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(392)	☒Quarter 1 (January 1 – March 31) 2021 ☐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: Dan Wadley	**Phone:** 785-291-2718	**E-mail:** Dan.Wadley@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, 2019**
Original Project End Date: **December 31, 2021**	**Current Project End Date:** **December 31, 2021**	**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
$390,000	$202,499.99	65%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$13,584.53	$13,584.53	5%

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. LC-HPC decks constructed prior to 2016 have included only portland cement as a cementitious material. Four LC-HPC decks were constructed between 2016 and 2018 and include a partial replacement of portland cement with slag cement along with internal curing through a pre-wetted fine lightweight aggregate. All LC-HPC projects used concrete with low cement paste contents and lower concrete slumps, along with controlled concrete temperature, minimum finishing, and the early initiation of extended curing. Methods to further minimize cracking–such as 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.

In 2020, the current study was expanded to perform crack surveys on an additional 20 bridge decks per year for two years in Minnesota to correlate the cracking on those decks with environmental and site conditions, construction techniques, design specifications, and material properties, and compare them with results obtained from previously studied conventional and LC-HPC bridge decks, as is currently being done for the newly constructed decks. The results of this expanded effort will be documented in project reports. MnDOT will select the bridges and provide plans and specifications, dates of construction, concrete mixture proportions, material test reports, and observations recorded during construction, if any, as well as traffic control during bridge deck crack surveys.

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

TASK 1: Work with state DOTs on specifications for LC-HPC bridge decks to be constructed over the three-year period of performance of this project.

Two more internally-cured LC-HPC bridge decks are planned for Kansas and anticipated to be placed in summer 2021. The first bridge deck is located on 199th St. over I-35. The second bridge deck is located on K-33 over BNSF Rail Road.

70% COMPLETE

TASK 2: Provide laboratory support prior to construction and on-site guidance during construction of the LC-HPC bridge decks.

A series of concrete mixtures were cast to assess if freeze-thaw durability of concrete as a function of the total weight of the binder or the amount of absorbed water in the lightweight aggregate (LWA). These mixtures have paste contents of either 23.7, 26.7 or 33.7%, contain 100% portland cement as the binder, and include nominal internal curing (IC) water contents of either 9 or 13% by the weight of binder. The mixtures contain a water-to-cement (*w/c*) ratio of either 0.41 or 0.45.

The mixtures are being evaluated for freeze-thaw durability following the regime specified in Kansas Department of Transportation (KDOT) Test Method KTMR-22, *Resistance of Concrete to Rapid Freezing and Thawing*, exposed to rapid freeze-thaw cycles as specified in ASTM C666 (Procedure B), scaling resistance in accordance with ASTM C672 and Canadian test BNQ NQ 2621-900, and compressive strength per ASTM C39. This work duplicates earlier work that followed MnDOT specifications, which requires the use of ASTM C666 (Procedure A).

66% COMPLETE

TASK 3: Perform detailed crack surveys on the bridge decks. If desired, DOT personal will be trained in the survey techniques and may assist in the surveys, as appropriate.

Six internally-cured bridge decks in Minnesota (38th and 40th St. over I-35W in Minneapolis, Dale Street in St Paul, Pokegama Lake Rd over I-35 in Pine City, and two bridge decks in Winona) and the bridge decks constructed in Kansas with internal curing water (Sunflower Rd. over I-35 and Montana Rd. bridge deck) will be surveyed in summer 2021.

Additional surveys will be performed on twenty bridge decks constructed in Minnesota with either low slump overlay or silica fume overlay, in summer 2021.

65% COMPLETE

TASK 4: Correlate the cracking measured under Objective 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.

KU researchers are working on drafting a report on cracking performance of twenty monolithic bridge decks with or without incorporating nonmetallic fibers surveyed in Minnesota, in summer 2020.

0% COMPLETE

TASK 5: Document the results of the study. Provide recommendations for changes in specifications.

0% COMPLETE

Anticipated work next quarter:

Laboratory testing of concrete mixtures with different quantities of internal curing, paste contents, and water-to-cement ratios will continue to be evaluated.

Future meetings and conference calls will be held. Pre-construction meetings will be held with representatives from KU, KDOT, and the contractors to discuss the details of mixture proportions and construction procedures.

Significant Results this quarter:

This quarter, freeze-thaw resistance testing was completed on the IC mixtures with paste contents of either 23.7 or 33.7%, with nominal IC water contents of either 9 or 13% (by the weight of binder), and a *w/c* ratio of 0.45. The mixtures were tested in accordance with ASTM C666 (Procedure A) with a failure limit of 90% of the initial dynamic modulus of elasticity. The results indicate that increasing the quantity of IC water (from 9 to 13%) decreases the freeze-thaw durability of concrete mixtures, regardless of the paste content or quantity of LWA. The dynamic modulus of elasticity of the mixtures with 9% IC water content (by the weight of binder), with a paste contents of either 23.7% or 33.7%, dropped below 90% of the initial values after 250 and 230 cycles, respectively, and failed the test. The dynamic modulus of elasticity of the mixtures with 13% IC water content (by the weight of binder), with a paste contents of either 23.7% or 33.7%, dropped below 90% of the initial values in fewer cycles, after 169 and 150 cycles, respectively. Freeze-thaw testing of the IC mixtures with paste contents of either 23.7 or 33.7%, with nominal IC water contents of either 9 or 13% (by the weight of binder), and a *w/c* ratio of 0.41 is underway.

Freeze-thaw results for the mixtures followed the regime specified in KTMR-22, exposed to rapid freeze-thaw cycles as specified in ASTM C666 (Procedure B) will be presented next quarter.

The IC mixtures with paste contents of 23.7 or 33.7%, with nominal IC water contents of 9 or 13% (by the weight of binder), and a *w/c* ratio of 0.41 or 0.45 are being evaluated for scaling resistance, in accordance with ASTM C672 and Canadian test BNQ NQ 2621-900. The scaling results in accordance with ASTM C672 of the concrete mixtures with a 23.7% paste content, *w/c* ratio of 0.45, with nominal IC water contents of 9 or 13% by weight of binder showed a visual rating of (2) by the end of 35 and 25 freeze-thaw cycles, respectively, opposite of what would be expected. The paired mixtures exhibited mass losses of 0.05 and 0.08 lb/ft^2, respectively, by the end of 35 freeze-thaw cycles, slightly lower than the failure limit of 0.1 lb/ft^2 when tested in accordance with Canadian test BNQ NQ 2621-900.

The scaling results in accordance with ASTM C672 of the concrete mixtures with a 33.7% paste content, *w/c* ratio of 0.45, with nominal IC water contents of 9 or 13% by weight of binder showed a visual rating of (2) by the end of 20 freeze-thaw cycles. The paired mixtures exhibited mass losses of 0.04 and 0.06 lb/ft^2, respectively, by the end of 21 freeze-thaw cycles when tested in accordance with Canadian test BNQ NQ 2621-900. Overall, the mixtures tested in accordance with Canadian test BNQ NQ 2621-900 had lower mass losses than the paired mixtures tested in accordance with ASTM C672.

The test results also indicate as the paste content increased from 23.7 to 33.7%, the scaling resistance of the specimens considerably decreased. To clarify, for a given *w/c* ratio (either 0.41 or 0.45) and quantity of IC water (9 or 13%), the mixtures with a higher paste content had more mass loss than the mixtures with the lower paste content. As with results obtained from freeze-thaw test, reducing the *w/c* ratio from 0.45 to 0.41 improved the scaling resistance of the concrete mixtures.

Scaling results will be completed and provided in the next quarter.

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).

COVID-19 has resulted in a reduction of work in the laboratory. Existing specimens continue to be evaluated, but work on new mixtures has been slowed.