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

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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	$366,932.31	85%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$27,343.73	$27,343.73	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 more internally-cured bridge deck is planned for Kansas. Construction is anticipated in Spring 2022. This bridge is located on K-33 over BNSF Rail Road.

90% 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 the freeze-thaw durability of IC concrete is a function of the percentage of IC water or the total amount of absorbed water in the lightweight aggregate (LWA). These mixtures have paste contents of 23.7, 26.7, and 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 have 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). This work duplicates earlier work that followed MnDOT specifications, which requires the use of ASTM C666 (Procedure A).

90% 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.

Four internally-cured bridge decks in Minnesota (38th St. over I-35W in Minneapolis, 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, Montana Rd., and 199th St. over I-35) will be surveyed in summer 2022.

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

KU researchers are also working with MnDOT to obtain the construction information for the bridge decks surveyed during summer 2021 in Minnesota with either low slump or silica fume overlays, with or without nonmetallic fibers and monolithic decks with or without nonmetallic fibers.

50% 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.

A series of concrete mixtures are planned to be cast starting from early January to be evaluated for scaling and freeze-thaw durability. 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 to evaluate the effects of total internal water provided by all aggregates (ranging from 3 to 16% by the weight of binder) on the durability of concrete. The mixtures are designed to provide various nominal quantities of internal curing (IC) water provided by pre-wetted lightweight aggregate (LWA) equal to 0, 7, and 10% by the weight of binder. The mixtures have a paste content of 24.2% and a *w/cm* ratio of 0.43.

Significant Results this quarter:

The freeze-thaw results 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 for the IC mixtures with paste contents of either 23.7, 26.7, or 33.7%, nominal IC water contents of 9 and 13% by the weight of binder, and a *w/c* ratio of 0.45 were summarized in the September 2021 quarterly report. This quarter, freeze-thaw resistance of IC mixtures with paste contents of either 23.7, 26.7, or 33.7%, with nominal IC water contents of 9 and 13% by the weight of binder, and a *w/c* ratio of 0.41 was evaluated using the same procedures. As expected, the results indicate that reducing the *w/c* ratio from 0.45 to 0.41 improved freeze-thaw durability, with the dynamic modulus of elasticity remaining above 95% of the initial value through 660 freeze-thaw cycles and, thus, passing the test.

As an overall observation, compared to the paired IC mixtures with either 9 or 13% IC water content tested in accordance with ASTM C666-Procedure A (presented in the June 2021 quarterly report), where all specimens failed the test (the dynamic modulus of elasticity of the mixtures dropped below 90% of the initial value in less than 300 cycles), IC mixtures with either 9 or 13% IC water content, showed adequate freeze-thaw resistance (passed the test) when tested following the regime specified KTMR-22. This is not unexpected, as ASTM C666-Procedure A keeps the specimens saturated during both freezing and thawing.

As with results obtained in the June and September quarterly reports, the extended curing periods, the less intense the testing environment, and the decreased *w/c* ratio resulted in better freeze-thaw performance.

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.