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: 07/23/2023	**Original Project End Date:** 12/31/2028	**If Extension has been requested, updated project End Date:**

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	$70,611	39%

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 completed measurements of the combined alkali thresholds (AT_{Mx}) for all coarse–fine aggregate combinations. Based on the AT_{Mx} results for 34 aggregate candidates, the team selected 16 concrete mix designs to evaluate the goals outlined in Task 3. The concrete mixes were divided into three groups:

- Class 1: mixes with a field history of more than 15 years, available accelerated physical expansion data, original mix design information, and well-documented ASR field performance.
- Class 2: mixes used in pavement for more than 15 years, with available accelerated physical expansion data and original mix design information.
- Class 3: mixes used in pavement for more than 15 years, with available accelerated physical expansion data (original mix design information is not available).

Table 1 summarizes the key information for each selected mix design.

Table 1. Final Concrete Mix Design list for Task 3.

Task 3 Objective	Mix Class	Mix ID	AT_{Mx} (lb Na_2O_{eq}/yd^3)	Binder Content (lb/yd^3)	Cement Type (Na_2O_{eq} %)	Alkali loading (lb Na_2O_{eq}/yd^3)
1	1	KCA Mix B5-700	3	700	Type I/II (0.44)	3.08
	1	MA Mix B26-708	3.2	708	Type I/II (0.66)	4.67
	1	AK Mix CA564HA	2.53	564	Type I/II (0.57)	3.21
	1	TX Mix C6-708	10.96	708	Type I/II (1)	7.01
	1	TX Mix C16-708	2.36	708	Type I/II (1)	7.01
	3	AK Mix CA564LA	2.53	564	Type I/II (0.33)	1.86
2	3	NC Mix CA176CMD2-25	5.73	707	Type I/II (0.77)	5.44
	3	NC Mix CA176CMD2-15	5.73	707	Type I/II (0.77)	5.44
3	1	AR Mix VS-518	6	518	Type I/II (1)	5.18
	1	MA Mix B1-708	2.5	708	Type I/II (1.11)	7.86
	1	NC Mix CA21CMD23	3.8	707	Type I/II (0.54)	3.82
	1	NC Mix CA100CMD16	5.06	619	Type I/II (0.55)	3.4
	2	PAMix GTC15	1.85	588	Type I/II (0.99)	5.82
	2	PAMix GTC25	1.85	611	Type I/II (0.99)	6.05
	3	CT Mix PCC04460-20	2.7	658	IL (12) (0.87)	5.72
	3	SDMix_M1CMD1 15	4.21	619	IL (10) (0.57)	3.53

Of the 16 selected mixes, six were chosen to validate the No-ASR criteria (alkali loading < AT_{Mx}) in the ASR risk-assessment chart (Goal 1, Task 3), two to optimize SCM addition (Goal 2, Task 3), and eight to validate recommended prevention strategies in the ASR risk-assessment chart (Goal 3, Task 3). In parallel, results from all 16 mixes will be used to develop a new job mix test (JMT).

Task 2. Characterization of supplementary cementitious materials (SCM)

The TPF team prepared pressed pellets of a Class-C fly ash with four KBr dosages (0%, 5%, 10%, and 15%). The 15% KBr formulation produced reasonably stable pellets. Raman spectra were collected over 250 × 250 µm areas and were of satisfactory quality, with very minimal spectral interference from KBr. The team then applied a recently developed Raman imaging method based on non-negative matrix factorization (NMF) to analyze the fly-ash + KBr spectra. This approach identified approximately 15 phases (including KBr) and successfully mapped about 87% of the scanned area.

Task 3: Prepare Concrete Samples

During this quarter, the TPF team shared pore-solution analysis data for the control, nanosilica, and BCSA cement paste samples with concrete-resistivity sensor manufacturers for comparison with resistivity measurements. Because the pore-solution results did not show meaningful differences in alkali loading among the three mixtures, the AKDOT concrete mixes for the pooled-fund study will be prepared using low-alkali cement to reach the target alkali loading.
In parallel, the TPF team completed cutting ten concrete sections (2" × 1" × 0.5") from cylinders of the two Pennsylvania mixes (PAMix GTC15 and PAMix GTC25). Cutting was performed using two oil-cooled table saws and a slow-speed precision saw. The team sent the samples for embedding in epoxy resin, lapping and polishing.

Anticipated work next quarter:

- Request cements for the concrete mixes listed in Table 1.
- Continue XRF and XRD analysis of the 10 in house SCMs.
- Batch two concrete mixes (TX Mix C6 708 and TX Mix C16 708).
- Adapt the DRI protocol for SEM analysis and complete analysis of the 12-month samples from the two Pennsylvania mixes (PAMix GTC15 and PAMix GTC25).

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