Kansas Department of Transportation

TECHNICAL SUMMARY

Construction of Low-Cracking High-Performance Bridge Decks Incorporating New Technology Phase II

Report Number: FHWA-KS-23-02 ▪ Publication Date: December 2023

Alireza Bahadori
David Darwin, Ph.D., P.E.
Matthew O'Reilly, Ph.D., P.E.
Mohsen Salavati Khoshghalb

The University of Kansas

Introduction

Bridges are essential components of the U.S. infrastructure, allowing for vehicles to move across the country to areas that would be otherwise inaccessible. There are more than 617,000 bridges in the United States. Forty-two percent of these bridges are over 50 years old and will most likely need to be rehabilitated or replaced (ASCE, 2021). In 2021, the American Society of Civil Engineers (ASCE) reported that 7.5% of U.S. bridges were structurally deficient (ASCE, 2021). Furthermore, for years, travel demands and the costs associated with bridge rehabilitation and replacement have increased while funding has been limited (Koch et al., 2002). As a result, the federal government estimates a backlog of bridge rehabilitation and replacement of $125 billion (ASCE, 2021).

In 2004, a nationwide survey of state transportation agencies by the Federal Highway Administration's (FHWA) High-Performance Concrete Technology Delivery Team (HPC TDT) indicated that cracking of concrete decks, corrosion of reinforcing steel, cracking of girders and substructures, and freeze-thaw damage of concrete were the topmost bridge deficiencies (Triandafilou, 2005). This study is aimed at the first of these deficiencies by minimizing cracking in bridge decks through the use of internal curing provided by prewetted fine lightweight aggregate combined with proven procedures for constructing low-cracking high-performance concrete (LCHPC) bridge decks.

Project Description

The objective of this study is to investigate the cracking of concrete bridge decks employing internal curing. Concrete mixtures incorporating internal curing, used in conjunction with slag cement with or without small amounts of silica fume (as partial replacements of portland cement), are investigated based on construction observations and crack surveys of bridge decks constructed in Kansas and Minnesota.

Observations for nine IC-LC-HPC and two control bridge decks in Minnesota and three IC-LC-HPC bridge decks in Kansas constructed between 2016 and 2021 in accordance with Minnesota and Kansas internally cured low-cracking high-performance concrete (IC-LC-HPC) specifications are used to develop recommendations that help to minimize or prevent cracking of bridge decks. The importance of following good construction procedures is discussed in light of previous research, which indicates that poor procedures can reduce the effectiveness of crack-reducing technology. The construction procedures, concrete properties, and documented field observations help provide guidance for the construction of future IC-LC-HPC decks.

Project Results

As demonstrated in earlier studies, the use of overlays on bridge decks is not beneficial in mitigating cracking; the two IC-LC-HPC bridge decks with an overlay exhibited much greater cracking than the IC-LC-HPC decks without an overlay. The use of overlays on bridge decks is not recommended and should be avoided. With paste contents between 23.8 and 25.8 percent of the concrete volume, the IC-LC-HPC decks constructed in this study in conjunction with the Minnesota and Kansas IC-LC-HPC specifications exhibited lower average crack densities than those without IC. This indicates that the combination of low paste, internal curing, and good construction procedures offer the potential to reduce cracking, but because the number of bridges was small, it deserves further study.

Good construction practices are needed for low-cracking decks. If poor construction practices, including poor consolidation and disturbance of concrete after consolidation, over-finishing, delayed application of wet curing, and tining as one of the potential causes for delayed curing, are employed, even decks with low paste contents and IC can exhibit high cracking. Delayed curing and over-finishing can also result in scaling damage to bridge decks.

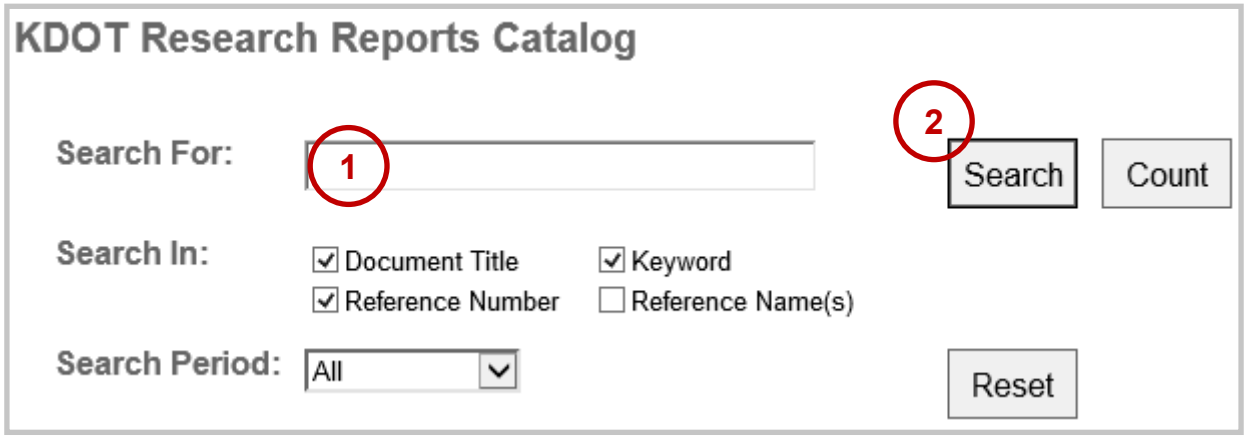
Project Information

For information on this report, please contact David Darwin, Ph.D., P.E., The University of Kansas, 1530 W. 15th St, Lawrence, KS 66045; 785-864-3827; daved@ku.edu.

Directions for Downloading the Full Report

To download the full report, visit https://kdotapp.ksdot.org/kdotlib/kdotlib2.aspx and do the following:

1. Enter FHWA-KS-23-02 in the search box.
2. Click the Search button to the right of the search box.
3. You may have to scroll to find the specific report.
4. To download the report, click on the title of the report to open the PDF file and save it to your hard drive.



If you have any questions, please email us at KDOT#Research.Library@ks.gov.