ULTRA HIGH PERFORMANCE CONCRETE
Better Concrete Conference
November 9, 2017
Buchanan County Iowa

- 259 Bridges over 20’
- 28-Railcar Bridges
- 6-GRA-IBS Abutments
- 2-Cast on Site Slabs
- 1-Press Brake Tub Girder
- 3-UHPC
- 3- Glue –Laminated Bridges
- 3 Internal Curing Concrete Bridges
- Working on UHPC
- Working on Maher Tadros design
- Using railroad bridges
Many of our bridges are old
Our System Cannot meet Today’s Demands
12000 2TAHD Trailboss LowPro
4000 Bu Grain Cart = 240000 Lb. +
We Have NOT kept up with Modern Agriculture
Postings Do Not Work unless I am there.
The world and our economy relies on Food
Pinned Trusses predated the Model T
This was posted at 9 tons
It was posted at 9 Tons. They did not care before
Weight kills
They always made it before, axle weights are an issue.
The Bridge does NOT Discriminate
ECONOMIC IMPACT OF CLOSING LOW-VOLUME RURAL BRIDGES

Thomas E. Mulinazzi, Ph.D., P.E., L.S.
Professor of Civil Engineering
The University of Kansas
2150 Learned Hall, 1530 W. 15th St.
Lawrence, Kansas 66045
Phone: 785-864-2928
Email: tom@ku.edu

Steven D. Schrock, Ph.D., P.E.
Associate Professor of Civil Engineering
The University of Kansas
2159B Learned Hall, 1530 W. 15th St.
Lawrence, Kansas 66045
Phone: 785-864-3418, Email: schrock@ku.edu

Eric J. Fitzsimmons, Ph.D.
Lecturer/Post-Doctoral Researcher
The University of Kansas
2159A Learned Hall, 1530 W. 15th St.
Lawrence, Kansas 66045
Phone: 785-864-1921
Email: fitzsimmons@ku.edu

Rachel Roth
Layout Designer
The University of Kansas
Lawrence, KS 66045
FIGURE 3. DETERMINING BRIDGE CLOSURE / REPAIR / REPLACE BASED ON ADT AND DETOUR LENGTH
Build Less Expensive Bridges

- **Report No. KS-14-16** • FINAL REPORT • December 2014
- **Guardrail and Bridge Rail Recommendations**
- **for Very Low-Volume Local Roads in Kansas**
- Ronald J. Seitz, P.E.
- Tod Salfrank
- Kansas Department of Transportation
- Bureau of Local Projects
- Division of Operations Bureau of Research
Timber String/multi-beam or girder
32 x 23.3 (0º Skew) Built 1899
SR=30 Scour=5
Last Insp: Jan 2015
Next Insp: Jan 2016 (12 mo cycle)
No piling in the abutment
The Initial PI beam Design

- Design Guidelines - University of New South Wales, France, and Japan
- Development of PI section by Dr Ulm at MIT
- Testing of UHPC and PI section (Turner-Fairbanks)
- I-Beam Testing by Turner-Fairbanks & Iowa State University
- Experience Wapello Co. project
- Discussions with Dr. Graybeal (FHWA) and Vic Perry (LaFarge North America)
Testing showed the Initial Designs Failed in Transverse Flexure and Local Stresses
UHPC Design Data

- Modulus of elasticity final = 7,500 ksi
- Compressive strength at release = 14.5 ksi
- Compressive strength final = 21.5 ksi
- Tensile strength ~ 1.20 ksi
PI Girder

- Developed by MIT/FHWA
- Optimized section
- No Mild Steel NEEDED
- Integral Deck
- 4-71 ft sections tested by Turner-Fairbanks Laboratory, FHWA
Improving Transverse Strength and Lateral Distribution

- Worked w/ existing forms initially
- Thickening deck
- Providing ribs
- Post-tensioning
  - High strength rods
  - Strands
- Addition of steel diaphragm
Korean UHPC Design
UHPC Material (Negative)

• Material is expensive (5% steel fibers = 200 Lbs. x@$2/lb. =$400/cy.

• Material Labor and equipment intensive
  – Mixing ~ ½ hr.
  – Initial Set ~ 40 hrs.
  – Curing ~ 48 hrs. at 195 deg

• Shrinkage high

• Concern fiber distribution

• Performance of cracked section

• Deck texture is an issue
UHPC Material (Positive)

• Self Consolidating
• High compressive strength (30 ksi)
• Dense low permeability
• Low creep post-cured
• High durability
• Fibers post-cracking strength
# Mix Design Comparison of Different Types of UHPC

<table>
<thead>
<tr>
<th>Constituents</th>
<th>lb/yd^3 (kg/m^3)</th>
<th>% by weight</th>
<th>variation</th>
<th>UHPC</th>
<th>Variation</th>
<th>UHPC</th>
<th>K-UHPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate</td>
<td>1739 (1032)</td>
<td>42.70%</td>
<td>42.70%</td>
<td>UHPC</td>
<td>1462 (867)</td>
<td>35.10%</td>
<td>35.30%</td>
</tr>
<tr>
<td>Sand</td>
<td>1429 (848)</td>
<td>35.10%</td>
<td>40.80%</td>
<td>K-UHPC</td>
<td>1329 (789)</td>
<td>28.50%</td>
<td>32.10%</td>
</tr>
<tr>
<td>Cement</td>
<td>600 (356)</td>
<td>14.70%</td>
<td>28.50%</td>
<td>UHPC</td>
<td>1200 (712)</td>
<td>28.50%</td>
<td>32.10%</td>
</tr>
<tr>
<td>Ground Quartz</td>
<td>355 (211)</td>
<td>8.40%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silica Fume</td>
<td>390 (231)</td>
<td>9.30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>300 (178)</td>
<td>7.40%</td>
<td>4.40%</td>
<td>UHPC</td>
<td>311 (184)</td>
<td>7.50%</td>
<td></td>
</tr>
<tr>
<td>Superplasticizer</td>
<td>52 (31)</td>
<td>1.20%</td>
<td>0.70%</td>
<td>K-UHPC</td>
<td>31 (18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accelerator</td>
<td>51 (30)</td>
<td>1.20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.0mm fiber</td>
<td>263 (156)</td>
<td>6.20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.3mm fiber</td>
<td>66 (39)</td>
<td>1.60%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.5mm fiber</td>
<td>131 (78)</td>
<td>3.20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defoamer</td>
<td>1 (0.5)</td>
<td>0.02%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRA</td>
<td>13 (8)</td>
<td>0.30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-mix*</td>
<td>797 (473)</td>
<td>19.30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4068 (2413)</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td>4142 (2457)</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Mixing Proportions and Process

<table>
<thead>
<tr>
<th>Mixing orders</th>
<th>SC180 KICT MIX</th>
<th>Total (lb/5.5CY)</th>
<th>Location</th>
<th>Mixing instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-mix</td>
<td>4386</td>
<td>County</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Cement</td>
<td>7310</td>
<td>Ready Mix Plant</td>
<td>Mix for 10 min</td>
</tr>
<tr>
<td>3</td>
<td>Wet Sand (MC = 4.2%)</td>
<td>8041</td>
<td>Ready Mix Plant</td>
<td>Mix for 5 min</td>
</tr>
<tr>
<td>4</td>
<td>Water</td>
<td>1710</td>
<td>Ready Mix Plant</td>
<td>Rotate at 10 RPM and move to county shop</td>
</tr>
<tr>
<td>5</td>
<td>SRA</td>
<td>73</td>
<td>County</td>
<td>After adding all liquid additives, Mix for 5 min at 10 RPM then, Mix for 5 min at Maximum speed</td>
</tr>
<tr>
<td>6</td>
<td>Defoamer</td>
<td>5</td>
<td>County</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Superplasticizer</td>
<td>140</td>
<td>County</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Steel Fiber (0.63 inch long)</td>
<td>362</td>
<td>County</td>
<td>Add for 7 min at 10 RPM</td>
</tr>
<tr>
<td>9</td>
<td>Steel Fiber (0.78 inch long)</td>
<td>723</td>
<td>County</td>
<td>Add for 13 min at 10 RPM then, Mix for 2 min. st maximum speed</td>
</tr>
</tbody>
</table>
Alex Building the forms (Dr. Joh, Dr. Ryu, Haena)
County Constructed Forms
2008 Placing Mixture into trucks
Placing the K-UHPC into trucks
Placing Super plasticizer
Placing The Admixtures
Placing Steel Fibers in Canada
We used a better method
We added a second vibrator
Pouring the Beams
Curing in Winnipeg
The Steam Curing Machine.
Steam Curing in our yard
Laboratory Testing of field Samples

• 6 samples from each truck was collected (12 samples from each girder – Total of 72 sample)

• They were kept in the same curing condition

July 6, 2015

July 9, 2015
Post Tensioning Check
Loading the Beams

[Image of a construction site with a crane and a truck loading beams]
Transporting the beam.
Standard Abutments
Not all the joints were perfect.
Highway Departments Have old Signs
Curing the joints.
Long waits for SL-1 Barrier Rail Posts
Minimal soil exposure
Reseeded with Hydromulcher

OCTOBER 7, 2015
We have a small footprint
Design and Construction of Hawkeye UHPC Bridge
Hawkeye UHPC Bridge

– 52 ft. long and 32 ft. 5in. Wide
Hawkeye UHPC Pi-girder

- 52 ft. long, 5 ft. 3 in. wide and 2 ft. 4 in. Deep
Hawkeye UHPC Pi-girder

2'-4" (711mm)

1" CHAMFER (TYPICAL)

5'-3" (1,600mm)

4½" 4" 3½"

3'-3"

3½" 4" 4½"

GIRDER(SYM.)

R=3"

1'-8"

9" 3½" 8" 3" 4½"

3'-10"

9¼"

5¼" 4"

3'-10"
Post-tensioning

- Seven 0.6 in. dia. longitudinal strands at the bottom of each flange (300 kips)
- Three 0.6 in. dia. transverse strands (105.5 kips) in each of five crossbeams
Accelerated Bridge Construction (ABC)
Compressive Strength Test

- Instron PRISM 5500 test machine with a capacity of 1.1 MN (247,290 lbf)
- Cracks developed vertically due to a high cohesive strength of K-UHPC
Laboratory Mix Prior to Construction

- Test mixes were prepared using a drum mix with a fixed speed at 20rpm
- A total of thirty-five 3 x 6 inch test cylinder molds were prepared
Mixing K-UHPC in Laboratory Drum Mixer
- 35 capped plastic molds were put into the curing chamber filled with warm water at room temperature of 72° F
Compressive Strength

Compressive Strength (psi)

Day 1                Day 2            Day 4             Day 7          Day 14

12,740               16,576           19,356           22,583         25,299

Day 28

26,208

Compressive Strength

C1
C2
C3
Average
Lessons Learned

• Follow the Mixing instructions, Mix the Premix and the Portland prior to the sand

• Always have super plasticizer available to add as needed.

• High density and high viscosity create pressures we are not accustom to. (uplift pulled the screws through the 2x4’s)

• Post tensioning is easy
Preparing for Deck Overlay
Wire mesh in the negative moments
Mixing the UHPC
It places better perpendicular
They Switched to placing perpendicular
Overlay prior to grinding
Grinding
Texture After Grinding
UHPC surface crack
Finished Deck Overlay
Lessons Learned

• It Can be done on a 5% grade
• High Shear Mixers work well
• Grind After 4 days do not wait!!!
• Dump the Buggy perpendicular to the bridge

• What I did not try
• Would a bull float work if sprayed with Vegetable Oil?
• Would a roller screed work?
• Would a Bidwell Deck Paver work?
MURLEYS BRIDGE

SECTION A-A

1" Ø Threaded Rod
3d1
3a1
4a1

1" TYP.
2" CL.

2 EQ. SP.

12 1/4
4 1/4

3 1/4
4 1/4

2 EQ. SP.

17 1/2

5 1/2

17 1/2

6 0
More Experience
The learning continues
If you are not at the table you will be on the menu.

Plan now to attend!

The Largest Event of County Infrastructure Professionals

NACE 2018

The Dells, Wisconsin

April 22-26 • Chula Vista Resort

Hosted By

National Association of County Engineers
The Voice of County Road Officials

www.countyengineers.org
Any Questions?
Press Brake Tub Girder
Dr. Karl Barth From West Virginia University and Dr. Michael Barker From The University of Wyoming
Galvanized Rolled Beams
GRUEN WALD Glue Laminated Bridge
US Forest Products Lab Research
Catt Bridge
We have constructed 27 Bridges from Railroad Flatcars
What Do They Look Like?
What They Look Like To Us
Use What you have
Fontana Park 3 Pin Arch
IF YOU ARE NOT AT THE TABLE YOU WILL BE ON THE MENU

PLAN NOW TO ATTEND!

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NACE CINCINNATI 2017

April 9-13 • Cincinnati, Ohio

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