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	$280,000	30%

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.
    - On July 21, 2022, the team at FHWA submitted written responses to the third set of 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 creep, shrinkage, and modulus of elasticity of UHPC and camber 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 July 18, 2022 (virtual meeting), August 3, 2022 (virtual meeting), August 22, 2022 (virtual meeting), September 19, 2022 (virtual meeting), and September 20, 2022 (in-person in Rosemont, IL).
    - At the September 20, 2022 meeting T-10 decided to use the FHWA proposed draft of the Guide Specification for Structural Design with UHPC as the framework and baseline upon which its further discussions would be built. T-10 also asked the FHWA team to develop a parallel document that speaks to the aspects of materials conformance pertaining to qualification testing and quality control testing.
- AASHTO T 397 "Standard Method of Test for Uniaxial Tensile Response of Ultra-High Performance Concrete" was published by AASHTO and is available for anyone to use as a standardized test that reports UHPC tensile properties.
- 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.
- 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.

- For this project, the previously tested portion of the girders is cut out of the existing girders, and the untested portions of the girders are ready for fatigue testing.
- The test setup was designed and erected; the needed instrumentation devices are calibrated. The cycling of the pilot girder was delayed due to required laboratory maintenance actions and the precedence of other high priority projects. The cycling is anticipated to begin by the end of 2022.

· A new research project at TFHRC has been kicked off. The project focuses on further investigation of the shear behavior of real-scale 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.

- Fabrication of approximately half of the tests specimens has been completed. These specimens were fabricated at a precast plant in Pennsylvania. The first of these test specimens have been delivered to FHWA's research lab.
- The other half of the test specimens will be fabricated by a separate precast plant. The date of fabrication has yet to be scheduled but is anticipated to be within the next 3 months.

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 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.

· Continue work on the UHPC tensile fatigue behavior project: start cycling the first girder.

· Fabricate remainder of 54 UHPC girders and beams and 18 development length pullout blocks for testing at TFHRC.

Significant Results:

· Draft proposed Guide Specification for Structural Design with UHPC was selected by AASHTO T-10 to be the framework upon which they build their intended AASHTO Guide Specification on Structural Design with UHPC.

· Fabricated first half of 54 large-scale UHPC component and 18 strand pullout blocks 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.