TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): FHWA

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *TPF-5(468)*	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31, 2023) ◘Quarter 2 (April 1 – June 30, 2023) ☐Quarter 3 (July 1 – September 30, 2023) ☐Quarter 4 (October 1 – December 31, 2023)

Project Title: Structural Behavior of Ultra-High Performance Concrete		
Name of Project Manager(s): Ben Graybeal	**Phone Number:** 202-493-3122	**E-Mail:** benjamin.graybeal@dot.gov
Lead Agency Project ID: TPF-5(468)	**Other Project ID (i.e., contract #):** n/a	**Project Start Date:** January 2021
Original Project End Date: December 2025	**Current Project End Date:** December 2025	**Number of Extensions:** 0

Project schedule status:

◘ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$800,000	$400,000	45%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$*40,000 and 5%*	$40,000	5%

Project Description:

Ultra-high performance concrete (UHPC) is the next generation of concrete, a concrete whose mechanical and durability properties far exceed those of conventional concretes. UHPC combines together a set of advancements in concrete technology from recent decades to create a concrete with compressive strengths at or greater than approximately 20 ksi, sustained post-cracking tensile strength at or greater than 750 psi, and a discontinuous pore structure that reduces permeability by an order of magnitude. During the past 10 years, UHPC has found significant usage in the US bridge sector as a field-cast grout cast between prefabricated bridge elements; effectively, UHPC enabled novel accelerated bridge construction methods to flourish. As the awareness of UHPC capabilities as grown, interest has turned toward using UHPC for primary structural elements in bridges. The handful of primary structural component deployments in the US so far (e.g., a few pretensioned girders, a few precast bridge decks, a few piles) have been completed as experimental deployments by innovative departments of transportation. Mainstreaming of this technology will require a broader knowledge base and greater standardization of engineering practices. Researchers at the FHWA Turner-Fairbank Highway Research Center have been leaders in advancing UHPC technology for the bridge sector for nearly two decades. The proposed project will allow them to broaden the scope of their efforts and thus provide more substantial input to the AASHTO community as formal guidance for the design of UHPC components is developed. The objective of the TPF project is to develop knowledge pertinent to the structural performance of UHPC. This knowledge will be of significant value as the AASHTO Committee on Bridges and Structures considers the use of UHPC-class materials in highway bridges and structures. The proposed project is focused on the design, fabrication, performance, and analysis of UHPC components. It is anticipated that various UHPC components will be designed, fabricated, and tested. The test results will be analyzed and used to inform proposed structural design guidance for UHPC components. Results will also be used to support usage of UHPC by interested departments of transportation. It is anticipated that bridge superstructure components (e.g., pretensioned girders) will be a significant part of this study, with behaviors related to flexure, shear, and end zones being investigated. Other components may be investigated based on available resources and the interest of participating partners.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

- AASHTO *Guide Specification for Structural Design with Ultra-High Performance Concrete*
    - Supported AASHTO Committee on Bridges and Structures (CBS) as they evaluated and balloted the FHWA proposed draft of the structural design guidance. FHWA team fielded questions, suggested updates, and proposed revisions. Ballot passed unanimously on May 25, 2023.
    - The FHWA team continued to develop and refine the draft UHPC Materials Conformance Guidance that will parallel the UHPC Structural Design Guide Specification. A third draft was provided to AASHTO T-10 for their consideration. A series of meeting to discuss this document are anticipated in 2023.
- The research team continues to work on publishing the results of a completed experimental study verifying the applicability of non-servo hydraulic loading frames in performing direct tension tests of UHPC specimens in accordance with AASHTO T 397. The research team is working to publish this work in the form of a journal paper.
- Fatigue Behavior of UHPC Beams.
    - Continued to work on investigating the tensile fatigue behavior of UHPC beams with the goal of refining the fatigue provisions proposed in the UHPC Guide Spec draft. The research team plans to conduct fatigue tests on existing large-scale UHPC girders that remained from a previous testing program that focused on UHPC prestressed girder behavior under static shear or flexure loading. The planned experimental work will subject the untested portions of the prestressed girders to repetitive cycles of loads and document any degradations in strength and stiffness as compared to those observed in the static testing of these girders.
    - Cyclic testing of the first test specimen was completed. The pretensioned girder underwent more than 8 million cycles of cyclic loading with the peak stress on each cycle exceeding the cracking stress of the web in shear. The shear resistance of the girder eventually degraded, a shear crack opened, and the cycling was stopped.
- Development Length of Prestessing Strands in UHPC
    - Initiated testing of 12 pretensioned beams containing either 0.6” or 0.7” strands. The six beams that each contained one strand were tested, and the remaining 6 (each having 3 strands) will be tested next.
    - Large block pullout tests that are companions to the pretensioned beam tests were also completed.
- Flexural Behavior of Heavily Reinforced UHPC

- A suite of beams has been fabricated and currently are awaiting test at FHWA-TFHRC. Precursor material testing has begun.

Anticipated work next quarter:

- Continue to support AASHTO Committee on Bridges and Structures (CBS) subcommittee T-10 on Structural Concrete to evaluate FHWA proposed draft UHPC Materials Conformance Guidance that has been requested by T-10.
- Continue work on a journal paper draft detailing the results of the experimental investigation utilizing servo-hydraulic and non-servo hydraulic loading frames in performing direct tension tests of UHPC specimens in accordance with AASHTO T 397.
- Work towards publishing an FHWA report on UHPC design recommendations and examples highlighting the analysis of a rectangular mild steel reinforced UHPC beam and a pretensioned UHPC I-Beam with a conventional concrete deck. This report is late in the editorial stage and publication is anticipated late in 2023Q3.
- Continue work on the UHPC tensile fatigue behavior project: begin cycling second girder.
- Continue testing of 12 pretensioned beams that were designed to investigate the development length of prestressing strands.

Significant Results:

- The AASHTO *Guide Specification on Structural Design with UHPC* is almost entirely based on the content that FHWA's team developed for their consideration. The document was successfully balloted by AASHTO on May 25, 2023.
- An FHWA report covering the technical content of the draft AASHTO Guide Spec on Structural Design with UHPC as well as two structural analysis and design examples is progressing toward publication in mid-2023.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None.

Potential Implementation:

The study team is actively engaging the nine contributing State DOTs to solicit their feedback and to ensure that the results are applicable. In short, the study team in partnering with the contributors to continually adjust the direction of the project into the most beneficial direction. It is anticipated that this method of project scoping and management will ensure that the project results are implementable by at least many of the contributing DOTs.