

PAST UHPC BRIDGE PROJECTS

DESIGNERS PERSPECTIVES

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Iowa DOT

UHPC For Local Bridge Applications
May 12th, 2016 Brandon, Iowa



Acknowledgment

- FHWA
- Iowa State University (Bridge Engineering Center)
- Iowa Department of Transportation
- Wapello Co., Iowa, Brian Moore, County Engineer
- Buchanan Co., Iowa, Brian Keierleber, County Engineer
- Lafarge North America
- Coreslab Structures of Omaha, Nebraska

Why UHPC?

- High compressive strength
- High durability
- Low permeability



Issues as Bridge Designer

- Extending Life Existing Bridges
 - Corrosion Decks, Joints, Beams
 - Deteriorating Concrete due to Traffic
- Improving New Bridges
 - How can we make better
 - Longer lasting

UHPC Design

- Goal Build on Experience
 - Research / Testing by Iowa State University and FHWA
 - Design Experience
 - Experience Other States
 - Review Specifications Other Countries
 - Precast
 - Cast in Place Field Joints
 - Current Overlay Project

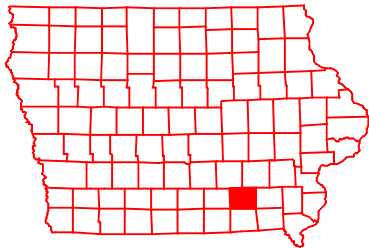
Understand UHPC

- Limits of Material?
- Where can it be used?
- Most Economical?

UHPC Projects in Iowa

- Small mixes, testing,
- Wapello County Bulb Tee Beam - 2005
- Buchanan County PI Girder - 2007
- Wapello County Precast Waffle Slab - 2011
- US 20 over US 71 Foundation Piles - 2011
- US 6 over Keg Creek/IA 92 over Silver Cr.
Modular Superstructure Joints 2015
- Buchanan County PI Girder 2015
- Buchanan County - Slab (KUHPC) and Overlay
(Ductal®) 2016

**Wapello County Bulb Tee
Beam (Ductal®)**



Preliminary Work



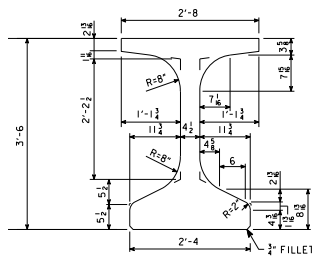
3 inch x 6 inch cylinders	Compressive Strength (psi)
1	23,820
2	24,570
3	22,510



ISU Test Program

- Compression of Cubes
- Flexure of Prisms
- Large-Scale Beam
 - Flexure Test
 - Shear Test
 - Flexure-Shear Test
- Small-Scale Beams

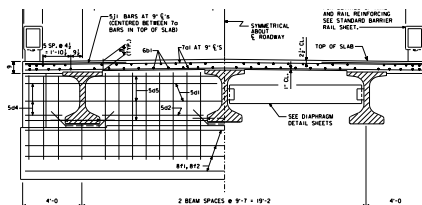
Section Used



Sec reduced 1" top, 2" bottom, 2" web
 $A = 512.3 \text{ in}^2$, $y_b = 18.72 \text{ in}$, $I = 123,654 \text{ in}^4$
 UHPC 14.6yd³

Bridge Description

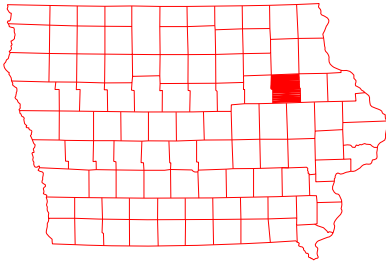
- 110' Single Span
- 3 Beam Cross Section
- Modified Iowa Bulb-T
- 24' Roadway Width
- Integral Abutments
- 8 inch CIP Deck



Completed Structure

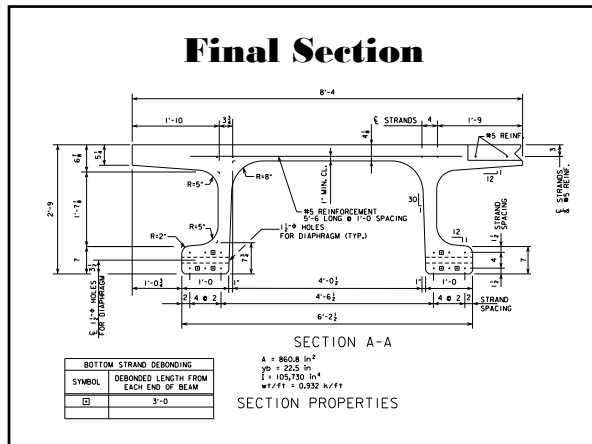


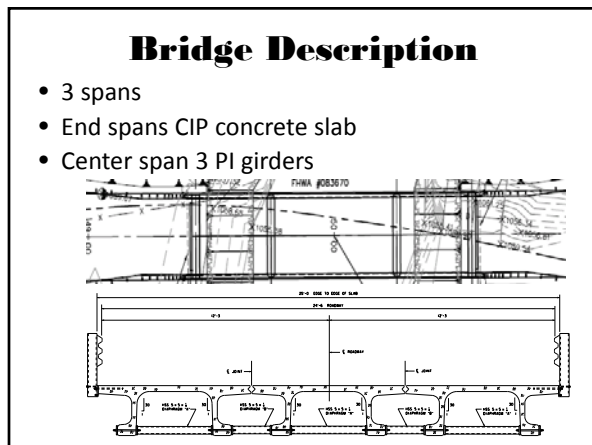
Buchanan County PI Girder (Ductal®)

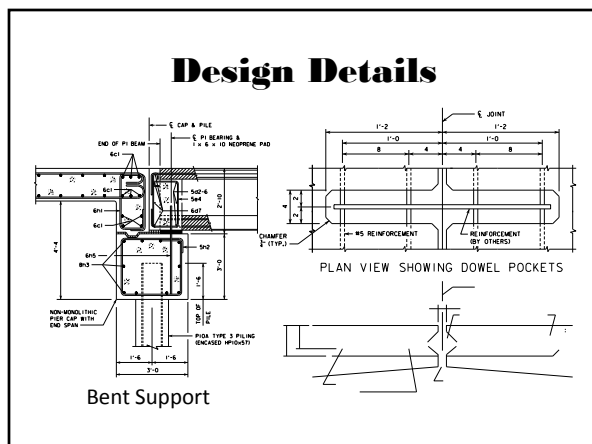


PI Girder Concept

- Developed by MIT/FHWA
- Optimized section
- No Mild Steel?
- Integral Deck
- Tested, Revised and Retested by FHWA







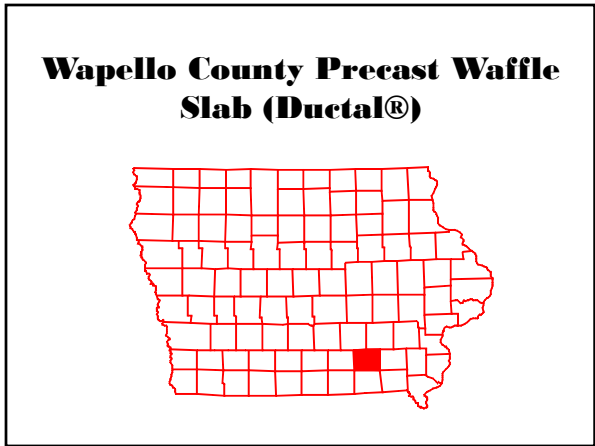
Girder Casting

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









Project Description

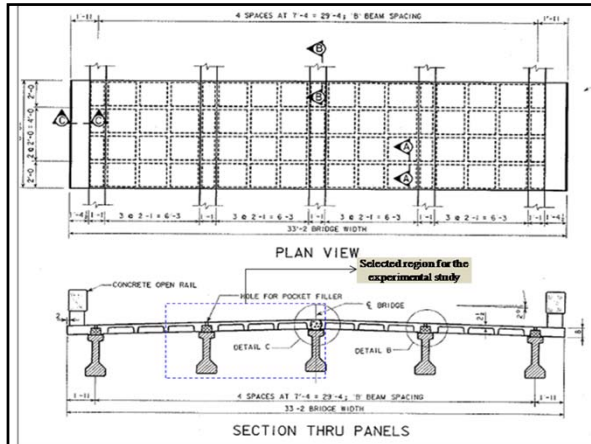
- FHWA HfL Tech Partnerships Grant
- Project Team
 - Coreslab Structures (Omaha), Inc. ← *Prime*
 - Iowa DOT
 - Iowa State University
 - Wapello County, Iowa
 - Lafarge North America, Inc.
- Multi-phase project
 - Waffle deck panel development: design, fabrication, and testing
 - Demonstration project
 - Design Guide development

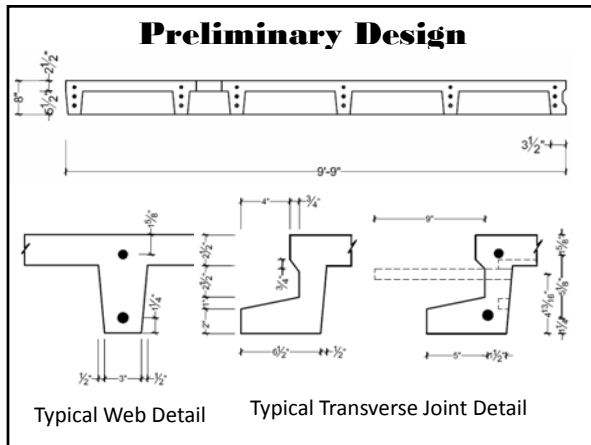
Design Concept

- Develop a UHPC two-way ribbed bridge deck panel which meets all design requirements, is lighter than a conventional deck, and is more durable
- Develop a simple splice connection detail which engages the short development lengths provided by UHPC to create a strong, durable joint

Design Details

- 33'-2 wide by 60'-0 single span prestressed concrete beam bridge (30'-0 Roadway)
- Five beam cross section spaced @ 7'-4
- Iowa B-beam (39 in. deep 9 in web)
- Individual waffle deck panels 8'-0 x 16'-2 ¾ tied at the centerline of roadway
- #6 reinforcing bars top and bot at rib spacing
- Total 14 precast panels for project
- Stainless steel reinforcing in field joints
- Field casting of joints using UHPC









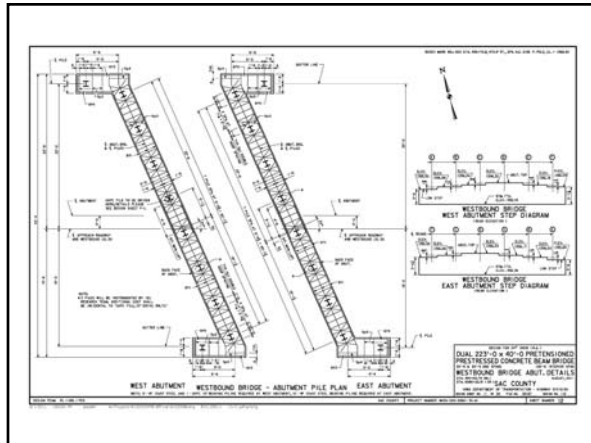




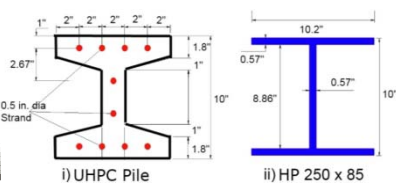
Design Guide for
Precast UHPC Waffle
Deck Panel System
including Connections

Link:
<https://www.fhwa.dot.gov/hif/pubs/hif13032/hif13032.pdf>





Final Selection



Parameter	Steel HP 10 x 57	UHPC Tapered H-Shape
Area	16.8 in ² (108 cm ²)	56.8 in ² (366 cm ²)
Weight	57.2 lb/ft (85.1 kg/m)	61.1 lb/ft (90.9 kg/m)
Stiffness Term (E-I)	8.53×10 ⁶ kip-in ² (2.25×10 ¹³ N-mm ²)	6.36×10 ⁶ kip-in ² (1.83×10 ¹³ N-mm ²)

UHPC Pile Driving Observations



- High-strength, highly durable pile
- Similar weight to steel pile
- Comparable moment capacity to steel pile
- Increased stress limits compared to normal concrete
- Use of same driving equipment as steel piles
- Possible use of no pile cushion
- Increased driveability over normal concrete piles
- Higher vertical load capacity than steel pile and reduced cost

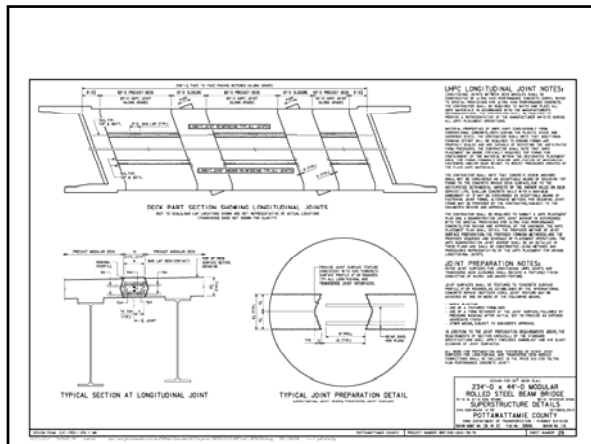
Iowa 92 over Little Silver Creek Modular Superstructure Joints (Ductal®)

LONGITUDINAL JOINTS

JOINTS BETWEEN MODULES

- **Shape**
 - 10" wide
 - Diamond shaped key
- **Roughened interface**
 - Concrete Surface Profile 6 (CSP-6) or rougher
 - Contractor opted to use formliner for joint texture (approx. CSP-10)
 - Sandblast cleaning/roughening
- **Reinforcing steel**
 - Stainless Steel
 - Non-contact transverse reinforcing lap with 6" stagger
 - Pair of continuous longitudinal bars in center of joint
- **Ultra-High Performance Concrete**
 - Superior strength and bond





Temperature Control





Future Work

- Waffle Slab?
- Overlays?
- Field Joints?
- Repairs?
- Piling?
