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(174)	☐Quarter 1 (January 1 – March 31) X Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 1 – December 31)

Project Title:
Construction of Crack-Free Concrete Bridge Decks, Phase II

Project Manager:	**Phone:**	**E-mail:**
Rodney Montney	785-291-3844	Rodney@ksdot.org
Project Investigator:	**Phone:**	**E-mail:**
David Darwin	785-864-3827	daved@ku.edu

Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:** **July 1, 2008**
Original Project End Date: **June 30, 2013**	**Current Project End Date:** **June 30, 2013**	**Number of Extensions:** 0

Project schedule status:

X 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
$995,000*	$409,211.91**	80%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$12,993.29		5%

*$1,545,000 including KUTRI, BASF, and SFA funds, **$959,567.91 including KUTRI, BASF, and SFA funds

Project Description:
Cracks in concrete bridge decks provide easy access for water and deicing chemicals that shorten the life of the deck. Both materials increase the effects of freeze-thaw damage, while the deicing chemicals lead to higher concentrations of chlorides, and subsequently, corrosion of reinforcing steel. Measurements taken on bridges in Kansas show that dense, high quality concrete can significantly slow the penetration of chlorides to the level of the reinforcing steel. However, measurements taken at cracks show that the chloride content of the concrete can exceed the corrosion threshold at the level of the reinforcing steel by the end of the first winter. The formation of cracks, thus, significantly lowers the effectiveness of other techniques that are used to increase the life of a deck.

Research, some of which dates back nearly 40 years, has addressed the causes of cracking in bridge decks in North America. The research includes three detailed bridge deck surveys carried out by the University of Kansas since 1993. The results of the studies provide specific guidance on modifications in materials and construction techniques that will reduce the amount of cracking in bridge decks. In spite of this accumulation of knowledge, only a small number of these findings have been used to implement changes in bridge deck design and construction procedures. In specific cases, on-site observations indicate that it is possible to develop nearly crack-free bridge decks, if “best practices” are followed. Even with these few successes, most bridge decks exhibit significant cracking, exposing the reinforcing steel to deicing chemicals and subsequent corrosion and increasing the degree of saturation, which increases the impact of freeze-thaw cycles. The current level of understanding, however, offers strong direction for constructing bridge decks with minimum cracking.

This improved understanding was put to use during the first phase of this study, in which 20 low-cracking, high-performance concrete (LC-HPC) bridge decks, with an equal number of control decks, were planned for construction. The decks involved the use of low cement and water contents, increased air contents, optimized aggregate gradations that produce pumpable, workable, placeable, finishable concrete with cement contents as low as 535 lb per cubic yard, temperature control during placement, limited finishing, and early curing. The study was successful in identifying low-cracking portland cement concrete mixtures. Several additional approaches, however, have been identified that have the potential to increase the benefits of the project, including using mineral admixtures, new sources of aggregate, and new approaches to finishing. These approaches could not be fully exploited in Phase I. Data indicates that, when coupled with internal curing (provided by fully or partially saturated KsDOT approved limestone with 2½ - 3% absorption), using blast furnace slag as a replacement for portland cement can reduce drying shrinkage by an additional 40%. Two other mineral admixtures, fly ash and silica fume (microsilica), are also under investigation, although with less advantageous results. They will continue to be evaluated, however, because of their widespread use and the desire to construct decks with minimum permeability (achieved using silica fume) and environmentally beneficial waste materials (fly ash). The new mixtures must be investigated for their shrinkage and freeze-thaw properties, as well as construction qualities, especially the ability to use pumps to place the new mixtures. Optimum procedures for concrete placement and fogging will continue to be areas of special emphasis. Finishing techniques have been restricted in the current study. Additional work is necessary to determine if some of the restrictions (principally on the placement and finishing equipment) may be lifted.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

TASK 1: Update plans to construct bridge decks with minimum cracking by incorporating “best practices” dealing with materials, construction procedures, and structural design. This step involves improving techniques in use in Phase I and meeting with department of transportation personnel from multiple states, as well as other experts, to select the procedures to be used and the bridge types to which they will be applied.

This task was largely completed during the Annual Meeting of Pooled Fund Sponsors held in Kansas City, MO at the Kansas City Airport Hilton on July 24, 2008, as well as in meetings with KDOT officials as reported in the report for the 1st quarter of 2009. This task will remain open until the end of the project to allow for slight modifications to LC-HPC bridge deck specifications and additional LC-HPC bridge deck construction as warranted.

90% COMPLETE

TASK 2: Perform laboratory work to evaluate the effects of slag cement, fly ash, silica fume, shrinkage reducing admixtures, and internal curing on the performance of concrete mixtures for use on LC-HPC decks.

Mixtures with different dosages of SRA and air contents lower than the LC-HPC specification requires (< 7%) are undergoing durability tests to determine if SRA mixtures can maintain durability at lower air contents. Mixtures with different quantities of pea gravel-size lightweight aggregate (LWA) (at 0, 8, and 10% replacement by volume of total aggregate) for internal curing, silica fume (0, 3 and 6% replacements by volume of cement), slag (0 or 30% replacements by volume of cement), and < 7% air contents are also undergoing durability tests. Concrete mixtures with different dosages of shrinkage reducing admixtures (SRA) [Tetraguard AS20, (0, 0.5, 1.0, and 2.0% by weight of cement), MasterLIFE CRA 007 which is described as a crack reducing admixture (CRA) (0, 0.5, 1.0, and 2.0% by weight of cement) and a new SRA powder known as PREVent-C] are being analyzed for shrinkage, scaling, freeze-thaw performance, strength, and air void properties in hardened concrete. Mixes with different dosages of Tetraguard AS20 (0, 0.5, 1.0, and 2.0% by weight of cement) and air contents within the LC-HPC specification requirements by use of Micro Air are being retested for shrinkage, scaling, freeze-thaw performance, strength, and air void properties in hardened concrete to complete a direct comparison with previous mixes which used the Miracon Tough Air air-entraining admixture.

75% COMPLETE

TASK 3: Work with state DOTs, designers, contractors, inspectors, and material suppliers to modify designs, specifications, contracting procedures, construction techniques, and materials to obtain decks exhibiting minimal cracking.

This task was largely completed during the Annual Meeting of Pooled Fund Sponsors held in Kansas City, MO at the Kansas City Airport Hilton on July 23, 2009, as well as in meetings with KDOT officials as reported in the report for the 1st quarter of 2009. This task will remain open until the end of the project to allow for slight modification to LC-HPC bridge deck specifications, construction methods and materials as warranted.

90% COMPLETE

TASK 4: Select and schedule bridges to be constructed using "best practices," and pre-qualify designers and contractors in application of the techniques. To date, 14 bridges in Kansas, two in South Dakota, one in Minnesota, and one in Missouri have been identified for construction. Twenty additional bridges are proposed for Phase II. Researchers from the University of Kansas and state DOT personnel will work closely with designers and contractors to achieve the desired results. Pre-qualification of designers and contractors includes the presentation of workshops sponsored by the University of Kansas to help educate and train engineers in implementing the "best-practices" identified in Tasks 1 and 3.

To date for Phase II, 4 LC-HPC bridge decks have been constructed in Minnesota, 3 LC-HPC bridge decks have been constructed in Kansas, with the 3rd Kansas LC-HPC bridge deck completed on September 28, 2011. Details on the construction of the first two bridge decks can be found in the 4th Quarter report for 2010. Details on the 3rd deck can be found in the 3rd Quarter report for 2011.

This task remains open until the end of the project to allow for additional LC-HPC bridge construction as requested.

75% COMPLETE

TASK 5: Perform detailed crack surveys on the bridge decks one year, two years, and three years after construction. The surveys are performed using techniques developed at the University of Kansas that involve identifying and measuring all cracks visible on the upper surface of the bridge deck. The majority of the early surveys will be done by the University of Kansas. As the project progresses, teams outside of the State of Kansas will be trained in the survey techniques. Three teams in South Dakota have been trained to date.

The annual crack surveys for LC-HPC bridges and corresponding control bridges in Kansas began this quarter. Crack surveys of LC-HPC bridge decks have been completed for eastbound Parallel Parkway over I-635, 34th Street over I-635, westbound 103rd Street over US-69, southbound US-69 bridge to I-435 ramp, southbound US-69 flyover bridge to westbound I-435, County Road 150 over US-75, E 1350 Road over US-69, E 1800 Road over US-69, K-130 over the Neosho River Unit 2, northbound US-69 over BNSF railroad, and northbound and southbound K-7 over Johnson Drive. Control decks that have been surveyed include westbound Parallel Parkway over I-635, eastbound 103rd Street over US-69, northbound US-69 ramp, southbound US-69 flyover bridge to eastbound I-435, northbound Antioch over I-435, K-52 over US-69, K-130 over the Neosho River Unit 1, southbound US-69 over BNSF railroad, and 132nd Street over US-69. In general, all decks had increased cracking compared to last year's surveys. Crack densities for control decks were found to be higher than those observed on LC-HPC bridge decks. Detailed results will be presented at the annual meeting in July.

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75% COMPLETE

TASK 6: Correlate the cracking measured in Task 5 with environmental and site conditions, construction techniques, design specifications, and material properties and compare with earlier data. Similar data from participating states, where it exists, will be incorporated in the analysis. Actual costs and future cost estimates

will be compared with potential benefits.

The correlation of cracking with the factors listed above is completed at the end of each annual crack survey. Results of the cracking analysis are presented at each Annual Meeting of Pooled Fund participants. The latest results were presented at the annual meeting that was held on July 19th, 2011 at the Kansas City Airport Hilton, which was described in the 3rd quarter report for 2011. The next annual meeting will be held on July 19th, 2012.

75% COMPLETE

TASK 7: Document the results of the study. A final report will be prepared and disseminated to participating states regarding the findings of Tasks 1-6.

This task is scheduled to begin in Fall 2012.

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TASK 8: Update the training program developed (and currently being presented) in Phase I to assist the participating states in implementing the findings of the study. The program consists of workshops to be held at the representative state DOT offices. These workshops are individually coordinated with each participating DOT. A technical committee, structured with one representative from each state providing funds, will oversee the project. A meeting of the committee will be held each year, as has been done for Phase I. The first meeting is scheduled for July 24, 2008.

Information was disseminated at the annual meeting on July 19th, 2011 at the Kansas City Airport Hilton. Meeting CDs were sent to all representatives. The next meeting is scheduled for July 19th, 2012.

75% COMPLETE

Anticipated work next quarter:

Mixtures with different dosages of SRA and low air contents (> 7%) will continue to be tested to determine durability performance at lower air contents. Different types of SRA, including Tetraguard AS20, MasterLIFE CRA 007, and PREVent-C, will be used in these durability tests. Mixtures with different combinations of lightweight aggregate, slag, and silica fume with low air contents will also continue to be tested next quarter to determine durability performance. A wide range of testing will be completed on mixes with the PREVent-C admixture, including shrinkage, scaling, freeze-thaw performance, strength, and air void properties in hardened concrete.

The annual bridge deck crack surveys will continue through the beginning of next quarter.

Significant Results this quarter:

LABORATORY RESULTS:

Concrete mixtures with lightweight aggregate and mixtures containing shrinkage reducing admixtures (SRA or CRA) with Micro Air are undergoing free shrinkage testing. The mixtures with the different replacement levels of lightweight aggregate are performing significantly better than comparable control mixtures after approximately 150 drying days. These results are similar to those in past research. Mixtures with a combination of lightweight aggregate and slag and mixtures with lightweight aggregate, slag, and silica fume are performing even better than mixtures with only the addition of lightweight aggregate after approximately 150 drying days. The mixtures with lightweight aggregate and slag (no silica fume) perform better than the mixtures with lightweight aggregate, slag, and silica fume until approximately 20 drying days. From 20 to 150 drying days, the mixtures with lightweight aggregate, slag, and silica fume have a lower shrinkage.

Mixtures with dosages by weight of cement of 0.5, 1.0, and 2.0% SRA with Tough Air have experienced approximately 15, 40, and 120 microstrain less shrinkage, respectively, than the control mixture after approximately 210 days of drying. Mixtures with dosages of 1.0 and 2.0% SRA with Micro Air have experienced approximately 140 and 190 microstrain less shrinkage, respectively, than a comparable control mixture after approximately 175 days of drying. A mixture with

0.5% SRA with Micro Air has experienced approximately 180 microstrain less shrinkage than a comparable control after approximately 110 days of drying. Mixtures with dosages of 0.5, 1.0 and 2.0% CRA with Micro Air have experienced approximately 140, 130, 200 microstrain less shrinkage, respectively, than the control mixture after 45 days of drying.

Scaling performance testing has been completed for mixtures with 0.5% and 2.0% SRA by weight of cement with Micro Air; both mixes maintained low mass loss through 56 freeze-thaw cycles. Freeze-thaw performance testing has been completed for mixtures with 1.0% and 2.0% SRA by weight of cement with Micro Air. The mix with 1.0% SRA with Micro Air maintained 97% of the initial dynamic modulus of elasticity after 300 freeze-thaw cycles (ASTM C666 Procedure B). The mix with 2.0% SRA with Micro Air maintained 95% of the initial dynamic modulus of elasticity after 300 cycles. Freeze-thaw performance testing is ongoing for a mix with 0.5% SRA with Micro Air, which has maintained 100% of the initial dynamic modulus of elasticity after 182 cycles. Freeze-thaw performance testing has been completed for a mixture containing 1.0% SRA with Tough Air (foaming air-entraining agent), which maintained only 73% of the initial dynamic modulus of elasticity during freeze-thaw testing after test completion at 300 cycles.

Mixtures containing different dosages of SRA (0, 0.5, 1.0, and 2.0% by weight of cement) and air contents below the LC-HPC specification requirement (< 7%) with Micro Air have been tested for scaling and freeze-thaw performance. Mixtures with 1.0% SRA & 6.5% air content, 0% SRA & 3.5% air content, 1.0% SRA & 5.25% air content, 0.5% SRA & 4.0% air content, 0.5% SRA & 7.0% air content, 2.0% SRA & 7.0% air content, and 2.0% SRA & 4.75% air content maintained low mass loss through 56 freeze-thaw cycles in the scaling test. A 0% SRA & 5.9% air content mix has maintained low mass loss through 35 cycles. Two separate 2.0% SRA & 3.5% air content mixes experienced mass loss levels beyond the fail limit after only 21 freeze-thaw cycles. A noticeable increase in scaling mass loss occurred for many of the low air content SRA mixes between 35 and 56 cycles, although all mixtures except two (two 2.0% SRA & 3.5% air content mixes) remained below the fail limit after 56 cycles.

A mixture with 1.0% SRA and 6.5% air content maintained only 80% of its initial dynamic modulus of elasticity during freeze-thaw testing after 300 cycles. A mix with 2.0% SRA and 3.5% air content dropped to 40% of its initial dynamic modulus of elasticity after only 74 freeze-thaw testing cycles. A control mix with 3.5% air content maintained 89% of its initial dynamic modulus of elasticity after 300 cycles. A mix with 1.0% SRA and 5.25% air content maintained 73% of its initial dynamic modulus of elasticity after 300 cycles. Another mix with 2.0% SRA and 3.5% air content dropped to 5% of its initial dynamic modulus of elasticity after only 133 cycles. A mix with 0.5% SRA and 4.0% air content maintained 98% of its initial dynamic modulus of elasticity after 221 cycles. A mix with 0.5% SRA and 7.0% air content maintained 96% of its initial dynamic modulus of elasticity after 221 cycles. A mix with 2.0% SRA and 7.0% air content has maintained 97% of its initial dynamic modulus of elasticity after 169 cycles. A mix with 2.0% SRA and 4.75% air content maintained 76% of its initial dynamic modulus of elasticity after 89 cycles. A control mix with 6.0% air content maintained 99% of its initial dynamic modulus of elasticity after 39 cycles.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Nothing to report.