

Innovative UHPC Mixing and Placing Techniques for the Repair of Three Illinois Bridges

Michael McDonagh, P.E., P.Eng.
Vice President, Eng. & Projects
michael@steelike.com



THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE



Agenda

1. UHPC Introduction
2. Project Overview
3. Repair Approach
4. Traditional UHPC Construction Practices
5. Innovative UHPC Construction Techniques
6. Lessons Learned
7. Summary

UHPC INTRODUCTION

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Steelike
Concrete

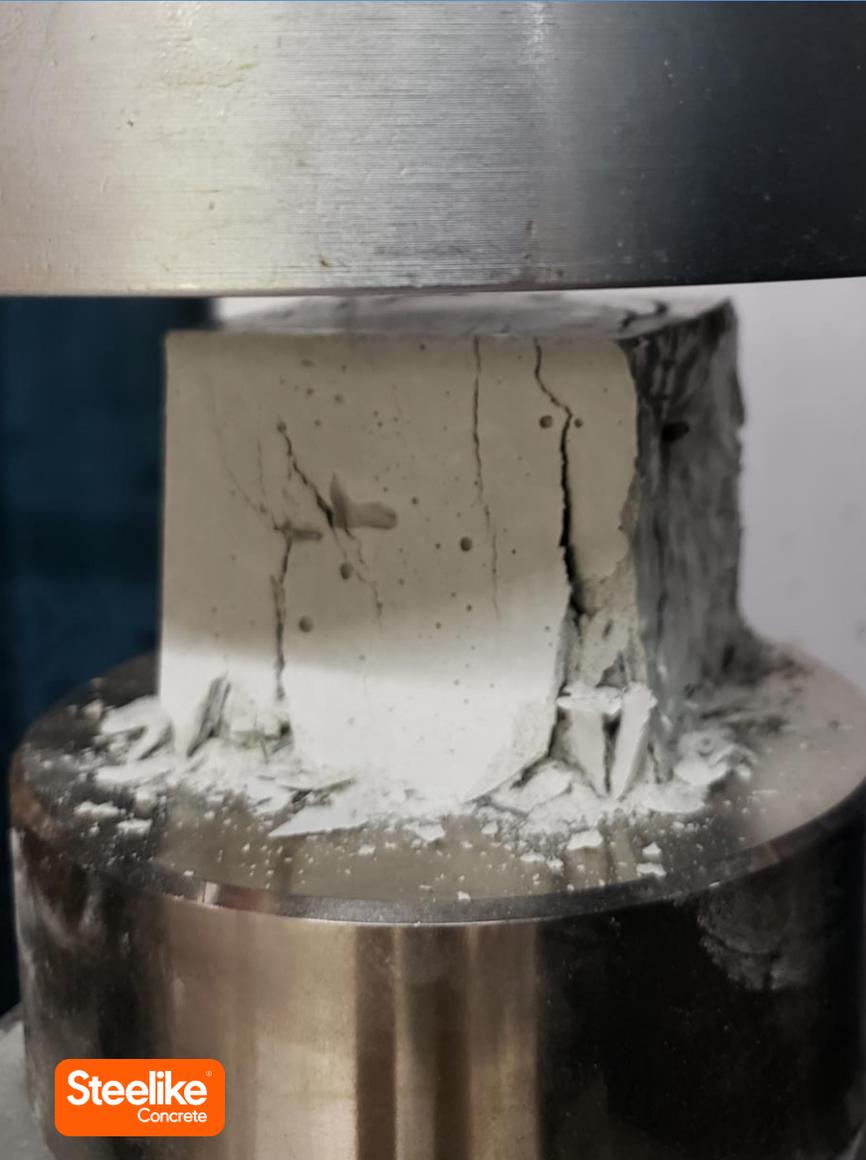
What is UHPC?

- Cementitious fiber-reinforced composite
- Largest particle is fine sand $\leq 0.5\text{mm}$ diameter
- Highly flowable, self-consolidating
- Water-cementitious material ratio < 0.25
vs. $0.40-0.60$
- Advantageous mechanical and durability properties



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UHPC Mechanical Performance

- 22,000 psi compressive strength vs. 4,000 psi
- ≥ 750 psi tensile strength vs. 0-200 psi
- 600 psi bond to conventional concrete vs. 0?
- Strain hardening to $\geq 0.0035 \mu\epsilon$ tension vs. brittle

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UHPC Durability Performance

- Rapid Chloride Test (ASTM C1202)
 - ≤ 250 coulombs permeability vs. 1,000-4,000
- Chloride Ion Diffusion Coefficient (ASTM C1556)*
 - 2×10^{-13} m²/s
 - 2×10^{-12} m²/s for high-performance concrete (HPC)
 - 2×10^{-11} m²/s for conventional concrete
 - No corrosion on rebar with 3/8-inch cover in UHPC samples left for 10 years at mean tide in northern Maine

* Source: FHWA Report FHWA-HRT-06-103
Material Property Characterization of Ultra-High Performance Concrete



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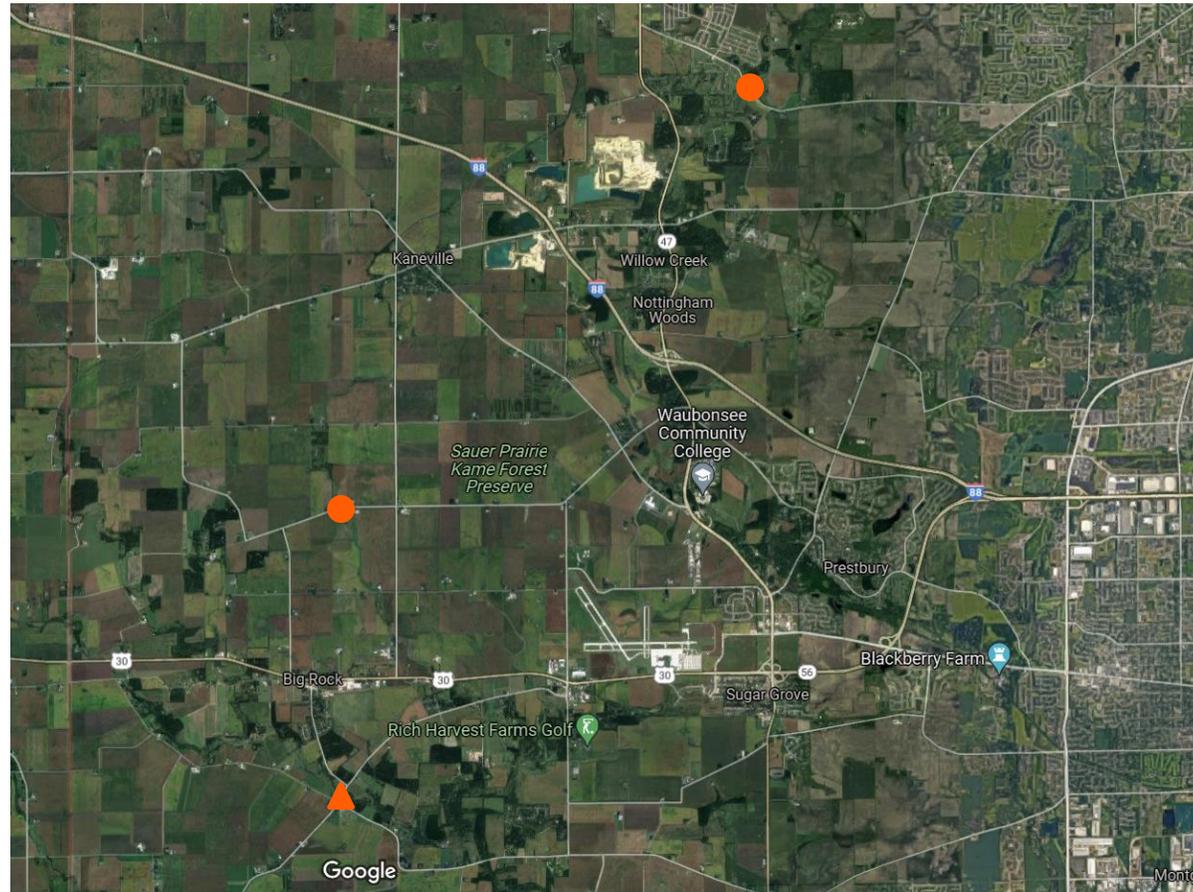
PROJECT OVERVIEW

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Project Overview

- Repair of Three Bridges
 - Kane County, IL
 - About 50 miles west of Chicago
 - All bridges within 15 miles of each other
 - Two box beam bridges with failing connections ●
 - One bridge deck rehabilitation ▲



Source: Google

Scott Road Bridge over Welch Creek



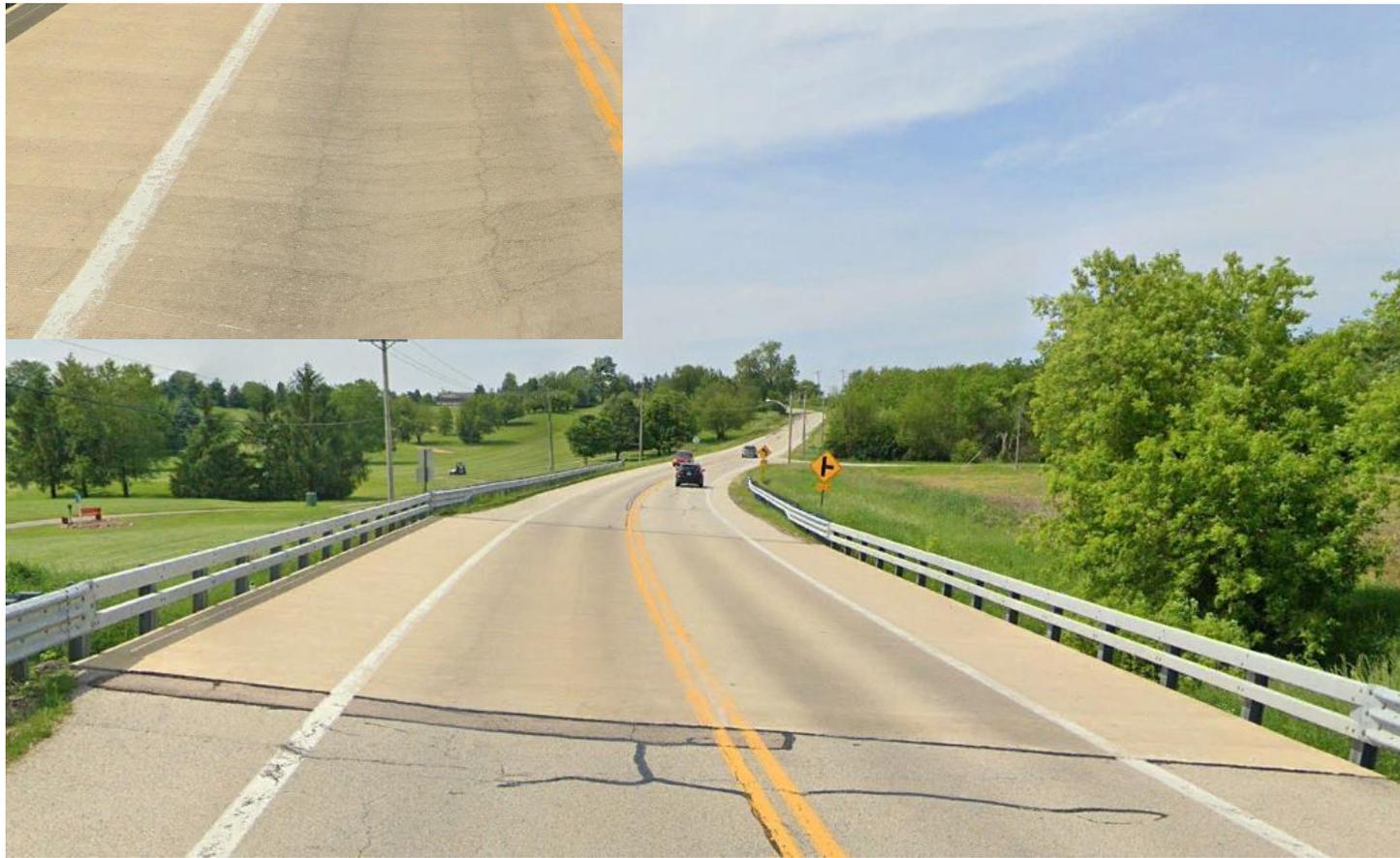
Source: Google

- Condition Prior to Repair
 - Side-by-side box beams
 - 75-feet long, 30-feet wide
 - Asphalt overlay
 - Reflective cracking in overlay
 - Failure of box beam grouted keyways

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Hughes Road Bridge over Blackberry Creek



Source: Google

- Condition Prior to Repair
 - Side-by-side box beams
 - 85-feet long, 40-feet wide
 - Concrete overlay
 - Reflective cracking in overlay
 - Failure of box beam grouted keyways

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Granart Road Bridge over Big Rock Creek



Source: Google

- Condition Prior to Repair
 - 140-feet long, 50-feet wide
 - Concrete deck
 - Cracking of deck

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The background image features a close-up of concrete test specimens. On the left is a rectangular specimen with 'Steelike Concrete' embossed on it. In the center is a large hexagonal specimen with 'AIRL' and 'JK' faintly visible. A yellow pencil lies horizontally across the bottom of the specimens. In the background, a large metal bolt is visible. The overall scene is set against a neutral, light-colored background.

SCOTT AND HUGHES ROAD BRIDGES REPAIR APPROACH

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Scott and Hughes Box Beam Keyway Repairs



- Demolition
 - Removal of overlays
 - Excavation and widening of keyway connections
 - Exposure of box beam rebar
 - V-shaped connection edges

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Scott and Hughes Box Beam Keyway Repairs



- Repair
 - New rebar stirrups link the box beam rebar across the connections
 - Connections filled with Steelike® UHPC
 - Only the 3rd and 4th applications of UHPC for box beam connection repair



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GRANART ROAD BRIDGE REPAIR APPROACH

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Granart Road Bridge Deck Rehabilitation



- Demolition
 - Hydrodemolition of deck surface

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Granart Road Bridge Deck Rehabilitation



- Repair
 - 1.5-inch Steelike® UHPC overlay

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UHPC DECK-LEVEL CONNECTIONS TRADITIONAL PRACTICES

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Traditional Practice: Mixing



Vertical shaft high-shear mixers

Source: FHWA

- Rent Specialty Mixers
- 0.6 CY Maximum Capacity
- Multiple Mixers
- Generators Required

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Traditional Practice: Top Forming



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Traditional Practice: Overfill



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Traditional Practice: Grind Overfill



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UHPC OVERLAYS TRADITIONAL PRACTICES

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Traditional Practice: Mixing



Horizontal shaft high-shear mixers

Source: NJDOT

- Rent Specialty Mixers
- 1.4 CY Capacity
- Multiple Mixers
- Generators Required

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Traditional Practice: Transporting

- Concrete Buggies



Discharging UHPC from concrete buggy in front of overlay screed

Source: NJDOT

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Traditional Practice: Curing



Plastic sheeting with wind blowing underneath

Source: WSP

- Curing Compound
- Plastic Sheeting
- Hold-downs

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Traditional Practice: Curing



Impressions in final grinded and grooved surface from sheeting

Source: WSP

What Can Go Wrong

- Wind blows under sheeting
- Wind blows sheeting into live traffic
- Sheeting or hold-downs leave deep impressions
- Workers leave deep footprints attempting to adjust hold-downs

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INNOVATIVE MIXING AND PLACING TECHNIQUES SCOTT AND HUGHES KEYWAY REPAIRS

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Scott and Hughes Box Beam Keyway Repairs



Mixing Steelike® UHPC in standard ready-mix truck

UHPC Mixing

- Steelike UHPC mixed in a locally available standard ready-mix truck
- Up to 6 CY mixed per batch
 - Discharged as fast as contractor could place it
- Eliminated:
 - Shipping of specialty mixers
 - Multiple mixers
 - Large generators



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Scott and Hughes Box Beam Keyway Repairs



Delivering Steelike® UHPC in standard ready-mix truck

UHPC Mixing

- Leftover material from overlay project was used on one occasion on Hughes Rd
- Batch was mixed 15 miles away and driven to bridge
- Steelike UHPC in truck was still workable after more than 1.5 hours since mixing
- Reduced significant material waste
- Saved time by eliminating mixing of a batch



Scott and Hughes Box Beam Keyway Repairs



Placing Steelike® UHPC in longitudinal connections with no top forms

UHPC Install

- No top forms
- Connections cast flush with deck along high edge
 - No trapped air
- Edge form along low edge

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Scott and Hughes Box Beam Keyway Repairs



Cured Connections

Source: Kane County DOT

UHPC Curing and Finishing

- Curing compound used for curing
- Eliminated grinding
 - Due to placement of asphalt overlay, the minimal overfills along the low edges were allowed to remain

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INNOVATIVE MIXING AND PLACING TECHNIQUES GRANART ROAD BRIDGE UHPC OVERLAY

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Granart Road Bridge UHPC Overlay



Discharging Steelike® UHPC from ready-mix truck

UHPC Mixing

- Steelike UHPC mixed in a locally available standard ready-mix truck
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Granart Road Bridge UHPC Overlay



Directly discharging Steelike® UHPC onto bridge deck in front of screed.

UHPC Transport / Discharge

- Steelike UHPC discharged directly to the deck from ready-mix truck
- Eliminated:
 - Concrete buggies
 - Buggy operators
 - Waste generated by transferring UHPC to buggies
- Accelerated placement
- Similar to ready-mix concrete discharge



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Granart Road Bridge UHPC Overlay



Curing Steelike® UHPC overlay without plastic sheeting.

UHPC Curing

- Only curing compound used to cure overlay (no sheeting)
- Eliminated risks of:
 - Wind blowing under sheeting
 - Wind blowing sheeting into live traffic
 - Impressions in overlay from sheeting or hold-downs
 - Footprints in overlay from workers adjusting sheeting



Granart Road Bridge UHPC Overlay



Completed project

Finished Project

- Overlay surface was grinded



LESSONS LEARNED

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Lessons Learned

- **Mockups are essential. The closer the mockups represent actual project conditions the better, especially for overlays.**
 - Contractor gets to practice and tune methods, including screed speed and vibration intensity for overlays.
 - UHPC supplier gets understanding of overlay consistency needs.
- **Contractors should follow past successful UHPC practices rather than assumptions.**
 - Overlays should be placed from low to high.
 - Proper sealing of forms
 - Keeping a clean site

SUMMARY

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Summary

Innovative UHPC Mixing Techniques:

- **Steellike UHPC mixed in standard, locally available ready-mix trucks**
 - Up to 6 CY batch sizes for connections
 - Up to 5 CY batch sizes for overlay
 - Partial batch transported from one bridge to another, reducing waste and saving time
 - UHPC remained workable in truck up to 1.5 hours after mixing

Summary

Innovative UHPC Placing Techniques (connections):

- No top forming
 - No trapped air
 - Eliminated grinding

Innovative UHPC Placing Techniques (overlay):

- UHPC directly discharged from truck to deck
 - Accelerated work, reduced labor, reduced waste
- Cured without plastic sheeting
 - Eliminated many risks associated with sheeting

Summary

Conclusions:

This was the contractor's first time working with UHPC, which created some challenges. However, with guidance that Steelike shared from other contractor's approaches, the contractor was ultimately able to successfully place Steelike® UHPC for connections and overlays on the three bridges.

The multiple unique Steelike innovations for mixing and placing UHPC helped accelerate portions of the contractor's work, reduced waste, and reduced the contractor's costs.

THANK YOU



Michael McDonagh, PE, P.Eng.
Vice President, Engineering & Projects
(215) 388-4445
Michael@Steelike.com

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