TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): ____Kansas DOT_____

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(336)*	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) 2018 ☐Quarter 2 (April 1 – June 30) ✕Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 1 – December 31)

Project Title: Construction of Low-Cracking High-Performance Bridge Decks Incorporating New Technology		
Project Manager: David Meggers	**Phone:** 785-291-3844	**E-mail:** Dave.Meggers@ks.gov
Project Investigator: David Darwin	**Phone:** 785-864-3827	**E-mail:** daved@ku.edu

Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:** **January 1, 2016**
Original Project End Date: **December 31, 2018**	**Current Project End Date:** **December 31, 2018**	**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	Total Percentage of Work Completed
$270,000	$241,444.61	90%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$55,859.03	$55,859.03	10%

Project Description:

Bridge decks constructed using low-cracking high-performance concrete (LC-HPC) have performed exceedingly well when compared with bridge decks constructed using conventional procedures. The LC-HPC decks have been constructed using 100% portland cement concretes with low cement paste contents, lower concrete slumps, controlled concrete temperature, minimum finishing, and the early initiation of extended curing. Methods to further minimize cracking, such as internal curing in conjunction with selected supplementary cementitious materials, shrinkage-reducing admixtures, shrinkage-compensating admixtures, and fibers have yet to be applied in conjunction with the LC-HPC approach to bridge-deck construction. Laboratory research and limited field applications have demonstrated that the use of two new technologies, (1) internal curing provided through the use of pre-wetted fine lightweight aggregate in combination with slag cement, with or without small quantities of silica fume, and (2) shrinkage compensating admixtures, can reduce cracking below values obtained using current LC-HPC specifications. The goal of this project is to apply these technologies to new bridge deck construction in Kansas and Minnesota and establish their effectiveness in practice.

The purpose of this study is to implement new technologies in conjunction with LC-HPC specifications to improve bridge deck life through reduction of cracking. The work involves cooperation between state departments of transportation (DOTs), material suppliers, contractors, and designers. The following tasks will be performed to achieve this objective.

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

TASK 1: Work with state DOTs on specifications for the construction of six LC-HPC bridge decks per state to be constructed over a three-year period.

All internally cured LC-HPC bridge decks for this project have been constructed. Documentation from the 2018 bridge deck is included in the June 2018 report.

100% COMPLETE

TASK 2: Provide on-site guidance during construction of the LC-HPC bridge decks.

100% COMPLETE

TASK 3: Perform detailed crack surveys on the bridge decks, 1 year, 2-3 years, and (if approved) 4-5 years after construction. Prior research has demonstrated that it takes at least three years to consistently establish the long-term cracking performance of a bridge deck. The surveys will be performed using techniques developed at the University of Kansas to identify and measure all cracks visible on the upper surface of the bridge deck. If desired, DOT personal will be trained in the survey techniques and may assist in the surveys, as appropriate.

Crack surveys for this project have been completed and were presented in the June 2018 report.

100% COMPLETE

TASK 4: Correlate the cracking measured in Task 3 with environmental and site conditions, construction techniques, design specifications, and material properties, and compare with results obtained on earlier conventional and LC-HPC bridge decks.

This task will be completed with submission of the final report for this project phase next quarter.

0% COMPLETE

TASK 5: Document the results of the study. Interim and final reports will be prepared covering the findings in Tasks 1-4.

The final report will be completed and submitted next quarter.

60% COMPLETE

Anticipated work next quarter:

Laboratory testing of concrete mixtures with internal curing will continue to be evaluated by KU researchers, including series of mixtures replicating 2017 and 2018 MnDOT internally cured concrete mix proportions.

Two series of laboratory mixtures using materials from the construction of the internally cured bridge deck from this year have been cast and are currently undergoing testing. Both series include a *w/cm* of 0.43, paste content of 26%, and different quantities of internal curing water that range from 0 to 12 lb/cwt. One series contains 28% slag by weight of binder and the other includes only portland cement as binder. Shrinkage, durability, and permeability testing will be completed for these mixtures, similar to the previous two years.

Significant Results this quarter:

Similar to previous years, the Job Mix Formula (JMF) for the 2018 contains nominally 8 lb/cwt of internal curing water and 28% slag by weight of binder. For concrete mixtures using materials from bridge decks placed in 2016 and 2017, a majority of concrete mixtures completed freeze-thaw testing with more than 100% of their initial dynamic modulus remaining. This included mixtures with internal curing amounts ranging between 5 and 9 lb/cwt. Only one mixture from 2017 contained a greater amount of internal curing water (14 lb/cwt) but still completed 300 cycles with 92% of its initial dynamic modulus (dropping below 90% shortly after). MnDOT specifications state that concrete mixtures are to maintain at least 90% of their initial dynamic modulus after 300 freeze-thaw cycles. For mixtures cast using materials from the 2018 project, freeze-thaw damage has been observed in significantly fewer cycles. During freeze-thaw testing of this year's concrete mixtures (for those that contain 28% slag by weight of binder and internal curing), significant damage was noted in mixtures with 8 lb/cwt or more of internal curing water. The 2018 mixture containing 28% slag and 12 lb/cwt of internal curing water dropped below 90% of its initial dynamic modulus in less than 100 cycles and below 60% after approximately 125 cycles. When batched in KU labs, the first 2018 JMF mixture exhibited behavior similar to the mixture containing 10 lb/cwt of internal curing water with both mixtures dropping below 90% of their initial dynamic moduli after approximately 200 cycles and below 60% in approximately 250 cycles. The 2018 JMF mixture has since been recast and will begin testing next quarter. It is expected that based on the unit weight of the first JMF mixture being lower than any other mixture in the series of mixtures with 28% slag and internal curing, the actual air content was significantly higher than the other mixtures in this series. This observation is reinforced by the compressive strength of the first JMF mixture being 15-20% lower than the other mixtures in this series. In terms of freeze-thaw durability, a higher air content likely produced larger air bubbles as opposed to more bubbles and with a smaller spacing factor. Coupled with a lower compressive strength, these attributes likely led to early deterioration. Results for the recast JMF mixture will be presented in the final report, next quarter. The other mixtures in this series, which contain 0-6.8 lb/cwt of internal curing water, are maintaining at least 100% of their initial dynamic modulus after 250 freeze-thaw cycles. Mixtures containing 100% portland cement as binder have only recently started durability testing and will also be completed next quarter.

To date, results for free shrinkage on the 2018 mixtures have been similar to the previous two years, with mixtures being within the MnDOT specification limit of 400 microstrain after 28 days of drying. Rapid chloride permeability (RCP) test results for the 2018 mixtures containing 28% slag by weight of binder have been similar to results obtained during the previous two years. All RCP test results for the series of mixtures with slag and internal curing have been within MnDOT specification limits for both 28 and 56-day tests with internally cured mixtures showing improved results compared to mixtures without internal curing. Scaling tests for of the 2018 mixtures containing 28% slag (with and without internal curing) have also averaged *lower* mass loss values and better visual ratings than in the previous two years, with all mixtures being within MnDOT specification limits for visual ratings (1 or less at the end of testing per ASTM C672), *including the mixtures that failed freeze-thaw testing*.

Circumstances 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).

The second internally cured bridge for Minnesota in 2016 was not successfully completed, and as previously indicated by MnDOT, a replacement bridge is not planned. Construction schedules for the internally cured bridges originally slated for 2018 have been delayed until 2019. One replacement project was identified as the 38th St. bridge over I-35W in Minneapolis that was placed last quarter. A second replacement deck for 2018 using internal curing was abandoned due to contract negotiations over the concrete change order. KU, however, is prepared to work with MnDOT if the decision is made to include replacement bridges in the study during the planned three-year extension of the project.