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(336)*	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) 2017 ✕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, 2016**
Original Project End Date: **December 31, 2018**	**Current Project End Date:** **December 31, 2018**	**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	$100,669.38	38%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$20,604.81	$20,604.81	10%

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. The LC-HPC decks have been constructed using 100% portland cement concretes with low cement paste contents, lower concrete slumps, controlled concrete temperature, minimum finishing, and the early initiation of extended curing. Methods to further minimize cracking, such as internal curing in conjunction with selected supplementary cementitious materials, 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 the construction of six LC-HPC bridge decks per state to be constructed over a three-year period.

An internally cured LC-HPC bridge deck was placed on 6/29/17 on TH 58 over TH 52 in Zumbrota, MN. All concrete tests performed at the construction site were within MnDOT specifications for slump and air content and the material was successfully pumped. Prior to construction, KU researchers recommended increasing the maximum slump limit from 3½ in. to 4 in. after analyzing data from Kansas LC-HPC and internally cured decks in Indiana and determining no negative effects in resultant crack densities.

The next internally cured bridge deck placement is scheduled for early next quarter on TH 52 near Cannon Falls, MN. An additional deck planned for next quarter will serve as a control in this study. KU has obtained materials from the concrete supplier and provided guidance for handling and storage of fine lightweight aggregate before and during batching. An internal curing mix design has been developed and submitted to MnDOT for approval.

55% COMPLETE

TASK 2: Provide on-site guidance during construction of the LC-HPC bridge decks.

KU researchers have provided recommendations for handling and preparation fine lightweight aggregate to the concrete supplier and the independent testing laboratory hired to test the Job Mix Formula for the planned internally cured bridge decks. This included providing the procedure developed the previous year on calculating absorption, specific gravity, and free surface moisture using a centrifuge. The concrete supplier is aware that the mix design may require modification if the fine lightweight aggregate on hand at the ready mix plant possesses a different absorption or specific gravity than originally designed for. For on-site guidance during batching, the concrete supplier has acknowledged the need to determine the free surface moisture of the fine lightweight aggregate immediately prior to batching. For a test pour recently conducted by the concrete supplier, it was indicated that the internally cured concrete had properties within MnDOT specification limits for slump and air content and was able to be pumped.

Two days prior to construction of the most recent internally cured LC-HPC bridge, KU personnel were present at the ready mix plant to perform tests on the fine lightweight aggregate to be used in batching. The resultant specific gravity of the material was 1.66 based on a pre-wetted surface dry condition, compared to 1.67 for material on hand at KU labs. The resultant absorption of the material was found to be 25.0% based on oven dry weight, providing approximately 8.6 lb/cwt of internal curing water. Approximately 14 hours prior to batching, sprinklers over the material were turned off. An hour prior to batching, KU researchers determined values for absorption and free surface moisture to provide an accurate moisture correction for this material. The free surface moisture was determined to be approximately 5.5% based on pre-wetted surface dry condition. After determining correction values, a single load was placed in bins for batching the entire bridge. The mix design was not changed and no issues arose during batching and construction. Additionally, at the end of construction, moisture values for the material were again determined to observe the effect of leaving the stockpile without any sprinkling for an additional four hours. No absorbed water was lost, but the free surface moisture dropped to approximately 3.5% based on pre-wetted surface dry condition.

40% COMPLETE

TASK 3: Perform detailed crack surveys on the bridge decks, 1 year, 2-3 years, and (if approved) 4-5 years after construction. Prior research has demonstrated that it takes at least three years to consistently establish the long-term cracking performance of a bridge deck. The surveys will be performed using techniques developed at the University of Kansas to identify and measure all cracks visible on the upper surface of the bridge deck. If desired, DOT personal will be trained in the survey techniques and may assist in the surveys, as appropriate.

On 6/27/17, KU personnel surveyed two pedestrian bridges over I-94 in St. Paul, MN. Both bridges have low crack densities. The only cracking found on these bridges was over the center pier. The internally cured bridge had short cracks less than 2 ft long. The control deck had transverse cracks on either side of the pier that extended the entire width of the bridge. Crack surveys of the internal curing and control decks for 2017 will be conducted during the summer, one and three years after construction.

30% COMPLETE

TASK 4: Correlate the cracking measured in Task 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. Interim and final reports will be prepared covering the findings in Tasks 1-4.

10% COMPLETE

Anticipated work next quarter:

Laboratory testing of concrete mixtures with internal curing will continue to be evaluated by KU researchers. For the upcoming projects, KU researchers will begin testing the series of mixtures replicating 2017 MnDOT internally cured concrete mix proportions.

Early next quarter, an additional internally cured bridge deck is scheduled to be placed. KU researchers will be present at the batch plant to record material properties and on the construction site to observe construction practices.

Significant Results this quarter:

The first internally cured LC-HPC bridge deck for 2017 in Minnesota was successfully placed. The amount of internal curing water provided was approximately 8.6 lb/cwt.

Concrete mixtures that resulted in slump and air contents within MnDOT specifications have been shown to meet the MnDOT specifications based on laboratory testing. Additional mixtures were developed to investigate the effect of lowering the water to cementitious material (*w/cm*) ratio from 0.45 to 0.42 and 0.39. Additionally, mixtures that include silica fume were also included in this test series. Mixtures incorporating silica fume have shown a reduction in scaling performance. Mixtures that have less than the minimum air content per MnDOT specifications have shown negative effects in scaling and rapid chloride permeability (RCP) tests.

The concrete mix design for 2017 internally cured LC-HPC bridges submitted to MnDOT includes a 27.3% replacement of cementitious material by weight with slag and a 26.0% paste content.

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).

The second internally cured bridge for Minnesota in 2016 was not successfully completed, and as previously indicated by MnDOT, a replacement bridge is not planned for the remainder of their study. KU, however, is prepared to work with MnDOT if the decision is made to include a replacement bridge to the study.