Period Covered: July 1 through September 30, 2006 (Quarterly Report)

KSDOT Progress Report
for the

State Planning and Research Program

PROJECT TITLE: Construction of Crack-Free Concrete Bridge Decks		
PROJECT MANAGER: Richard L. McReynolds, P.E.	Project No: TPF-5(051)	Project is: ____ PLANNING __X__ RESEARCH & DEVELOPMENT
Annual Budget	**Multi Year Project Budget** $950,000	

Progress:

CONSTRUCTION ACTIVITIES

The third LC-HPC bridge deck in Kansas was cast on September 13, 2006, marking the fifth time (two trial slabs and three bridge placements) that this contractor has placed concrete under the provisions of the LC-HPC specifications. Performance has improved with each placement. The LC-HPC specifications continue to be reevaluated based on the latest field and laboratory results.

Two pre-bid conferences were held, one for three LC-HPC bridges (Chanute, KS) on July 6, 2006 and one for a single LC-HPC bridge (Hutchinson, KS) on July 28, 2006. Minor changes to the specifications have been made based on reviews during the pre-bidding process. These changes focus on the concrete used in corral rails, including a reduction of the maximum size aggregate (MSA) to ¾ inch to maintain clear spacing requirements in the rails and modification in the optimized aggregate gradation limits to reflect the optimum gradation for a ¾ inch MSA. Load limits have also been reviewed so as to clarify when loading may occur during construction.

The LC-HPC specifications for Minnesota DOT (one bridge) and Missouri DOT (one bridge) were developed, reviewed, and revised.

LABORATORY ACTIVITIES

Work continues in the materials laboratory. A series of binary and ternary mixtures containing Grade 100 and Grade 120 Ground Granulated Blast-Furnace Slag (GGBFS) (60% or 80% replacement) and silica fume (6% replacement) with reduced paste contents were cast to determine drying shrinkage, strength, and permeability characteristics. Specimens cast for this series were cured for 14 days and contain paste contents equivalent to 535, 497, or 460 lb/yd^3 of cement with a 0.42 water-cement ratio. Optimized aggregate gradations were used for the mixes, all of which exhibited high workability at a 3-inch slump.

Based on promising initial results with the use of both Grade 100 and Grade 120 GGBFS, additional free-shrinkage, permeability, and strength specimens have been cast with different aggregate types (limestone, granite, and quartzite) and GGBFS obtained from multiple sources.

A series of free-shrinkage and strength specimens were cast to determine the effects of increases in superplasticizer and/or paste content that are required when the aggregate gradation is not optimized. Two mixes with a constant paste content reflecting a prototypical LC-HPC bridge deck mix (535 lb/yd^3 of cement, 0.42 water-cement ratio, 8 ± ½ percent air content) were cast with different aggregate gradations. One mixture contained an optimized gradation, while the other contained a severely gap-graded aggregate that generally reflects standard practice in the concrete industry. The gap-graded mix required a higher superplasticizer content. In addition, a control batch containing the gap-graded aggregate was cast with an increased paste content (obtained by increasing cement and water at a constant water-cement ratio) to obtain the same slump as the optimized mixture. The superplasticizer dosage was held constant for the control batch comparison.

Additional free-shrinkage and strength specimens cast this quarter include mixtures with Type III cement (to evaluate the effects of cement fineness) and binary mixtures with a 20 and 40% replacement of Type I/II cement with Class F fly ash containing added gypsum, which is claimed (by the producer) to reduce shrinkage. These mixtures otherwise represent the prototypical low-cracking bridge deck mix.

RESULTS

The free-shrinkage series cast last quarter with water-cement ratios ranging from 0.36 to 0.42, while maintaining a constant paste content (equivalent to 535 lb/yd^3 of cement with a 0.42 water-cement ratio), indicate slightly decreased shrinkage with decreasing water-cement ratios. The results of the permeability evaluation are not yet available.

The free-shrinkage series cast last quarter with a reduced paste content (497 lb/yd^3 of cement with a 0.42 water-cement ratio) to determine the effect of three different aggregate types (limestone, granite, and quartzite) on drying shrinkage is ongoing. Preliminary results indicate that, when the concrete is cured for 7 days, the 30-day shrinkage of mixes containing limestone is greater than the same mixes containing either granite or quartzite. Specimens cured for 14 days show uniformly lower shrinkage than specimens cured for 7 days, with very little difference in shrinkage as a function of aggregate type. This continues to reinforce the importance of extended curing for all mixture types, with special emphasis on the limestone mixes. Additional mixtures containing 60% GGBFS have been added to the series to determine the combined effects of GGBFS and aggregate type on drying shrinkage.

Preliminary results for the free-shrinkage study using Type III cement with both 7 and 14-day curing indicate increased shrinkage as compared to the prototypical LC-HPC control mix using Type I/II cement. Similarly, mixtures with a 20 and 40% replacement of cement with Class F fly ash containing gypsum, cured for either 7 or 14 days, have significantly increased shrinkage at 30 days compared to the prototypical LC-HPC mix, with no apparent shrinkage reduction provided by the gypsum. These test results are consistent with previous evaluations of mixes containing Class F and Class C fly ash.

OTHER ACTIVITIES

The annual meeting was held on July 17, 2006 in Kansas City, MO.

Project Personnel: David Darwin (Principal Investigator), JoAnn Browning (Co-Principal Investigator)

SUMMARY OF ACTIVITIES EXPECTED TO BE PERFORMED NEXT QUARTER:

A one-year crack survey of the first LC-HPC bridge in Kansas is scheduled for October. Pending weather conditions, a six-month crack survey may occur for the second LC-HPC bridge in Kansas. Post-construction meetings on the second and third bridge LC-HPC bridges in Kansas are scheduled the next quarter.

A series of freeze-thaw and scaling specimens will be cast to evaluate the performance of the most promising mixtures containing GGBFS and silica fume. In addition, freeze-thaw tests to evaluate the effect of aggregate type and different air-entraining agents on freeze-thaw performance are planned.

The ponding cycle will be completed for the AASHTO T 259 permeability specimens to evaluate binary and ternary mixtures containing GGBFS and silica fume, and the series examining water-cement ratios ranging from 0.36 to 0.42 while maintaining a constant paste content. Chloride sampling and testing will begin.

Additional sources of GGBFS have been obtained and will be evaluated to ensure consistent results between different sources.

STATUS AND COMPLETION DATE

Percentage of work completed to date for total project is: 70%

__X__ on schedule _____ behind schedule, explain:

Expected Completion Date: March 31, 2008