MONTANA
Department of Transportation
Research

Technical Brief

## About This Research

### Objective

- Demonstrate the effectiveness of Montana's UHPC material by using it between precast concrete elements on two Montana bridge replacement projects.

### Benefits

- Hands-on experience and direct insight into batching, mixing, and application procedures in the field
- Real-world data confirming the material's strength and durability

## About This Project

Project title: Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana: Implementation

Project number: 9925-818

### Technical Panel

Lenci Kappes (Chair, MDT), Stephanie Brandenberger (FHWA), Paul Bushnell (MDT), Meghan Coon (MDT), Wes Dess (MDT), Oak Metcalfe (MDT), Matt Needham (MDT), Jin Nelson (MDT), and Tyler Steffan (MDT)

### Principal Investigator

Michael Berry
Research Assistant Professor
Western Transportation Institute
berry@montana.edu
406-994-1566

# PUTTING MONTANA'S ULTRA-HIGH PERFORMANCE CONCRETE TO WORK

*MDT used UHPC between the joints of precast concrete elements on this bridge replacement project.*

## Research Need

Ultra-high performance concrete (UHPC) is significantly stronger, more water-resistant, and longer-lasting than conventional concrete. However, UHPC's proprietary formula makes the material too expensive for use in most applications.

For the past several years, the Montana Department of Transportation (MDT) has collaborated with university researchers to develop nonproprietary UHPC mixes. Made with materials found locally in Montana, this new formula is designed specifically to suit the state's environmental conditions and can be created at a much lower cost than its proprietary counterpart.

To validate MDT's research to date under real-world conditions and gain practical experience with the Montana-specific UHPC mixture at an actual jobsite, two deteriorated state bridges were selected as demonstration projects to showcase the potential of UHPC and identify any unknown barriers.

## Research Process

The location of the two bridges that were selected for this project made rerouting traffic a challenge, so MDT used an accelerated construction method. By building with preformed concrete elements and using UHPC to fill the joints and hold the components in place, each bridge could be demolished and reconstructed in only 96 hours.

> *"This demonstration project provided us with practical, hands-on experience for working with Montana's UHPC in the field. Thanks to this work, we have a better understanding of how the material will perform and another tool in our toolbox for building and repairing bridges in the state."*
>
> —Lenci Kappes, Project Champion

### MDT Project Champion

Lenci Kappes
Structures Engineer
Bridge Bureau, MDT
lkappes@mt.gov
406-751-2033

### Learn More About This Project

Final report is available in ROSA P.

A review of previously published research revealed a number of successful strategies and practices to avoid when mixing and applying the UHPC on-site. Drawing from this knowledge, the researchers then investigated how different mixing methods and temperatures could affect Montana's UHPC, creating trial batches of the material and applying it to sample bridge joints to better understand how the material would perform in the field under a variety of conditions.

To reconstruct the bridges, concrete components that had already been formed and cured were delivered to the jobsite where the UHPC was batched, mixed, and applied to the research's exacting specifications.

## Research Results

The process revealed a number of valuable findings for working even more effectively with UHPC in the field. Below are some of these findings:

**Batches can be mixed consecutively.** Because mixing UHPC properly requires significant power, the material is typically created in small batches to avoid overwhelming the equipment. This project required a large quantity of UHPC, and batching and mixing would be a time-consuming part of the construction process. During the trial period, researchers discovered that consecutive batches of UHPC could be mixed without the need to stop and clean the equipment between batches, providing a viable option for saving time and increasing efficiency.

**Ambient temperature plays an important role.** Temperature extremes were noted on-site, ranging from overnight lows of approximately 20 degrees Fahrenheit to daytime highs in the upper 80s, which affected UHPC performance. Strategies for reducing the effects of temperature included warming the mixers before batching to combat the cold and replacing some water in the mix with ice when heat was excessive. UHPC placed when temperatures were lower generally performed better, as higher temperatures and windy conditions were found to cause premature stiffening.

**Strength estimates are reliable.** The project followed an industry standard method for estimating concrete strength, which allowed each stage of construction to proceed without the need for destructive and costly core testing.

As predicted, Montana's UHPC formula performed well, and the bridges were built and opened to the public within the expected accelerated timeline.

## Research Implementation

The project provides MDT with greater insight for working with Montana's nonproprietary UHPC formula and clears the path for more widespread use in the future.

The research was honored with the President's Transportation Award for Research and a 2022 Supplemental High Value Research Award.

Future research could investigate the use of higher-volume mixers to create larger batches of UHPC, the potential of different additives to reduce the viscosity of the UHPC mixture so that it could be applied to sloped locations, and the substitution of ingredient materials that are becoming difficult to source.