



## 2018 STIC Incentive Project 12 Month Report - BFRP-RC Standardization

**Fed Project No: STIC-0004-00A; FPID 443377-1**

This is the second report for the Basalt Fiber-Reinforced Polymer (BFRP) Bar Standardization for Reinforced Concrete (RC) with the FHWA allocation memorandum dated March 1, 2018. This report covers a slightly extended period from November 2018 until May 2019, since there were a number of key work products completed in April/May 2019.

### Description of the proposed work

Develop standard (guide) design specification, and standard material and construction specifications for basalt fiber-reinforced polymer (BFRP) bars for the internal reinforcement of structural concrete. Tasks involve (*highlighted tasks are completed or partially completed*):

- i. Establishing design and durability parameters using current state-of-the-art BFRP test data with *ACI 440.1R* as a design model framework, supplemented with *AASHTO's LRF Bridge Design Guide Specification for GFRP Reinforced Concrete - 2<sup>nd</sup> Edition (BDGS-2)* - published December 2018;
- ii. Develop FDOT design modifications to *BDGS-2* for inclusion of BFRP reinforcing - *see BDV30 986-01 Deliverable #3 (Attachment 3) to be expanded into the Structures Manual by July 17 cutoff*;
- iii. Develop FDOT material specification for acceptance based on the 2017 *ASTM D7957: Standard Specification for Solid Round Glass Fiber Reinforced Polymer Bars for Concrete Reinforcement* - *see BDV30 986-01 Deliverable #4 April 2019 (Attachment 4), and FDOT Materials Manual 12.1 revisions May 2019 (Attachment MM)*;
- iv. Develop FDOT Construction Specifications based on *BDGS-2* and *FDOT Specification Section 415 & 932* GFRP reinforcing specifications - *Prepared for Internal/Industry review, see Attachment CS*.
- v. Develop BFRP Reinforcing Database for collection of current and future test results based on FDOT GFRP reinforcing test library developed under *BDV30 977-18* and new research project *BE694 "Testing Protocol and Material Specification for BFRP Rebars"*. *Initial test data from BDV30 986-01 in Deliverable #2 (Attachment 2)*;
- vi. Deliver a designer focus live workshop at the end of the STIC project in central Florida (and national event if funding permits). Post the delivered training material on [FDOT FRP Innovation](#) website for broader access and future updating - (a) *BFRP-RC Designer Training schedule for 3 sessions at the FDOT Transportation Symposium (FTS2019) on June 4th*; (b) *Mini-symposium on BFRP-RC for coastal and marine structures is organized for the Bridge Engineering Institute conference (BEI2019) July 23-25, additionally several papers on BFRP-RC have been accepted for presentation by the*

**STIC project participants;** (c) The **FTS2019** BFRP-RC Designer Training is also being offered to Hawaii DOT Bridge Office on July 22, 2019;

- vii. **Demonstration Project - Plans developed and contract awarded for BFRP-RC link-slab on pedestrian bridge in Port Charlotte, FL (along US 41).** Construction delayed until September 2019 due to utility coordination issues. **Monitoring contract executed with University of North Florida under *BDV29 986-02*, to instrument link-slab and BFRP rebar to monitor initial and longer-term response. see Deliverable #1 (**Attachment 5**) for literature review, and draft Deliverable #2 (**Attachment 6**) for preliminary instrumentation plan.**

### Project Breakdown and Schedule

The project is broken into several phases with distinct tasks some of which were not completely scoped, pending progress and findings in the early Phases. **Table 1** shows a summary of the project Phases. It is anticipated that there will be at least two services contracts with Florida Universities for the various tasks of: Existing information collection and curation (Phase 1a); Development of model specifications and standards (Phase 1b); Provision of supplemental test data and analysis (Phase 2a); Development of Materials Database (Phase 2b); Technology Transfer (Phase 3).

PROJECT PHASE	1	2	3
<b>PROJECT WORK TASKS</b>	Develop Standards: <i>(BDV30 986-01)</i> <ul style="list-style-type: none"> <li>• Design Spec.</li> <li>• Materials Qualification and Verification Test Procedures</li> <li>• Construction Spec.</li> </ul>	<ul style="list-style-type: none"> <li>• Full-scale <u>Link-Slab Demo and Monitoring</u> <i>(BDV34 986-02)</i></li> <li>• Supplemental Bar Testing</li> <li>• BFRP Database Completion <i>(BDV30 986-01)</i></li> </ul>	<ul style="list-style-type: none"> <li>• Technology Transfer <i>(FTS2019 &amp; BEI2019)</i></li> <li>• Final Report</li> </ul>
<b>PROJECT DELIVERABLES</b>	<ul style="list-style-type: none"> <li>• LRFD Guide Design Spec. <i>(in AASHTO format)</i></li> <li>• Testing Spec. <i>(in ASTM format)</i></li> <li>• Construction Spec. <i>(in FDOT format)</i></li> </ul>	<ul style="list-style-type: none"> <li>• Test Reports</li> <li>• Electronic Database of physical and mechanical properties</li> </ul>	T <sup>2</sup> Workshop in central Florida for information dissemination and training
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<b>PROJECT TIMELINE</b>	Month 1-11	Month 7-15	Month 17

*Table 1- Project Summary (update 3/28/19)*

### Activities March-September 2018:

1. 04/05/2018 - Funding authorization from Division FHWA approved under 2018 STIC Incentive Proposal: STIC-004-00A / FPID 443377-1;

2. 05/21/2018 - Procurement completed for Principle Investigator of Phase 1 & 2b: Technology Review, Specifications & Database Development. Research Task Work Order (TWO) issued under FDOT research project **BDV30-986-01**;
3. 05/30/2018 - Kickoff meeting held for **BDV30-986-01**;
4. 09/11/2018 - **BDV30-986-01**, Task 1 completed and Deliverable 1 (BFRP Technology Review Report) approved;
5. 09/14/2018 - Collaboration meeting on design of Full-Scale demonstration of BFRP-RC element for testing and monitoring.

### Activities October-May 2019:

1. 12/7/2018 - **BDV30-986-01**, Task Work Order Amendment#1 executed for time extension due to manufacturer delays in providing BFRP rebar samples for testing.
2. 1/11/2019 - Procurement completed for Principle Investigator of Phase 2a BFRP-FRC Link-Slab Demonstration Project. Research Task Work Order issued under FDOT research project **BDV34-986-02**. See **Appendix A** for the scope.
3. 2/6/2019 - **BDV30-986-02**, (BFRP-FRC Link-Slab Demonstration Project) Kickoff Meeting held. See **Appendix B** for the meeting presentation.
4. 2/4/2019 - **BDV30-986-01**, Draft Deliverable 2 (BFRP Testing Procedure and Results) submitted. Revisions requested by PM.
5. 2/28/2019 - **BDV30-986-01**, Task 2 completed and Deliverable 2 (BFRP Testing Procedure and Results) approved. See **Appendix C** for the full report
6. 2/28/2019 - **BDV30-986-01**, Draft Deliverable 3 (BFRP Material Specification Recommendation Report) submitted. Revisions requested by PM.
7. 3/26/2019 - **BDV30-986-01**, Task 3 completed and Deliverable 3 (BFRP Material Specification Recommendations) approved. See **Appendix D** for the full report
8. 3/4/2019 - **BDV30-986-02**, Draft Deliverable 1 (BFRP-FRC Link-Slab Demonstration Project - Literature Review) submitted. Revisions requested by PM.
9. 3/24/2019 - **BDV30-986-02**, Task 1 completed and Deliverable 1 (BFRP-FRC Link-Slab Literature Review) approved. See **Appendix E** for the full report.
10. 5/4/2019 - **BDV30-986-01**, Draft Deliverable 4 (BFRP Design Specification Recommendations) submitted. Revisions requested by PM.
11. 5/13/2019 - **BDV30-986-02**, Draft Deliverable 2 (BFRP-FRC Link-Slab Demonstration Project: Instrumentation and Monitoring Plan) submitted and under review.
12. **BEI-2019** Mini-Symposium organization with Prof. Jimmy Kim (TRB co-sponsored event June 22-25: <http://www.beibridge.org/BEI2019.html> ). Two Abstracts accepted for presentation See **Appendix F**:
  - a. *Basalt FRP-RC Standardization for Florida DOT Structures*
  - b. *Evaluation of Bond-to-Concrete Characteristic of Basalt Fiber-Reinforced Polymer Rebars for Design Code Implementation*

### Planned Activities for May 2018-November 2019

#### *Phase 1:*

1. Complete some minor outstanding water absorption testing characterization for one BFRP bar manufacturers (BDV30-986-01, Task 2)
2. Develop Material & Construction Specifications in FDOT format (BDV30-986-01, Task 3)

3. Provide Design Recommendations for *FDOT Structures Manual* - FRPG Guide Specifications (BDV30-986-01, Task 4)
4. Prepare Draft Final Report BDV30-986-01

*Phase 2:*

5. Develop mockup testing specimen for Link-Slab Field Demonstration BFRP-RC element (Phase 2a)
6. Coordinate with District 1 EOR on final design, instrumentation, and monitoring for full-scale FRP-RC Link-Slab under FPID 435390-1-52-01: US 41 from Midway Blvd to Enterprise project.
7. February 27, 2019 construction letting of FPID 435390-1-52-01: US 41 from Midway Blvd to Enterprise project.
8. Complete initial database for BFRP characterization (*BDV30-986-01*, Task 2 results)

*Phase 3:*

9. Conduct Designer training of BFRP-RC Design at FDOT Transportation Symposium in Orlando on 6/4/2019.
10. Present two papers at BEI-2019 Mini-Symposium on BFRR for marine and coastal structures.
11. Update [\*FRP-Innovation\*](#) webpage with final reports, papers and presentation

## Budget

Project Line Item	FHWA STIC Contribution	FDOT In-Kind Match (20%)	Total Budget
<b>Phase 1</b> <i>(100% BDV30 986-01)</i>	\$48,000	\$12,000	\$60,000
<b>Phase 2</b> <i>(50% BDV30 986-01; 50% SRC/U Testing)</i>	\$36,000	\$9,000	\$45,000
<b>Phase 3</b>	\$16,000	\$4,000	\$20,000
<b>Total Project</b>	<b>\$100,000</b>	<b>\$25,000</b>	<b>\$125,000</b>

*Table 2- Project Phase Funding Distribution (update 5/21/18)*

## Project Schedule

Work Phase	Month																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
1. Develop Design, Materials and Construction Specifications																		
2a. Mockup testing at SRC and/or Full-scale slab instrumentation and monitoring																		



2b. BFRP Supplemental bar testing and Database development																					
3. Technology Transfer Workshop and Final Report																					

*Table 3- Project Timeline (update 3/14/18 – Month 1 = April 2018)*

**Appendices include:**

- Appendix A - University Task Work Order: BDV30 986-02 (BFRP-FRC Link Slab Instrumentation and Monitoring)
- Appendix B - Presentation: BDV30 986-02 Kickoff Meeting
- Appendix C - Deliverable 2: BDV30 986-01 BFRP Testing Procedure and Results
- Appendix D - Deliverable 3: BDV30 986-01 BFRP Material Specification Recommendations
- Appendix E - Deliverable 1: BDV30 986-02 BFRP-FRC Link Slab – Literature Review Report
- Appendix F - BEI-2019 Accepted Abstracts for BFRP Mini-Symposium



## Appendix A

### University Task Work Order: BDV34 986-02 ((BFRP-FRC Link Slab Instrumentation and Monitoring)

(11 pages)

## **Appendix B**

### **Presentation: BDV34 986-02 Kickoff Meeting**

(10 pages)

## **Appendix C**

### **Deliverable 2: BDV30 986-01 BFRP Testing Procedures and Results Report**

(39 pages)

## **Appendix D**

### **Deliverable 3: BDV30 986-01 BFRP Material Specifications Recommendations Report**

(7 pages)

## **Appendix E**

### **Deliverable 1: BDV34 986-03 BFRP-RC Link-Slab Demonstration Project – Literature Review Report**

(31 pages)

## Appendix F

### **BEI-2019 Mini-Symposium on BFRP Emerging Standards for Marine and Coastal Structures: Accepted Abstracts**

- a. *Basalt FRP-RC Standardization for Florida DOT Structures*
- b. *Evaluation of Bond-to-Concrete Characteristic of Basalt Fiber-Reinforced Polymer Rebars for Design Code Implementation*

(2 pages)