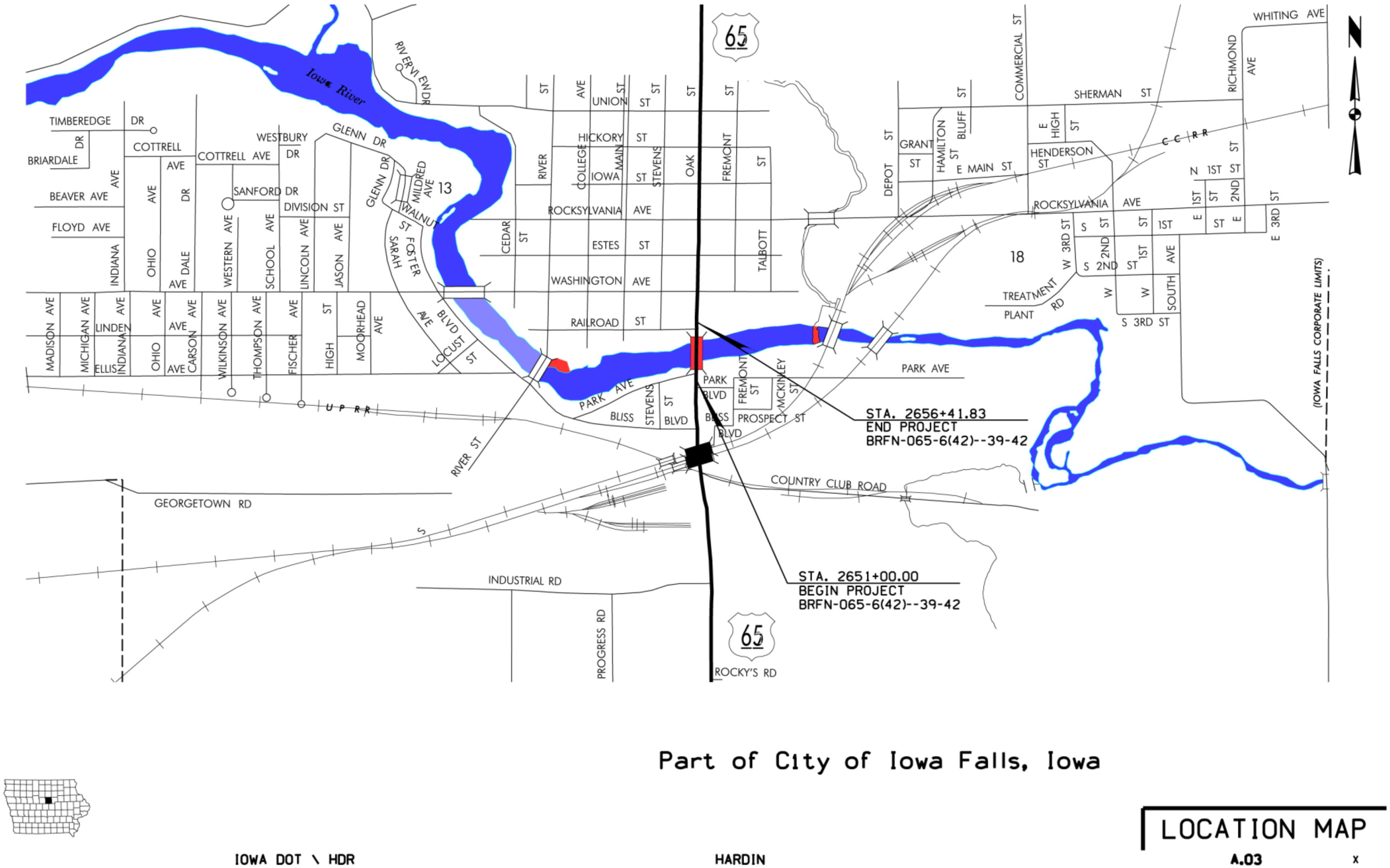
US 65 Oak Street Bridge

DESIGN, CONSTRUCTION & STRUCTURAL HEALTH MONITORING OF A STEEL ARCH BRIDGE

Iowa Falls, Iowa

Location of Project



Introduction

- Demolition Concepts
- Concept Design
- Final Design
- Construction
- Health Monitoring

Existing Bridge

- Built in 1928
- 255-foot Open Spandrel Concrete Arch Bridge
- 24-foot Roadway and Two Sidewalks
- Deck Supported by R/C Floor Beams

Existing Bridge

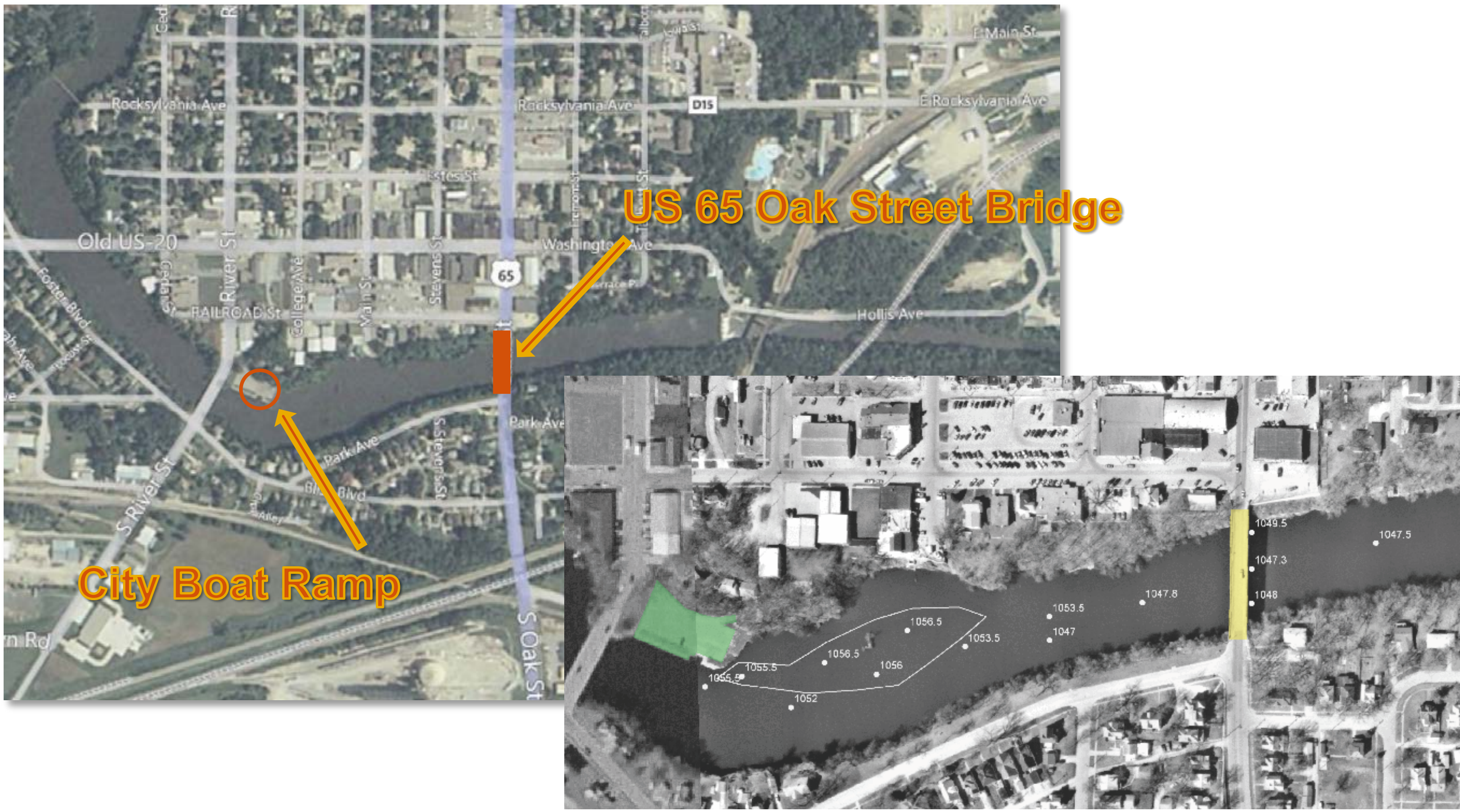
- Rehabilitated 7 Different Occasions
- Needed Widening and Strengthening
- Replace Rather than Rehabilitate

Concept Stage Type Study

- Identify Constraints and Constructability Concerns
- Identify Feasible Demolition Concepts
- Identify Feasible Replacement Alternatives
- Cost
- Timeline for Construction

Constraints and Constructability Issues

» Site Access



Constraints and Constructability Issues

- Historic Church
  - NW Corner of Bridge
  - Listed on the National Register of Historic Places

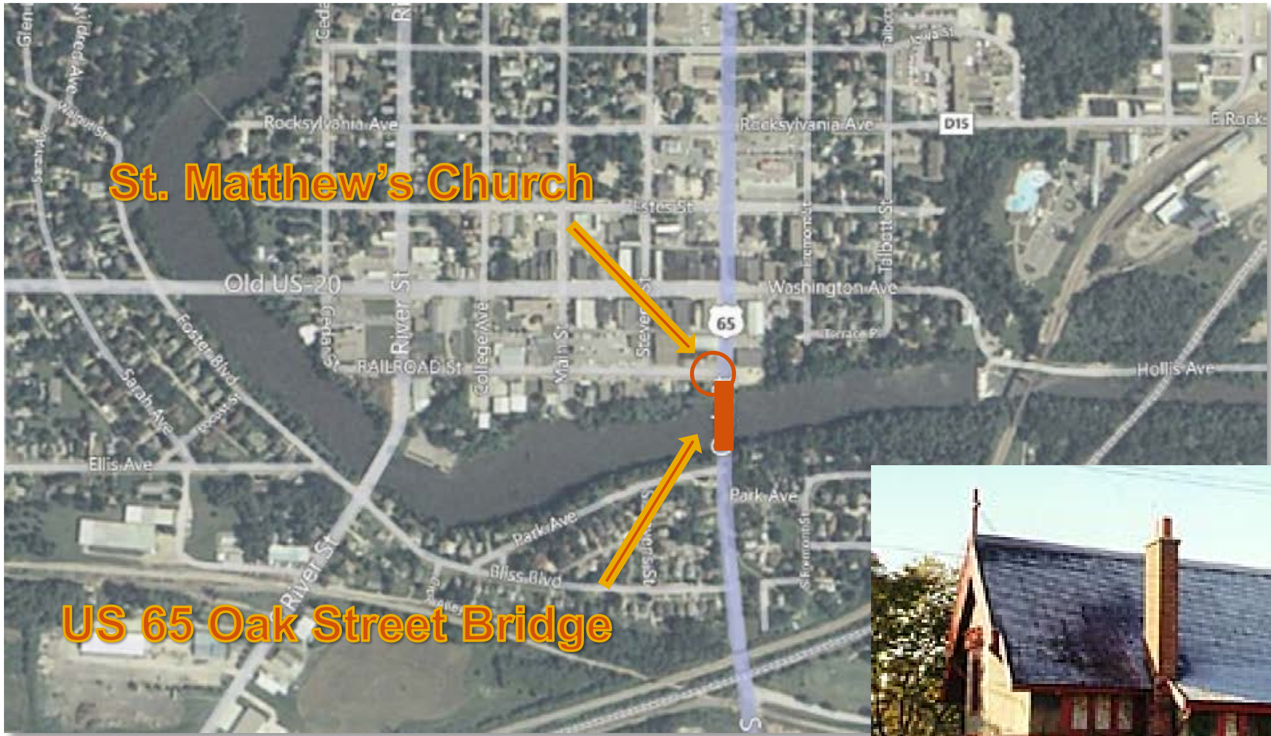



Photo by: iafalls.com

Constraints and Constructability Issues

- Dam
  - Maintain Water Level

Demolition Concepts Assumptions

- No Environmental Restrictions
- Access to River is Available
- No Prohibition on Use of Engineered Explosives
- Vibration Monitoring Required
- Cost versus Clean up

Actual Demolition

- Started mid October 2010 and Finished mid December 2010.
- Lowered the Iowa River with Cooperation of the Downstream Dam
- Constructed an Access Road and Causeway Utilizing a System of Steel Bridge Beams and Crane Mats over the Open Water

Actual Demolition

- Constructed a System to Protect the Sanitary Sewer Lines
- Demolished the Bridge using the Causeway
- Deck and Columns were Demolished using two Excavators with Hydraulic Breakers
- Each excavator started at the Center of the Bridge

Actual Demolition

- Demolished the Arches Using the same Excavators with a Mounted Hammer
- Arch Pieces were Broken Down and Hauled Off-Site by Truck
- Vibration Monitoring was Provided at the Adjacent Church and Residences

Bridge Replacement Alternatives

- City of Iowa Falls
  - Scenic City
  - River Cruises is a Major City Attraction
  - Several Types of Bridges that Span Across Iowa River

Bridge Replacement Alternatives
Washington Avenue Concrete Arch Bridge


Photo by: HistoricBridges.org

Bridge Replacement Alternatives Assumptions

- No Environmental Restrictions
- Access to River
  - Launch Segmental Barges
  - Erect a Suitable 150-ton Crane
- Vibration Monitoring Required

Bridge Replacement Alternatives
Two Span Prestressed Concrete Alternative

- Easiest to Construct
- Drilled Shaft at Pier Eliminates Need for Cofferdam
- Drilled Shaft at Abutments Reduces Vibration Impacts
- Less Rock Excavation than other Alternatives
- Most Economical Option

Bridge Replacement Alternatives
Simple Span Haunched Girder Alternative

- Non-conventional Super Type
- Heavy Girder Pieces
- Require Temporary Bents or Falsework
- Substantial Rock Excavation
- Require Lead Time for Fabrication

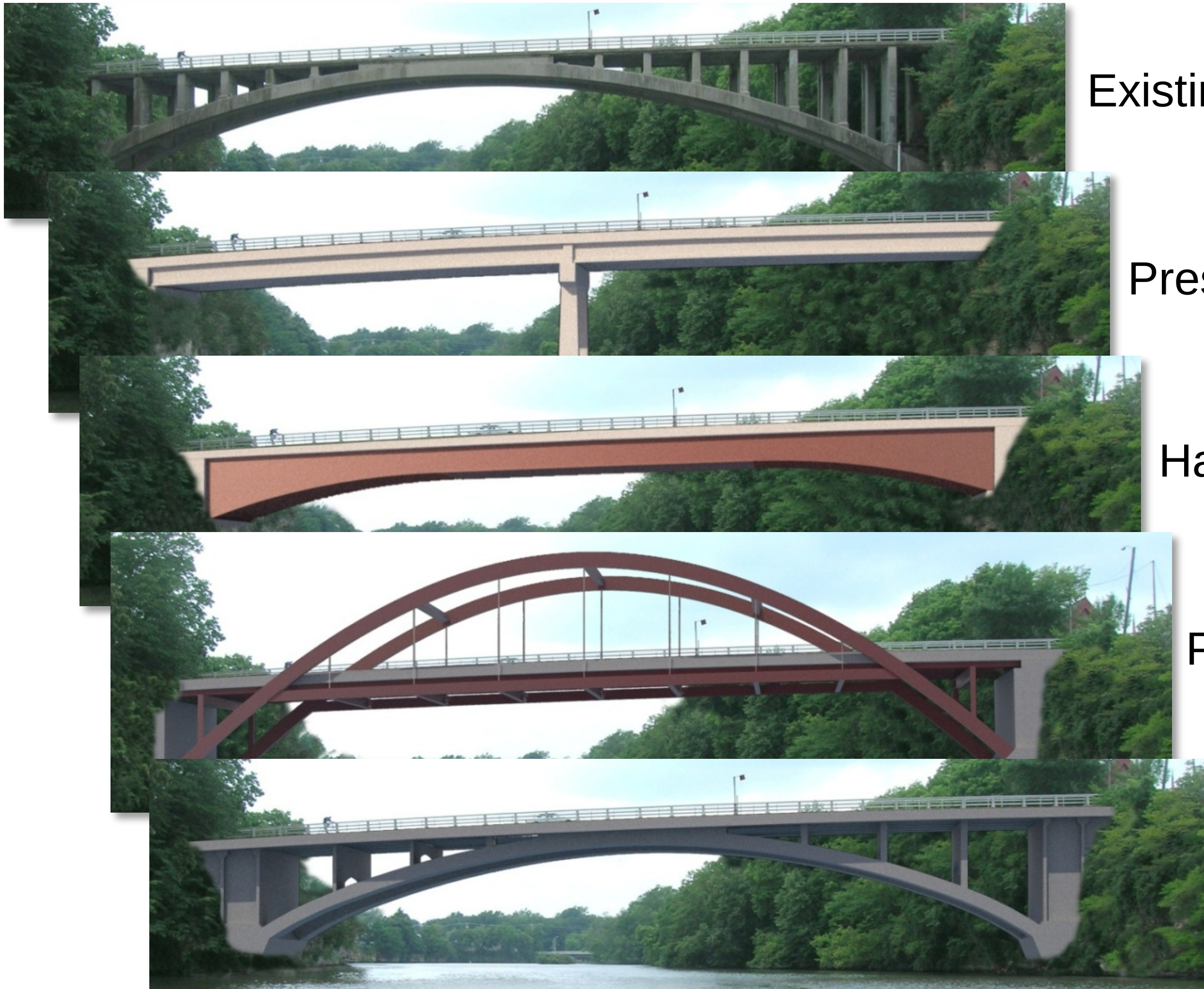
Bridge Replacement Alternatives
Partial Thru Steel Arch Alternative

- Easier to Construct Relative to Concrete Arch
- Shorter Construction Period than Concrete Arch
- Require Temporary Bents, Falsework or Tied-Back Systems to Construct
- Additional Inspection and Maintenance of Suspenders
- Requires Construction Engineering

Bridge Replacement Alternatives
Concrete Deck Arch Alternative

- Most Difficult/Complex to Construct
- Rib Shortening Issues
- Requires Temporary Bents or Falsework or Tied- Back Systems
- Longest Construction Period
- Requires Construction Engineering

Bridge Replacement Alternatives
The Alternatives



Existing Concrete Deck Arch

Prestressed Concrete Girder

Haunched Steel Girder

Partial Thru Steel Arch

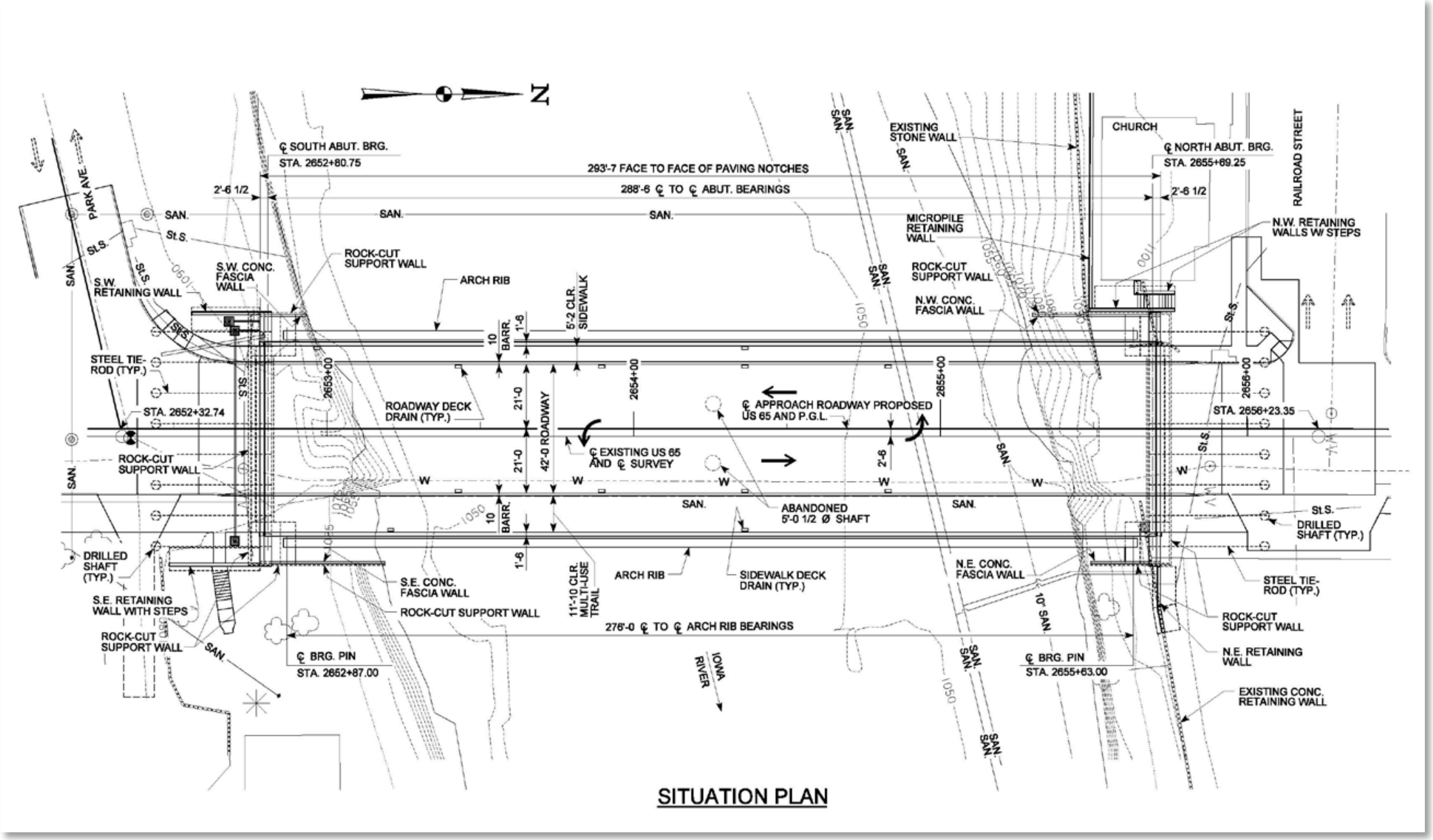
Concrete Deck Arch

New Bridge – Aerial View

Final Design Considerations

- Tight Geometrics
- Bridge Footprint
- Retaining Walls and Rock Cuts
- Substructure Sizing and Sustainability
- Protection of the Superstructure

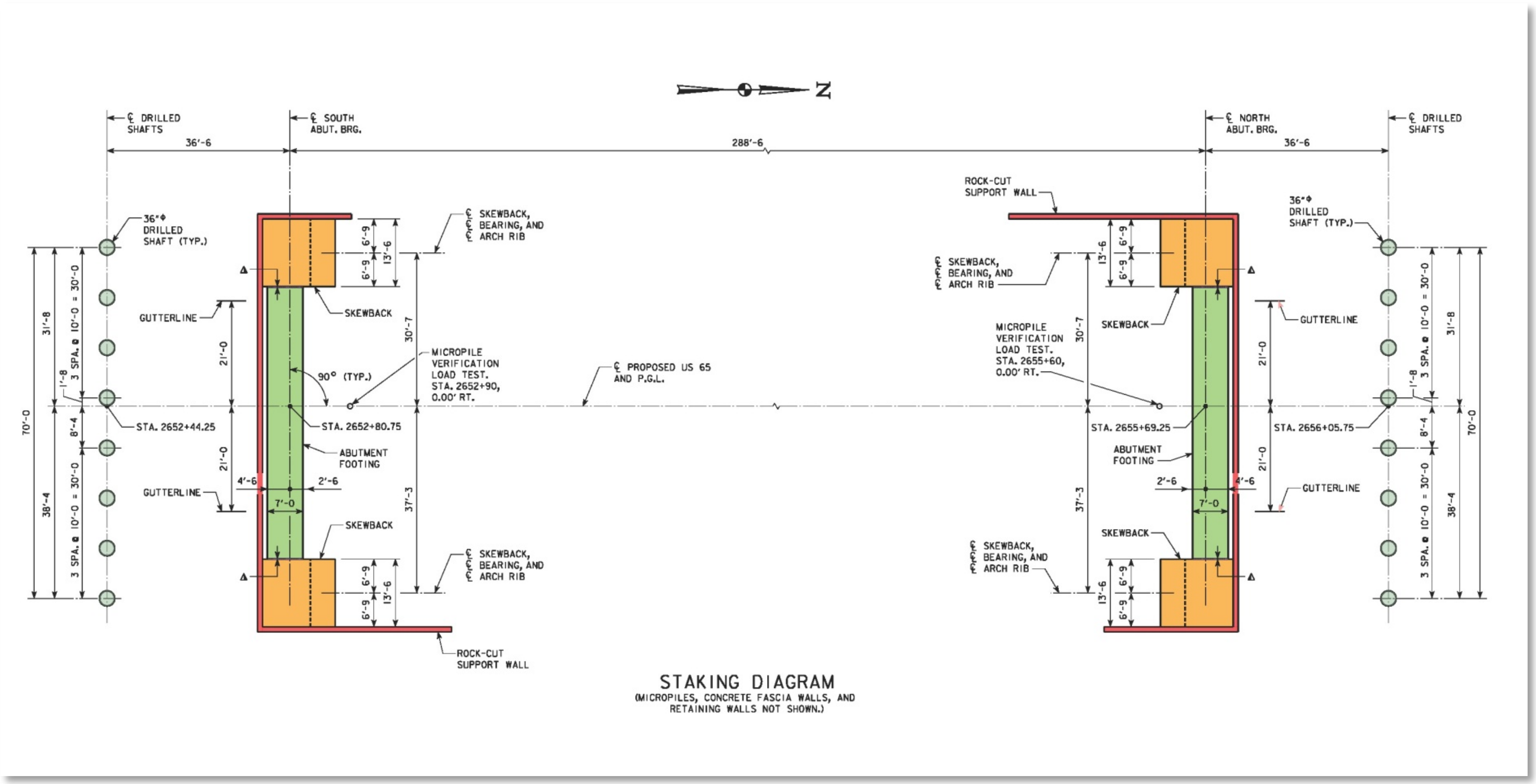
Tight Geometrics



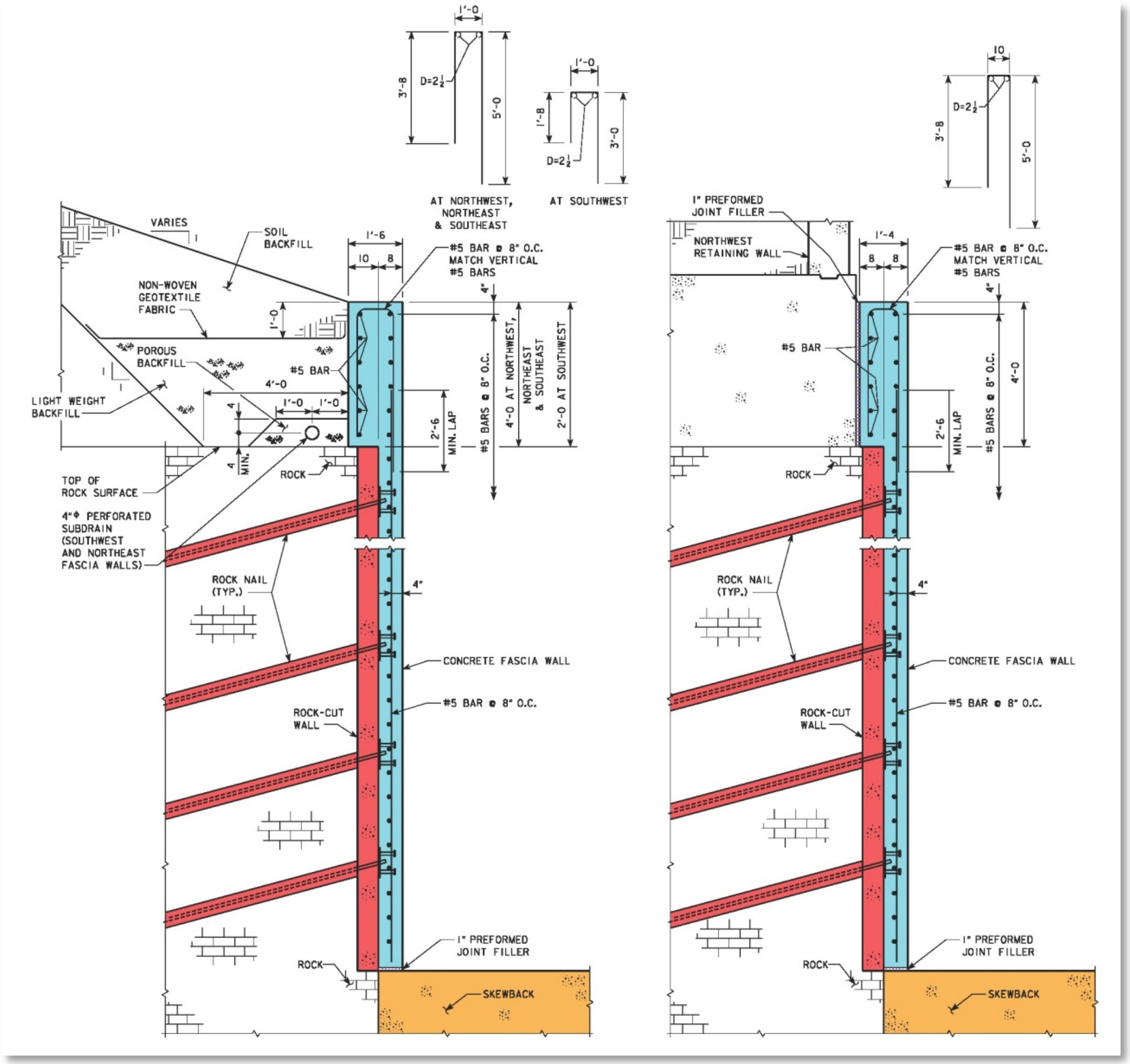
Existing Church Retaining Wall

Micropile Retaining Wall

Rock Cut Support Walls



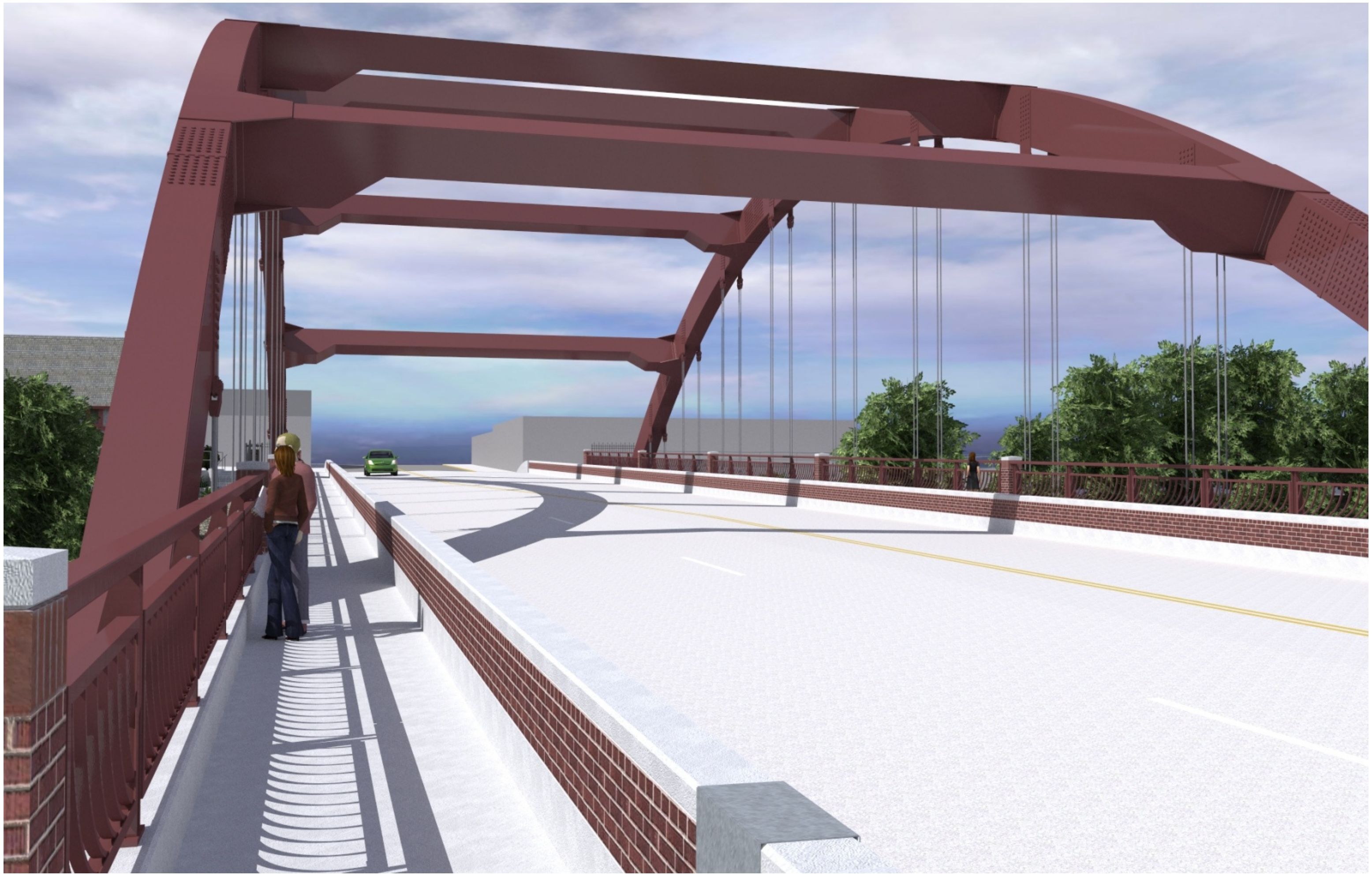
Rock Cut and Concrete Fascia Walls



Aesthetics and Renderings

- Kimball Olson
  Aesthetics coordinator – Iowa DOT
- Used to convey
  - Size
  - Perspective
  - Spatial relationships
- Useful in Design and Presentation to the General Public

Rendering – Showing Trail



Actual Bridge

Deck and Hanger Cables

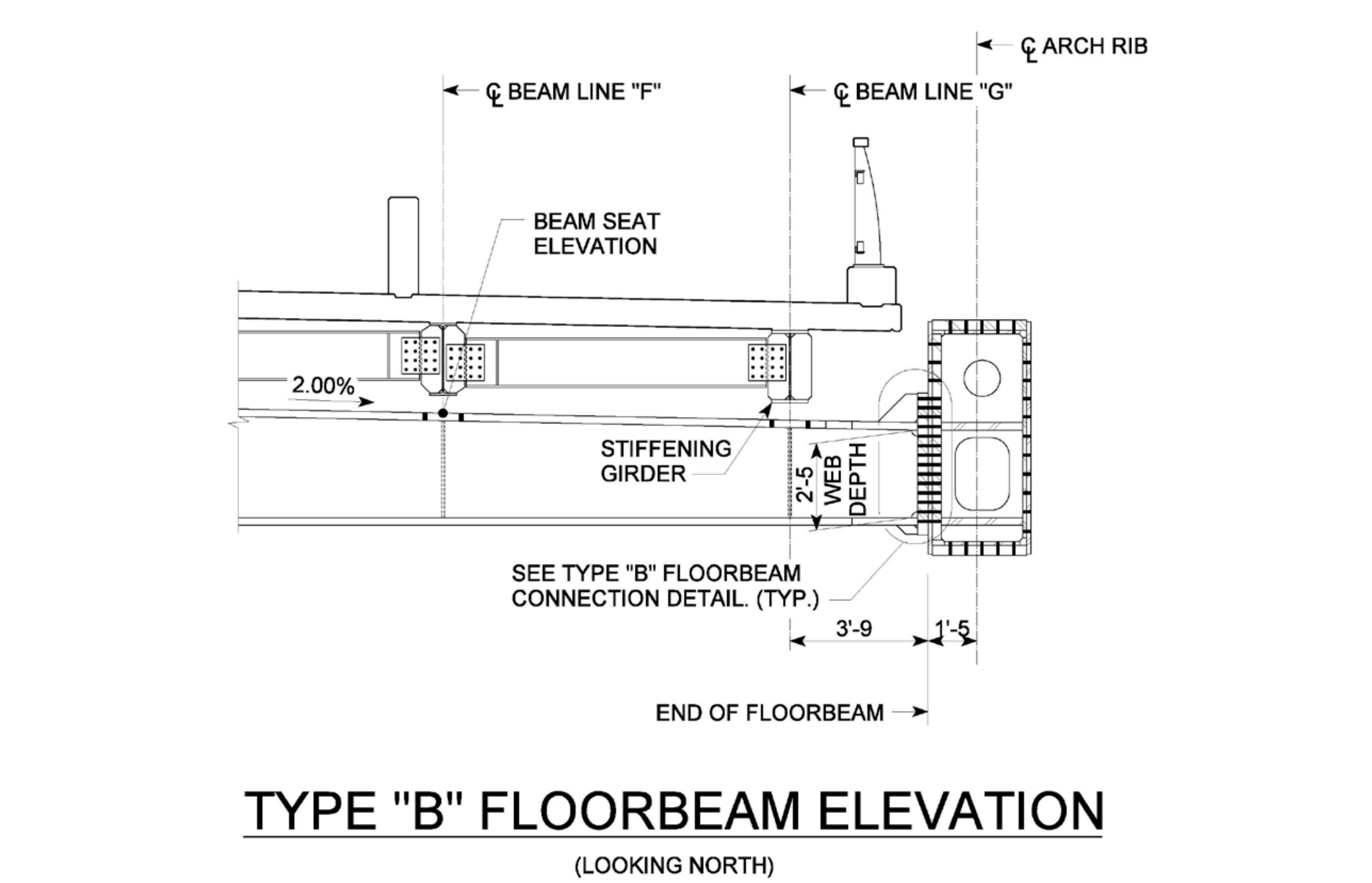
- Floor Beam and Stinger system suspended from the Arch Rib
- End Floor Beams frame directly into the Arch Rib
- Deepened Exterior Stringer / Stiffening Girder
  - Distributes vehicular loads from deck to multiple hanger cables
  - Minimize local live load deflections

Arch Design

- Grade 50 Weathering Steel with Protective Coatings
- Built in Replacement of Hanger Cables
- Pinned Bearings
- Wide aspect ratio
  - Length to Width ratio = 4
  - No trussed sway bracing.

Interior Floor Beam and Hangers

End Floor Beam



Pinned Bearings

- Net Zero Change in Steel Weight from a Fixed Connection
- Reduced Footing Size
- Minimized Impacts to Surrounding Properties

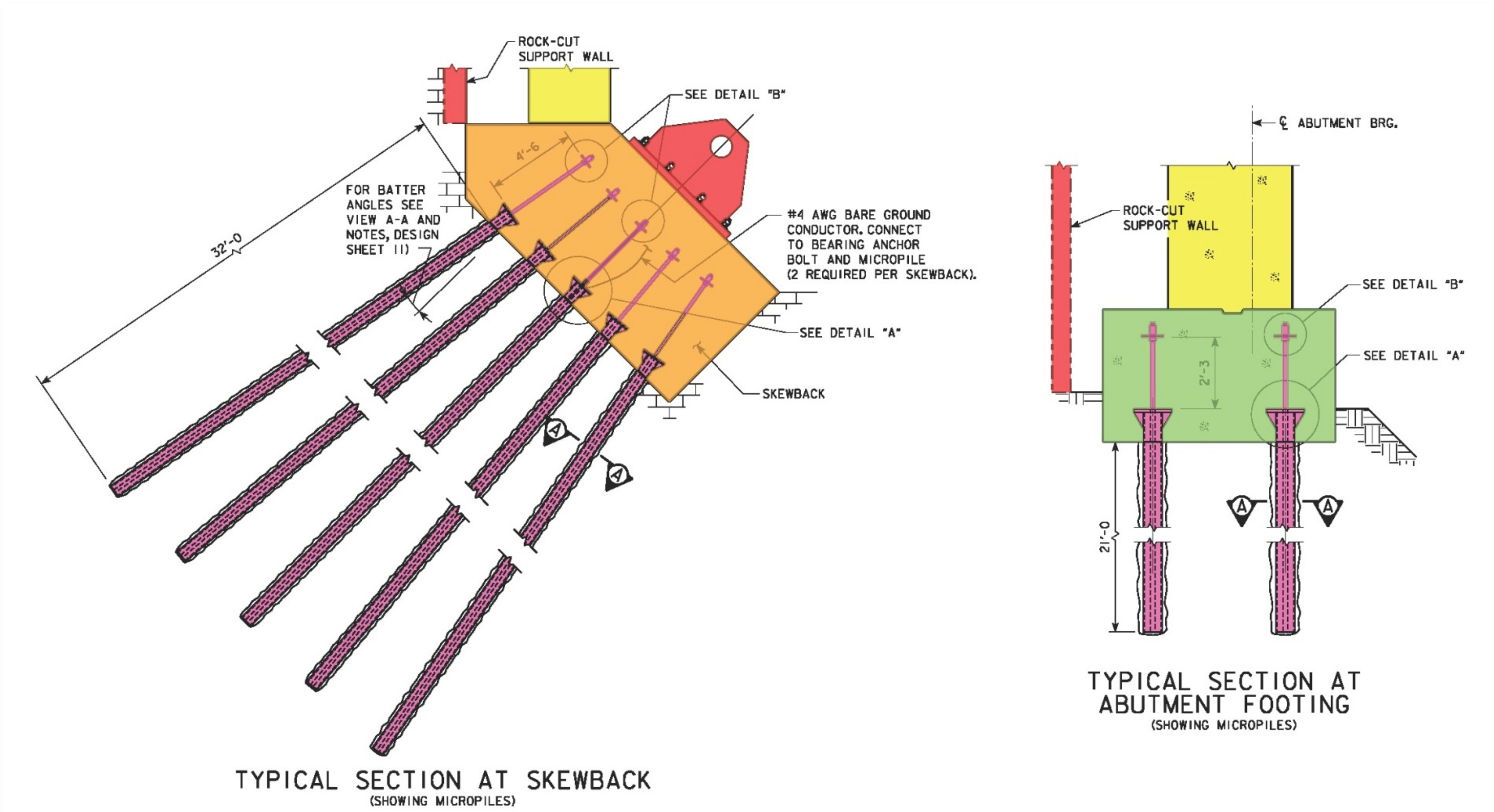
Foundations

- Issues:
  - Existing Bridge Showed Signs of Undermining
  - Arch Skew Back Behave Differently than the Retaining Wall Abutment.
- Solutions:
  - High Capacity Micropiles
  - Separate Foundations
  - Tied-back Abutment
  - Lightweight Backfill

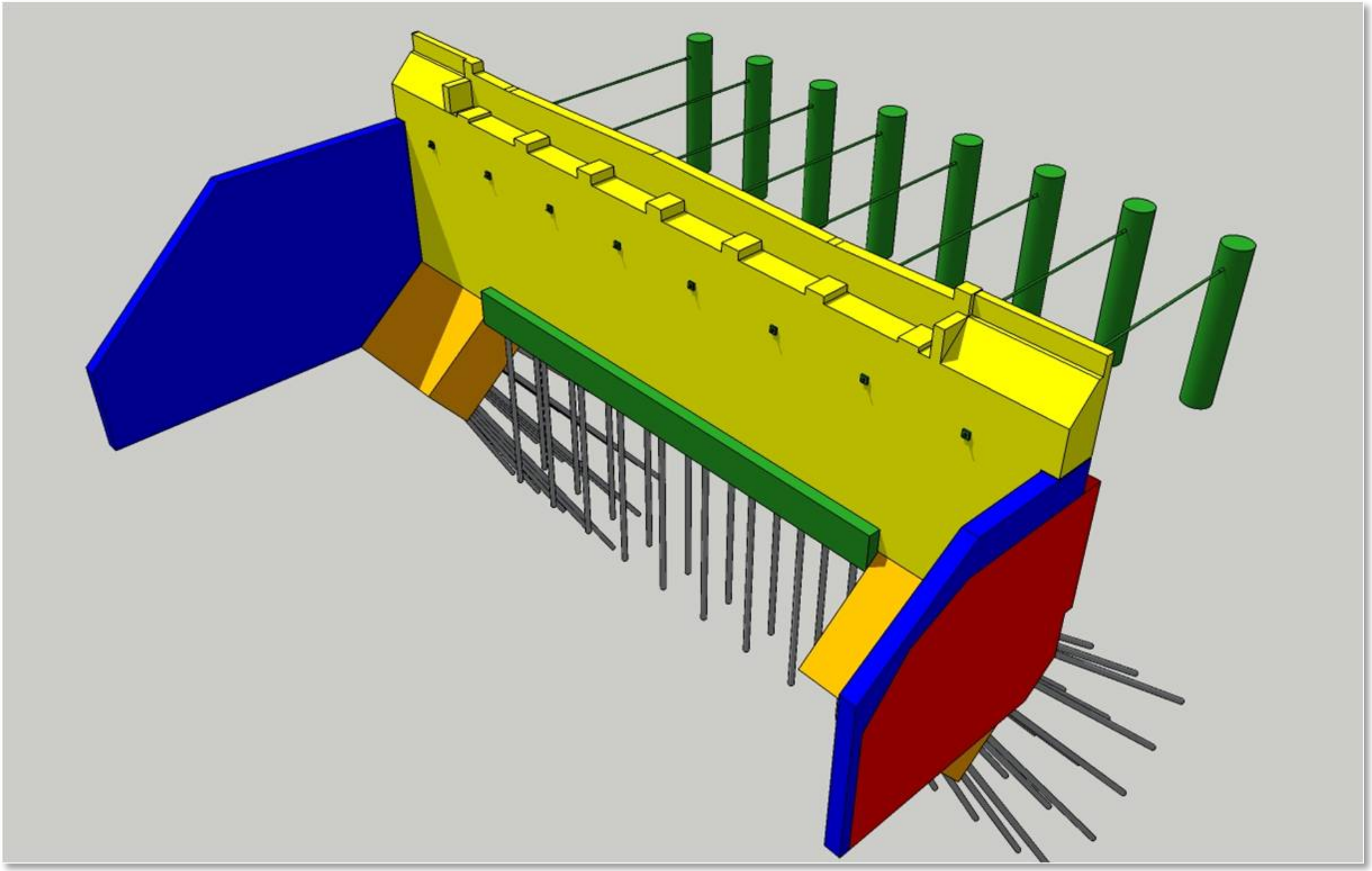
Foundation Issues

- Existing Bridge Undermining

Micropiles


ROCK-CUT
SUPPORT WALL
SEE DETAIL "B"
4'-6
FOR BATTER
ANGLES SEE
VIEW A-A AND
NOTES, DESIGN
SHEET 11)
32'-0
#4 AWG BARE GROUND
CONDUCTOR. CONNECT
TO BEARING ANCHOR
BOLT AND MICROPILE
(2 REQUIRED PER SKEWBACK).
SEE DETAIL "A"
SKEWBACK
TYPICAL SECTION AT SKEWBACK
(SHOWING MICROPILES)
℄ ABUTMENT BRG.
ROCK-CUT
SUPPORT WALL
SEE DETAIL "B"
SEE DETAIL "A"
2'-3
21'-0
TYPICAL SECTION AT
ABUTMENT FOOTING
(SHOWING MICROPILES)

Abutment and Micropile Schematic



Pin and Hanger Steel Tolerances

- Construction tolerance issues during fabrication of the Pins and Hangers:
  - ASHTO 6.8.7.3
    - Requirement: 0.031”

- Maximum Difference
- As Fabricated
- Pin to Pin Plate: 0.04”
- Pin to Socket: 0.14”

Pin and Hanger Steel Tolerances

- Resolution – Perform additional tests on the Pin to Socket connection to quantify permanent deformation under load.
  - 55% Proof load – No permanent deformation allowed as measured to nearest 0.001"
  - Contractor also tested two connections to 100% load

Pin and Hanger Steel Tolerances

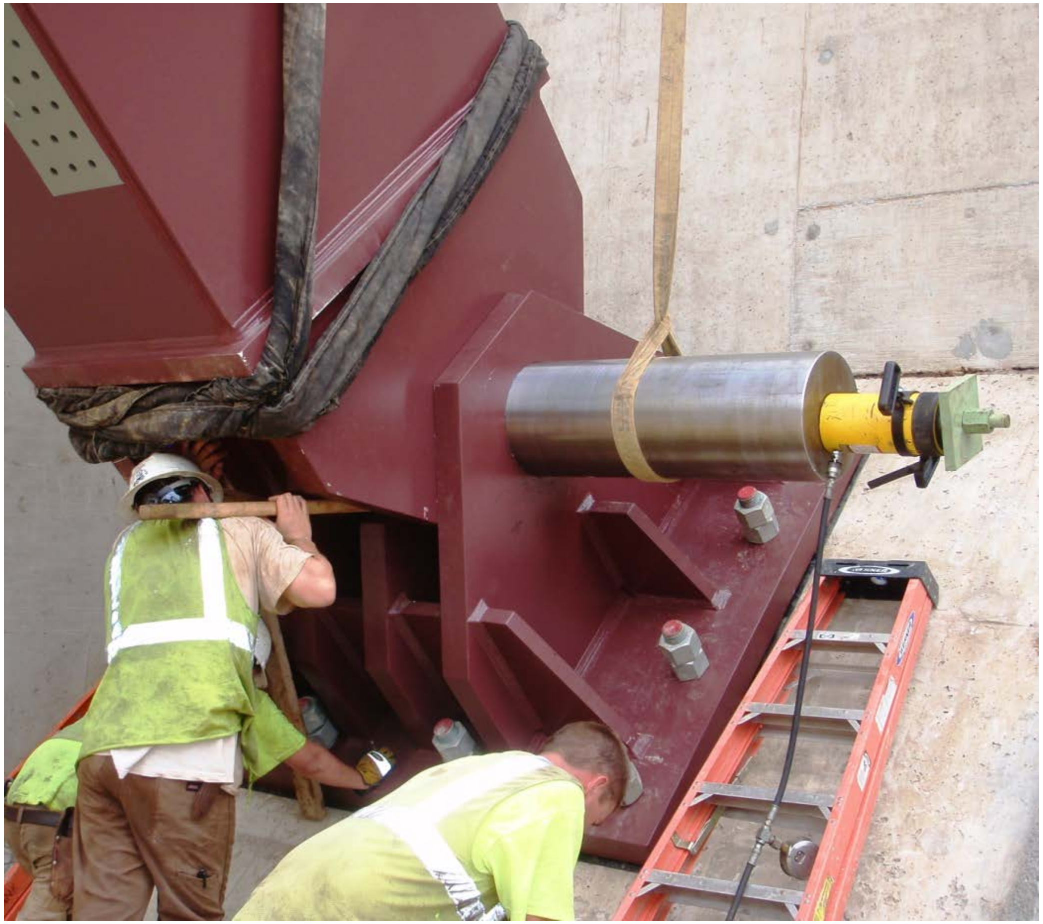
- Observed Deformations
  - Proof load = 0.00”
  - 100% load = 0.04”
- Contractor was allowed to use the pins and sockets as fabricated.

Fabricated Bearing Tolerances

- Bearing Side Plates
  - Warped out of tolerance
  - Would not allow upper unit to fit with the lower unit
- Masonry Plate
  - Curved upward on the edges
  - Would not allow full bearing on the concrete skew back

Fabricated Bearing Tolerances

- Bearing Side Plates
  - Total conflict 1/4”
  - Fabricator milled 1/8” from upper and lower units
  - Difference was evaluated and deemed acceptable
  - Complicated fit

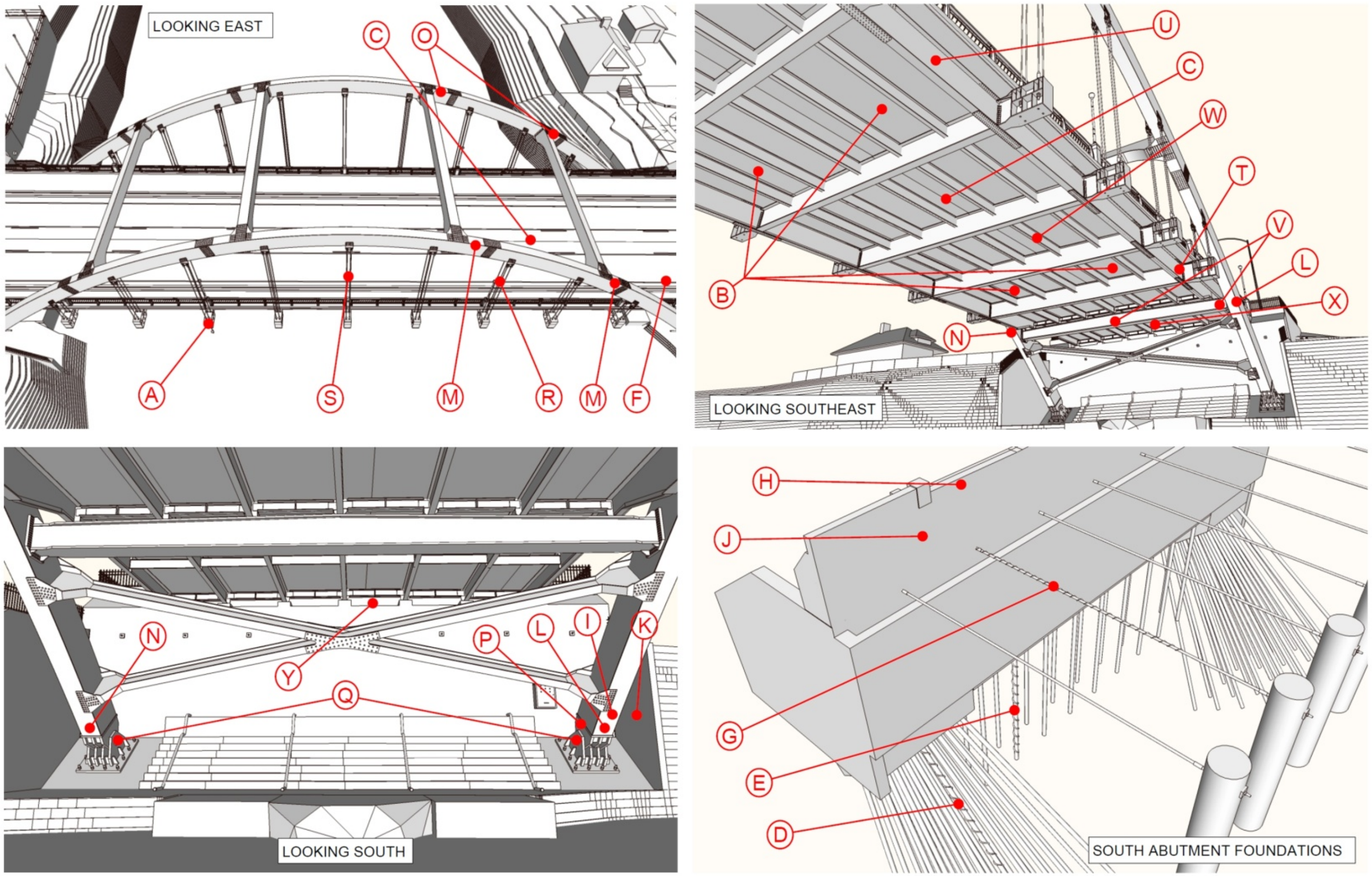


Fabricated Bearing Tolerances

- Masonry Plate
  - Maximum gap of 3/4” at the edge
  - Steel erection allowed to proceed
  - Jacked and grouted prior to pouring the concrete deck

Health Monitoring

» Iowa State University - Dr. Brent Phares



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QUESTIONS?