KANSAS DEPARTMENT OF TRANSPORTATION

RESEARCH SUMMARY

DEVELOPMENT AND CONSTRUCTION OF LOW-CRACKING HIGH-PERFORMANCE CONCRETE (LC-HPC) BRIDGE DECKS: FREE SHRINKAGE, MIXTURE OPTIMIZATION AND CONCRETE PRODUCTION*

*Available Electronic Only

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Introduction

The development and evaluation of low-cracking high-performance concrete (LC-HPC) for use in bridge decks is described based on laboratory test results and experience gained during the construction of 14 bridges.

The study is divided into three parts covering the development of an aggregate optimization and concrete mixture design program entitled KU Mix, free-shrinkage tests to evaluate potential LC-HPC mixtures developed for use in bridge decks, and the construction and preliminary evaluation of LC-HPC bridge decks constructed in Kansas. This report emphasizes the material aspects of the construction process, design, and environmental factors affecting the performance of LC-HPC bridge decks.

Project Objective

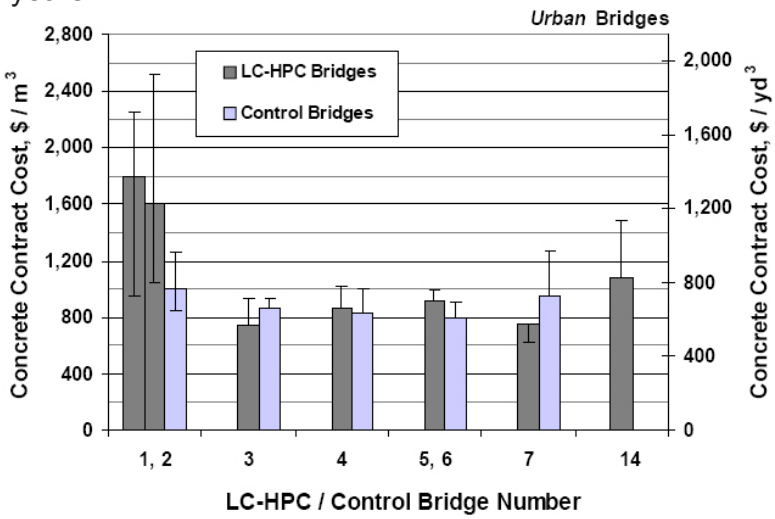
Bridge deck cracking is a well-documented and well-studied problem, and while there is much agreement on practices that contribute to cracking, there are still many questions that exist, especially with regard to the implementation of techniques to reduce cracking in the field. This study bridges that gap through the development and implementation of techniques to construct LC-HPC bridge decks.

Project Description

The KU Mix design methodology for determining an optimized combined gradation uses the percent retained chart and the Modified Coarseness Factor Chart. Experiences with the KU Mix design methodology during the construction of several LC-HPC bridge decks indicate that the process is easily implemented and transferred to concrete suppliers and governing officials. The study also involved evaluating the effect of paste content, water-cement (w/c) ratio, coarse aggregate type, mineral admixture type (silica fume, slag cement, and Class F fly ash each at two levels of replacement), cement type and fineness, a shrinkage reducing admixture, and the duration of curing on the free-shrinkage characteristics of concrete mixtures in the laboratory tested in accordance with ASTM C 157. The evaluation of shrinkage properties includes a total of 56 individual concrete batches. Both a high-absorption (2.5 to 3.0%) coarse aggregate and a low-absorption (less than 0.7%) coarse aggregate were evaluated in many of the comparisons.

Project Results

Experiences with the KU Mix design methodology during the construction of several LC-HPC bridge decks indicate that the process is easily implemented and transferred to concrete suppliers and governing officials. The results indicate that a reduction in w/c ratio (achieved by reducing the water content), longer curing periods, and the addition of a shrinkage reducing admixture reduce concrete shrinkage. When cast with a high-absorption coarse aggregate, the addition of either silica fume or slag cement results in a reduction in shrinkage at all ages, while the addition of fly ash increases early-age shrinkage but has little or no effect on long-term shrinkage. For mixtures containing a low-absorption coarse aggregate, the addition of silica fume or slag cement results in increased early-age shrinkage if the specimens are cured for seven days. These mixtures exhibit reduced shrinkage at all ages when the curing period is increased to 14 days. The addition of fly ash increases shrinkage at all ages for either curing period. The high-absorption limestone used in the study provides internal curing water, which results in the shrinkage of mixtures containing slag cement or silica fume. A preliminary evaluation of these decks indicates that, on average, the LC-HPC decks are performing at a level approximately equal to or exceeding the best performing monolithic decks in Kansas surveyed over the past 15 years.



Report Information

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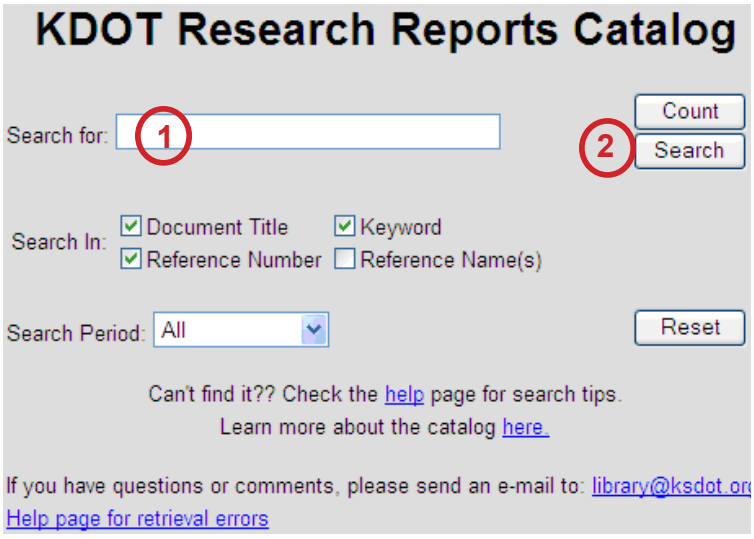

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