Status of FRP Deployment for ACMA-Transportation Structures Council Meeting

Structures Design Office
(September 29th, 2016)
steven.nolan@dot.state.fl.us
(850) 414-4272
Outline:

- **Design Standards**
- **Developmental Design Standards**
  - Halls River Bridge Replacement Demonstration Project
  - Halls River Bridge FRP Workshop
- Other Projects
- Looking Ahead
- Tech Transfer
- Research
- AASHTO-T6
**Design Standards:** Prestressed Concrete Piles (with CFRP & SS)

- **Indexes:** 22600, 20601, 22612, 22614, 22618, 22624, & 20630

- New corrosion resistant piling for intermediate bridge pile bents in Extremely Aggressive Environments (marine)
  - see *Structures Design Bulletin 15-10* for more information and
  - *SDG* Table 3.5.1-1 for application.

- Carbon FRP strands (single or 7-strand) & spiral reinforcing or Stainless Steel strand (7-wire) and spiral reinforcing (at contractor’s/producer’s option)

---

**ALTERNATE STRAND PATTERNS**

- 20 ~ 0.6" Ø, CFRP 7-Strand, at 34 kips
- 20 ~ ½" Ø, CFRP Single-Strand, at 33 kips

**SECTION A-A**

- See Alternate Strand Patterns

**STRAND PATTERN**

- 28 ~ ½" Ø, HSSS at 26 kips

**SECTION A-A**

- See Strand Pattern

**Change to 0.2" for 2017/18**
Recently Published FRP-RC DDS’s

- **Index D6011c**: Gravity Wall – Option C (GFRP Reinforced)
- **Index D22420 series**: Traffic Railing (32” F Shape – GFRP Reinforced)
- **Index D22440 series**: Precast Concrete CFRP/GFRP Sheet Pile Wall
- **Index D22900 series**: Approach Slabs (GFRP Reinforced)
FRP-RC DDS’s to be Revised…

- **Index D21310 series**: FRP Bar Bending Details
  - To be updated to match steel reinf.
  - Bar bending index per agreement at FDR-GFRP Workshop 6/15/16
  - Send to ACMA-RMC?
Halls River Bridge Replacement Demonstration Project

**DDS’s in this project:**

- **Index D21310** – FRP Bar Bending Details;
- **Index D22420** – GFRP reinforced 32” F-Shape Traffic Railing;
- **Index D22440** – Precast Concrete CFRP/GFRP Sheet Pile Wall:
  - CFRP strands 3.5” cover / GFRP Stirrups 3” cover (Type A).
  - Steel strands 5” cover / GFRP Stirrups 2” cover (Type H).
- **Index D22618 series** – 18” Square CFRP Prestressed Concrete Piles (no HSSS strand option);
- **Index D22900** – GFRP reinforced Approach Slab;

- Also includes:
  - Hybrid Composite Beams (superstructure)
  - GFRP-RC Bridge Deck and Pile Bent Caps
Halls River Bridge Replacement Demonstration Project

Sheet Pile Walls: Index D22440 series
Halls River Bridge Replacement Demonstration Project

Sheet Pile Walls: Index D22440 series
Halls River Bridge Replacement Demonstration Project

Sheet Pile Walls: Index D22440 series
Halls River Bridge FRP Workshop

FDOT – Halls River Bridge FRP Workshop Outline (Draft)

Date: May 3rd - 4th 2017
Location: FDOT - District 7 HQ, Auditorium
11201 North Malcom Mckinley Drive
Tampa, Florida 33612

PRELIMINARY AGENDA
5/3/2017 – Wednesday 1:00 pm to 5:00 pm, D7-HQ Presentations
http://www.dot.state.fl.us/structures/innovation/2017-HallsRiverFRPWorkshopOutline.pdf
(Possible webinar live streaming for wider participation?)
Other Projects

i. Cedar Key SR24 Bulkhead Rehabilitation
   - Construction completed June 2016
   - (FPID 432194-1-52-01)
   - Construction Project Overview

ii. Skyway South Rest Area Seawall Rehabilitation
    - Design-Build contract E1P44
    - (FPID 438528-1-52-01)
    - Advertisement 04/11/2016

iii. Bakers Haulover Cut Bridge Bulkhead Rehabilitation
    - Letting 6/15/2016
    - (FPID 432194-1-52-01)
Looking Ahead

Future standards under consideration:

- **Index D20700 series** – Precast Intermediate Bent Cap;
  - GFRP Option in Mathcad Design Program

- **Index D20450G series** – FSB’s with GFRP Stirrups:
  - Option 1 – 2.5” minimum cover to steel strands
  - Option 2 – 3.5” Minimum cover to steel strands
  - Option 3 – CFRP/SS strands 2.5” cover

- **Index D22440 series** – Non-Prestressed Concrete Sheet Piles – GFRP Reinforced (under analysis).
Technology Transfer (T²)

**NCHRP Report 768** (2014):

10 key components provide practitioners with a “roadmap” through a guided T² process:

1. Address societal and legal issues;
2. Have an effective champion; (Rick Vallier-Structures / Chase Knight-Materials)
3. Engage decision makers; - FDOT-FHWA Corrosion-Resistant Rebar Seminar – 07/17/12; - FRP Rebar Industry-FDOT Workshop – 06/15/16; - ACMA-Transportation Structures Council - CAMX 9/29/16;
4. Develop a T² plan; (Developmental Design Standards Reports, Roadmap for FRP Deployment...)
5. Identify, inform, and engage stakeholders; (Invitation to Innovation, FDOT-SRC Research Update webinars, FDOT Design Training Expo, …)
6. Identify and secure resources; (FRPG, Developmental Specs. & DDS)
7. Conduct demonstrations/showcases; (Halls River Bridge, Haulover Cut Rehab. - 2017)
9. Evaluate progress; (SEACON, FDOT Monitoring Project 430021-1-62-03)
10. Reach [wider] deployment decision;
Technology Transfer Opportunities

Florida Transportation Builder Association 2017
2017 Construction Conference
February 2-3, 2017
Hyatt Regency Orlando
9801 International Drive
Orlando, FL 32819
Telephone: (407) 284-1234

FDOT – Halls River Bridge FRP Workshop Outline (Draft)
Date: May 3rd - 4th 2017
Location: FDOT - District 7 HG, Auditorium
11201 North Malcolm McKinley Drive
Tampa, Florida 33612

Design Expo 2017 – June 5-7, 2017
Caribe Royale in Orlando

SEACON FORUM AND HALLS RIVER BRIDGE FRP WORKSHOP
May 3 - 4, 2017
Tampa, Florida

http://seacon.um-sml.com/seacon-forum.html

http://seacon.um-sml.com/seacon-forum.html

FDOT For Road Safety Awareness

SEACON Forum
Wednesday, May 3, 2017 8:00 AM to noon
Holiday Inn & Suites Tampa North
11310 North 30th Street, Tampa, Florida 33612
Service Life Enhancement thru Durability:

The composites research at the SRC has been constant since the late 80’s early 90’s. Large focus initially was on repair and retrofit, and continues, but attention is now shifting towards new construction (see examples below).

<table>
<thead>
<tr>
<th>Date</th>
<th>Title</th>
<th>Authors</th>
<th>Institution</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/30/2018</td>
<td>Performance Evaluation of GFRP Reinforcing Bars Embedded in Concrete Under Aggressive Environments</td>
<td>R. Kampmann</td>
<td>Florida State University</td>
<td>BDV30</td>
</tr>
<tr>
<td>3/31/2018</td>
<td>Degradation Mechanisms and Service Life Estimation of FRP Concrete Reinforcements</td>
<td>A. El Safty</td>
<td>University of North Florida</td>
<td>BDV34</td>
</tr>
<tr>
<td>4/16/2014</td>
<td>Investigation of Carbon Fiber Composite Cables (CFCC) in Prestressed Concrete Piles</td>
<td>M. Roddenberry, P. Mtenga</td>
<td>Florida State University</td>
<td>BDK83</td>
</tr>
<tr>
<td>11/30/1998</td>
<td>Studies on Carbon FRP (CFRP) Prestressed Concrete Bridge Columns and Piles in Marine Environment</td>
<td>M. Arockiasamy</td>
<td>Florida Atlantic University</td>
<td>B-9076</td>
</tr>
<tr>
<td>8/1/1995</td>
<td>Durability of CFRP Pretensioned Piles in Marine Environment Volume II</td>
<td>R. Sen</td>
<td>University of South Florida</td>
<td>0510642</td>
</tr>
</tbody>
</table>
Update of GFRP Guide Specification
✓ White Paper circulated by Dr. Nanni

T-6 is currently working on a strategic plan (the primary objective is to support the overall AASHTO SCOBS strategic plan)

Discussion that the CFRP pretensioning will be getting ready for ballot as a separate Guide Specification.

NCHRP Research
✓ NCHRP 20-68A Domestic Scan 13-03 – Best Practices in FRP Composites (O'Connor, University of Buffalo) should be published very soon.
✓ NCHRP 47-12 (Synthesis) – Use of FRP in Transportation Infrastructure (Dr. Kim, University of Colorado)
✓ NCHRP 12-97 – Guide Specification for the Design of Concrete Bridge Beams Prestressed with CFRP Systems (Dr. Belarbi – University of Houston)

AASHTO Innovative Initiative (A.I.I.)
✓ Method of Promoting Innovation/Usage (CFRP pre- and post-tensioning currently listed)
Questions?

Structures Design Office:
Steven Nolan, P.E. (Standards Coordinator)
(850) 414-4272
Steven.Nolan@dot.state.fl.us

State Materials Office:
Chase C. Knight, PhD.
(352) 955-6642
Chase.Knight@dot.state.fl.us

Structures Design Office:
Rick Vallier, P.E. (FRP Coordinator)
(850) 414-4290
Rick.Vallier@dot.state.fl.us
CAMX
THE COMPOSITES AND ADVANCED MATERIALS EXPO

September 26–29, 2016: Conference / September 27–29, 2016: Exhibits
Anaheim Convention Center / Anaheim, California

COMBINED STRENGTH. UNSURPASSED INNOVATION.

www.thecAMX.org

PRODUCED BY
ACMA
SAMPE
Reinforcements of Concrete: Next Frontier for Composites

Mikhail Vorobiev
Global Product Manager
Owens Corning

© 2016 Owens Corning. All Rights Reserved
Key Topics

- **Infrastructure**: A Major Growth Opportunity for Composites?
- **Fundamental Science**: Beyond Corrosion
- **Sustainability Play**: Durability, Resilience and Resource Conservation
- **Winning Together**: Industry Collaboration
Who is Owens Corning?

- Founded in 1938
- 2015 Sales $5.4 billion
- 16,000 Employees in 25 countries
- Three Divisions based on fiber glass
  - Composite Solutions
  - Roofing & Asphalt
  - Insulation
- Component of the Dow Jones Sustainability index
Megatrends Shaping the Construction Industry’s Future

- Markets
  - Ageing Infrastructure
  - Big & Complex Projects

- Sustainability
  - Resource Scarcity
  - Resilience Challenge

- Society
  - Urbanization
  - Talent & Ageing Workforce

Source: Press Reports; “Shaping the Future of Construction: A Breakthrough in Mindset and Technology” World Economic Forum; The Boston Consulting Group
Why Corrosion Matters?

"Collapse of reinforced concrete structures due to steel reinforcement corrosion could be the most immediate vulnerability resulting from climate change..."

Source: Boston Guide, October 2014
How Big is The Problem?

- 1/9 of US bridges rated as structurally deficient
- Corrosion one of the largest asset management costs
- Current alternatives provide an expensive or not sustainable solution

<table>
<thead>
<tr>
<th>Category</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVIATION</td>
<td>D</td>
</tr>
<tr>
<td>BRIDGES</td>
<td>C+</td>
</tr>
<tr>
<td>DAMS</td>
<td>D</td>
</tr>
<tr>
<td>DRINKING WATER</td>
<td>D</td>
</tr>
<tr>
<td>ENERGY</td>
<td>D+</td>
</tr>
<tr>
<td>HAZARDOUS WASTE</td>
<td>D</td>
</tr>
<tr>
<td>INLAND WATERWAYS</td>
<td>D-</td>
</tr>
<tr>
<td>LEVEES</td>
<td>D-</td>
</tr>
<tr>
<td>PORT</td>
<td>C</td>
</tr>
<tr>
<td>PUBLIC PARKS</td>
<td>C</td>
</tr>
<tr>
<td>RAIL</td>
<td>C</td>
</tr>
<tr>
<td>ROADS</td>
<td>D</td>
</tr>
<tr>
<td>SCHOOL</td>
<td>D</td>
</tr>
<tr>
<td>SOLID WASTE</td>
<td>B</td>
</tr>
<tr>
<td>TRANSIT</td>
<td>D</td>
</tr>
<tr>
<td>WASTEWATER</td>
<td>D</td>
</tr>
</tbody>
</table>

A: Exceptional, B: Good, C: Mediocre, D: Poor, F: Failing

http://www.infrastructurereportcard.org/ and http://www.infrastructurereportcard.org/a/#p/grade-sheet/gpa
Why Composites?

- High strength-to-weight ratio
- Corrosion resistance
- Ease of application and installation
- Cost-effective solutions at installation point
- ¼ the weight of steel
- >2.5x less expensive over 100 years of service life

Images courtesy of AT Italy and/or University of Miami.

Source: CFRP Prestressing by Matthew J. Chynoweth, P.E. Michigan Department of Transportation 2015 AASHTO Subcommittee on Bridges and Structures Technical Subcommittee T-6, Composites
What is The Opportunity?

Global Steel Rebar Market
EC & SS Solutions
NA Rebar Market
Composites Rebar

Bridges & Highways
Buildings & Parking
Preservation
Marine Structures
Tunnels

Source: Tunnel courtesy of ATP, Italy. Other images courtesy of Hughes Brothers and University of Miami.

INNOVATION IN THE VALUE CHAIN OFFERS SIGNIFICANT GROWTH OPPORTUNITIES FOR THE COMPOSITES INDUSTRY
Key Challenges

- Lack of Standards
- Insufficient Training
- Limited Research Consensus
- Lack of Design Examples
- No Implementation Strategy
- Lack of Industry Collaboration
Product Solutions

- Classical Rebar solutions are common
- Complex material solutions are increasingly available

Non mandatory language describing the products in ACI Design guide: 440.1R-0
Mandatory language covering testing & evaluation of the bars: ACI 440.6-08 and ACI 440.5-08 covers preparation placement
AASHTO guide specifications published 11/2009
Fundamental Science

- Glass science to deliver superior performance:
  H-Glass / S-Glass / Advantex® Glass
- Interfacial science to drive the performance of composite structures
  Windstrand® Roving, Pipestrand® Roving, Pulstrand® Roving
- Developing new characterization methodologies to underpin future applications of composite materials
Real World Example

15+ years of GFRP Rebar Performance

Images courtesy of University of Miami.
• Sierrita de la Cruz Creek Bridge, Amarillo, Texas constructed in 2000
Proven Historical Durability

GFRP materials maintained their microstructural integrity and mechanical properties after 15 years of service.
Good Bonding with Concrete

The GFRP rebar to concrete interfacial bond was maintained properly and no sign of bond degradation nor loss of contact was observed after 15 years.

Long-term Durability of GFRP Reinforcement in Concrete: A Case Study after 15 Years of Service - O. Gooranorimi, E. Dauer, J. Myers, A. Nanni

1, 4 Dept., Civil, Architectural and Environmental Engineering, 2 Dept., Biomedical Engineering, University of Miami, Coral Gables, 33146, Florida, USA.
3 Dept., Civil, Architecture and Environmental Engineering, Missouri University of Science and Technology, Rolla, 65409, Missouri, USA.
Sustainability Play

• Concrete industry limits chloride content for control of steel reinforcement corrosion.

• If relaxed, its product becomes more economical, durable and environmentally friendly.

• Sustainable concrete using seawater, salt-contaminated aggregate and GFRP reinforcement.
Industry Collaboration

SEACON: global consortium of industry, academia and government
International Partnership

Advancing innovative, near-market materials or processes, that will make highway infrastructure sustainable.

GOAL
Advancing innovative, near-market materials or processes, that will make highway infrastructure sustainable.

SEACON
Sustainable Concrete

LAST LONGER
COST LESS
PERFORM EFFICIENTLY
ONE OUT OF NINE FINALISTS
SELECTED FROM 103 PROPOSALS

Infravation
An Infrastructure Innovation Programme
Winning Together

• INFRASTRUCTURE is clearly a key market for future composite growth aligned with a number of megatrends and availability of potential funding.

• Development of the infrastructure market (GRFP reinforcement) will depend on development of BOTH key science to support product use and development of strong value chains.
Thank you!