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, 2022) ☐ Quarter 2 (April 1 – June 30, 2022) ☐ Quarter 3 (July 1 – September 30, 2022) ☐ Quarter 4 (October 1 – December 31, 2022)

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	$200,000	25%

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.):

- Continued to support AASHTO Committee on Bridges and Structures (CBS) subcommittee T-10 on Structural Concrete to evaluate FHWA proposed draft of an “AASHTO Guide Specification for Structural Design with Ultra-High Performance Concrete” for possible adoption.
    - The research team at FHWA responded to all comments received by January 31, 2022 and delivered new versions of all prepared documents to the chair of AASHTO CBS T-10. The documents include new versions of the UHPC Guide Spec draft (i.e. v1.2), two comment sheets detailing the responses to comments made by the members and friends of T-10, and two examples highlighting the analysis of a rectangular mild steel reinforced UHPC beam and a pretensioned UHPC I-Beam with a conventional concrete deck. AASHTO CBS T-10 will use those documents as a basis for the development of a UHPC Guide Spec document that may be adopted.
    - On March 1, 2022, the team at FHWA submitted written responses to a few questions inquired by Modjeski and Masters, Inc., as part of their contract with AASHTO CBS T-10 to review the UHPC Guide Spec draft. The questions and answers focused on UHPC mechanical behavior in compression and tension, creep behavior of UHPC, and flexural behavior of UHPC elements.
    - The team met with AASHTO CBS T-10 and supported the discussion on the UHPC design concepts proposed in the Guide Spec draft. The meetings were held on February 22, 2022 (virtual meeting), March 3, 2022 (in-person in Kansas City, MO), and March 21, 2022 (virtual meeting).
- Continued the development of visual aids to assist users in performing the soon-to-be-published AASHTO T 397 “Standard Method of Test for Uniaxial Tensile Response of Ultra-High Performance Concrete”.
- 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.
- Executed seven experimental tests (Phase I) in the research project focused on prestressing strand development length in UHPC. The results verified the test method for evaluating the development length of

various strand diameters in UHPC-class materials and provided a reference for efficiently conducting future tests.

- 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. Work on this project during the past quarter included designing the test setup and cutting off the previously tested portion of the girders.
- Continue to work on a parametric study to investigate the effects of various input material, geometrical, and design characteristics on UHPC bridge girder behavior and the development of design aids for designing UHPC bridges. The study aims to provide designers with support to enable the appropriate use of UHPC's improved material behaviors in the design of highway bridges.
- Started a new research project focused on further investigation of the shear behavior of UHPC girders, the flexural behavior of prestressed and non-prestressed UHPC beams, the transfer and development length of 0.6 in. and 0.7 in. prestressing strands in UHPC beams, and the early age creep of prestressed beams and piles.
    - The design calculations and shop drawing of the planned 29 large-scale UHPC components have been finalized.
    - The research team plans to fabricate these components at one or multiple precaster plants using one or multiple available UHPC materials and test them at TFHRC. A solicitation to various UHPC suppliers and precasters was put out for bids.

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 of an "AASHTO Guide Specification for Structural Design with Ultra-High Performance Concrete" for possible adoption. Perform parametric studies and prepare visual aids to facilitate discussions and highlight concepts. Continue to work on the parametric study to investigate the effects of various input material, geometrical, and design characteristics on UHPC bridge girder behavior and the development of design aids for designing UHPC bridges. The study aims to provide designers with support to enable the appropriate use of UHPC's improved material behaviors in the design of highway bridges.
- Finalize 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.
- Execute experimental tests on the remaining initial test specimens for the prestressing strand development length project.
- Continue work on the UHPC tensile fatigue behavior project: finalize the workplan, build the test setup, and start cycling the first girder.
- Start the procurement process of the planned UHPC large-scale components: construction schedule, instrumentation plans, testing of the UHPC materials supplied by the selected precasters and/or suppliers, and preparing instrumentation for quick installation in fresh UHPC during construction.
- Develop work plans for testing the procured components at TFHRC.

Significant Results:

- Delivered new versions of all prepared documents to the chair of AASHTO CBS T-10. The documents include new versions of the UHPC Guide Spec draft (i.e. v1.2), two comment sheets detailing the responses to comments made by members and friends of T-10, and two examples highlighting the analysis of rectangular mild steel reinforced UHPC beam and a pretensioned UHPC I-Beam bridge with conventional concrete deck; Supported AASHTO CBS T-10 discussions in various meetings on the structural concepts detailed in the proposed UHPC guide spec.

- Executed the seven experimental tests on the initial test specimens for the prestressing strand development length project; the results verified the test method for evaluating the development length of various strand diameters in UHPC-class materials and provided a reference for further improvement.
- Finalized test setup for tensile fatigue testing of large-scale UHPC girders.
- Finalized designs for 29 large-scale UHPC component for testing at TFHRC; these tests focus further investigating the shear behavior of UHPC girders, the flexural behavior of prestressed and non-prestressed UHPC beams, the transfer and development length of 0.6 in. and 0.7 in. prestressing strands in UHPC beams, and the early age creep of prestressed beams and piles.

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.