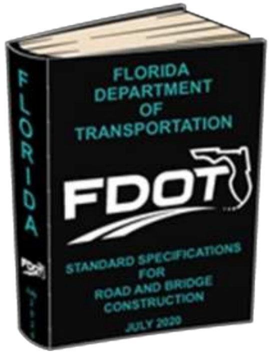
Company: Tuf-Bar Inc.
Contact: Jay Christopher **Email:** jay@tufbarcanada.com
Phone: (519) 833-5050 **Fax:**
Physical Address: 7 Erin Park Dr, CANADA
Mailing Address: 7 Erin Park Dr, CANADA

QC Plan Status: Quality Control Plan ACCEPTED 12/11/2017

What are the Quality Control expectations?

Uniform Approval Processes

- Standard FRP Construction and Material Specifications



DIVISION I

GENERAL REQUIREMENTS AND COVENANTS

Section		Page
1	Definitions and Terms	1
2	Proposal Requirements and Conditions	10
3	Award and Execution of Contract	16
4	Scope of the Work	20
5	Control of the Work	32
6	Control of Materials	52
7	Legal Requirements and Responsibility to the Public	57
8	Prosecution and Progress	82
9	Measurement and Payment	95

DIVISION II CONSTRUCTION DETAILS

STRUCTURES

400	Concrete Structures	370
407	Three-Sided Precast Concrete Culvert	409
410	Precast Concrete Box Culvert	416
411	Epoxy Injection of Cracks in Concrete Structures	424
413	Sealing Cracks and Concrete Structure Surfaces	427
415	Reinforcing for Concrete	434
416	Installation of Post-Installed Anchor Systems and Dowels for Structural Applications in Concrete Elements	441
425	Inlets, Manholes, and Junction Boxes	444
430	Pipe Culverts	448
431	Pipe Liner	461
462	Post-Tensioning	647
470	Timber Structures	679
471	Fiber Reinforced Polymer Fender Systems	682

DIVISION III MATERIALS

ACCESSORY MATERIALS FOR CONCRETE PAVEMENT AND CONCRETE STRUCTURES

931	Metal Accessory Materials for Concrete Pavement and Concrete Structures	1047
932	Nonmetallic Accessory Materials for Concrete Pavement and Concrete Structures	1051
933	Prestressing Strand and Bar	1066
934	Non-Shrink Grout	1071
946	Cast Iron Pipe	1087
948	Optional Drainage Products and Liner Repair Systems	1088
972	Recycled Plastic Products	1141
973	Fiber Reinforced Polymer (FRP) Composite Structural Shapes	1142
975	Structural Coating Materials	1147

How can a new/novel FRP product or material get approved for use?

– Uniform Approval Processes

- Unique product (widget) that fits a Department Need – **Innovative Products List** (**IPL**)
  - ➢ *https://fdotwp1.dot.state.fl.us/ApprovedProductList/Specifications?IsDevSpec=True*
- Standard products (widgets) that the Department needs – **Approved Product List** (**APL**)
  - ➢ *https://fdotwp1.dot.state.fl.us/ApprovedProductList/Specifications*
- Novel or Project Specific Need – **Technical Special Provision** (**TSP**)
  - ➢ *Work with District Specs Office and Project Manager*
- Materials/Construction Process that is not mature – **Developmental Specification**
  - ➢ *https://www.fdot.gov/programmanagement/otherfdotlinks/developmental/default.shtm*
- Standard Materials/Construction Process (institutionalized acceptance) – **FDOT Standard Specifications for Road and Bridge Construction** (**Specs**)
  - ➢ *https://www.fdot.gov/programmanagement/implemented/specbooks/default.shtm*

What do we worry about? - CPR&T

- **Consistency** – Creating a level "playing field" and setting clear expectations → *uniform processes and standards.*

- **Predictability** – Mechanical and Durability →
  - ➢ *Improvement can lead to more efficiency in design reduction factors with the same level of confidence.*

"You get what you test"

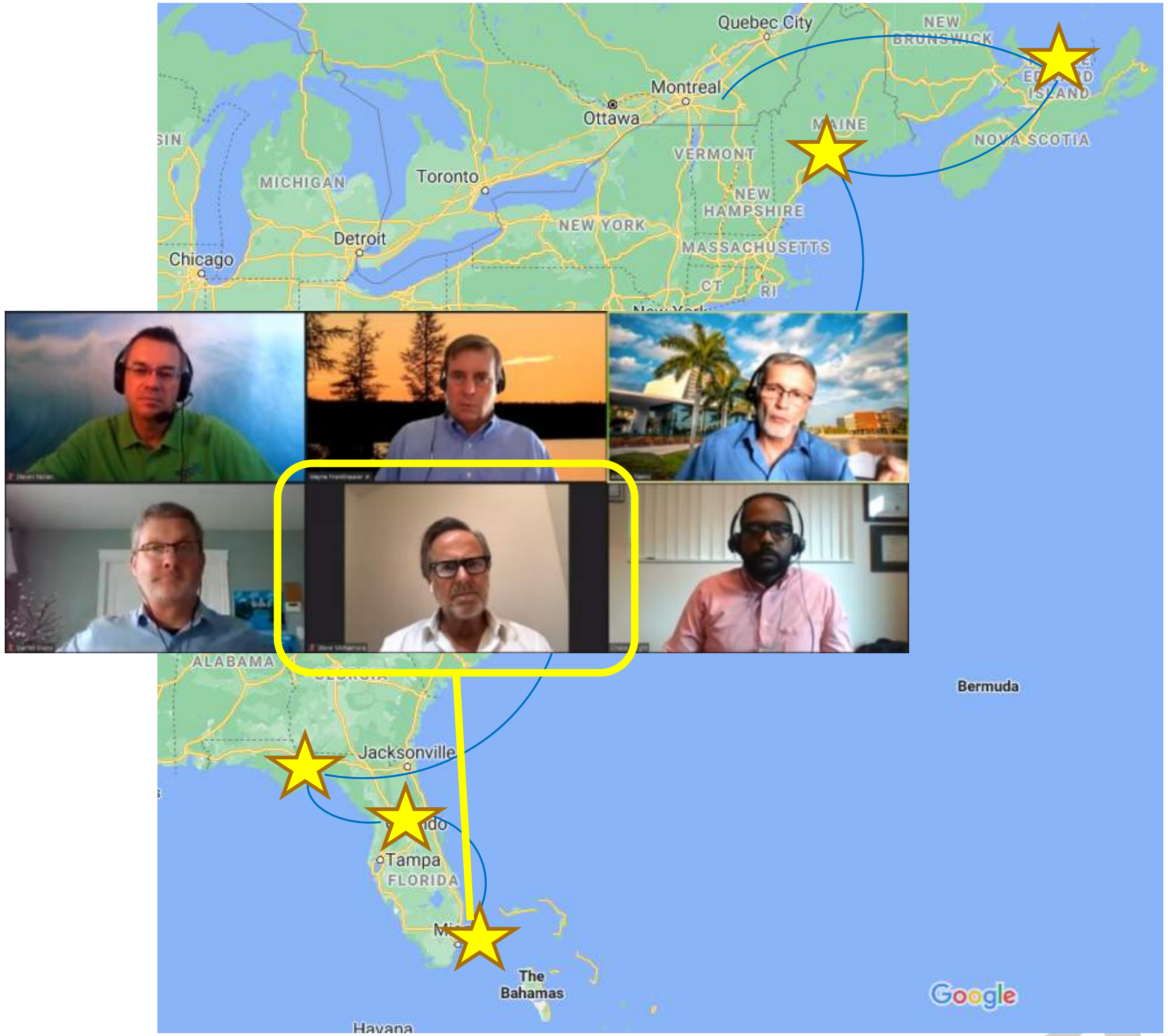
- **Repeatable/Reliability** – Builds confidence with owners, inspectors, contractors, and ultimately the public taxpayers →
  - ➢ *can lead to reduced inspection and testing requirements.*

- **Traceability** – When "stuff" happens, we need to be able to find out why, and where else this could be a problem. e.g.→
  - ➢ *PT Grout "Chloride contamination (2002-10)", and then later "Soft".*
  - ➢ *Polymer adhesive-anchor creep failure from Boston Tunnel ceiling collapse*


Portion of U.S. 1 bridge collapses in North Palm
Part of sidewalk, railing fall into canal after two post-tension wires fail.

OUTLINE

- Moderator: Antonio Nanni, PhD. PE. *(University of Miami)*
- Speaker 1: Darrell Evans, PE. *(PEI Dept. of Transportation, Infrastructure & Energy)*
- Speaker 2: Wayne Frankhauser Jr., PE *(Maine Dept. of Transportation)*
- Speaker 3: Steven Nolan, PE. *(Florida Dept. of Transportation)*
- Speaker 4: Chase Knight, PhD. PE. *(Florida Dept. of Transportation)*
- Speaker 5: **Steve McNamara, *(ANZAC CONTRACTORS, INC.)***



N.E. 23rd Avenue Bridge [IBIS-Waterway] Prestressed GFRP-Piles & GFRP-RC Seawall

Steven McNamara, C.G.C., C.U.C.
President, ANZAC Construction, Inc., Florida

Christian C. Steputat, P.E., C.G.C., LEED AP BD+C
Ph.D. Candidate, University of Miami, Coral Gables, FL

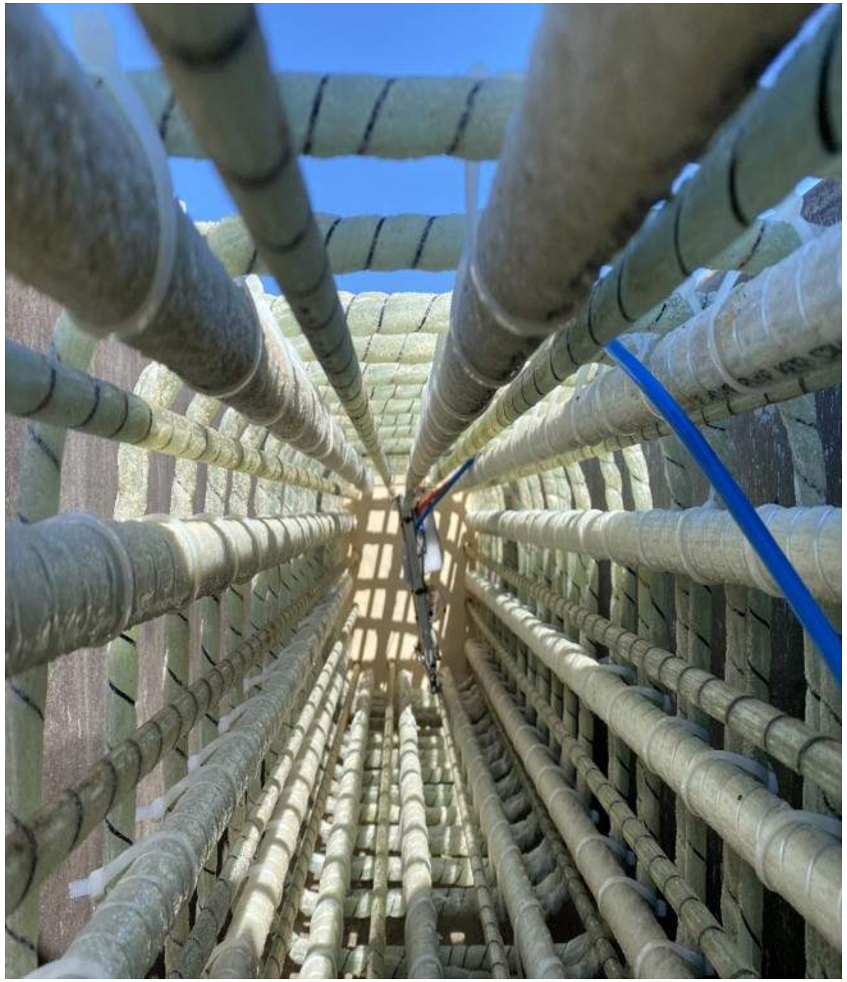
CAMX
THE COMPOSITES AND ADVANCED MATERIALS EXPO
September 21-24, 2020 / www.theCAMX.org

INNOVATIVE GFRP-BRIDGE CONCEPTS

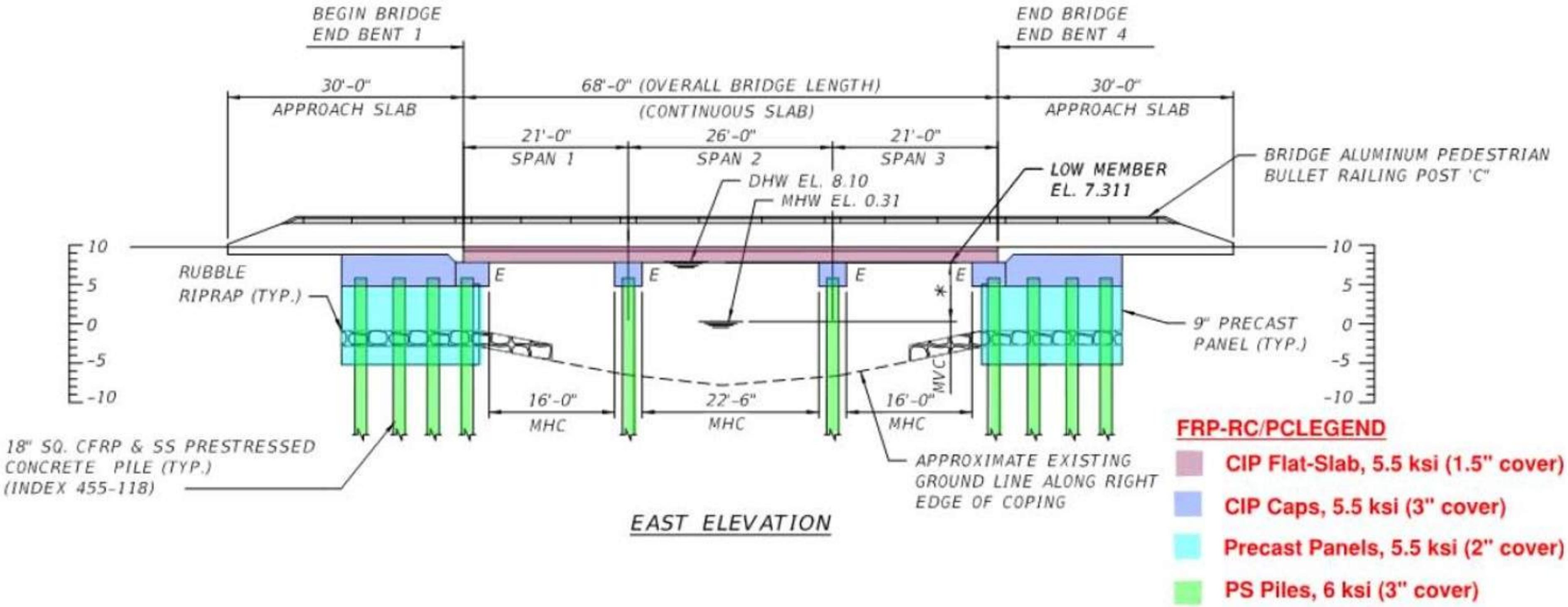
1. **Prestressed and Driven GFRP-Piles with Monitoring.**

2. **GFRP-RC CIP End-Bents, Intermediate Bent-Caps and Bulkhead Caps.**

3. **First Soldier Pile Bulkhead-Seawall with GFRP-RC Precast Panels in Florida.**



INNOVATION AND LAYOUT



- First of its kind, currently under construction, GFRP-RC 3-Span continuous Flat-Slab Bridge and first Soldier-Pile Bulkhead-Seawall with GFRP-RC Precast-Panels, in the State of Florida, USA.

BRIDGE - REPLACEMENT VIA GFRP

IBIS-Waterway Bridge replacement phase of project, in Lighthouse Point, Florida.
Removal, Template-Construction and driving of Prestressed GFRP-RC Piles.

BRIDGE - PILE DRIVING PHASE

The IBIS Waterway Bridge Pile-Driving included the driving of GFRP-RC Piles. Relative “hard” soil conditions and powerline locations challenged the driving.

BRIDGE - SEAWALL GFRP PANELS

INTERMEDIATE-BENTS

IBIS-Waterway Bridge GFRP placement at Intermediate-Bents atop Prestressed GFRP-RC driven Piles.

\

Cage-Construction with GFRP bars is fast and efficient, due to lightweight and is also corrosion resistant.

GFRP REINFORCED END-BENTS

IBIS-Waterway Bridge GFRP placement at End-Bents atop Precast Seawall-Panels, and at Intermediate-Bents

GFRP LESSONS LEARNED

- Correct scheduling of FRP/GFRP/BFRP bar deliveries is critical
- Verify and check Shop-Drawings (Dimensions, Angles, Splices)
- For Structural Tie-Backs verify that slotted block-outs are designed for the corresponding angles of installation in both the vertical and horizontal plane (to easily accommodate the GFRP)
- Anticipate some bar-breakage and order some additional bars
- The lightweight and high strength of GFRP bars makes it easy to work with and improves installation efficiency by more than 52%
- The use of GFRP bars allows for less expensive Mix-Designs

CONCLUSIONS & RECOMMENDATIONS

- There is a strong case for use of FRP/GFRP/BFRP in structural concrete exposed to corrosive environment
- Economics of FRP comparable to steel upfront and return on investment is higher on a life cycle cost analysis basis
- GFRP anisotropic and linear elastic up to failure
- Specifications and Design Guides exist
- Accessible design tools exist for design professionals
- Prestressed GFRP-RC Piles were successfully driven

IBIS-WATERWAY

THANK YOU
FOR WATCHING

CAMX
THE COMPOSITES AND ADVANCED MATERIALS EXPO

SEPTEMBER 21-24
A VIRTUAL EXPERIENCE
2020