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) 2018 ✕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	$185,585.68	80%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$23,632.99	$23,632.99	15%

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.

The two internally cured LC-HPC bridge deck projects originally identified by MnDOT for construction in 2018 have been delayed until 2019. This includes a bridge on I-35 near Pine City, MN and one near Chaska, MN. A replacement project was identified and has been placed along 38th St. over I-35W in Minneapolis, MN (MnDOT Bridge No. 9619). A second replacement project for 2018 was not designated.

100% COMPLETE

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

An internally cured bridge deck was placed along 38th St. over I-35W in Minneapolis, MN on the evening of 5/15/18. During the prior week, mixture proportions were modified in response to pumping issues with the first trial batch. When KU researchers tested the fine lightweight aggregate, a higher absorption than originally designated for was found (30.2% vs. 23.6%). As a result, over 12 lb/yd^3 of water was being treated as free surface moisture and withheld from the batch. The higher absorption also led KU researchers to recommend a lower amount of pre-wetted fine lightweight aggregate to maintain the intended amount of internal curing water (8 lb/cwt). To further address pumping issues, mixture proportions were modified to include a 26% paste content (originally 25.4%) while maintaining the original 0.43 *w/cm* ratio. The dosage of viscosity modifying admixture was also increased from 3 to 5 oz/cwt. No pumping issues were reported for subsequent trial placements or during deck placement. The average slump, air content, and temperature at placement for this bridge were 4¾ in., 8.9%, and 64°F, respectively. The average amount of internal curing water based on average trip ticket proportions was approximately 7.9 lb/cwt.

100% 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.

Crack surveys for the internally cured deck and control deck were conducted on 5/8/18. Both decks are pedestrian bridges over I-94 in St. Paul, MN. Crack densities for both of these bridges were low with similar cracking patterns as those seen in the 2017 surveys. Crack surveys for the bridge decks in this study placed in 2017 were conducted on 5/10/18. There were two bridge decks that include internal curing and one control. These decks have a 2-in. high density overlay placed over the internally cured portion. For the internally cured deck in Zumbrota (no control), no cracking was observed during the survey. For the internally cured deck in Cannon Falls, the majority of cracking was observed within 15 ft. of each

abutment. The crack density for this bridge was 0.165 m/m^2. Photographs taken from the underside of the deck did not show any of these cracks reflecting through. It is expected that with the overlay being placed in mid-late July 2017, cracking in the overlay due to restrained drying shrinkage, made worse by high temperatures, may have been the primary cause of this result. The control deck in Cannon Falls, which also has a similar overlay, did not exhibit any cracking. This bridge was constructed later in the season (September 2017).

100% 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.

40% COMPLETE

Anticipated work next quarter:

Laboratory testing of concrete mixtures with internal curing will continue to be evaluated by KU researchers, including series of mixtures replicating 2017 and 2018 MnDOT internally cured concrete mix proportions.

Casting laboratory mixtures using materials from the construction of the internally cured bridge deck from this year are underway and will be completed next quarter. Shrinkage, durability, and permeability testing will be completed for these mixtures, similar to the previous two years. Mixtures will include a *w/cm* of 0.43, paste content of 26%, and vary the amount of internal curing water from 0 to 12 lb/cwt for a series containing a replacement of portland cement with 28% slag. Mixtures with 100% portland cement as the binder will also be evaluated.

Significant Results this quarter:

For all internally cured decks placed in this study since 2016, the same source and material was used as the fine lightweight aggregate. The absorptions of the various stockpiles of this material sampled in this study have resulted in values that can differ by more than 10%, which would alter the amount of internal curing water provided for a given proportion of fine lightweight aggregate. In cases where DOTs and other agencies specify a fixed volume percentage for lightweight aggregate in internally cured mixtures, the actual amount of internal curing water can vary significantly between projects and material sources. Furthermore, incorrectly accounting for absorption and free surface moisture of these materials can result in an excess or deprivation of mix water.

For the internally cured bridge deck placed this quarter, modifications to the concrete mixture proportions bases on actual material properties were needed prior to construction to address pumping issues. The first steps were to address the moisture correction values used for the fine lightweight aggregate. It was determined that the absorption of the aggregate in the stockpile was considerably higher than original design value (30.2 vs. 23.6%), which led to over 12 lb/yd^3 of water being treated as free surface moisture instead of absorbed water during the first unsuccessful trial batch. For that trial batch, the actual paste content was below 25%. The proportion of fine lightweight aggregate was also adjusted to provide the intended amount of internal curing water (8 lb/cwt). Further modifications to the mixture proportions included increasing the paste content to 26% by adding cementitious material and maintaining the *w/cm* ratio to aid pumping, along with increasing the dosage of viscosity modifying admixture. Trial batches using these adjustments showed that the modified concrete could be pumped without issue and to be within MnDOT specifications for slump and air content. This case reinforces the importance of testing individual fine lightweight aggregate stockpiles for absorption and specific gravity to maintain the design *w/cm* ratio and amount of internal curing water.

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. Construction schedules for the internally cured bridges originally slated for 2018 have been delayed until 2019. One replacement project was identified as the 38th St. bridge over I-35W in Minneapolis that was placed this quarter. A second replacement deck for 2018 using internal curing was abandoned due to contract negotiations over the concrete change order. KU, however, is prepared to work with MnDOT if the decision is made to include replacement bridges in the study later this year and in the planned three-year extension of the project.