EXPLORING FIBER-REINFORCED POLYMER CONCRETE FOR ACCELERATED BRIDGE CONSTRUCTION APPLICATIONS

Quarterly Progress Report
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1. Background and Introduction

The use of precast concrete superstructure elements is a popular strategy for accelerated bridge construction (ABC) and rehabilitation projects. The major advantage is that precast concrete elements can be fabricated before, or in parallel with, on-site activities, thus expediting project delivery. To complete the superstructure, closure joints between adjacent precast superstructure elements are filled with a field-cast material, creating continuity between the concrete elements and splicing steel reinforcement protruding from the precast members into the joints. The geometry of the closure joints, the speed at which the connections can be completed, the curing time before the bridge can be opened to traffic, and the cost of the system are all dependent on the material that is used to fill the gaps between precast elements. The closure joint material must possess strength and durability equal to or better than the adjacent concrete and must be capable of transferring the tensile forces between reinforcement from adjacent elements.

2. Problem Statement

The tension and bond strengths of ultra-high performance concrete (UHPC) make it an excellent closure joint material. However, the time at which UHPC achieves its design strength is directly proportional to the rate of hydration of the cementitious binder. While UHPC may provide the best solution in many instances, alternative joint materials that utilize polymer binders, instead of cementitious ones, may be more suitable if rapid strength gain is needed. This project explores a potential alternative closure joint material, fiber-reinforced polymer concrete (FRPC), which displays levels of the two critical characteristics (bond and tension strength) that are comparable to, or potentially better than, those of UHPC. FRPC has the advantage of requiring shorter closure windows (approximately 4 hours versus 72 hours of UHPC) due to the very rapid strength gain of the polymer, which could be ideal for overnight construction or rehabilitation projects, and provides an additional option to the engineer and contractor when choosing a closure joint material for a particular circumstance.

3. Objectives and Research Approach

The objectives of the proposed research are to review the most promising FRPC materials, assess the temperature dependent properties of FRPC behavior, characterize the mechanical properties (tensile, flexural, and compressive strength) of cast FRPC, and characterize the splice performance of deformed bars embedded in FRPC materials. Based on the results of this experimental investigation, recommendations for the use of FRPC in ABC applications will be developed to maximize the benefit of this relatively new material for different ABC project applications.

4. Description of Research Project Tasks

The following is a description of tasks carried out to date.

Task 1 – Literature Review

A comprehensive review of past experimental research involving fiber reinforced polymer concrete will be completed, and a database will be established that compares the available polymer chemistries in terms of their mechanical and physical properties.

This task is in progress. Previous research on fiber reinforced polymer concrete has been compiled and separated into areas of interest pertinent to bridge construction applications. A chapter of the final report, summarizing the findings of this research, is currently being written. Additional details summarizing the literature review will be provided in subsequent quarterly reports.

Task 2 – FRPC Material Characterization

The mechanical properties of FRPC materials (compressive strength, modulus of elasticity, flexural toughness, and tension strength) will be measured at several test temperatures and ages using standard test methods that would be part of a typical quality control program.

This task is in progress. A commercially available FRPC material has been identified (Kwik Bond Polymers Hybrid Composite Synthetic Concrete). The research team have met with representatives from the manufacturer to discuss the project and solicit their input. A preliminary experimental plan has been developed for this task, to be completed over Summer 2021, and a meeting with the advisory panel is being scheduled to finalize details of the tests.

Task 3 – Testing of Splice Specimens

The tests will focus on a simplified, non-contact splice configuration that isolates the behavior of reinforcement in a closure joint to a specimen size that can be conditioned to different temperatures using conventional laboratory equipment and tested using a universal testing machine under precise displacement control. The variables that will be investigated include the temperature at time of testing, embedded length of the bar, overlap length between bars, bar spacing, side cover, and bar size.

Planning for this task is underway. A preliminary test procedure has been developed, and a meeting with the advisory panel, to finalize details of the tests, is expected shortly. Fabrication of the testing fixtures will commence as soon as the procedure is finalized and is expected to be completed over Summer 2021.

Task 4 – Development of Design Recommendations

The results of the non-contact lap-splice tests and the measured mechanical properties will be used to develop design recommendations for precast concrete closure joints using FRPC. These design recommendations will be used to develop example joint configurations for connecting common precast concrete superstructure elements, such as decked girders or precast deck panels.

No progress has yet been made on this task.

Task 5 – Interim and Final Reporting

The research team will submit timely quarterly reports, present annually at the Research Days meeting, and complete final report summarizing findings reached during the project.

This task in ongoing.

5. Expected Results and Specific Deliverables

The successful completion of the research project will directly impact the design/construction industry, by providing a better understanding of the properties of FRPC and its potential for use in closure joints between precast members, such as decked bulb tees, PCI NEXT beams, or precast deck panels. The main deliverable will be a report that summarizes:

- Recommendations for the selection of FRPC as a closure joint material in ABC applications,
- Design equations for the required development length of epoxy coated reinforcement embedded in FRPC, and
- Example closure joint geometry utilizing FRPC.

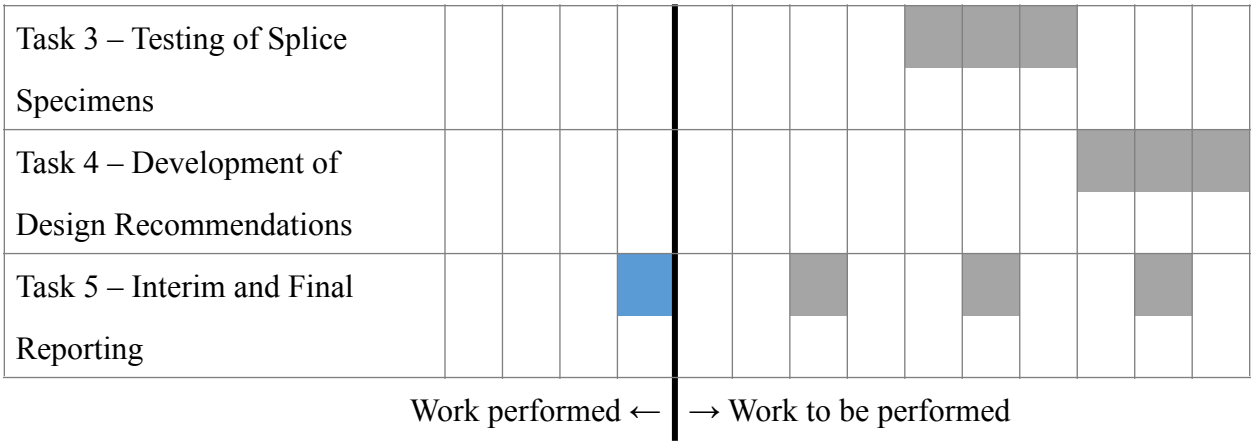
In addition, the results of the project will be summarized in a 5-min demonstration video and a journal publication.

6. Schedule

Progress on tasks in this project is shown in the tables below.

Item	% Completed
Percentage of Completion of this project to Date	15%

Research Tasks	2021											2022		
	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Task 1 – Literature Review														
Task 2 – FRPC Material Characterization														



7. References