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) 2019 ☐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, 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	$188,915.46	60%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$10,165.42	$10,165.42	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.

One internally-cured low-cracking high-performance concrete (IC-LC-HPC) bridge deck (No. 35-30 KA-3102-01) was cast in two placements this quarter, located on Montana Rd. over I-35 near Ottawa, Kansas. A KU representative traveled to the concrete ready-mix plant prior to construction to test the lightweight aggregate and, as necessary, provide modifications to the mixture proportions to maintain the desired quantity of internal curing water. Based on the absorption and specific gravity values measured by KU and KDOT on the construction days, no modifications to the mixture proportions were required.

The first trial batch was completed on 6/4/2020 and included in the June quarterly report. A second trial batch for this bridge deck was completed on 10/13/2020 with KU and KDOT personnel in attendance. The mixture contained a binary binder composition (a 30% replacement by weight of portland cement with slag cement). The design paste content and the water-cementitious material (*w/cm*) ratio were 24.2% (by concrete volume) and 0.43, respectively. The design quantity of internal curing water was 7% by the weight of binder. The concrete properties at the ready-mix plant after about 15 minutes haul time were out of KDOT specifications for air content (with a value of 6.0%, slightly lower than the lower LC-HPC specification limit of 6.5%) and slump (with a value of 6 ¾ in., well above the upper LC-HPC specification limit of 5 in.). For the bridge deck construction, the concrete supplier was required to increase the air-entraining admixture dosage in concrete batches.

Major issues during placement, finishing, and curing were observed during construction of Montana Rd. bridge deck. The deck was cast in two placements, on 11/3/2020 (placement about 15% of the bridge deck area) and 11/11/2020. The concrete was consolidated with machine-mounted internal gang vibrators (including two sets of four-hand vibrators spaced within 15 ft from each other) followed by a spud vibrator near the barrier reinforcement. A double-drum roller screed followed by a metal pan was used for finishing the concrete surface. During the first placement, the slump ranged from 3.0 to 3½ in. (after pumping), with an average of 3¼ in., and the air content ranged from 6.2% to 8.0% (after pumping), with an average of 7.1%. During the second placement, the slump ranged from 2.0 to 7¼ in. (after pumping), with an average of 4¾ in. and the air content ranged from 6.1% to 11.0% (after pumping), with an average of 8.3%. Based on the ticket values, the average paste content for the deck was 24.0%, and the average *w/cm* ratio was 0.42, compared with the design value of 0.43.

KU researchers and KDOT held an online meeting on 12/3/2020 to discuss the issues that arose during construction. During the meeting, the importance of following the LC-HPC specifications in placement, finishing, and curing the concrete throughout the construction was emphasized. KU researchers suggested a discussion with KDOT representatives and contractors regarding some provisions of the LC-HPC specifications in the future.

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.

66% 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. These mixtures have paste contents of either 23.7, or 33.7%, contain 100% portland cement as the binder, and include nominal 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, freeze-thaw durability in accordance with 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.

The internally-cured bridge deck (38th St. over I-35W) in Minneapolis 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 20 monolithic bridge decks constructed in Minnesota with or without nonmetallic fibers, in summer 2021.

60% 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.

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 internal curing will continue to be evaluated. Additional IC mixtures will be cast, including a series containing 26.7% paste content with a *w/c* ratio of either 0.41 or 0.45 and nominal IC water contents of either 9 or 13% by the weight of binder.

Significant Results this quarter:

One IC-LC-HPC bridge deck was constructed in two placements in Kansas. For the first placement, KU researchers found a free-surface moisture of 1.25% for the LWA prior to casting, but values of between 15 to 24% were determined and used by the ready-mix plant personnel. The deviation of moisture content resulted in a 4.9 lb/yd^3 (on average) decrease in mixture water content or a 0.08 decrease in *w/cm* ratio.

Construction of the Montana Rd. bridge deck was attempted on 11/3/2020 but had to be abandoned after the finishing machine was broken, resulting in long delays (up to an hour) between placing and finishing the concrete. As with the trial batches, the concrete supplier had difficulty producing concrete within the specifications throughout the placement. In multiple trucks, drivers had to increase the dosage of air-entraining and high-range water reducer admixtures at the job site. On multiple occasions, construction personnel were observed walking in a 2-ft space between the gang vibrators and the roller screed, disturbing the freshly consolidated concrete. The loss of consolidation in bridge decks results in a substantial increase in crack density. At times, contractor personnel using a highway straightedge worked excess bleed water back into the concrete surface. Overfinishing the deck in the presence of bleed water, leading to a thin paste layer with a high *w/cm* at the concrete surface, will result in map cracking and scaling damage. Before the construction, the burlap was not soaked in water. Contractor personnel wet the burlap at the job site, delaying the application of curing.

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.