Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for use in Highway Bridges in Montana: Phase III: Implementation

Authors: Michael Berry
Elias Hendricks
Kirsten Matteson

Research completed for: The State of Montana Department of Transportation - FHWA/MT-23-002/9925-818
in cooperation with: The U.S. Department of Transportation Federal Highway Administration

Background

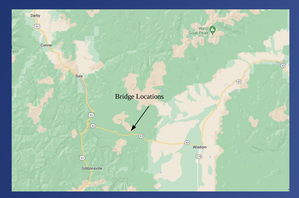
Advantages of UHPC

- Exceeds mechanical and durability properties of conventional concrete
- Reaches compressive strength upwards of 20 ksi

Research Objective and Scope

Objective

The focus of this project was on the field implementation of MT-UHPC. Specifically, MT-UHPC was used in all field-cast joints on two ABC bridges spanning Trail Creek on Highway 43 near Lost-Trail Pass outside of Wisdom, MT.

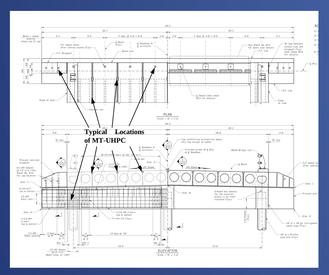


Bridge Locations

One of existing Trail Creek Bridges

Tasks

- Document materials to be used in trail creek structures.
- Conduct implementation-related research to ensure the successful field application of MT-UHPC. Specifically, mixing methods and temperature effects were investigated, and a maturity curve was developed to predict early strength gain in the field. Investigate issues related to field batching and mixing in various conditions.
- Perform trial batches of MT-UHPC and place them in mockup bridge joints. This was done on site using the same methods and under the same environmental conditions expected on the day of construction.
- Implement Montana UHPC in the replacement of the Trail Creek bridges. Specifically use it for all field-cast connections, including the pile-to-pile cap connections, the connections between the beams and caps, the wing walls, and the longitudinal shear-keys between adjacent beams.



Materials

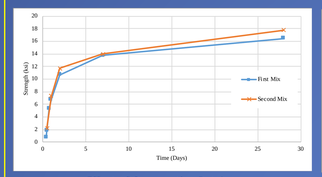
Source Materials

- Cement was a Type I/II/IV from the GCC cement plant in Trident, MT.
- Fly ash was a Class F ash sourced from Prairie State Energy Campus in Marissa, IL.
- Fine aggregate was a masonry sand processed and packaged by QUIKRETE near Billings, MT.
- Silica fume was MasterLife SF 100 from BASF.
- High range water reducer (HRWR) was CHRYSO Fluid Premia 150.
- Steel fibers were sourced by Hiper Fiber and were 13 mm long, had a diameter of 0.2 mm and a tensile strength of 285 ksi.

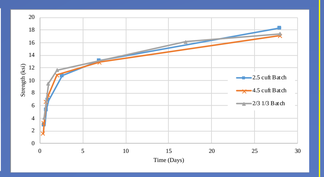
Implementation Research

Scope

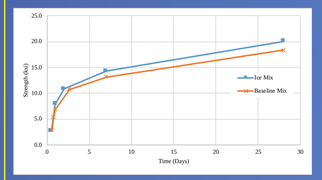
- Ensure successful field implementation of MT-UHPC.
- Mixing process.
- Batch size.
- Mixing and curing temperatures.
- Maturity curve development.
- Collaboration with contractor was key.



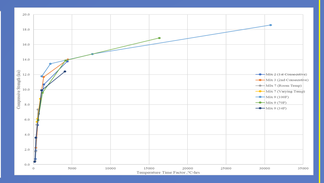
Effect of Consecutive Batches



Effect of Batch Size



Effect of Using Ice in Mix



Maturity Curves

Trial Batches and Mockup

Scope

- Batch near location of bridge replacement (Wisdom, MT).
- Same methods and environmental conditions expected during construction.
- Three replica field-cast connections: Mockup Pile Cap, and two mockup keyways.

UHPC Batching/Mixing

UHPC Placement in Pile Cap and Keyway

Keyway Finishing

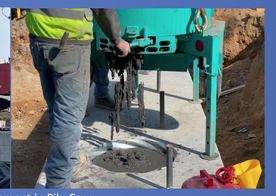
Bridge Construction

Scope

- Use MT-UHPC in all field-cast joints on Trail Creek Structures.
- Pile-to-Pile cap connections.
- Keyways between deck elements.

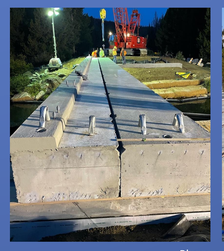
Demolition and Site Preparation

Pile Cap Placement



UHPC Placement in Pile Caps

Placement of Beam/Deck Elements



Placement of Beam/Deck Elements

Keyway Preparation

Bridge Construction

MT-UHPC Placement

Removal of Forms and Grinding

Finished Bridge with Epoxied Keyways

Bridge Observations at 1 Year

Research Team

Overall Conclusion

This project was a successful demonstration of using a nonproprietary UHPC in field-cast joints for an accelerated bridge construction project. All placed UHPC had adequate flows, gained strength quickly, and reached the required minimum compressive strengths.