UHPC in Iowa
Omaha, Nebraska

Presented by:
Dean Bierwagen, Methods Engineer,
Office of Bridges and Structures, Iowa Department of Transportation
Overview

- Wapello Co Project
- PI section
- Buchanan Bridge Project
Presentation

- UHPC / Ductal®
- Project overview
- Testing of UHPC
- Design
- ISU Testing
- Casting
- Bridge Construction
- Future Research
Acknowledgment

• Iowa Department of Transportation
  – Norm McDonald, Ahmad Abu-Hawash, Todd Hanson, Ken Dunker, Thayne Sorenson

• County Engineers
  – Brian Moore Wapello Co. and Brian Keierlieber Buchanan Co.

• FHWA
  – Joey Hartmann, Ben Graybeal, Curtis Monk

• Bridge Engineering Center (ISU)
  – Dr. Wipf, Dr. Phares, Doug Wood, Brian Degen and Isaac Couture
Acknowledgment

• LaFarge North America,
  – Vic Perry, Gavin Geist, Bruce Dawson

• MIT
  – Dr. Ulm

• Prestressed Services, Lexington, KT,
  – Chris Hill
UHPC Development

- France in 1990’s
- Industrial projects (France, United States)
- Commercial (France, Canada, United States)
- Pedestrian bridges (Canada, Japan, Korea, France)
- Highway bridges (France, Australia, United States)
Why UHPC?

- High compressive strength
- High durability
- Low permeability
- Fibers (removal mild reinforcement)
- After curing (stable, minimal creep and shrinkage)
- More efficient sections
What is UHPC / Ductal®?

- High performance cement based material
- Finely graded, silica fumes (glass), cement, fine sand, water, superplasticizer, and fibers
- Metallic or organic fibers (2% by volume)
- Steel Fibers (0.008 inches x 0.5 inches)
- Largest aggregate (fine sand 0.024 inches)
- W/C ratio 0.15-0.20
Properties?

- Compressive strength = 18-33 ksi.
- Tensile strength = 1.1-1.6 ksi
- Flexural strength = 4-7 ksi.
- Final modulus of elasticity = 7,800 ksi
- Density = 0.156 kips/ft³
Why Ductal®?

- Available in the U.S.
- Testing by FHWA
Wapello Co Bridge

- 110 ft Single Span
- 3 Girder cross section
- Prestressed girders cast with UHPC
Wapello Co. Bridge
110’ Girder Casting
Completed Structure
PI Girder

- Developed by MIT/FHWA
- Optimized section
- No Mild Steel
- Integral Deck
- Tested by FHWA
PI Girder X-sec

Diagram dimensions:
- Length: 96 in.
- Width: 33 in.
- Height: 8 in., 3 in., 1.5 in., 11 in., 79 in.
PI Girder X-sec
Testing Results by FHWA

- Longitudinal
- Low service capacity transverse in deck
- Low live load distribution between girders
Improving Transverse Strength and Lateral Distribution

- Worked w/ existing forms initially
- Thickening deck
- Providing ribs
- Post-tensioning
- Addition of steel diaphragm
Finite Element Analysis

- Analyzed by ISU and FHWA
- Analyzed girder unit and bridge
- Load combinations 16 kip single and 12.5 kip tandem wheel loads with impact.
FEA

NODAL SOLUTION
STEP=1
SUB =1
TIME=1
SX
Rsys=0
DNO = .045048
SMN = -805.617
SMX = 1410

TRANSVERSE STRESS IN THE BOTTOM OF THE DECK
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
Allowable Service Stresses

- Compr stresses at release
  \[0.6(14.5 \text{ ksi}) = 8.7 \text{ ksi}\]
- Compr stresses at service
  \[0.6(21.5 \text{ ksi}) = 12.9 \text{ ksi}\]
- Tensile stress at service
  \[0.7(\sim 1.20 \text{ ksi}) = \sim 0.80 \text{ ksi}\]
Revised Section

- High initial bid
- FHWA suggested purchase new forms for improved section
- Use in additional projects
Revised Section

- Deck width increased to 8 ft – 4 in.
- Deck thickness increased to 4 inches
- Web thickness increased by ½ inch
- Webs shifted 2” closer
- Round fillets added
- Steel diaphragms provided at ¼ pts
- Grouted dowel connection between girders
- Mild steel added
Girder Casting

- Premixed bags
- Mixed in two redi-mix truck
- Water added as ice cubes
- Total mixing time ~ 6-7 hours
Curing procedure

- Initial set to break forms (25-30 hrs)
- Strand release (40 hrs)
- Steam cure (48 hrs at 195 degree F)
Buchanan Bridge Project
Buchanan Bridge Project

• 3 spans
• End spans CIP concrete slab
• Center span 3 PI girders
Plan View Proposed Bridge
PI cross-section
Bent support
Final Section New detail

Plan View Showing Dowel Pockets

Typical Longitudinal Section Thru Joint Detail at Pocket Locations
Girder Placement

- Two cranes
- Set on 1 in neoprene pads
- Steel diaphragms installed at ¼ points after placement
- Girder ends encased in CIP concrete on site
Grouting Pockets
Current Status

- Casting completed September 2008
  - 2-25 ft test girders for FHWA
  - 3-51 ft bridge girders
- Bridge Project let in June 17, 2008
- Construction started September 2008
- Girders placed October 16, 2008
- Pockets grouted October 21, 2008
- End spans cast October 30, 2008
Acknowledgment

- County Engineers - Brian Keierleber, Buchanan Co.
- Iowa Department of Transportation
  - Norm McDonald, Ahmad Abu-Hawash, Thayne Sorenson, Jim Rhynas (Student)
- FHWA - Ben Graybeal, Curtis Monk
- Bridge Engineering Center (Iowa State Univ.)
  - Dr. Wipf, Dr Fanous, Dr. Phares, Isaac Couture (Grad. Student)
- LaFarge North America - Vic Perry