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) 2022 ☐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, 2019**
Original Project End Date: **December 31, 2021**	**Current Project End Date:** **December 31, 2023**	**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
$390,000.00	$386,158.23	90%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$178.96	$178.96	1%

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.

One more internally-cured bridge deck is planned for Kansas. Construction is anticipated in Spring 2023. This bridge is located on K-33 over a BNSF Railroad line.

95% COMPLETE

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

The laboratory testing of a series of concrete mixtures has been completed to evaluate the effects of total internal (TI) water provided by all aggregates (not just LWA), ranging from 7 to 17% by the weight of binder (corresponding to IC contents ranging from 0 to 14%) on the durability of concrete. The mixtures have different binder compositions (either 100% portland cement or 30% replacement of portland cement with slag cement) and contain either limestone or granite as coarse aggregate. The mixtures have a paste content of 24.2% and a water-to-cementitious material (*w/cm*) ratio of 0.43.

The mixtures were 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 in accordance with a modified version of BNQ NQ 2621-900 (with minor changes to temperature), and compressive strength in accordance with ASTM C39.
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93% 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.

Crack surveys will be performed for three internally-cured low-cracking high-performance concrete (IC-LC-HPC) bridge decks constructed in Kansas (Sunflower Rd., Montana Rd., 199th St. over I-35), in summer 2023.

90% 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 have submitted the first draft report (SL Report 22-1, on July 25, 2022) on the cracking performance of 19 monolithic bridge decks with or without incorporating nonmetallic fibers surveyed in Minnesota during summer 2020. It is now under the first revision after receiving MnDOT feedback on September 1, 2022. Additionally, a report on crack surveys of 19 bridge decks with either low slump or silica fume overlays, with or without nonmetallic fibers, and monolithic decks with or without nonmetallic fibers surveyed in Minnesota during summer 2021 has been drafted and is expected to be submitted by next quarter.

55% COMPLETE

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

55% COMPLETE

Anticipated work next quarter:

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, scaling resistance testing was completed on the IC mixtures with paste contents of 24.2%, total internal water (TI) contents in the range of 7 to 17% (by the weight of binder), and a *w/cm* ratio of 0.43, in accordance with Canadian test BNQ NQ 2621-900. As a general observation, mixtures with granite as the coarse aggregate exhibited lower mass losses (ranging from 0.008 to 0.073 lb/ft^2) than paired mixtures with limestone (ranging from 0.012 to 0.160 lb/ft^2) by the end of 56 freeze-thaw cycles. One possible reason for the higher scaling resistance of granite mixtures could be the lower absorption of granite (0.6% OD) mixtures compared to that of the limestone mixtures (1.8% OD). Mixtures with a partial replacement of portland cement with slag cement exhibited higher mass losses than mixtures with 100% portland cement, regardless of aggregate type. The results also indicate that increasing the quantity of TI water has different effects on scaling resistance depending on the binder composition. For mixtures with portland cement as the only binder, increasing the TI water content from 7 to 16% by weight of binder (0 to 13% IC water by the weight of binder) resulted in higher mass losses, while for mixtures with slag cement, increasing the TI water content from 7 to 12% (0 to 10% IC water) resulted in lower mass losses. Freeze-thaw tests have also been completed. In general, all of the mixtures with limestone as the coarse aggregate failed the test (with the average relative E_{Dyn} dropping below 95% of the initial value well below the specified 660 freeze-thaw cycles), regardless of the binder composition. This observation is in line with what KDOT observed in similar specimens when tested for freeze-thaw resistance. The likely reason for the poor performance of the limestone aggregate mixtures is the high absorption of the limestone aggregate (1.8% OD). An increase in the quantity of total internal water improved the freeze-thaw performance of the limestone mixtures. Mixtures with granite (absorption of 0.61% OD) exhibited higher freeze-thaw resistance than paired mixtures with an equal quantity of TI water and limestone as the coarse aggregate (absorption of 1.8% OD). For granite mixtures with less than 16% TI water by the weight of the binder, the average relative E_{Dyn} regardless of binder composition was above 95% of the initial value after 660 freeze-thaw cycles. The only mixture with granite to fail in freeze-thaw had 16% TI water by the weight of the binder (corresponding to 15% IC), and failed at 171 freeze-thaw cycles. An increase in the quantity of total internal water decreased the freeze-thaw performance of the granite mixtures, in contrast with the limestone mixtures. Furthermore, since the freeze-thaw resistance varied significantly even though the TI water content in the mixtures with limestone and granite were equal, it was observed that internal water from the coarse aggregate plays a significant role in freeze-thaw resistance.

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).

None.