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	$178,750.14	55%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$41,579.03	$41,579.03	9%

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.

Three internally-cured low-cracking high-performance concrete (IC-LC-HPC) bridge decks (Br. 85862, Br. 85863, and Br. 62735) were placed in Minnesota this quarter. KU researchers traveled to the concrete ready-mix plants prior to construction to test the lightweight aggregate and provide modifications in the mixture proportions to maintain the desired quantity of internal curing water. Adjustments were made to mixture proportions based on the absorption and specific gravity of the pre-wetted lightweight aggregate.

A trial placement for the first IC-LC-HPC bridge deck (Br. 85862, located on CSAH 12 over I-90) in Winona, MN was completed on 8/12/2020 with no KU personnel in attendance. The mixture proportions contained a 30% replacement by weight of portland cement with slag cement. The design quantity of internal curing water was 8% (by the weight of binder). The lightweight aggregate was pre-wetted for more than eight days prior to batching, and the design absorption value was 30.0% (OD basis). The air contents were 7.9% (before pumping) and 8.4% (after pumping), and the slump was 4 in. (after pumping). Although the concrete properties were within MnDOT specifications, there were concerns regarding the placement and finishing of concrete. During the trial placement, MnDOT personnel observed bleeding water channeling, as well as the appearance of trapped air pockets on the finished surface of the concrete. Additional bleedwater pockets appeared for at least 1½ hours after placement. The contractor also had difficulties in finishing the concrete. KU researchers and MnDOT representatives held an online meeting on 8/17/2020 to discuss these issues. At the meeting, KU researchers recommended reducing the amount of set retarding admixture in the mixture proportions as well as providing on-site guidance on controlling the aggregate moisture content.

A second trial placement for this bridge deck was completed at the job site on 8/19/2020 with KU and MnDOT personnel in attendance. The concrete properties at the job site (after pumping), except for slump (5½ in.) were within MnDOT specifications Although small trapped air pockets appeared on the surface of the concrete, MnDOT personnel approved the trial placement.

The deck for Br. 85862 was placed on 8/20/2020 without issues.

The second bridge (Br. 85863) is located on I-90 over Dakota Valley Dr., Winona, MN and was placed on 9/4/2020. The concrete supplier and the contractor were the same as for Br. 85862. The only difference in the mixtures was the design quantity of internal curing water, which was 7% (by the weight of binder) based on KU researchers' recommendations for bridge decks cast late in the construction season to minimize durability problems. No significant issues arose in concrete placement. The concrete in the first truck had a 7-in. slump, well above the upper MnDOT specification limit of 5 in. and was rejected. The remaining trucks had both slump and air content within the specification limit and were approved. The slump ranged from 3 to 3½ in. (before pumping), with an average of 3 in. MnDOT personnel believed the concrete supplier added undocumented water to the truckloads. KU researchers are working with MnDOT and the concrete supplier to obtain additional information.

The deck on Br.62735 was cast in two placements on 6/24/2020 and 9/22/2020. Br. 62735 is located on Dale Street in St. Paul, MN. No significant issues arose during concrete pumping, placement, or finishing.

The construction of two IC-LC-HPC bridge decks (Montana Rd. over I-35 and 199th St. over I-35) in Kansas has been delayed until October 2020.

60% 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 cast before and included in the March quarterly report are being evaluated at KU lab for shrinkage and freeze-thaw durability. These mixtures have different binder compositions (either 100% portland cement or a ternary binder composition including slag cement and silica fume), and various types of coarse aggregates (either granite or limestone) to evaluate the effects of total absorbed water (TW) provided by all aggregates (ranging from 3.0% to 12.5% by the weight of binder) on the durability of concrete. The mixtures were designed to provide various nominal quantities of internal curing (IC) water provided by pre-wetted lightweight aggregate (LWA) equal to 0, 6, and 9% by the weight of binder.

The mixtures are being evaluated for free shrinkage in accordance with a modified version of ASTM C157 (readings begin just after final set), and freeze-thaw durability in accordance with ASTM C666 (Procedure A).

50% 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.

This quarter, as part of the construction of LC-HPC bridge decks incorporating internal curing technology, crack surveys were performed on four bridge decks, including one internally-cured bridge deck (TH 52 SB over Cannon River) along with a control deck (TH 52 NB over Cannon River) located in Cannon Falls, and two internally-cured bridge decks (TH 58 over TH 52 near Zumbrota and Pokegama Lake Rd. over I-35 near Pine City). This was the third survey for bridge decks placed in Zumbrota and Cannon Falls in 2017 and the first survey for the deck placed in Pine City in 2019.

The internally-cured bridge deck (38th St. St. over I-35W) in Minneapolis and the single bridge deck constructed in Kansas with internal curing water (Sunflower Rd. over I-35) in Edgerton will be surveyed next summer.

In this quarter, additional surveys were performed on 20 monolithic bridge decks constructed in Minnesota with or without nonmetallic fibers constructed between 2015 and 2018. The results will be summarized in the next quarter.

50% 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:

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

Additional IC mixtures will be cast, including a series using the same materials used for the internally-cured LC-HPC bridge deck placed this year in Minnesota.

Significant Results this quarter:

Free shrinkage results in accordance with modified ASTM C157 procedures indicate that for a given binder composition, as the total absorbed water by all aggregates (TW) increases, shrinkage of concrete decreases. Ternary mixtures exhibited lower shrinkage than mixtures containing 100% portland cement as the binder for similar quantities of TW. For example, the ternary mixture with 3.4% TW exhibited a shrinkage of 480 microstrain through 180 days of drying, 67 microstrain less than the mixture with 100% portland cement as the binder with the same quantity of TW during the same period. The ternary mixture with 6% IC water (12.0% TW) exhibited the lowest shrinkage through 180 days of drying with 367 microstrain. The mixture with 100% portland cement as the binder and no IC water (3.4% of TW) exhibited the greatest shrinkage through 180 days of drying with 547 microstrain.

Tests for freeze-thaw resistance have been completed on the 100% portland cement and ternary mixtures containing 0 to 9% of IC water (3.4% to 12.5% TW) by the weight of binder. The mixtures were evaluated in accordance with ASTM C666 (Procedure A). Per MnDOT specifications, the specimens should maintain at least 90% of their initial dynamic modulus of elasticity values after 300 freeze-thaw cycles to pass the test. The effects of binder composition and the total absorbed water (TW) were assessed on freeze-thaw resistance. The results indicate that the total absorbed water (provided by all aggregate) is more dominant for freeze-thaw resistance than the quantity of IC water (only provided by LWA). In the ternary mixtures with IC water nominally equal to either 0 or 6% (by the weight of binder), the dynamic modulus of elasticity of the mixtures with higher quantities of total absorbed water dropped below 90% of the initial value in fewer cycles. The results also show that in mixtures with TW equal to either 3.4% or 8.7% (by the weight of binder), the mixtures that contained 100% portland cement as the only binder had considerably higher freeze-thaw resistance than the paired ternary mixtures. All mixtures with portland cement as the only binder as well as ternary mixtures with less than 9.0% of TW maintained at least 90% of their initial dynamic modulus of elasticity values after 300 freeze-thaw cycles and passed the test.

Materials being used for the IC-LC-HPC decks on Br.85862 and Br.85863 were obtained and are being tested in the laboratory.

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 was halted temporarily. Laboratory work, however, is again underway.