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 # *TPF-5(392)*	**Transportation Pooled Fund Program - Report Period:** ☐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
$270,000	$87,670.84	33%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$25,676.10	$25,676.10	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.

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.

KU researchers have finalized the Kansas LC-HPC specifications with KDOT for future LC-HPC projects. Included are provisions for lightweight aggregate handling and pre-wetting along with making adjustments to mixture proportions to maintain the design quantity of internal curing water in LC-HPC mixtures. Additionally, a checklist was developed to help evaluate LC-HPC batching and construction. The checklist is generally applicable to most bridges decks and includes items pertaining to aggregate handling and storage, modifications of mixture proportions to adjust for changes in aggregate internal and external moisture content, consolidation, finishing, and initiation of curing.

50% COMPLETE

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

The trial placement for the internally cured Kansas LC-HPC bridge deck was completed on 10/22/2019 with KU and KDOT personnel in attendance. The mixture proportions included a ternary binder composition (a 30% replacement by weight of portland cement with slag cement, and a 3% replacement by weight of portland cement with silica fume). The design paste content and the water-cementitious material (*w/cm*) ratio were 24.6% (by concrete volume) and 0.45, respectively. The design quantity of internal curing water in this project was 7.0 lb/cwt. The lightweight aggregate used to provide internal curing exhibited variable absorption values throughout the pre-wetting period. The lightweight aggregate that was delivered on 10/21/2019 was pre-wetted for only nine hours prior to batching, resulting in a lower absorption (11.6%, OD basis) than the design value (14.25%, OD basis). For the bridge deck placed the following month, the lightweight aggregate stockpile was pre-wetted for three days prior to batching concrete. KU researchers traveled to the ready-mix plant prior to construction to test the lightweight aggregate. The concrete properties at the construction site were within KDOT specifications for air content (with an average of 6.3%), although a lower range of air contents were listed in this project's specifications compared to previous and upcoming LC-HPC specifications. The average slump was 5¼ in., slightly higher than the KDOT specification limit of 5 in.

The bridge deck (KA-3083) is on Sunflower Rd. over I-35 in Edgerton, KS and was placed on 11/26/2019. The average absorption and the specific gravity of the lightweight aggregate were 13.66% and 1.75, respectively, differing from the values indicated in original mixture proportions (14.25% and 1.65, respectively). Having a lower absorption than the design value led to an internal curing water content of 6.7 lb/cwt instead of the design value of 7.0 lb/cwt. Prior to casting, KU personnel measured a free-surface moisture of 2.61%, while a free-surface moisture of either 3.5 or 4% was determined and used by the ready-mix plant personnel. This deviation decreased the mixture water and the *w/cm* by 3.5 lb/yd^3 and 0.006, respectively. During construction, a 90-minute delay occurred about halfway through placement due to equipment problems at the ready-mix plant. The deck was consolidated with a spud vibrator near the edges of the deck and a manual gang

vibrating system operated by two workers, immediately followed by a Bid-Well double-drum roller screed, followed by two metal pan drags. Two work bridges followed closely behind for workers to bullfloat the deck and apply wet burlap. Based on the trip tickets, the quantity of internal curing water provided was approximately 6.7 lb/cwt. No adjustments were made to the mixture proportions based on differences in lightweight aggregate properties from those used in the original design. The average water-to-cementitious material ratio (*w/cm*) was 0.44, and paste contents ranged from 23.9% to 24.4%, with an average of 24.2%.

33% 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 of the MnDOT LC-HPC bridge decks were completed last quarter. Additional surveys will be conducted in summer 2020.

25% 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:

Mixtures using materials from the 2019 Kansas LC-HPC deck, including replications of mixture proportions of the deck, continue laboratory testing for shrinkage, durability, and permeability.

Significant Results this quarter:

One LC-HPC bridge deck was successfully constructed in Kansas this quarter. The lightweight aggregate used to provide internal curing exhibited variable absorption values throughout the pre-wetting period. The absorption on the day of casting was 13.66% compared to a 14.25% (design value), resulting in an internal curing water content of 6.7 lb/cwt instead of the 7.0 lb/cwt (design value). The difference in absorptions also led to a difference in the correction for free-surface moisture. KU researchers found a free-surface moisture of 2.61% prior to casting, but values of either 3.5 or 4% were determined and used by ready-mix plant personnel. The deviation of moisture content resulted in a 3.5 lb/yd^3 decrease in mixture water content or an 0.006 decrease of *w/cm* ratio. Based on the average of trip ticket values, the average paste content for the LC-HPC deck was 24.2%, and the average *w/cm* ratio was 0.44, compared with the design value of 0.45.

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.