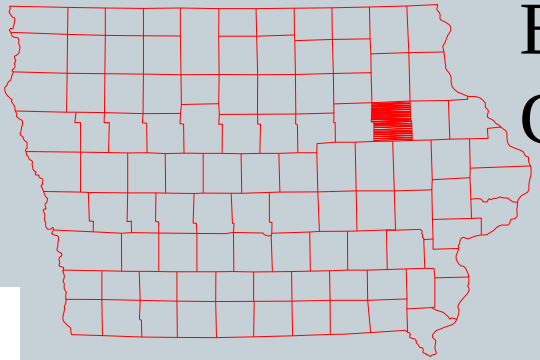
# Structural Design, Construction and Evaluation of a Prestressed Concrete Bridge Using **UHPC Pi** Girders

Jakway Park Bridge



Buchanan County

# What is UHPC?

- Compressive strength = 16-30+ ksi.
- Flexural strength = 4-7 ksi.
- Highly ductile with low (zero) permeability.

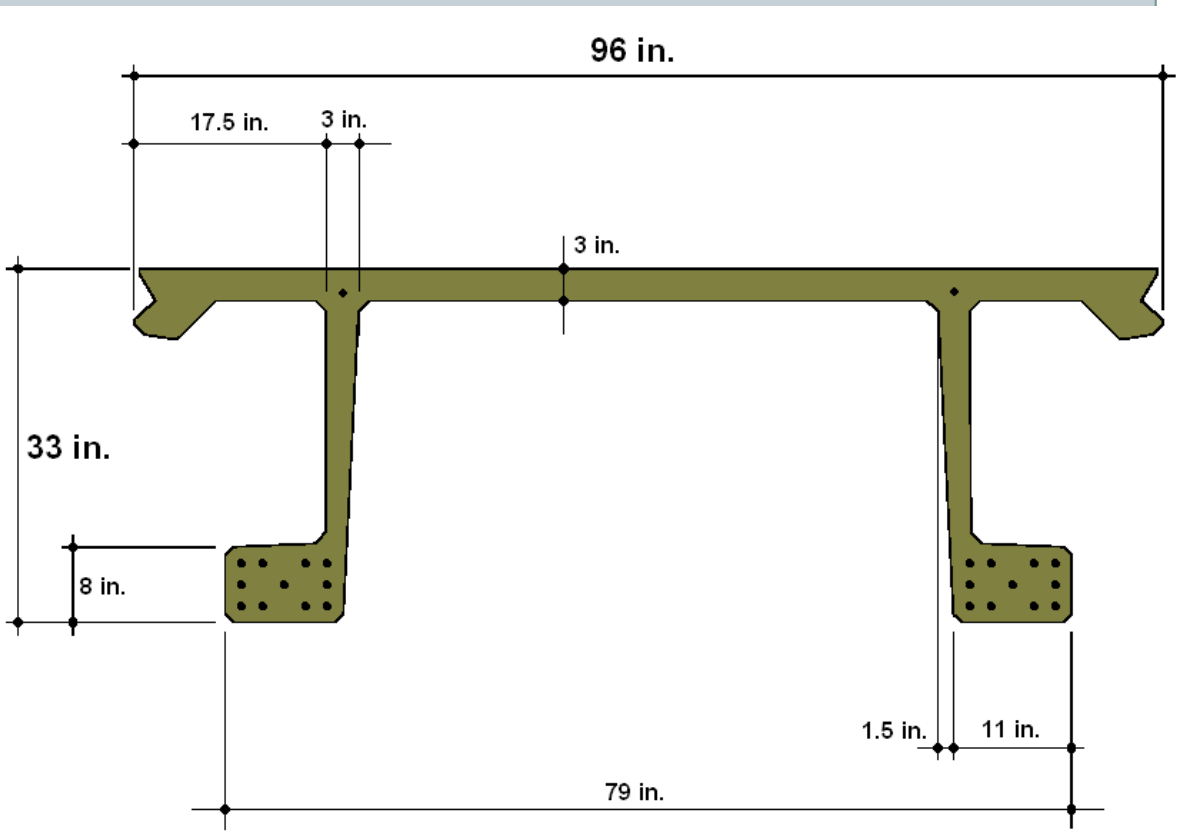
Ductal®

# Project Objectives

- Advance the state-of-the-art in concrete bridge construction technology.
- Develop and build on experience in Iowa in the design and construction of bridges utilizing advanced materials.
- Evaluate the long-term performance of the nation's first Pi Shape UHPC bridge.

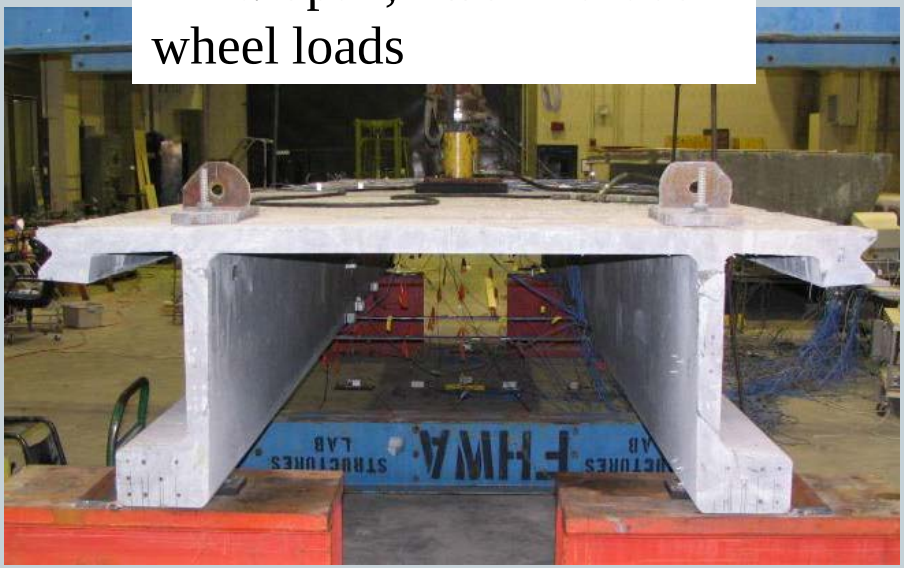
# First Generation Pi-Girder

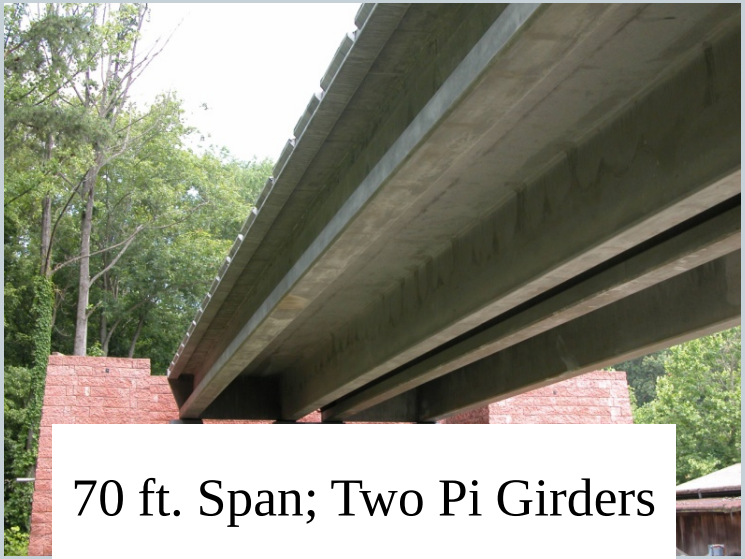
- Developed by MIT/FHWA
- Optimized section for shear and flexural capacity
- Prestressed
- No mild steel reinforcement
- Integral Deck
- Tested by FHWA



# Testing Results by FHWA

24 ft. Span; Two mid-deck wheel loads



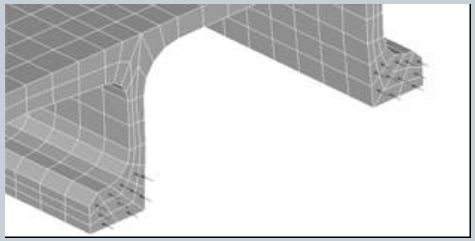



70 ft. Span; Two Pi Girders

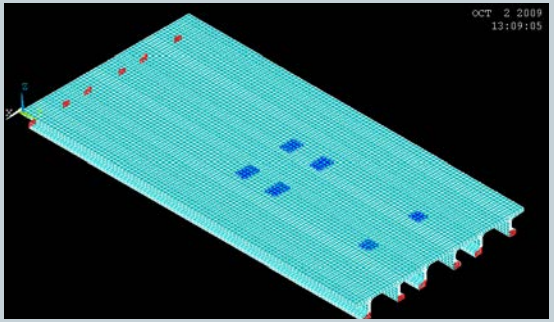
- Longitudinal flexural and shear capacity OK
- Low transverse flexural capacity in deck
- Low live load distribution between girders
- Low lateral stiffness of webs

# Revising the Section

- FEM analysis by ISU Bridge Engineering Center and FHWA (complemented Iowa DOT conventional evaluation)

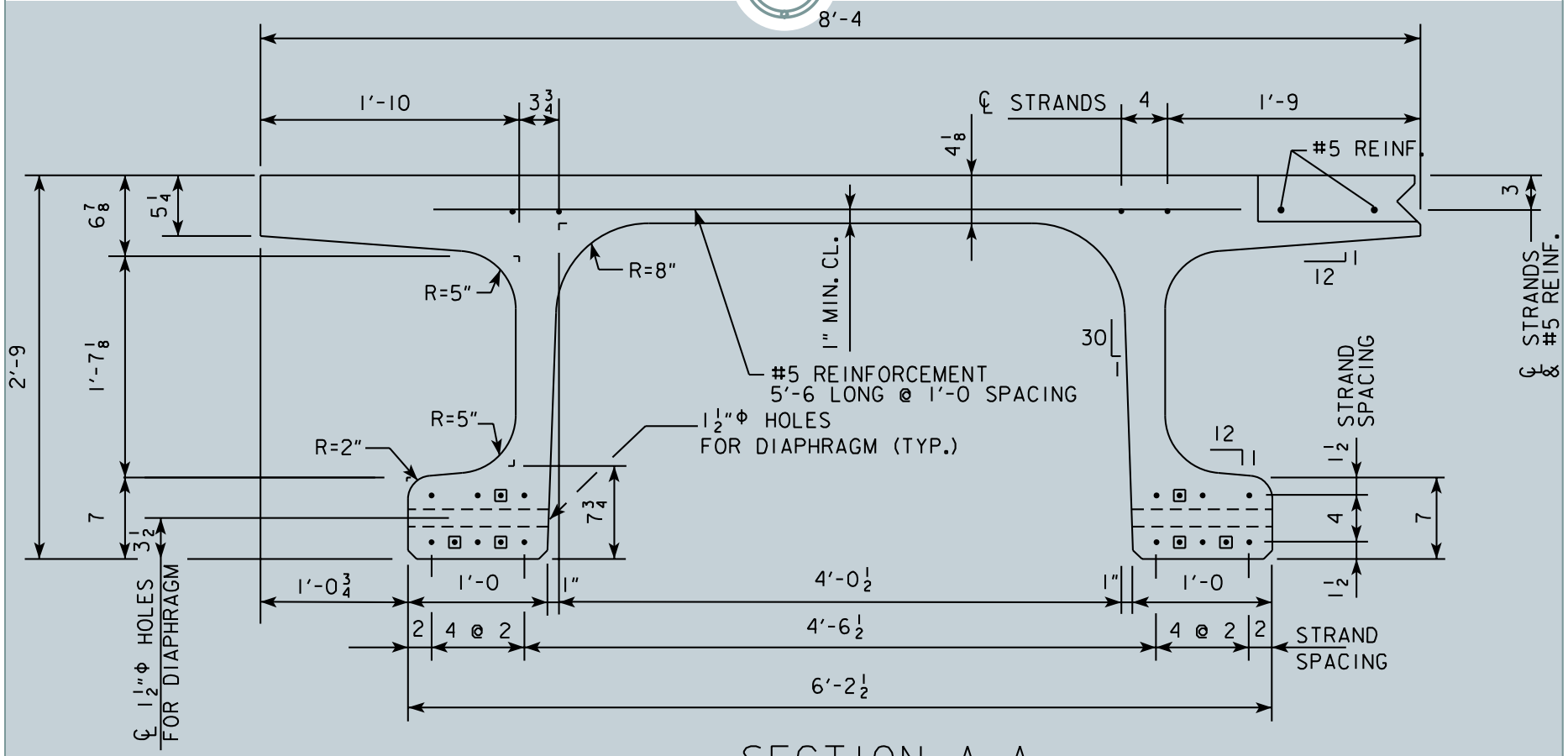


- Analyzed girder unit and complete bridge



- Limit service stress levels below cracking for durability

# Second Generation Pi Girder



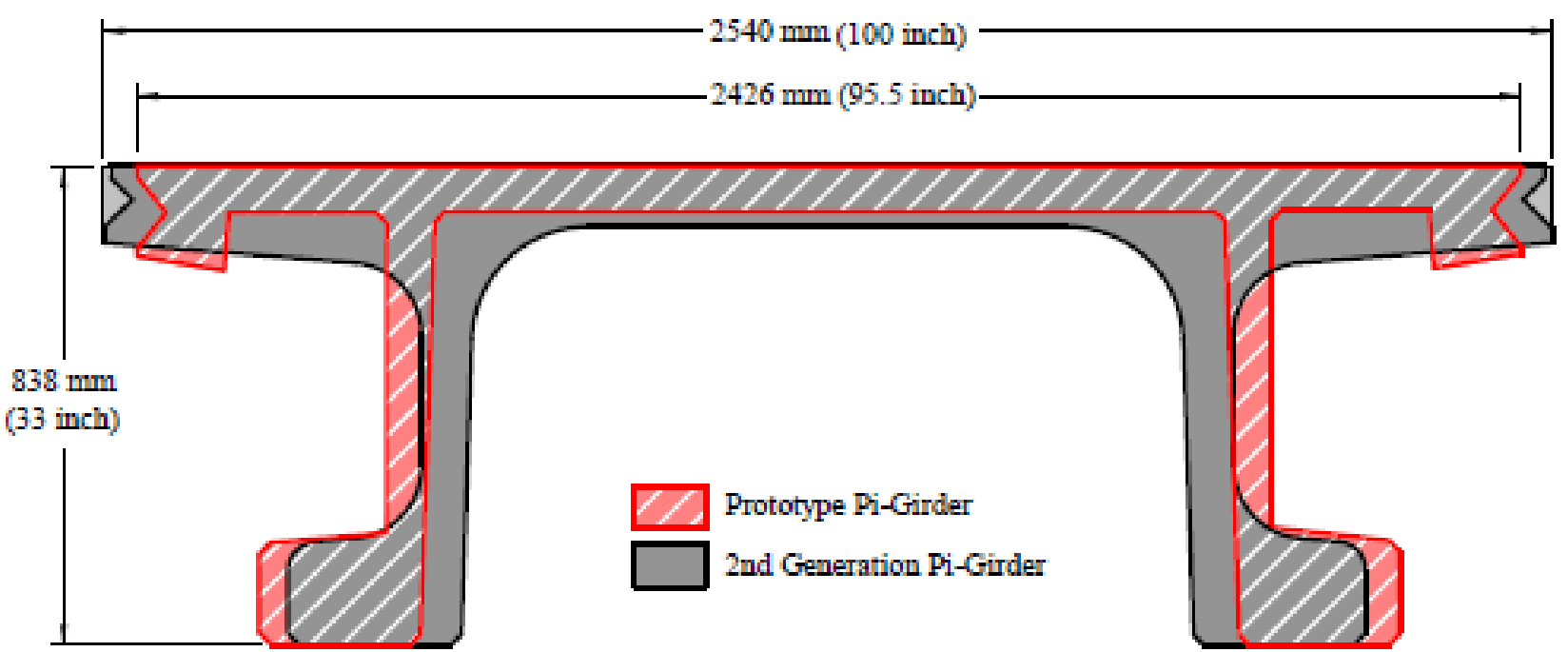

SECTION A-A

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

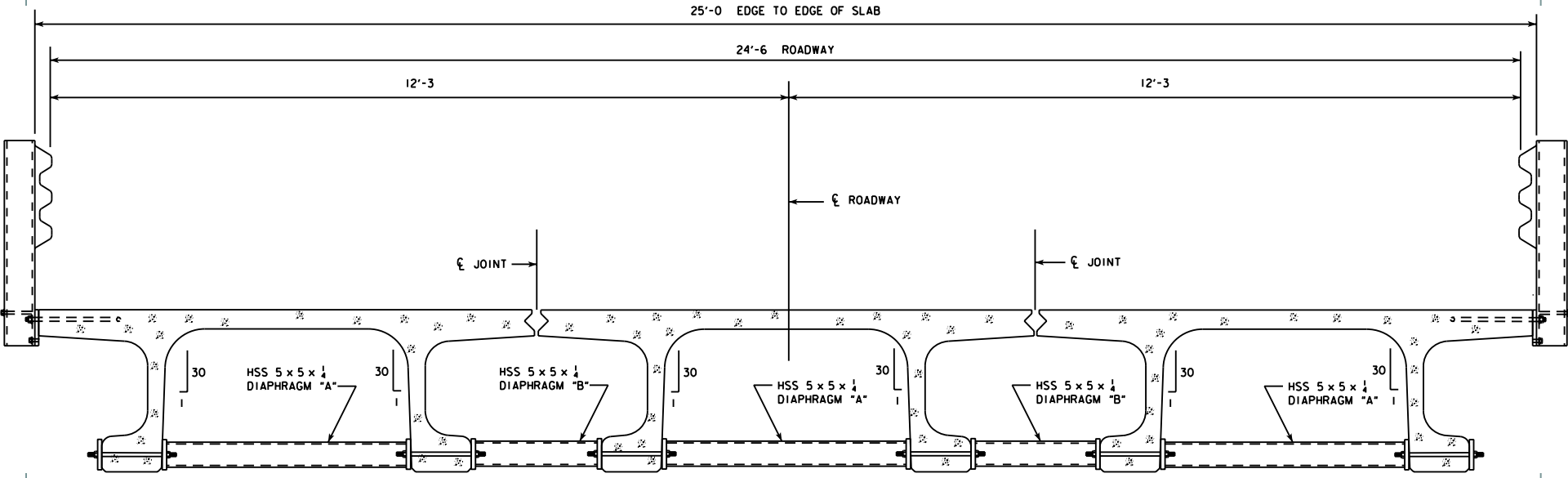
A = 860.8 in$^2$
yb = 22.5 in
I = 105,730 in$^4$
wt/ft = 0.932 k/ft

SECTION PROPERTIES

# First vs. Second Generation Pi Girder



# Cross-Section View of Pi Girders



# Bridge Description

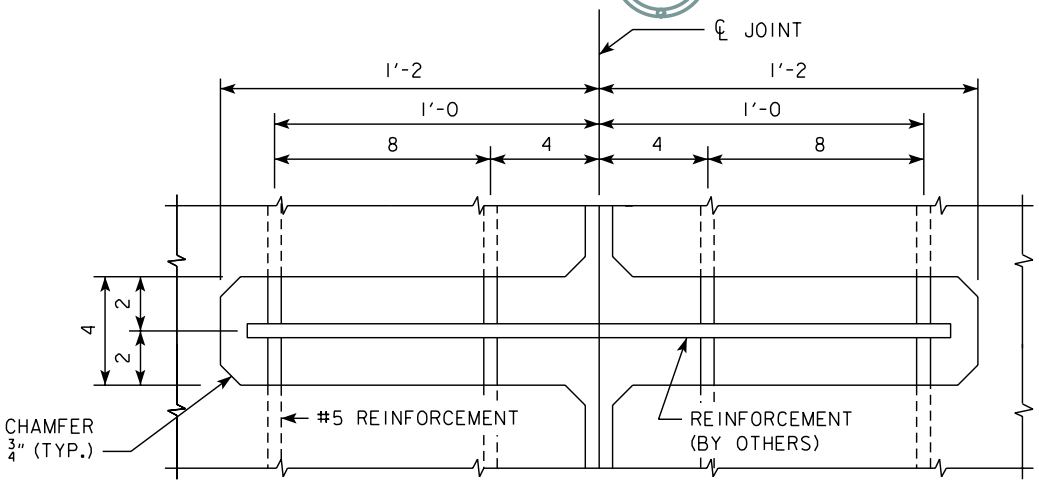
- **24’-6” wide** x 112’-4” long
- 3 simple spans (32’-2”, **52’-0”**, 30’-2”)
  - End spans: 18 in, CIP concrete slab
  - Center span: 3 PI girders

# Girder Casting

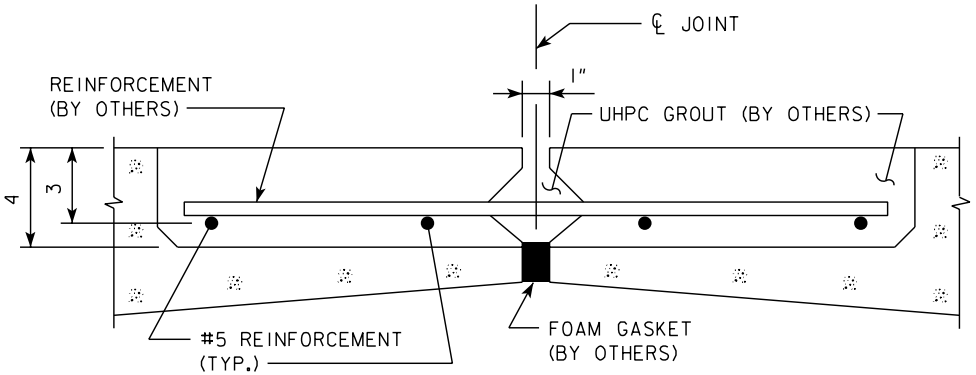
- Cast by Lafarge, Winnipeg, Manitoba, Canada
- 11.3 cu. yd. per beam
- Premixed bags of Ductal mixed in two ready-mix trucks
- Water added as ice cubes
- Total mixing time ~ 6-7 hours

25 ft lab specimen

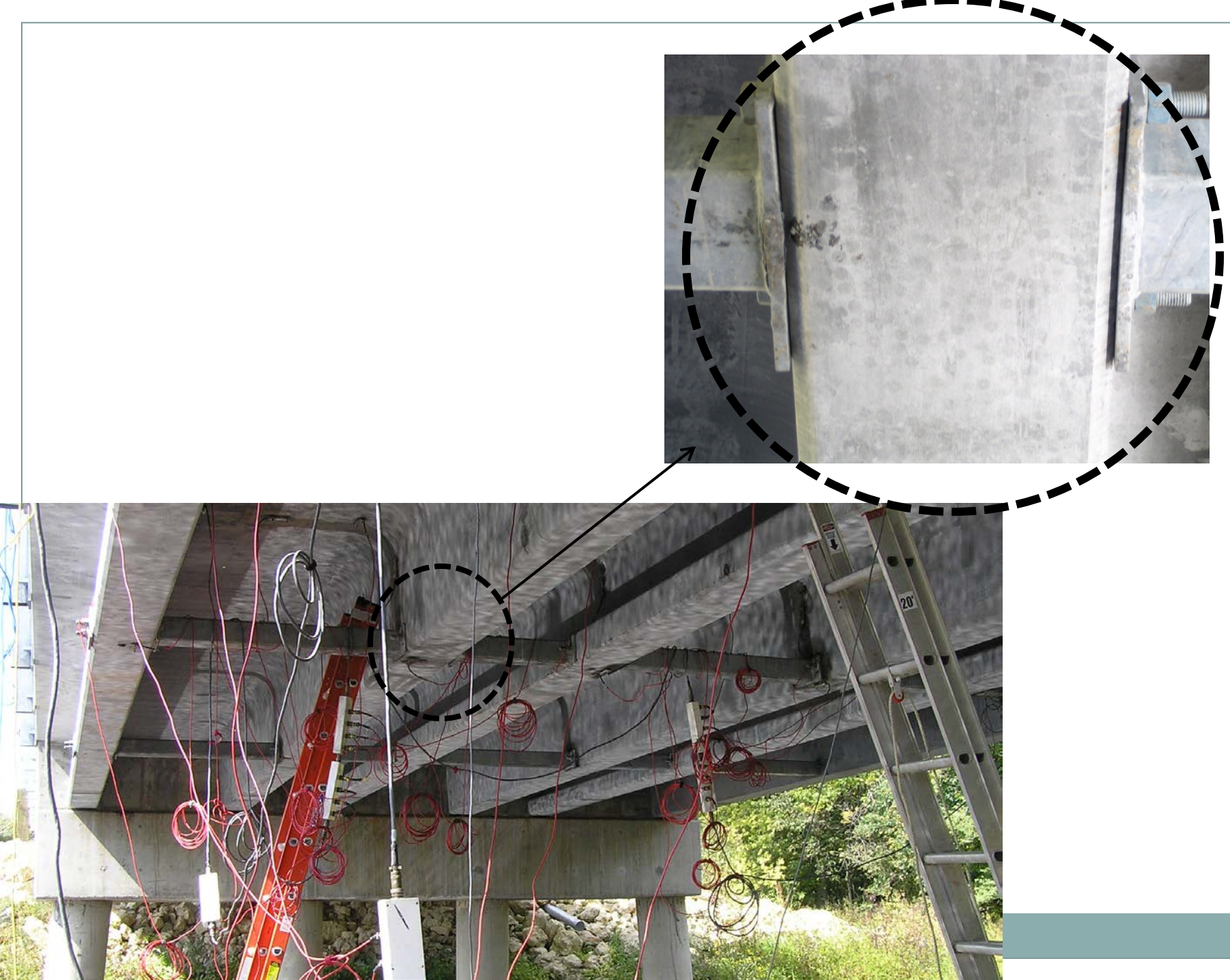
# Girder Connection Detail




PLAN VIEW SHOWING DOWEL POCKETS




TYPICAL LONGITUDINAL SECTION
THRU JOINT DETAIL AT POCKET LOCATIONS



# Field Evaluation

- 1st live load test performed immediately after construction
- 61,000 lb. truck, 28 passes over bridge
- 32 strain transducers monitoring
  - Longitudinal bulb strains
  - Transverse and longitudinal deck strains
  - Bending strains in webs
- 6 deflection gages at mid-span

# Results of First Load Test

- Much improved Live Load Distribution compared to First Generation Pi Girder
- Measured strains matched FEM predictions closely
- All measured strain levels below cracking strain
- Highest tensile strains measured in webs
- Design was conservative, bridge performing well

# Field Evaluation

- 2nd live load test performed approx. 1 yr. later
- 61,000 lb. truck, repeated passes from 1st test
- Also performed higher speed passes (~20-25 mph)
- 32 strain transducers with similar layout as 1st test
  - Additional web strain measurements made
- Performed crack survey of underside of girders

# Results of Second Load Test

- Strains generally 10-15% higher than in first test
- All measured strain levels still below cracking strain
- Highest tensile strains measured in webs
- Minimal cracking observed
- Bridge performing well

# Acknowledgments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- Taylor Construction Inc. (General Contractor)
  - Pat Krapfl

# Elevation View