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 #	**Transportation Pooled Fund Program - Report Period:**
TPF-5(336)	☐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

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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:** **July 31, 2019**	**Number of Extensions:** 1

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	$270,000	96%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$28,555.39	$28,555.39	6%

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.

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 has been drafted and will be submitted early in the next quarter.

90% COMPLETE

Anticipated work next quarter:

The final report will be completed and submitted.

The following work will be done under the successor project scheduled to begin January 1, 2019:

Laboratory testing of concrete mixtures replicating 2018 MnDOT internally cured concrete mix proportions will continue to be evaluated by KU researchers.

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. Lightweight aggregate in these mixtures was soaked for 72 hours prior to casting to reach a constant absorption and provide the design amount of internal curing water. One series contains 28% slag cement by weight of binder and the other includes only portland cement as binder. Shrinkage, durability, and permeability testing are being completed for these mixtures, similar to the previous two years. For the mixture containing a 28% replacement of portland cement with slag cement and 12 lb/cwt of internal curing water, duplicate mixtures have been cast with the same volume of lightweight aggregate (17.6% of the total aggregate volume) but with varied soaking times. These mixtures are being tested to determine whether the volume of lightweight aggregate, the amount of internal curing water, or the amount of water absorbed in the aggregate is more detrimental in freeze-thaw testing.

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 cement by weight of binder and internal curing), significant damage was noted in mixtures with 8 lb/cwt or more of internal curing water. For both 100% portland cement and 28% slag cement mixtures, a higher amount of internal curing water has resulted in fewer freeze-thaw cycles needed to drop test specimens below 90% of their initial dynamic modulus value. For a given amount of internal curing water, mixtures with 100% portland cement required more cycles to produce this damage than those with 28% slag cement. The only mixture with 100% portland cement as binder that dropped below 90% of its initial dynamic modulus in less than 300 cycles was the one that contained 12 lb/cwt of internal curing water. For the mixtures with 28% slag by weight of binder, 17.6% lightweight aggregate by total aggregate volume, and varied soaking times for the lightweight aggregate (5 minutes to 72 hours), the resultant amount of internal curing water has ranged between 7.0 and 12.1 lb/cwt. For freeze-thaw test results to date, the mixture with a 5-minute soak for the lightweight aggregate (resulting in 7.7 lb/cwt of internal curing water) required more cycles to drop specimens below 90% of its initial dynamic modulus than mixtures with lightweight aggregate soaked for 72 hours. Additionally, the mixture with 17.6% lightweight aggregate and 7.7 lb/cwt internal curing water also required more cycles to cause this amount of damage compared to the mixtures with 10.9-11.6% lightweight aggregate and 7.8-8.0 lb/cwt of intern curing water. These results indicate that the amount of absorbed water in the lightweight aggregate is more influential on freeze-thaw durability than the amount of internal curing water. These mixtures have since been recast to verify these observations and will continue testing next quarter.

Free shrinkage test results for the 2018 mixtures have been similar to the previous two years, with all mixtures being within the MnDOT specification limit of 400 microstrain after 28 days of drying. Regardless of binder composition, mixtures with higher amounts of internal curing water have resulted in less drying shrinkage through 30 days than those with lower amounts or no internal curing. 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. Mixtures with 100% portland cement have exceeded specification limits for RCP test results, similar to the previous two years. Regardless of binder composition, the internally cured mixtures have showed improved RCP results compared to mixtures without internal curing. Scaling tests for of the 2018 mixtures (with and without internal curing) have also averaged *lower* mass loss values and better visual ratings than in the previous two years. All mixtures containing 28% slag cement were 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*. For the 100% portland cement mixtures, the highest mass loss and associated visual ratings (2) were associated with the mixture without any internal curing followed by the one with the highest amount in that series (12 lb/cwt).

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 next phase of the project.