MONTANA Department of Transportation
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Implementation Report

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EXPLORATION OF UHPC APPLICATIONS FOR MONTANA BRIDGES

https://www.mdt.mt.gov/research/projects/uhpc.aspx

Introduction and Purpose

Ultra-high performance concrete (UHPC) has mechanical and durability properties that far exceed those of conventional concrete. Montana State University has conducted a series of research studies on UHPC, including an implementation project using UHPC for precast member connections on two bridges spanning Trail Creek on Highway 43, west of Wisdom, MT. The current project aimed to build on the successes of this previous research and explore additional applications of UHPC on Montana bridges. Bridge deterioration, including decks and other structural members, is a significant issue across Montana. UHPC overlays and patching/repair methods may offer a viable alternative to complete bridge or member replacement. The research discussed herein mainly focused on using UHPC as a bridge deck overlay material, and included the necessary testing to ensure its successful implementation in this new application. Overall, this research was a critical step toward capitalizing on the benefits of using UHPC in new applications, ultimately increasing the lifespan of Montana's existing concrete infrastructure.

This research began with a literature review of UHPC applications for bridge repair, primarily focusing on thin-bonded overlays and bridge member repair. Additional research was conducted into completed UHPC bridge deck overlay projects and specifications from other states. A recently published FHWA report on UHPC-based preservation and repair methods served as the primary source for this investigation, supplemented by UHPC-related material specifications/provisions from four other state DOTs. The success other states have had using UHPC for overlays is very promising for its potential use in an overlay implementation project in Montana.

Material-level testing was conducted on three UHPC mixes to investigate the workability, compressive and tensile strengths, and bond strengths with varying surface preparation techniques. Structural testing was then performed on five slabs with UHPC overlays to quantify the effects that UHPC overlays have on the behavior and capacity of existing bridge decks. The test results demonstrated that the inclusion of a UHPC overlay significantly improved the stiffness and ultimate capacity of the slab specimens. Additionally, the results indicated that a bridge deck constructed with lower-strength concrete retrofitted with a thin UHPC overlay can exhibit comparable performance to a deck built with higher-strength conventional concrete.

Overall, this research clearly demonstrated the benefits of using UHPC as an overlay to repair/strengthen existing bridge decks; however, there are several implementation related challenges that should be investigated/addressed before it can be widely used for bridge deck strengthening/repairs on Montana bridges.

Implementation Summary

Despite the promising attributes of UHPC in enhancing the durability, strength, and overall performance of existing bridge decks, there are knowledge gaps regarding its practical implementation as a bridge deck overlay in Montana. The current state of knowledge is insufficient in addressing key challenges related to construction methodologies, material availability and handling, and the potential structural implications of integrating UHPC overlays into existing bridge infrastructure.

Implementation Recommendations

RECOMMENDATION 1:

Conduct a UHPC Bridge Deck Overlay Implementation/Field-Demonstration Project

To further investigate potential construction issues that may hinder the use of UHPC as a bridge deck overlay, an implementation/field-demonstration project should be pursued.

The successful execution of this project will clearly demonstrate the benefits of using UHPC as a bridge deck overlay material in Montana. Beyond the immediate extension of the selected bridge's lifespan, this project will instill confidence within MDT regarding the effective use of UHPC in this application. By addressing critical implementation questions, this research will pave the way for the successful rehabilitation of numerous deteriorating bridge decks across Montana in the future. Building upon the already established potential of UHPC in various bridge applications, the successful completion of an additional implementation project will provide MDT with another valuable tool in its bridge repair toolbox.

MDT RESPONSE:

MDT is interested in pursuing a UHPC bridge deck overlay implementation project and is working to identify an appropriate bridge project for this additional research.

RECOMMENDATION 2:

Considerations for Using MT-UHPC in Overlay Projects

It is recommended that a proprietary UHPC mix be used for bridge overlay applications rather than the nonproprietary MT-UHPC. Before MT-UHPC can be used in this application, several limitations of MT-UHPC need to be addressed. Specifically, the thixotropic version of MT-UHPC needs to be thoroughly developed and tested to achieve desirable flows (both dynamic and static) while maintaining high compressive and tensile strengths. The researchers recommend investigating additional admixtures and optimizing their dosages to enhance flow properties without compromising strength. Additionally, the batch sizes of MT-UHPC must be increased to accommodate the large quantities required for overlay projects. Currently, batch sizes are limited to 3 ft^3 (0.11 yd^3) when mixing MT-UHPC with IMER Mortarman 360s, and the existing UHPC overlay projects investigated as part of this research required UHPC volumes ranging from 13 yd^3 (small project) to 328 yd^3 (large project). The current batch size limitation of MT-UHPC will result in an unreasonable number of batches for an overlay project.

MDT RESPONSE:

If MDT uses UHPC as an overlay to strengthen bridge decks, it will use a proprietary mix unless it conducts or sponsors the necessary research to make MT-UHPC a viable alternative.

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