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	$138,524.57	50%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$37,855.19	$37,855.19	12%

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 7/6/17 on southbound TH 52 over the Little Cannon River near Cannon Falls, MN. KU personnel were present for construction. All concrete properties based on tests performed at the construction site were within MnDOT specifications for slump and air content and the material was successfully pumped. For internally cured LC-HPC bridge deck construction in 2017, the maximum allowable slump was increased to 4 in. based on results KU researchers obtained from crack surveys of internally cured bridge decks Indiana from 2016. The 2-in. wearing course for this was placed on 7/21/17 and 7/24/17. KU personnel were present for the second placement day. The 2-in. wearing course for the internally cured LC-HPC deck in Zumbrota was placed on 8/23/17. KU personnel were not present for this placement. On 9/15/17, the control deck for the internally cured bridge near Cannon Falls was placed (northbound TH 52).

60% COMPLETE

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

KU researchers were present at the ready mix plant one day prior to construction of the internally cured LC-HPC bridge near Cannon Falls. The specific gravity of the lightweight fine aggregate was 1.67 in the pre-wetted surface dry condition. The absorption of the material was found to be 24.50% based on oven-dry weight, providing approximately 8.4 lb/cwt of internal curing water based on the proportions in the Job Mix Formula. The material properties remained the same the following morning just before batching. Approximately 12 hours prior to batching, sprinklers over the lightweight fine aggregate 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 6.8% based on pre-wetted surface dry condition. This was the only value used for moisture correction of the lightweight aggregate. The mix proportions were not changed and no issues arose during batching and construction. Based on the average mix proportions according to trip tickets, the actual amount internal curing water provided was approximately 8.6 lb/cwt.

60% 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 7/24/17, KU researchers were present for the second half of placement of the 2 in. wearing course on the internally cured bridge near Cannon Falls. The first half of this overlay was placed on 7/21/17. No cracks were observed on the deck before placing the overlay. The internally cured bridge in Zumbrota (Bridge No. 25037, placed on 6/29/17) had its overlay placed on 8/23/17. KU researchers also surveyed this deck for cracking on 7/24/17 before the surface was prepared for overlay placement and observed some small cracks over the center pier. Crack surveys of the internal curing and control decks for 2017 will be conducted during the summer, one and three years after construction.

35% 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.

20% 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 continue testing the series of mixtures replicating 2017 MnDOT internally cured concrete mix proportions.

Significant Results this quarter:

Construction of the internally cured bridge decks for 2017 is complete. The average resultant *w/cm* ratio, paste content, and amount of internal curing water provided for the two bridge decks placed this year were 0.43, 25.3%, and 8.6 lb/cwt, respectively.

Concrete mixtures using similar materials as the internally cured bridge from 2016 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. Mixtures that include silica fume were also included in this test series for a *w/cm* ratio of 0.45. 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. Variations of this mix in the laboratory include varying the *w/cm* ratios from 0.45, 0.43, and 0.41. One mix per *w/cm* ratio will not include any pre-wetted lightweight fine aggregate to compare results with concrete without any internal curing. Other mixtures will include 7 and 9 lb/cwt of internal curing water. A repeat of each mixture with 9 lb/cwt will include the same dosage of set retarder as the Cannon Falls bridge and part of the Zumbrota bridge (3 oz/cwt). Two mixtures replicating average trip ticket proportions for this year's bridges, one with 3 oz/cwt of set retarder and one without, are also included. An additional ternary series will include a 3% replacement of silica fume in addition to the 27% replacement with slag for a *w/cm* ratio of 0.43. The mix design for the control deck, which includes a 35% replacement of cement with Class F fly ash by weight will also be replicated, along with mixtures including internal 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).

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. KU, however, is prepared to work with MnDOT if the decision is made to include a replacement bridge to the study.