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
Overview

State Materials Office Roles:

- Material Specifications
- Sampling and Testing Requirements
- Quality Control Program – Production Facility Approvals
- Conduct and Facilitate Research – Durability/Service Life
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
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 9.3

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

3. MAC

http://www.dot.state.fl.us/programmanagement/implemented/specbooks/default.shtm
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

http://www.dot.state.fl.us/programmanagement/Implemented/URLinSpecs/Section121V2.shtm
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

http://www.dot.state.fl.us/programmanagement/OtherFDOTLinks/Developmental/Default.shtm
http://www.dot.state.fl.us/programmanagement/Implemented/SpecBooks/default.shtm

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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
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
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
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Research

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

ACI 440.3R
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Research

1. Degradation mechanisms
2. Service life estimation
3. Performance of surface enhancements
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 enhancements
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;

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.

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.


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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;

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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.

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Roadmap to the safe deployment of GFRP reinforcement for concrete structures

- Barriers to expanded GFRP Implementation
- Potential Focus Areas
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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 (phi 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

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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);

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Potential Focus Areas (cont.):

8. Continued Standardization
9. Accommodation of potential customization and optimization of FRP reinforcing and other products
11. Project Monitoring
12. Outreach and Technology Transfer
13. Repair Methods [added]
14. Bridge Inspection [added]

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Questions ??

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