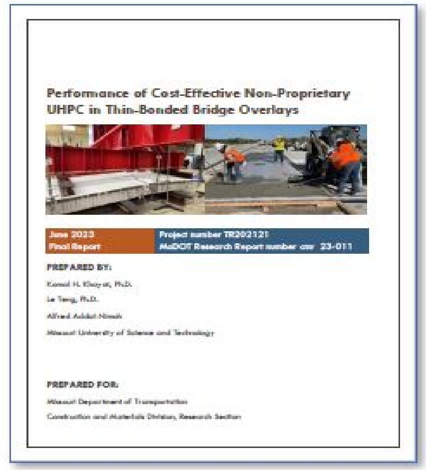
For more information contact: Brent Schulte (573) 526-4328

Research Summary

Performance of Cost-Effective Non-Proprietary UHPC in Thin-Bonded Bridge Overlays


Performance of Cost-Effective Non-Proprietary UHPC in Thin-Bonded Bridge Overlays

June 2023
Final Report

Project number TR202121
MoDOT Research Report number cmr 23-011

PREPARED BY:

Kamal H. Khayat, Ph.D.

Le Teng, Ph.D.

Alfred Addai-Nimoh

Missouri University of Science and Technology

PREPARED FOR:

Missouri Department of Transportation

Construction and Materials Division, Research Section

The constructability and performance of non-proprietary thixotropic ultra-high-performance concrete (UHPC) for thin bonded bridge deck overlay construction was investigated.

Task 1 reviewed the main literature on UHPC for thin bonded overlays and non-proprietary UHPC. Crack monitoring and pull-off bond strength of 16 composite overlay slabs prepared with substrate bridge concrete and thin bonded overlays cast mainly with UHPC were investigated. Flexural testing of the composite slab elements showed that the use of UHPC overlay delayed crack opening and propagation in slab specimens.

Figure 1: Flexural testing of composite slabs repaired with thin bonded UHPC overlay

Task 2 involved fine tuning of two non-proprietary UHPC mixtures to enhance thixotropy. The use of 0.5% ABS admixture, by mass of binder, exhibited the highest thixotropy without mitigating mechanical properties of the UHPC. A 3.25% volume of steel microfibers measuring ½ in. in length was selected to enhance hardened properties. The robustness of the optimized UHPC was evaluated by varying the w/cm by ±10% and the sand moisture content by ±1%. These variations had insignificant effect on rheology, shrinkage, and compressive strength. A minimum of 7 days of moist curing was recommended for field construction.

Task 3 proposed provisional performance-based specifications for the non-proprietary thixotropic UHPC for bridge overlay construction. The specifications included two proven mixture designs, batching and mixing protocols, test methods, and performance criteria for workability, mechanical properties, as well as autogenous and drying shrinkage.

Task 4 involved the implementation of the LWS17 and SRA1-3.25% UHPC mixture for the rehabilitation of two MoDOT bridge decks. A mockup slab was prepared at to demonstrate the constructability of the UHPC. After 8 months of outdoor exposure, the slab did not exhibit any cracking. A field mockup test consisting of two slabs measuring 12 x 12 ft was conducted by the contractor using 1-in. long twisted steel fiber. The UHPC was used to rehabilitate two bridge measuring approximately 202 ft. in. length and 21 ft. in. width. The temperature of the fresh UHPC ranged from 90 to 99 °F, which is higher than the specified value of 86 °F. The slump flow, air content, and variation of static yield stress with rest time met the performance specifications of the UHPC. However, there were problems in maintaining continuous moist curing. In-situ temperature of the 1.5-in. thick UHPC overlay dropped from 78°F to 40° F after 3 days in the case of the Route M overlay then to 20° F at 7 days. Field inspection was carried out after one week and approximately 3 months. The South bound lane of Route Z Bridge had no signs of cracking after 96 days.

> *"The objective of this research was to evaluate the constructability and performance of the non-proprietary thixotropic UHPC for thin bonded bridge deck overlay construction."*

Figure 2: Field implementation of thin-bonded thixotropic UHPC for Route Z Bridge, over Highway 70 in Missouri

Based on the field observations, the performance-based specifications of the UHPC can be maintained except for the initial slump flow before and after jolting that was 4 to 6 in. and 6 to 7 in., respectively. It is recommended to ensure strict quality control of the water content during mixing, especially any additional water available from the saturated LWS. The LWS should be used under SSD conditions. Furthermore, it is important to ensure a minimum of 7 days of continuous moist curing of the UHPC overlay before bridge opening.

Project Information

PROJECT NAME: TR202121—Performance of Cost-Effective Non-Proprietary UHPC in Thin-Bonded Bridge Overlays

PROJECT START/END DATE: April 2021-May 2023

PROJECT COST: $149,997

LEAD CONTRACTOR: Missouri University of Science & Technology

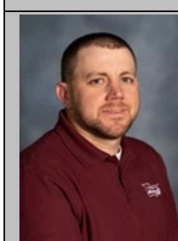
PRINCIPAL INVESTIGATOR: Kamal H. Khayat, PhD, P.Eng.

REPORT NAME: Performance of Cost Effective Non-Proprietary UHPC in Thin-Bonded Bridge Overlays

REPORT NUMBER: cmr 23-011

REPORT DATE: May 2023

Project Manager



CONTACT INFORMATION:

Brent Schulte
Senior Research Analyst
Missouri Dept. of Transportation
1617 Missouri Blvd.
Jefferson City, MO 65109
(573) 526-4328
Brent.Schulte@modot.mo.gov