UHPC in Iowa

Omaha, Nebraska

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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
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- FHWA
  - Joey Hartmann, Ben Graybeal, Curtis Monk
- Bridge Engineering Center (ISU)
  - Dr. Wipf, Dr. Phares, Doug Wood, Brian Degen and Isaac Couture

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- MIT
  - Dr. Ulm
- Prestressed Services, Lexington, KT,
  - Chris Hill

UHPC / Ductal®

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

Ductal®

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/ft^3

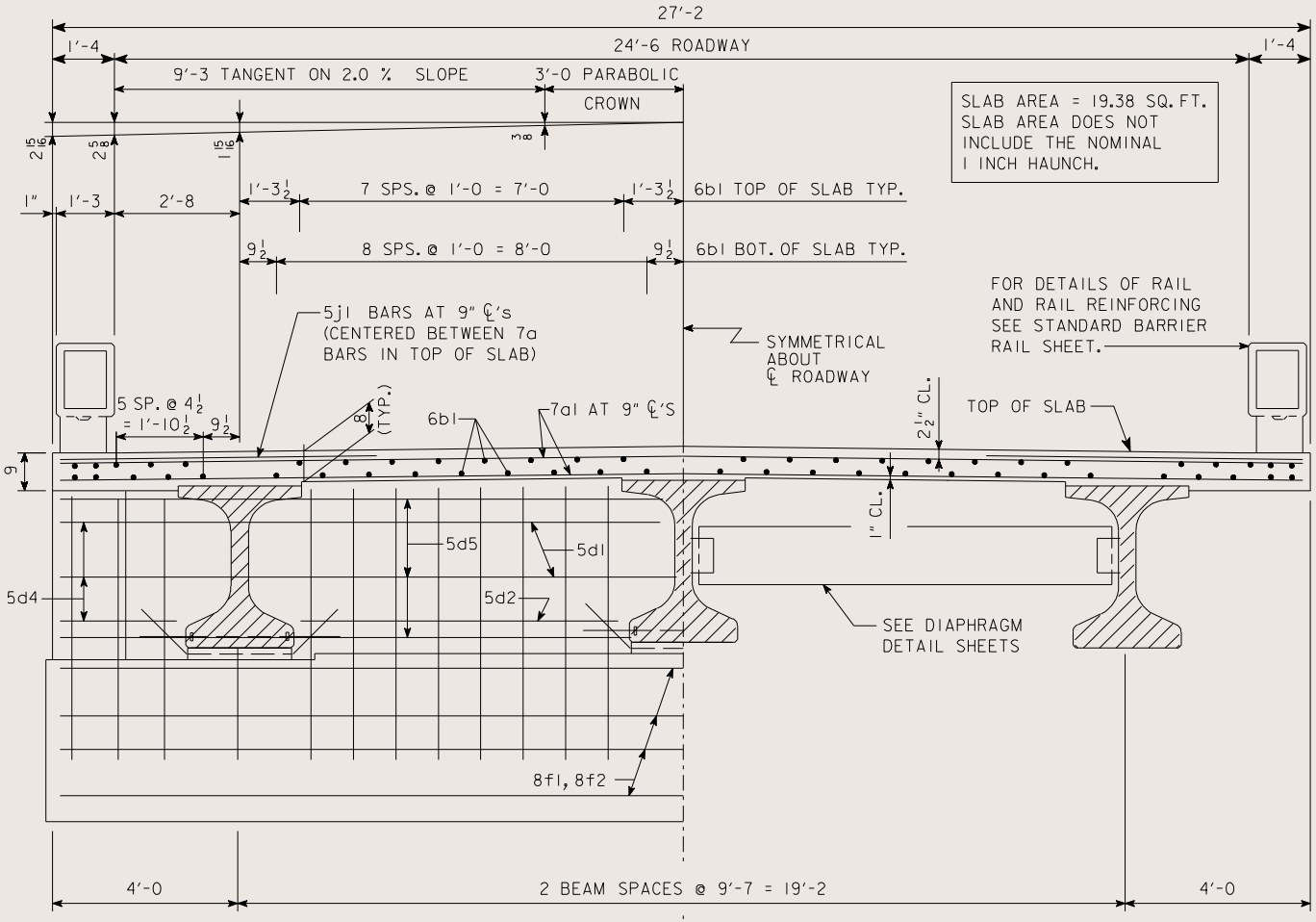
Why Ductal® ?

- 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



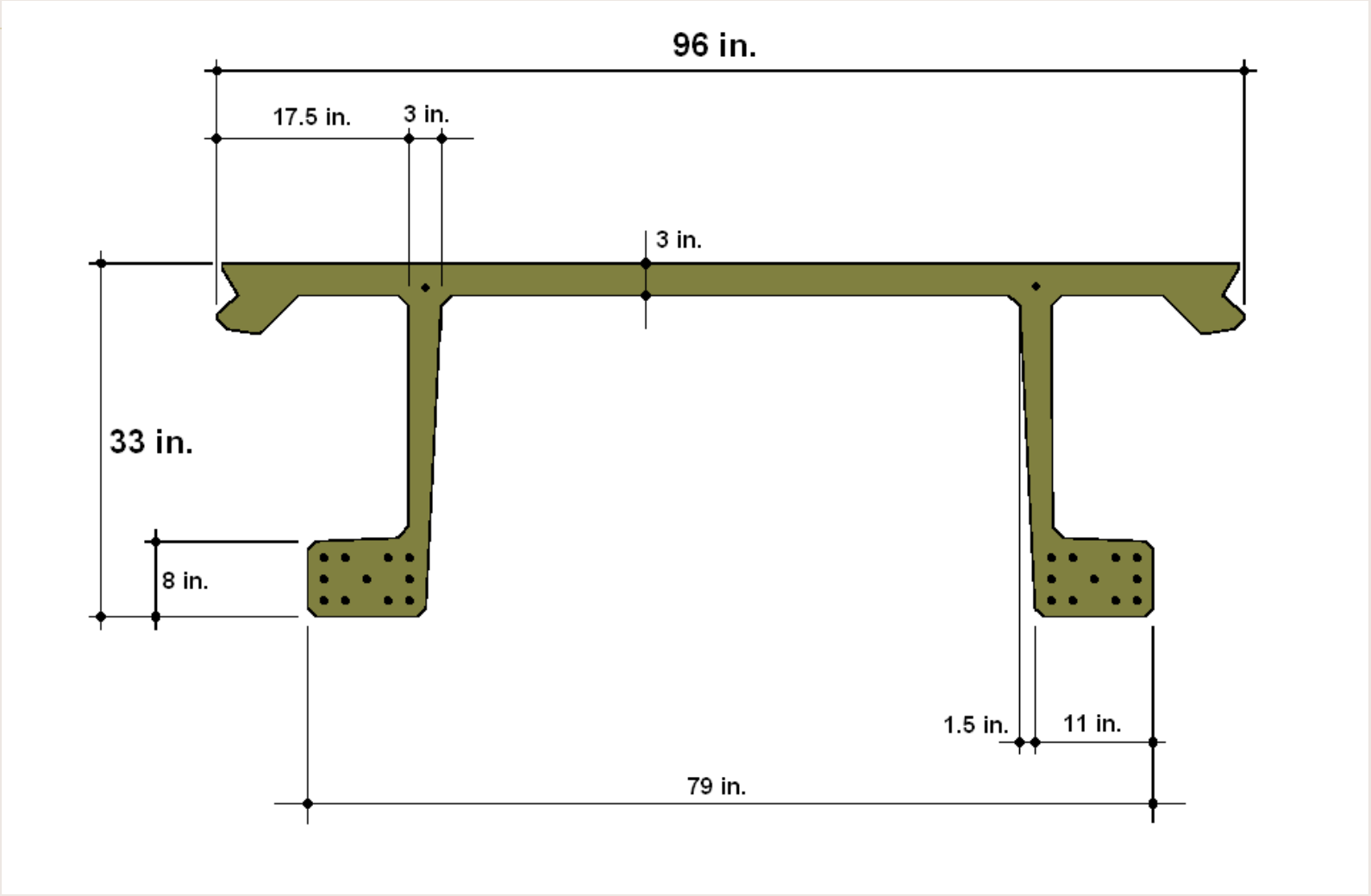
110’ Girder Casting

Completed Structure

PI Girder

- Developed by MIT/FHWA
- Optimized section
- No Mild Steel
- Integral Deck
- Tested by FHWA

PI Girder X-sec



PI Girder X-sec

Testing Results by FHWA

- Longitudinal
- Low service capacity transverse in deck
- Low live load distribution between girders

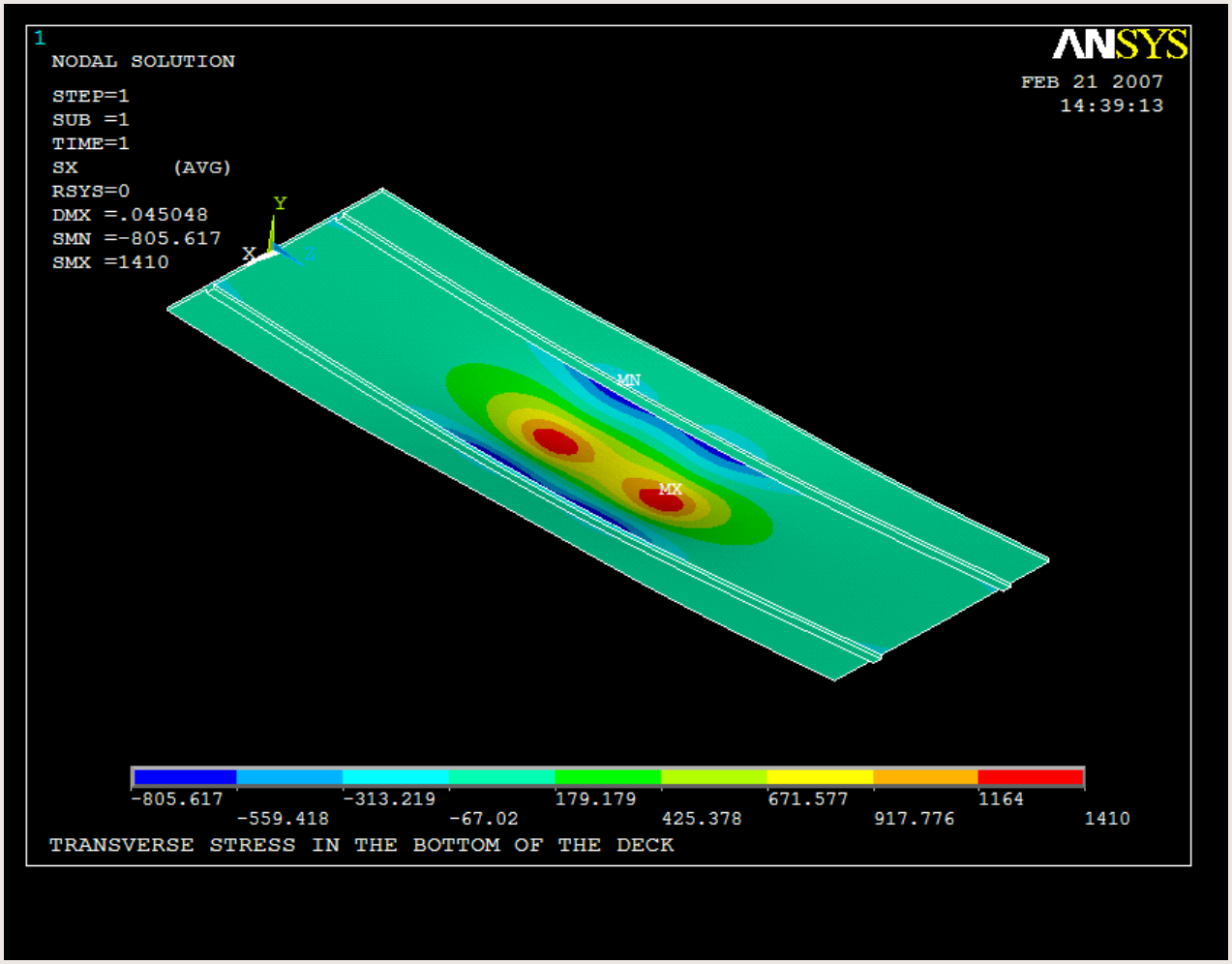
Improving Transverse Strength and Lateral Distribution

- 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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SUB =1
TIME=1
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RSYS=0
DMX =.045048
SMN =-805.617
SMX =1410
ANSYS
FEB 21 2007
14:39:13
Y
X
Z
MN
MX
-805.617
-559.418
-313.219
-67.02
179.179
425.378
671.577
917.776
1164
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 ksi) = 8.7 ksi

- Compr stresses at service

  0.6(21.5 ksi) = 12.9 ksi

- Tensile stress at service

  0.7(~1.20 ksi) = ~0.80 ksi

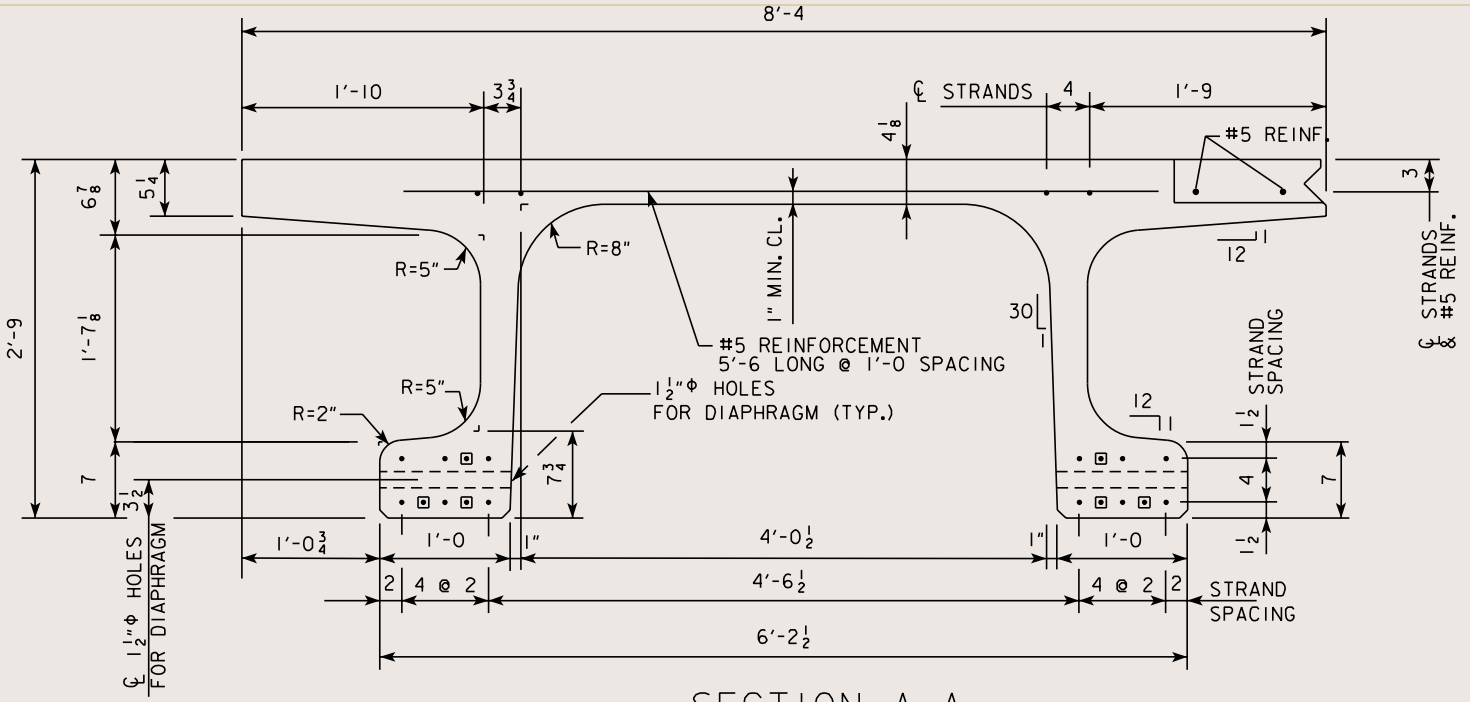
Revised Section

- 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

Final Section New detail



SECTION A-A

BOTTOM STRAND DEBONDING	
SYMBOL	DEBONDED LENGTH FROM EACH END OF BEAM
⊡	3'-0

A = 860.8 in^2
yb = 22.5 in
I = 105,730 in^4
wt/ft = 0.932 k/ft

SECTION PROPERTIES

Girder Casting

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

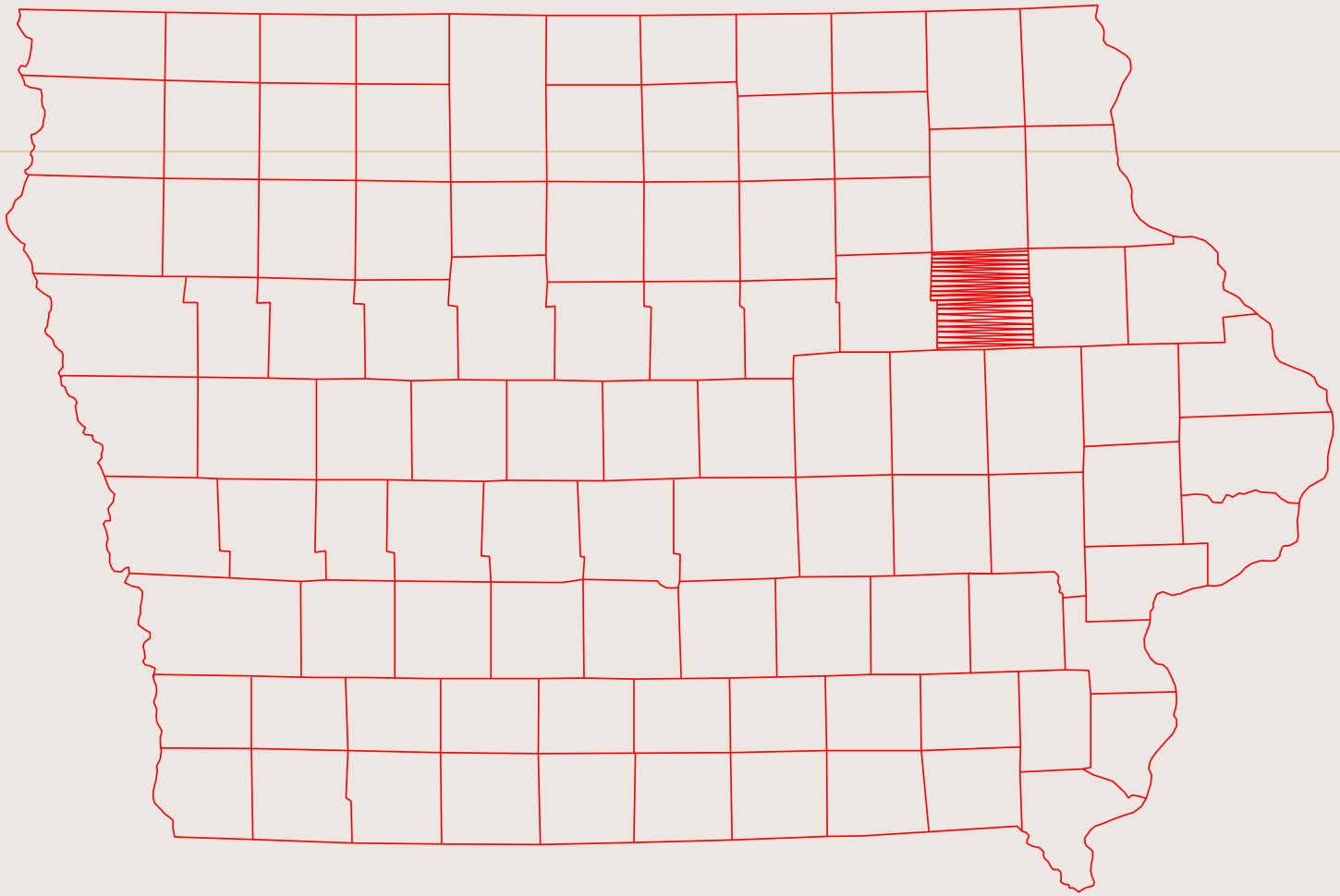

25
3


DANGER
ARCTIC GLACIER

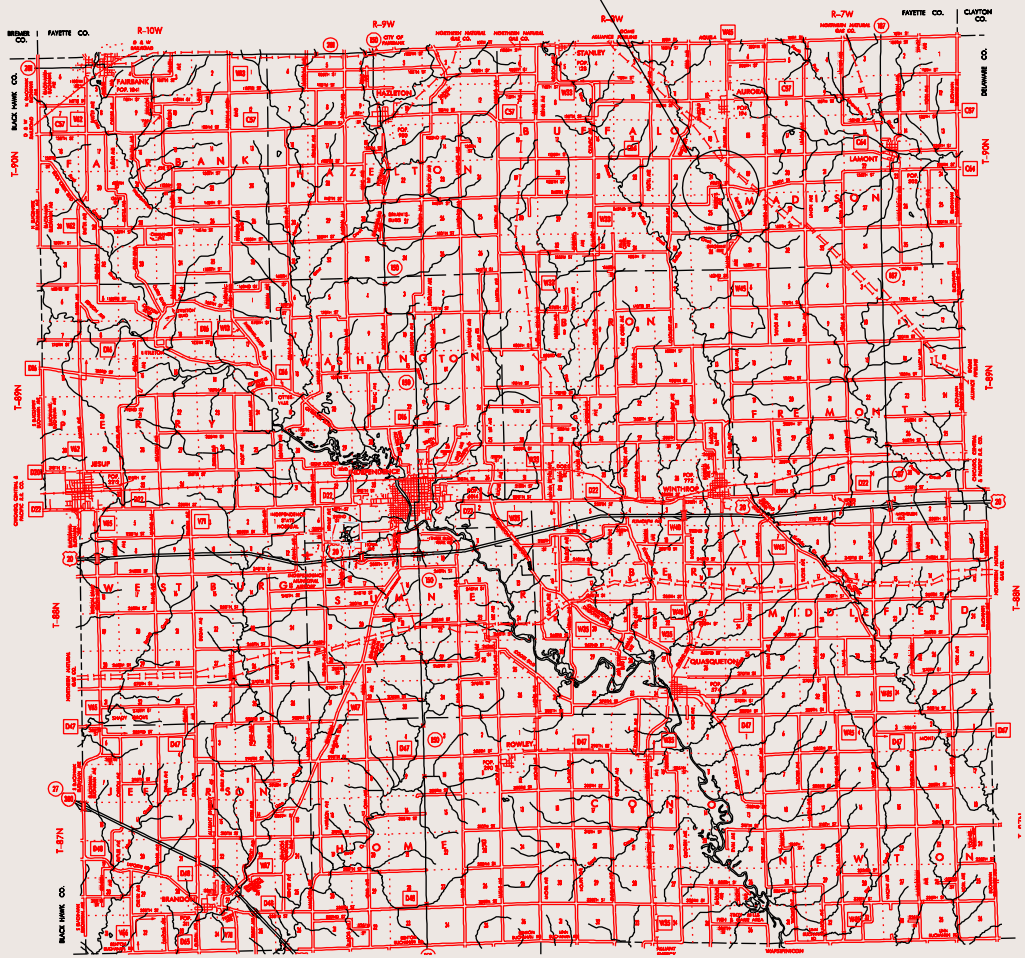
Curing procedure

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

Buchanan Bridge Project



Bridge Location

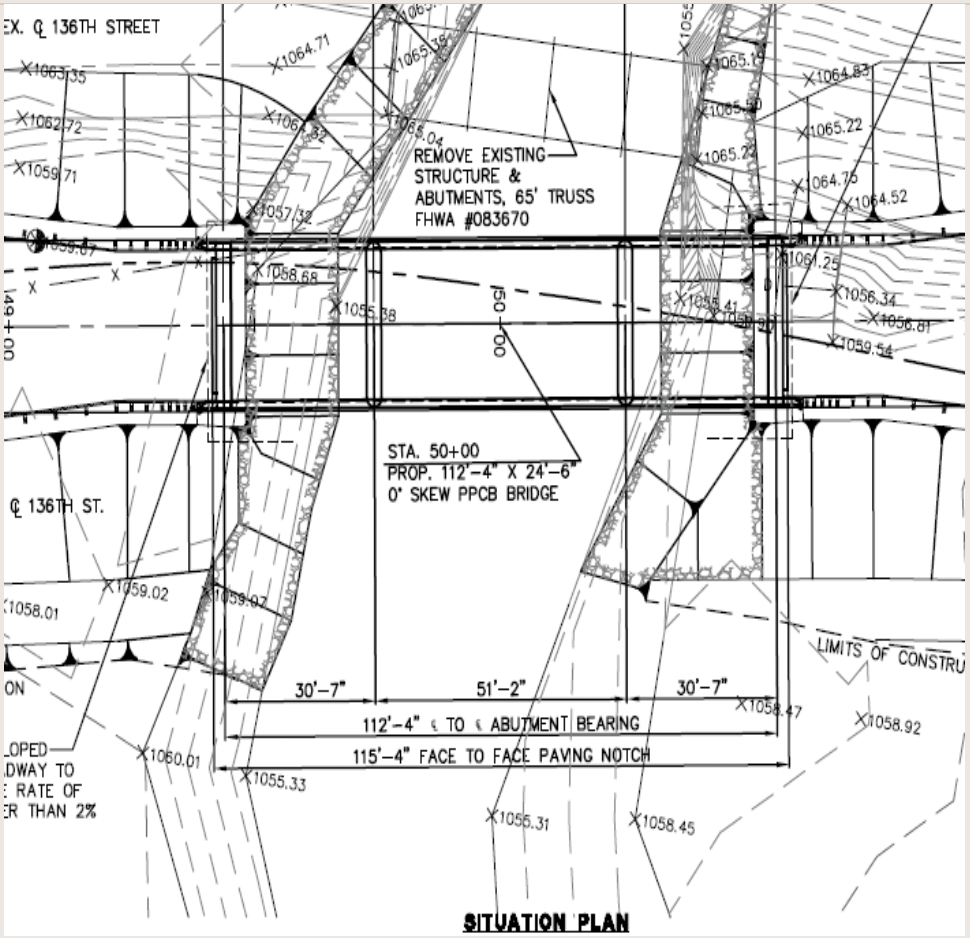



ROAD
CLOSED

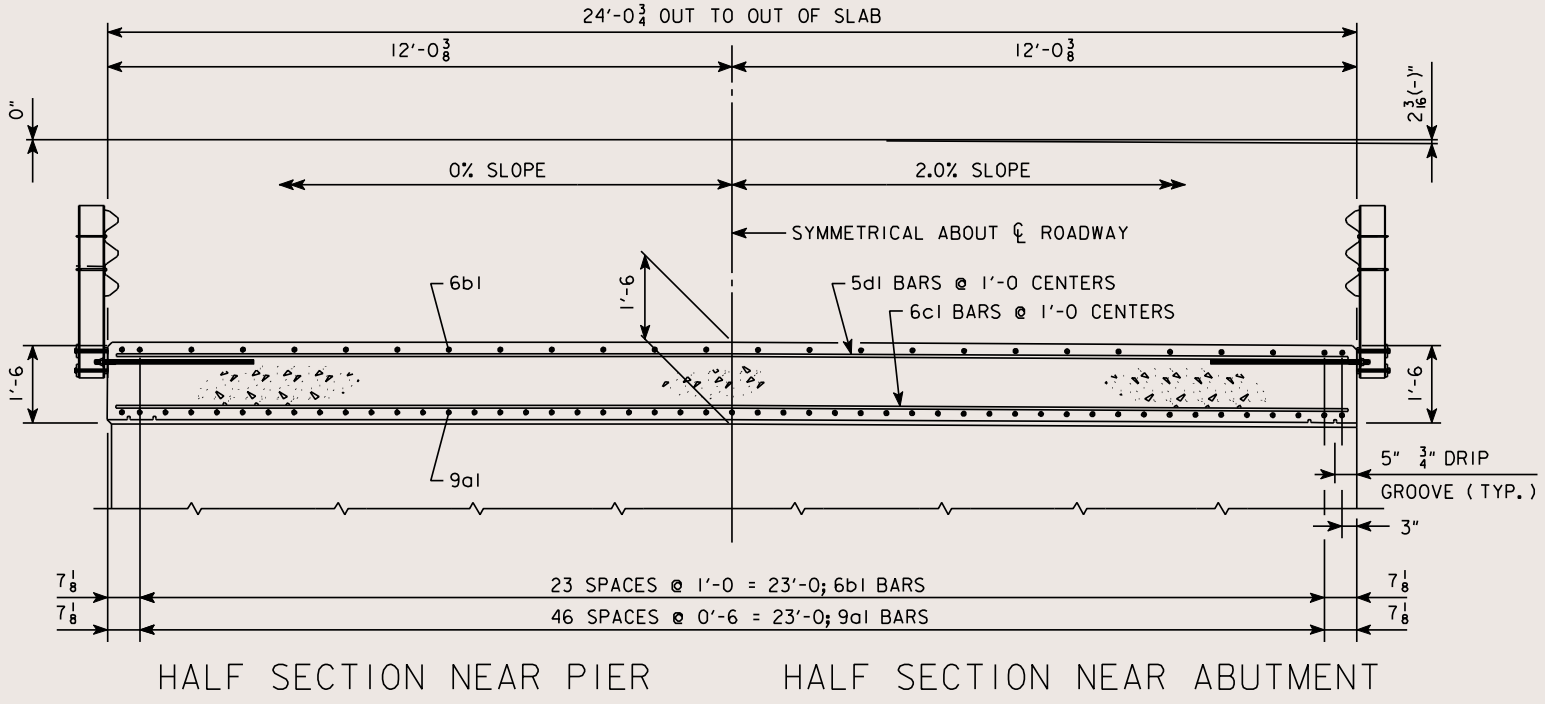
Buchanan Bridge Project

- 3 spans
- End spans CIP concrete slab
- Center span 3 PI girders

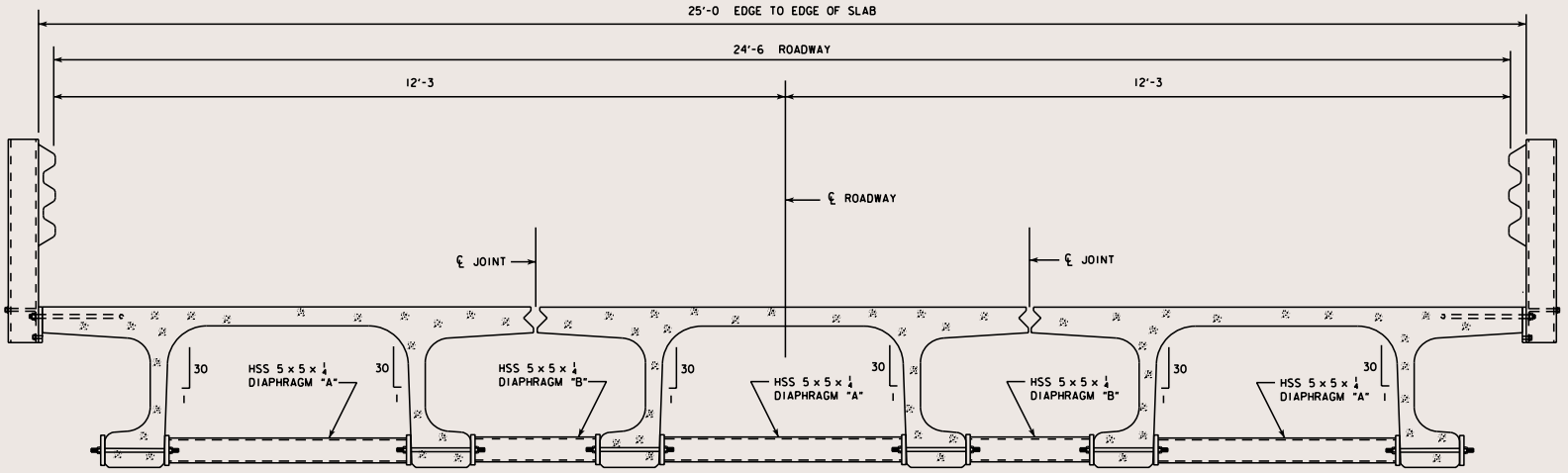
Plan View Proposed Bridge



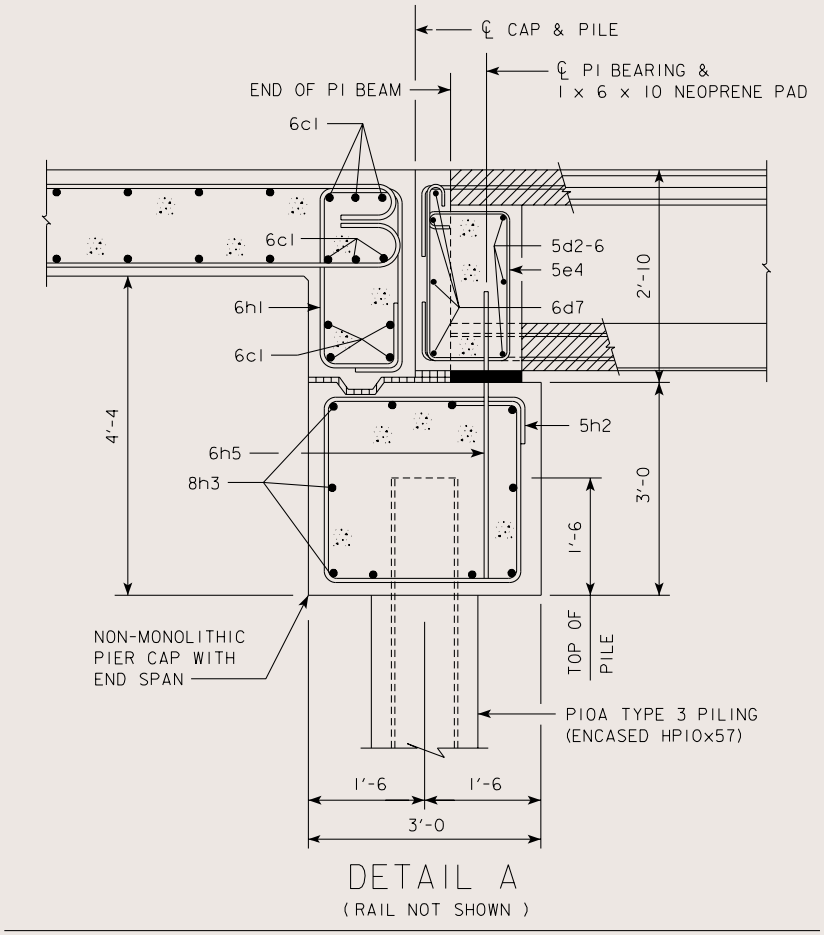
End Span Cross Section



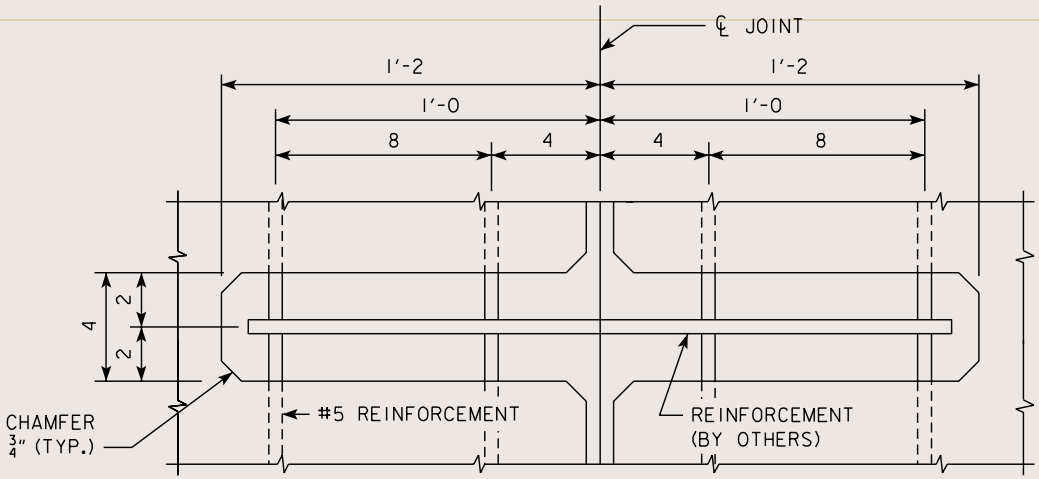
PI cross-section



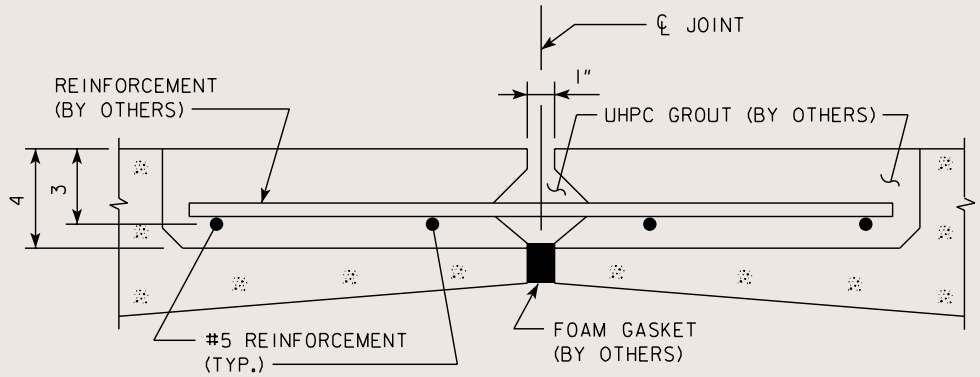
Bent support



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)
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