TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT):
________FHWA_______________________________________

INSTRUCTIONS:
Lead Agency contacts 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 #	**Transportation Pooled Fund Program - Report Period:**
TPF5-(521)	☐ Quarter 1 (January 1 – March 31) ■ Quarter 2 (April 1 – June 30) ☐ Quarter 3 (July 1 – September 30) ☐ Quarter 4 (October 1 – December 31)

TPF Study Number and Title:
TPF5(521) New Performance Approach to Evaluate ASR in Concrete

Lead Agency Contact:	**Lead Agency Phone Number:**	**Lead Agency E-Mail**
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Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
Original Project Start Date:	**Original Project End Date:**	**If Extension has been requested, updated project End Date:**
07/23/2023	12/31/2028	

Project schedule status:

■ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Funds Expended This Quarter	Percentage of Work Completed to Date
$315,000	$66,952	37.33%

Project Description:
The Turner-Fairbank Highway Research center has developed two new alkali–silica reaction (ASR) tests, the AASHTO TP-144-23 (T-FAST) and the AASHTO T 416-24 (ATT). The T-FAST is sensitive method capable of accurately detecting the presence of alkali–silica reactive phases in any type of aggregate. The ATT is a simple and reliable method to determine the alkali threshold (AT) of any aggregate combination. The AT is defined as the specific alkali level at which the ASR reaction is triggered in an aggregate. Knowing the AT of an aggregate combination is an important piece of

information that provides insight into the field behavior of the aggregates when used in a concrete of specific alkali loading.

A new performance and prescriptive approach have been proposed based on the information provided by the T-FAST and ATT to predict the alkali–silica susceptibility of any concrete mix design. The two newly proposed approaches are based in the widely accepted notion that any given combination of aggregates will develop ASR inside of a specific concrete only when the alkali loading (AL) of the concrete is higher than the AT of the aggregates. The AL of the concrete depends on the mix design proportions, type and content of the cement, and the presence of supplementary cementitious materials. While previous research supports the theory that ASR can be prevented by limiting AL below AT, there is a need to understand the extent of the influence played by available alkalis and aluminum released by SCM in the AL of the concrete and AT of the aggregates, respectively. Lastly, it is also necessary to expand T-FAST capabilities to evaluate ASR mitigation strategies. This is a requirement because it is not always possible to avoid the use of reactive aggregates due to lack of availability or other reasons.

The principal objective of the project is to evaluate a wide selection of concrete mix designs to validate the use of T-FAST and ATT methods in conjunction with mix design data, cement mill reports and SCM properties to determine the likelihood of ASR gel formation in concrete.

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

Task 1: Selection of Aggregates and characterization using TFHRC toolkit tests

During this quarter, the TPF Team continued to measure the combined alkali thresholds (AT_{Mx}) of various concrete mixes. The team measured 9 AT_{Mx} values for mixes from South Dakota. Table 1 summarizes the binder content and AT_{Mx} values of the 9 mixes.

Table 1. Concrete Mix Design to Measure AT_{Mx}.

Mix ID	Coarse Agg ID #1	Coarse Agg ID # 2	Coarse Agg ID # 3	Fine Agg ID	Binder Content (kg/m^3)	AT_{Mx} (kg Na_2O_{eq}/m^3)
SD Mix M1CMD1	SD-CA1	N/A	N/A	SD-FA1	367	2.6
SD Mix M1PCC460	SD-CA1	N/A	N/A	SD-FA1	390	2.1
SD Mix M1CMD2	SD-CA1	N/A	N/A	SD-FA1	419	1.8
SD Mix M2CMD1	SD-CA2	N/A	N/A	SD-FA2	367	R
SD Mix M2PCC460	SD-CA2	N/A	N/A	SD-FA2	390	R
SD Mix M2CMD2	SD-CA2	N/A	N/A	SD-FA2	419	R
SD Mix M3CMD1	SD-CA1	N/A	N/A	SD-FA3	367	1.7
SD Mix M3PCC460	SD-CA1	N/A	N/A	SD-FA3	390	1.8
SD Mix M3CMD2	SD-CA1	N/A	N/A	SD-FA3	419	1.8

N/A = not applicable; R = repeat

Task 2. Characterization of supplementary cementitious materials (SCM)

The team conducted processing and analysis of Raman spectra obtained from SCM samples embedded in epoxy. The analysis identified significant fluorescence interference within a substantial portion of the spectra. To mitigate this issue, the team investigated the use of potassium bromide (KBr) as an alternative embedding medium for Raman imaging of SCM samples. Several pressed pellets of Class C fly ash were prepared using a manual hydraulic press and a dry pellet pressing die, employing KBr as the flux. These experiments aimed to determine the optimal sample-to-flux ratio.

Task 3: Prepare Concrete Samples

During this quarter the team completed mixing and casting of cylinders for pore solution analysis and paste cylinders with embedded resistivity sensors for three ordinary portland cement (OPC) mixes: a control (100% OPC), an OPC–nanosilica blend, and an OPC–BCSA blend. Sufficient specimens were prepared to extract pore solution at 7, 21, and 28 days. Prior to the expression experiments, the team ran optimization trials to the improve pore-solution extraction process; these trials involved using filter paper to prevent channel clogging in the extraction rig and adjusted the loading rate and maximum applied pressure. After finalizing the extraction protocol, pore-solution expression was completed for all three mixes at 7, 21, and 28 days. Concentrations of sodium (Na), potassium (K), calcium (Ca), aluminum (Al), sulfur (S), and silicon (Si) in the pore-solution samples were measured using an inductively coupled plasma (ICP) spectrometer. Results indicate a slight decrease in alkali content in samples containing nanosilica after 28 days of curing. In parallel, the team continuously monitored paste resistivity for all specimens from the three mixes.

Anticipated work next quarter:

- Perform XRD analysis and perform a qualitative analysis of the mineral phases that may be present in the 6 SCMs.
- Prepare fly ash pressed pellets with established protocol using KBr and collect Raman spectra.
- Collect a 0.33% Na_2O_{eq} OPC based on the AT_{Mx} of the aggregate combinations and pore solution experiments for the Alaska aggregates.
- Batch two concrete mixes using the Alaska aggregates.
- Perform SEM analysis from two Pennsylvania concrete mixes that are 12 months old.
- Prepare SEM specimens from two Pennsylvania concrete mixes that are 12 months old for analysis.

Significant Results:

None

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:

None