Iowa UHPC Bridge Overlays

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Office of Bridge and Structures
Iowa Department of Transportation
UHPC – Quick Introduction
(Ultra High Performance Concrete)

- Cementitious composite material
- Optimized gradation of granular constituents
- Water-to-cement ratio less than 0.25
- High percentage of discontinuous internal fiber reinforcement
- Compressive strengths greater than 21.7 ksi
- Sustained postcracking tensile strength greater than 0.72 ksi
- Discontinuous pore structure
Typical Iowa DOT overlay

- 1970’s Iowa DOT
- Low Permeability
- More Durable
- Low Slump
UHPC Vs. Conventional Overlay

Potential Benefits
- 10x Lower Permeability
- Fiber Crack Control
  - 3.25% vs 2% typical Ductal
- Freeze–Thaw Resistance
  - 400 cycles –no degradation
- Strengthening
- Durability

Challenges
- Unfamiliar
- Composite Action/Bond
- Cost
- Mixing on site
- Material Flows – Placing and Finishing
- Grinding and Grooving
Location 1 – Mud Creek
Mud Creek Objectives

- Evaluate constructability on superelevation
- Test UHPC overlay as a maintenance application
- Predict bridge strength improvements (Can HL–93 Loading be accommodated?)
- Research building block
The Original Bridge

- Built in 1967
- 3 span Continuous Concrete Slab Bridge
- 0° Skew
- 5% Superelevation
- Located 2.25 miles West of Brandon on Laporte road over Mud Creek
### Original Bridge Characteristics

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Properties</th>
<th>Properties Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway Width (ft)</td>
<td>Concrete Compressive Strength (ksi)</td>
<td>3</td>
</tr>
<tr>
<td>Out to Out Width (ft)</td>
<td>Rebar Grade (ksi)</td>
<td>40</td>
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<tr>
<td>Original Concrete Thickness (in)</td>
<td>Concrete Modulus of Elasticity (ksi)</td>
<td>3300</td>
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<tr>
<td>Total Length Length (ft)</td>
<td>Steel Modulus of Elasticity (ksi)</td>
<td>29000</td>
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<tr>
<td>Exterior Span Length (ft)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior Span Length (ft)</td>
<td></td>
<td>39</td>
</tr>
</tbody>
</table>
Repair and Overlay Description

- Buchanan county bridge – Brian Keierleber
- Removal to top bars
- Plan to repair patches using HPC
- UHPC mix provided by Lafarge North America
- Welded wire fabric over piers in one lane
- Additional removal west abutment (Typical)
- No Additional removal on east abutment
- Mockup for testing by Iowa State
- FHWA direct tension test – report pending
UHPC Overlay Plans
UHPC Overlay Plans
<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grinding depth (in)</td>
<td>UHPC Compressive Strength (ksi) 20</td>
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<tr>
<td>Overlay Thickness (in)</td>
<td>UHPC Tensile Strength (ksi) 0.9</td>
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<tr>
<td>Surface Raise (in)</td>
<td>UHPC Modulus of Elasticity (ksi) 8000</td>
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<tr>
<td></td>
<td>WWF Strength (ksi) 65</td>
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<tr>
<td></td>
<td>WWF Modulus of Elasticity (ksi) 29000</td>
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</tbody>
</table>
Negative Moment Capacity

Increase amount of material available to resist tension

- UHPC
  - Cracking & Strain Limit
  - Tensile Strength
  - Concrete Interface

- Welded Wire
  - Over Piers
  - WWF engaged?
  - Substantial Crack Control?

- 31% increase
Positive Moment Capacity

Increase moment arm for positive moment capacity

- Smaller compression block due to higher compressive strength
- Greater depth of Steel
- 16% increase
Slab Positive Moment Arm

Original Slab
(3.0 ksi)

Slab with UHPC Overlay
(20.0 ksi)
Construction

- Two stages with cold joint
- Inexperienced Contractor – Mock up
- Mixed on site – required power supply
- Placement required 2x larger crew
- Used vibrating truss screed
- Second Lane took 3–4 hours

Grinding
- Occurred 4 days after placement
- Concrete ranged from 10–13ksi
Is a 1.5 inch thickness appropriate?
How can we be certain the mesh is engaged?
Can HL–93 loading be proven?
Can a economic and durable shear interface be achieved?
Is the UHPC overlay viable with staged construction and associated traffic vibrations?
Sioux County Overlay
(Previously Kossuth County)
Sioux County Overlay (Previously Kossuth County)

- US 18 over Floyd River
- 205’-6 x 44’ PPCB Bridge
- 49 CY of UHPC – 1000 SY
Sioux County Overlay
(Previously Kossuth County)

- **Differences**
  - Primary Road System
  - Open to traffic
  - No welded wire
  - 3x Larger Area
  - Hydro Demolition

- **Goals**
  - Start collecting long-term data for primary system
  - Test fiber effectiveness with traffic vibrations
  - Evaluate success of increased pour rate with on-site batching
Acknowledgements


Questions?