I-74 Corridor in the Quad Cities

A State of the Art Design

Mid-Continent Transportation Research Symposium

August 16-17, 2017

Presented By: Norm McDonald, Iowa DOT State Bridge Engineer

Illinois Department of Transportation

benesch
engineers · scientists · planners

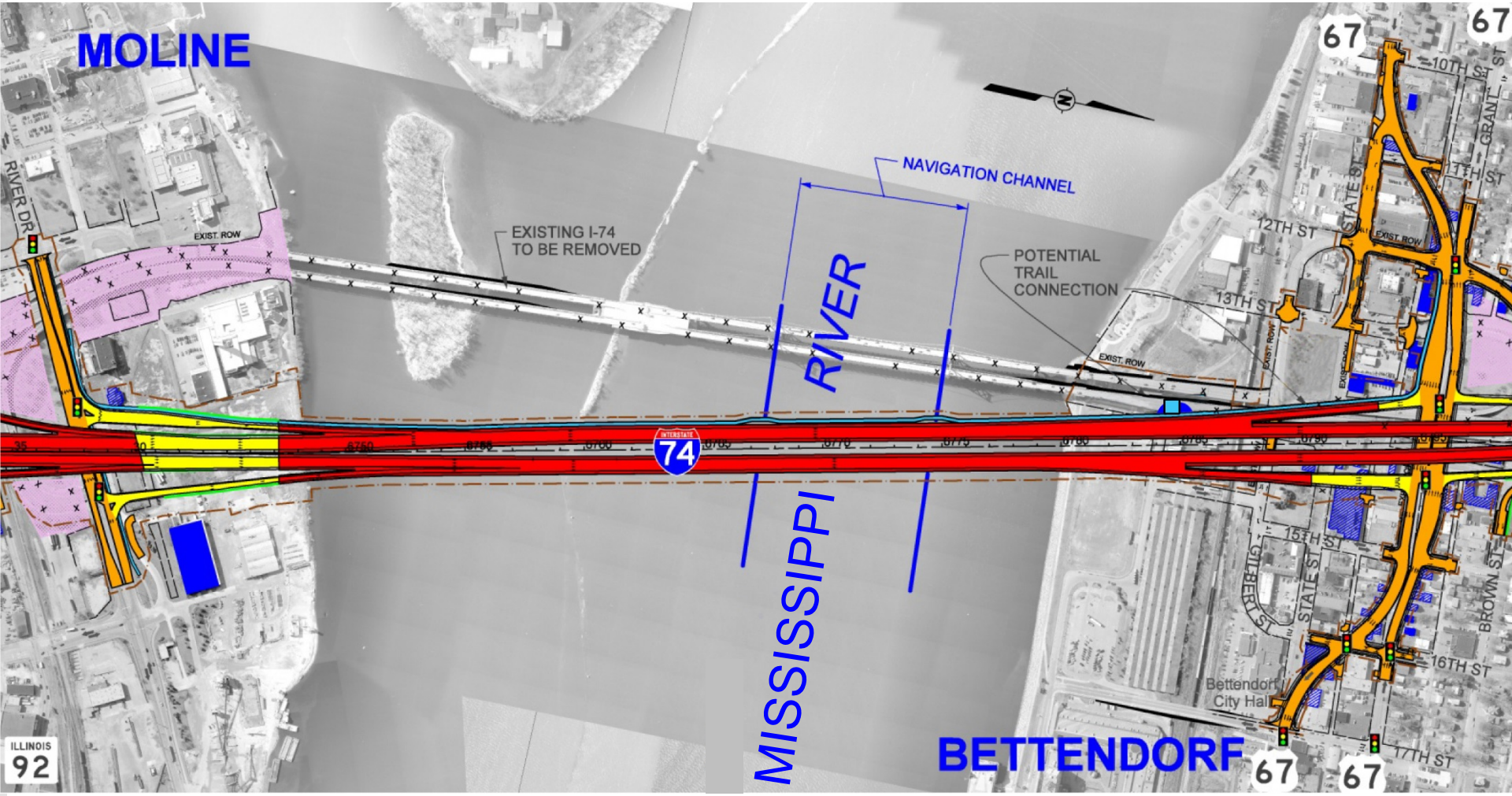
IOWA DOT

PRESENTATION OUTLINE

- Project Background
- Design Challenges
- Aesthetics and Enhancements
- Maintenance and Monitoring

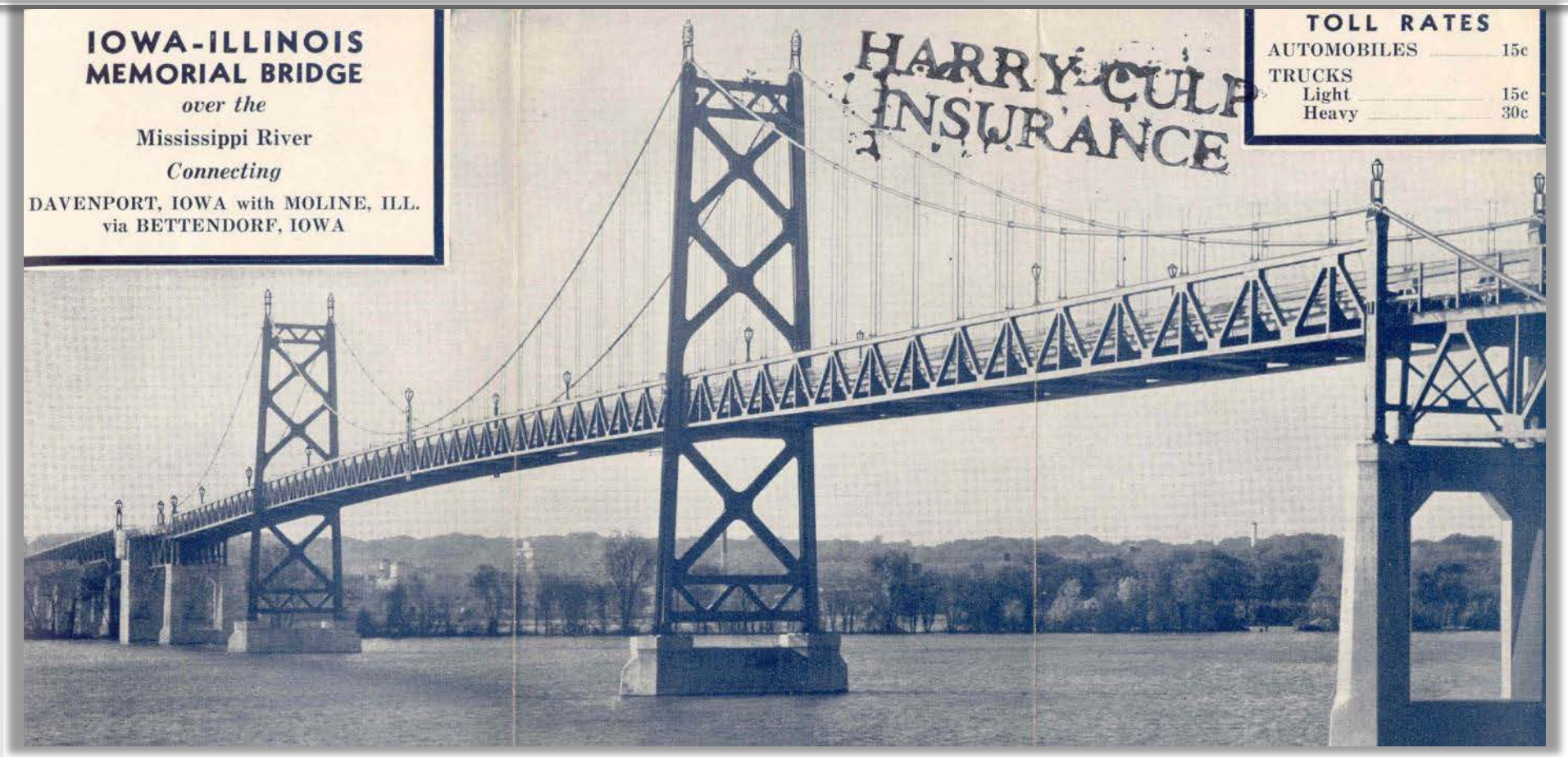
- 2035 I-74 ADT = 99,800
- 45% of the Total Traffic Crossing the Mississippi

PROJECT OVERVIEW - IOWA



EXISTING BRIDGES

EXISTING NORTHBOUND BRIDGE



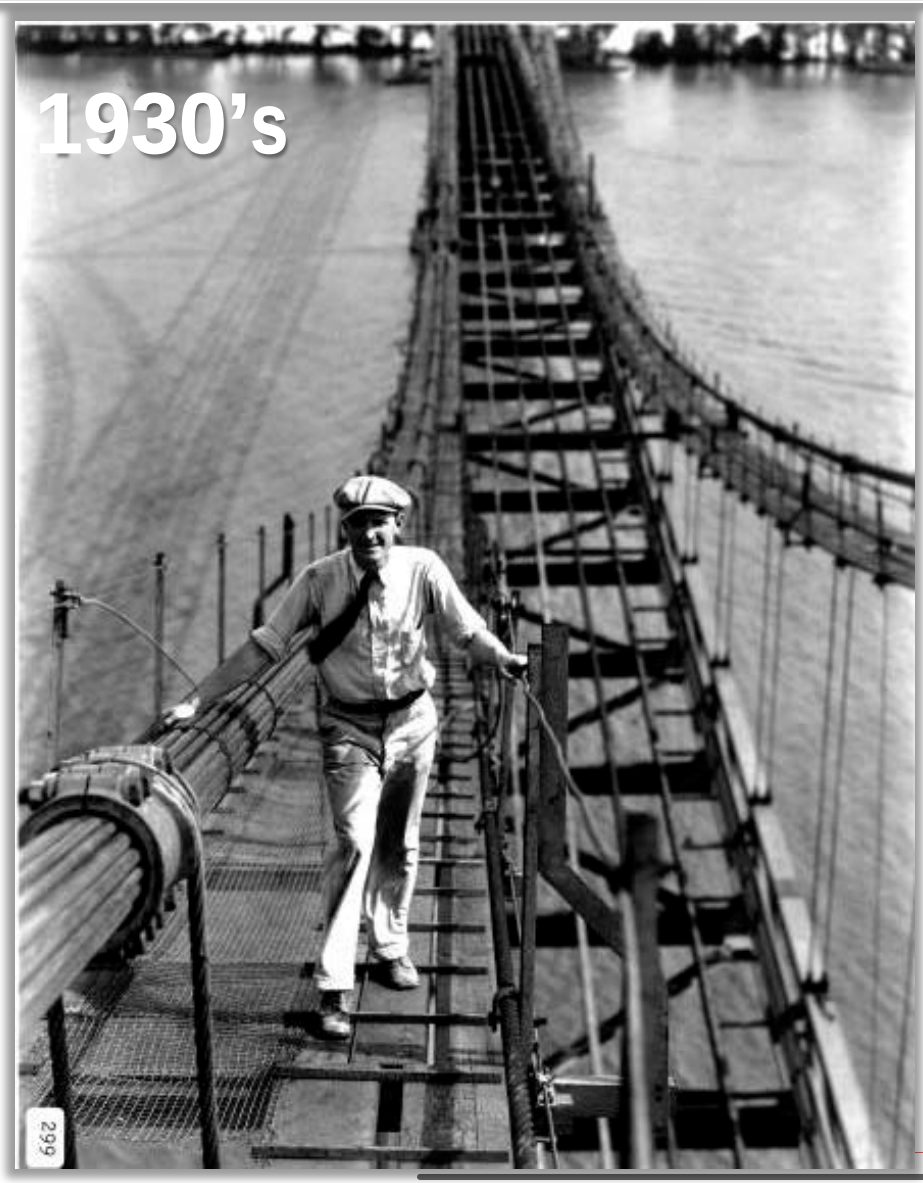
Open to Traffic in 1935 – 15 Cent Toll

Construction Cost - $1.5 Million

EXISTING NORTHBOUND BRIDGE

Source: Upper Mississippi Valley Digital Image Archive

EXISTING NORTHBOUND BRIDGE



EXISTING SOUTHBOUND BRIDGE

EXISTING BRIDGES

Converted to I-74 in 1970's

EXISTING BRIDGES

EXISTING BRIDGES

PROPOSED BRIDGES

PROPOSED BRIDGES

CORRIDOR MILESTONES

1998: Mississippi River Crossing Study

2000: I-74 Corridor Study began

2003: Draft Environmental Impact Statement (EIS)

2005: Preferred Alternative identified

2006: Main Span Bridge Type chosen

2007: Preliminary Engineering completed

2009: Final EIS Approved & Record of Decision Received

Alfred Benesch Final Design team begins work

2014: Construction begins on Advanced Local Roads

2017: Construction begins on I-74

2021: Construction of South & Central Sections Completed

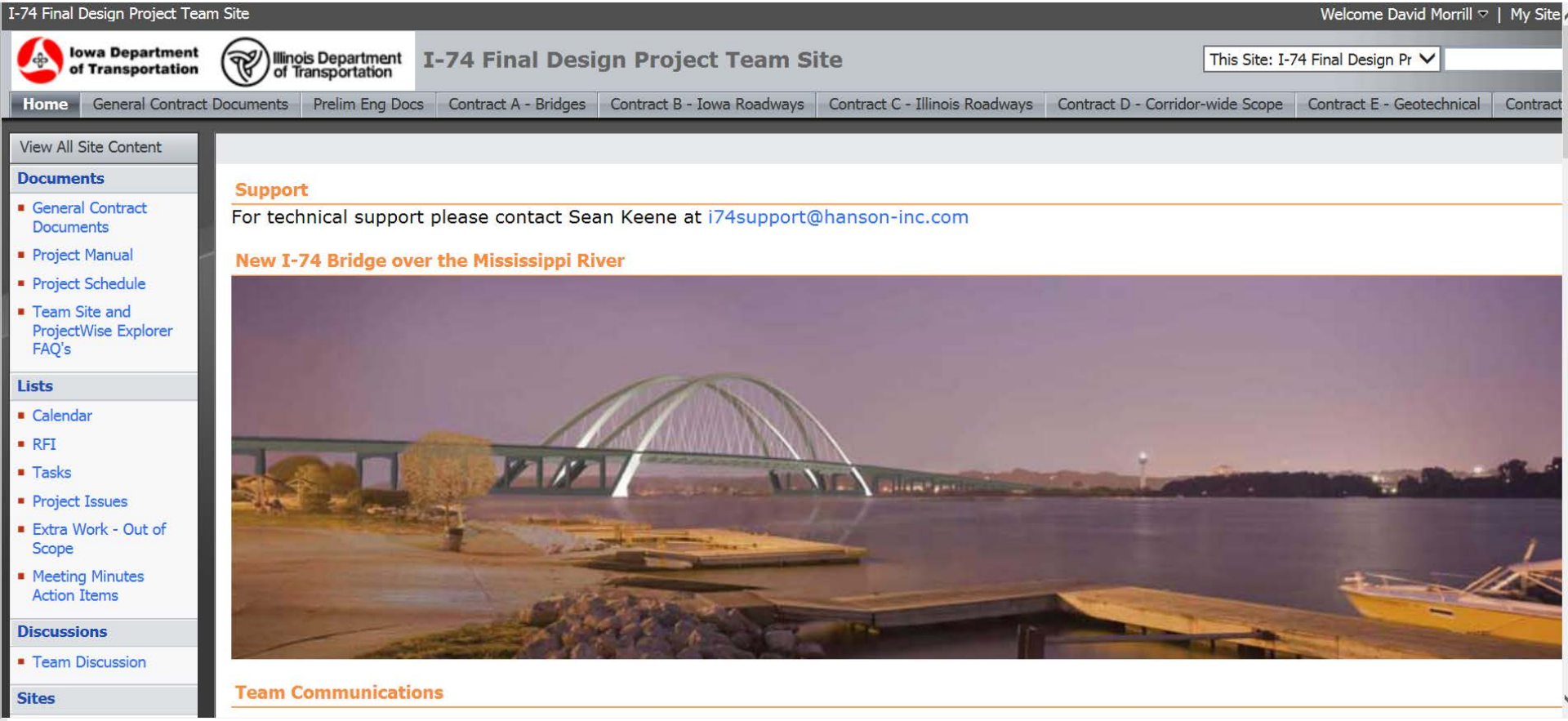
????: Construction of North Section Completed

FINAL DESIGN TEAM

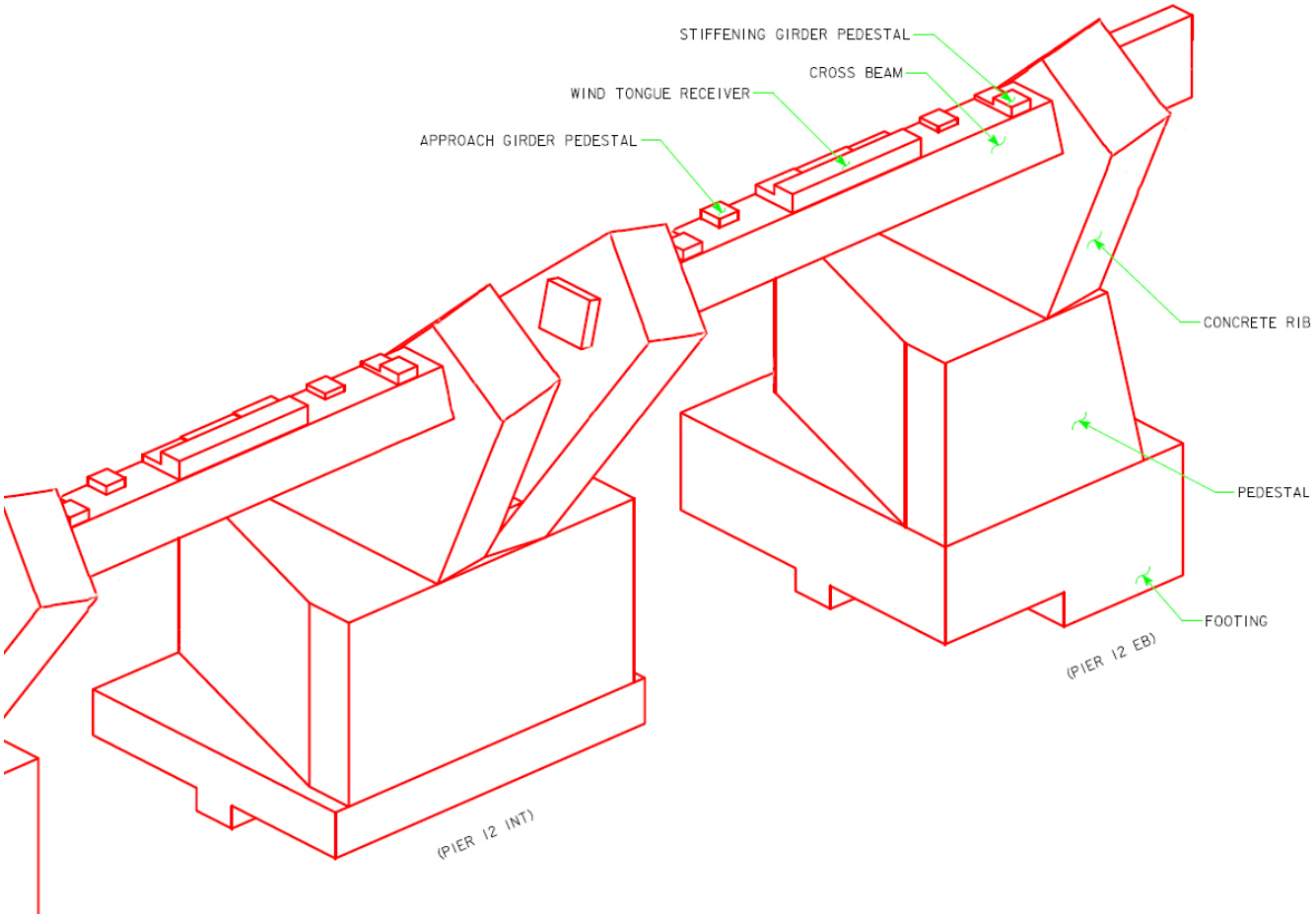
- Iowa & Illinois DOT's, FHWA (2 divisions)
- 3 Cities and 2 Counties
- Bi-State Regional Commission
- Benesch Team
  - Alfred Benesch & Co. – *Prime, Bridges, Iowa Interstate*
  - Modjeski & Masters, Inc. – *Arch, Illinois Bridges*
  - Hanson Professional Services – *Illinois Roadway, Geotech*
  - WHKS & Co. – *Iowa Local Roads and Iowa Viaduct*
  - American Surveying & Eng. – *Survey, Utilities, ROW*
  - FluidClarity Ltd. – *Drainage*
  - Illumination Arts LLC – *Aesthetic Lighting*
  - Shive-Hattery, Inc. – *Aesthetics, Public Involvement*
  - Iteris, Inc. – *Intelligent Transportation Systems*
  - Terracon, Inc. – *Geotechnical*

WEB-BASED PROJECT MANAGEMENT SYSTEM

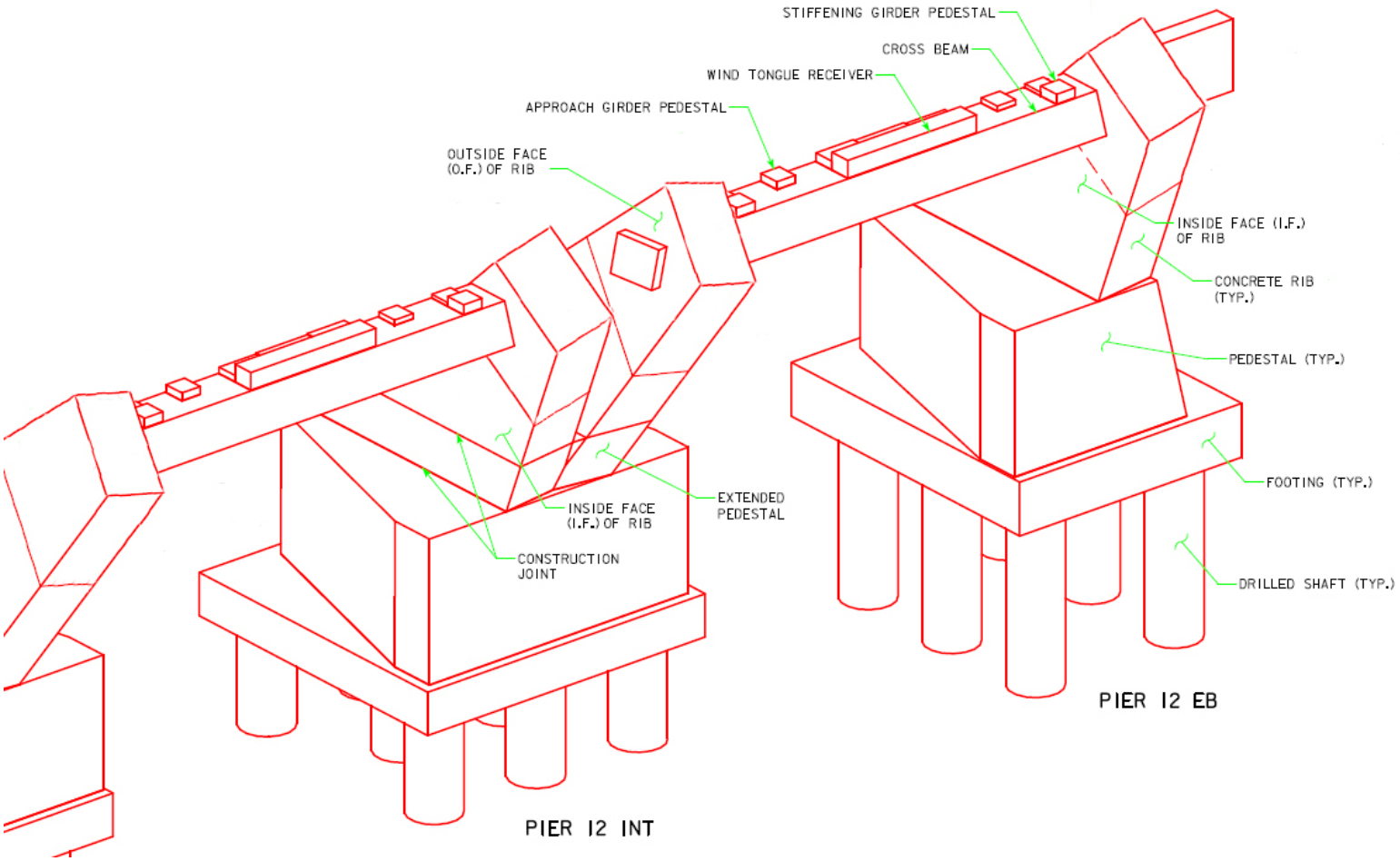
SharePoint and ProjectWise



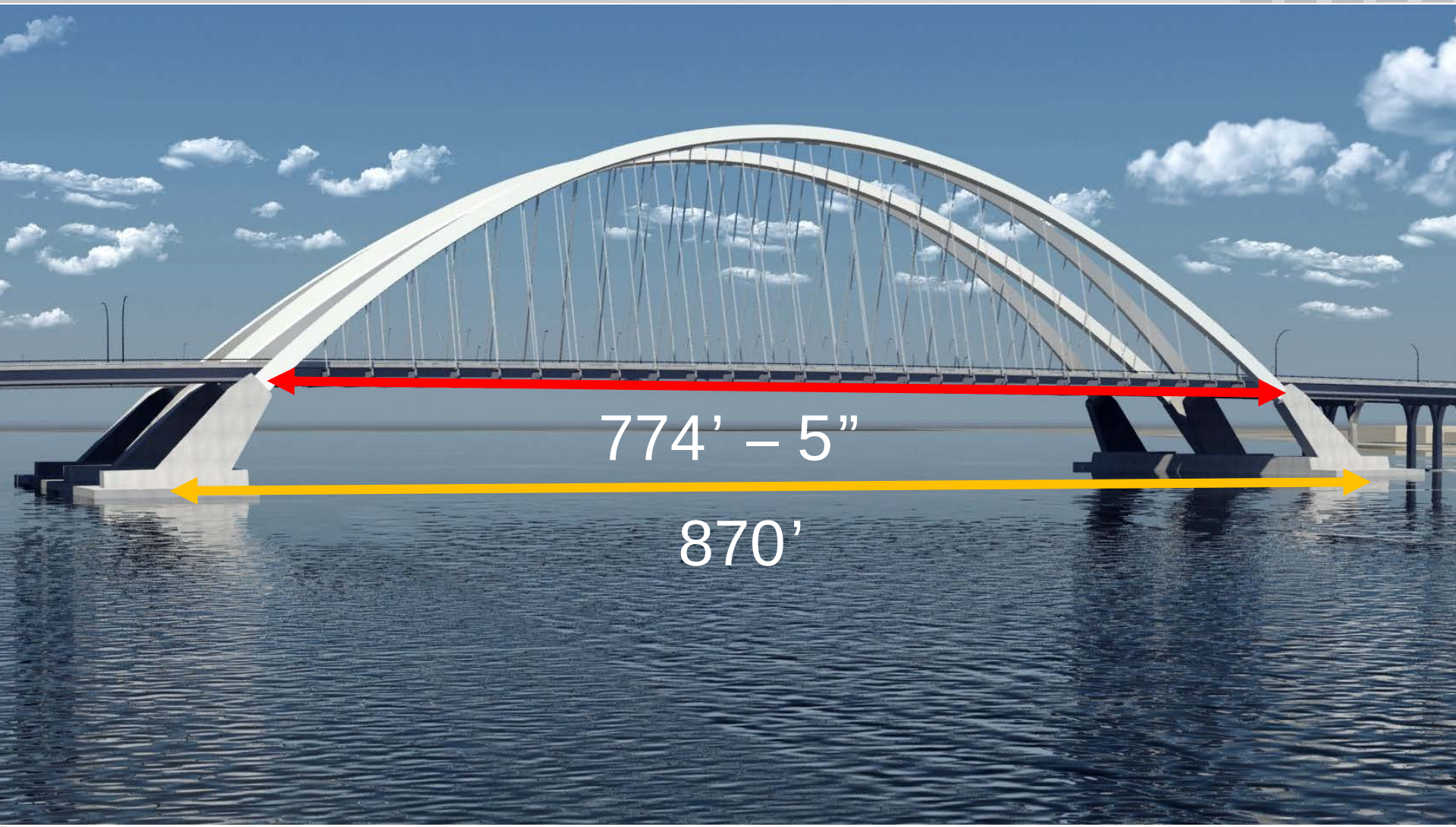
ARCH SPAN – FOOTING FOUNDATION



ARCH SPAN – HYBRID FOUNDATION



ARCH SPAN - SUPERSTRUCTURE



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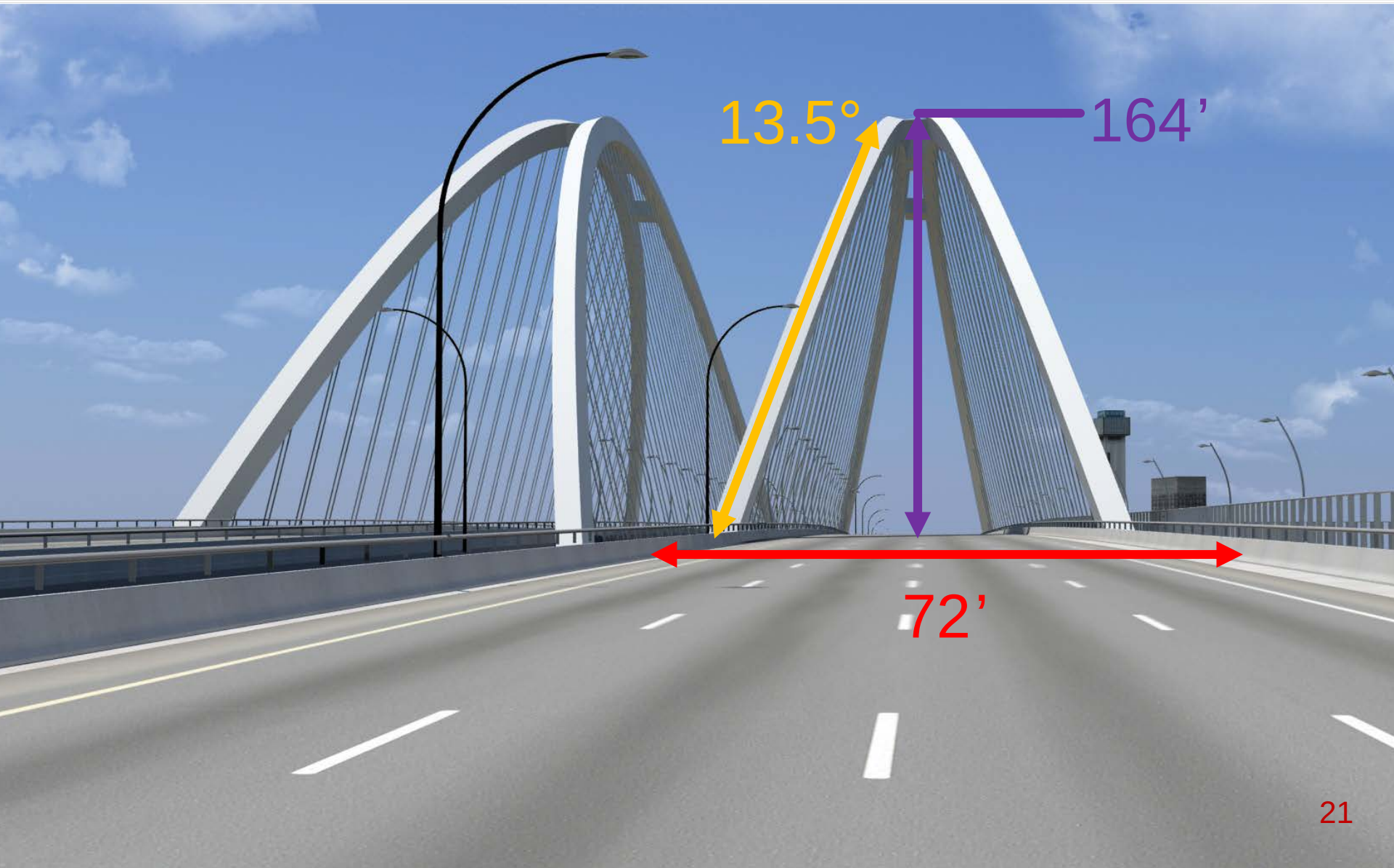

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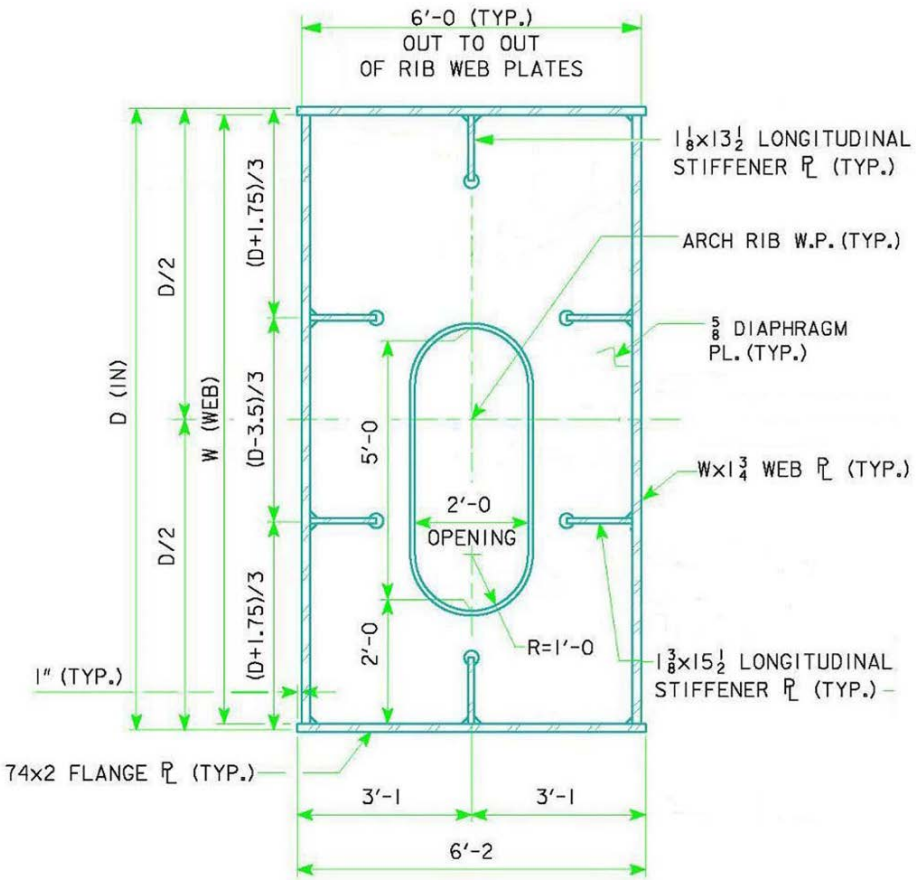
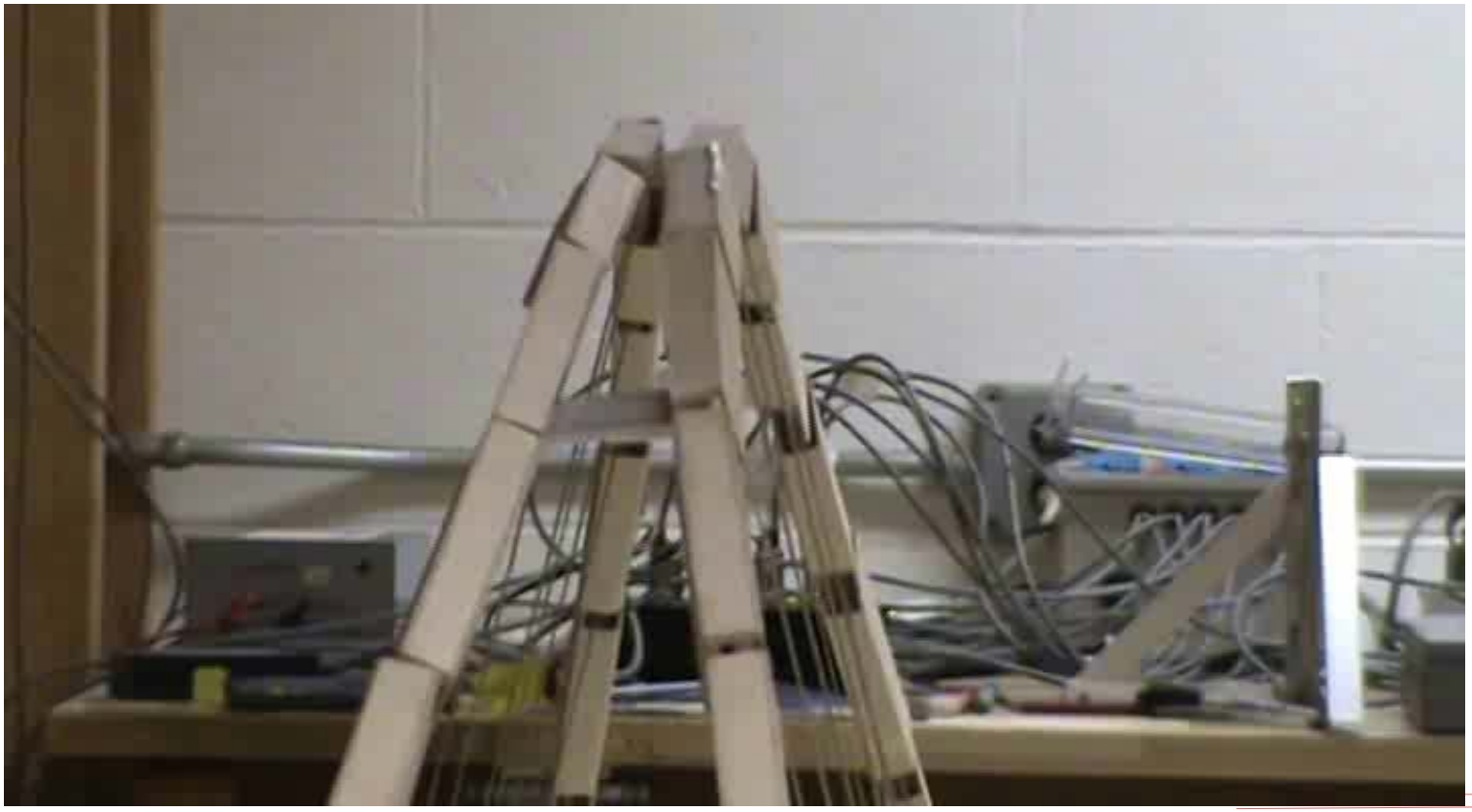


- Section through the arch rib at a diaphragm
  - Depth of Steel Rib (D) varies between 9' (top) and 12' (base)
  - Diaphragm opening for inspection/maintenance access
  - Longitudinal stiffeners are full length of rib

ARCH SPAN - AERODYNAMIC INVESTIGATION

- Susceptibility to vortex shedding vibrations
- Buffeting winds- forces and displacements
- Stability against flutter



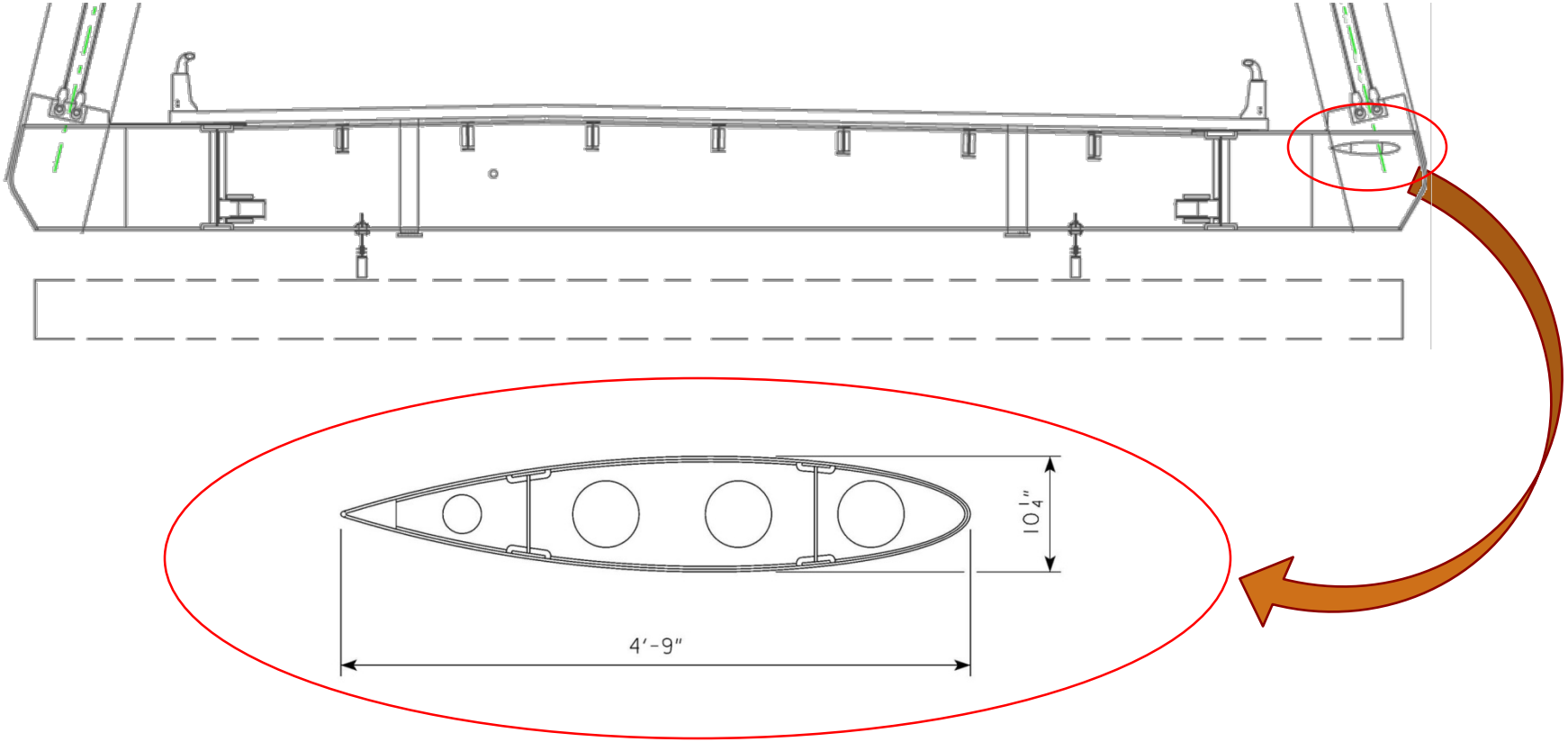
ARCH SPAN - AERODYNAMIC INVESTIGATION

- Initially believed a need for fairings on the arch ribs
  - Located at the outermost exterior corners of the ribs
  - Costly and unattractive

- Wing shape fairing, a Winglet, at the edge of the deck
  - Multi-use trail serves as the fairing on the EB structure
  - Placed on the WB structure only
  - Reduced the vibrations significantly

ARCH SPAN – AERODYNAMIC INVESTIGATION

- Winglet (airfoil shape):



WIND DESIGN

Wind from one direction only

Airfoil shape

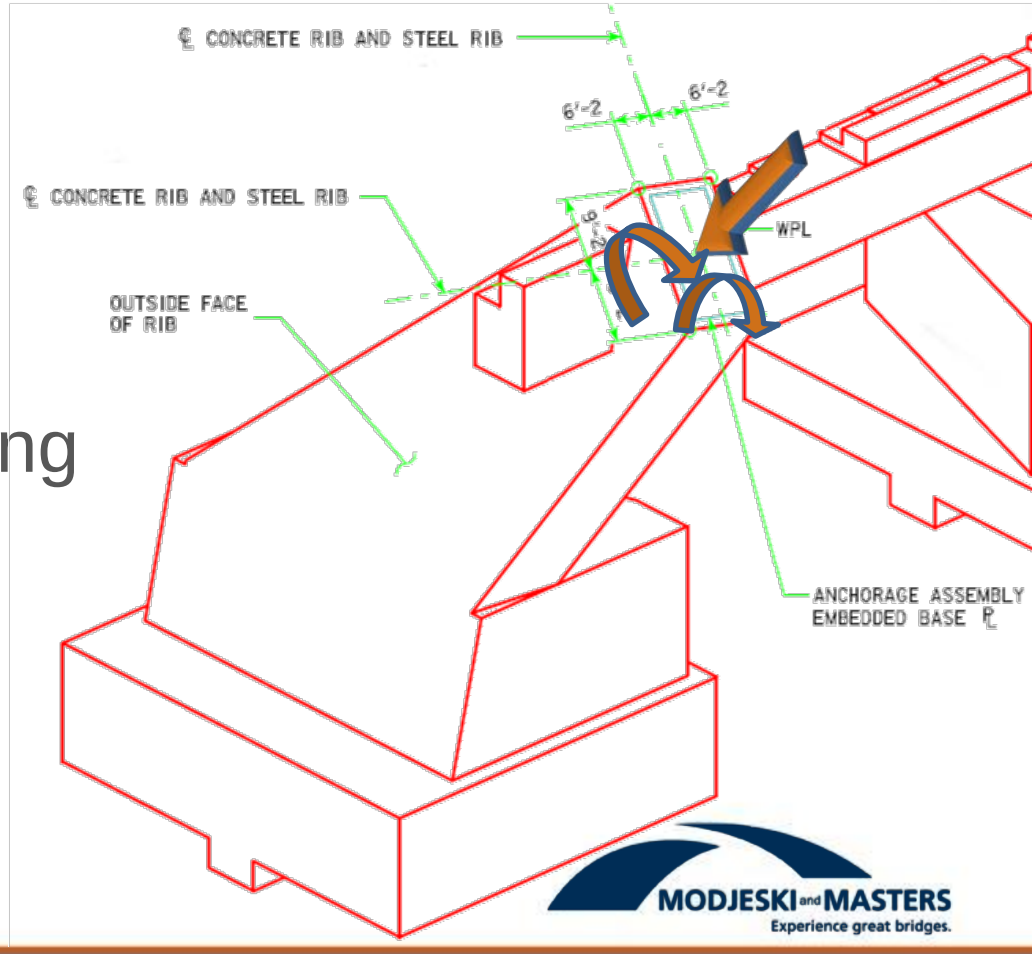
- NACA 0018
- B-17 wing

ARCH SPAN – ARCH RIB ANCHOR BOLTS

ARCH SPAN – ARCH RIB ANCHOR BOLTS

Arch Force Resisting System

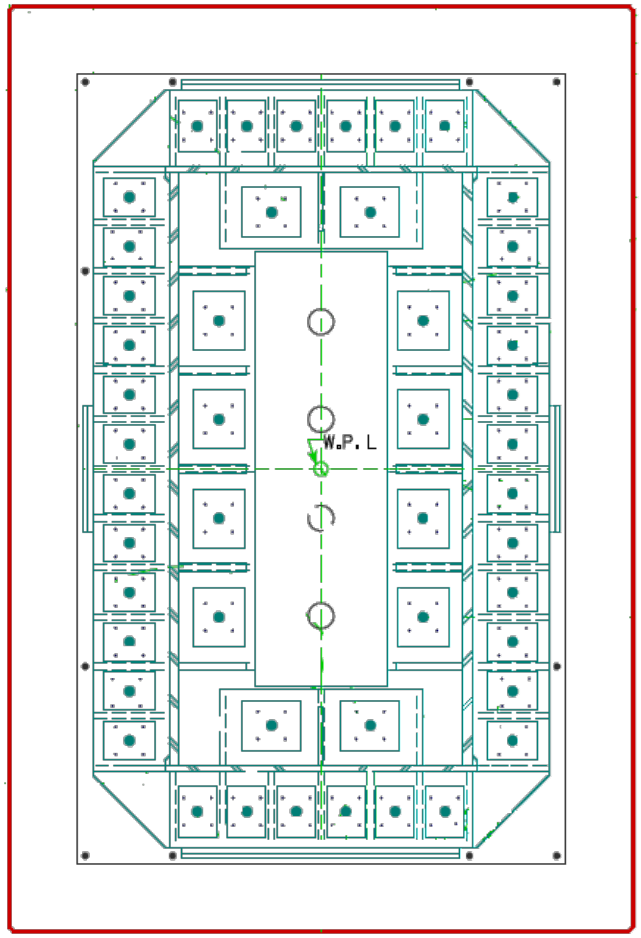
- Arch Steel/concrete Interface Connection
  - Combined Forces
    $P + M_x + M_y$
  - Significant lateral bending
  - High concrete bearing pressures

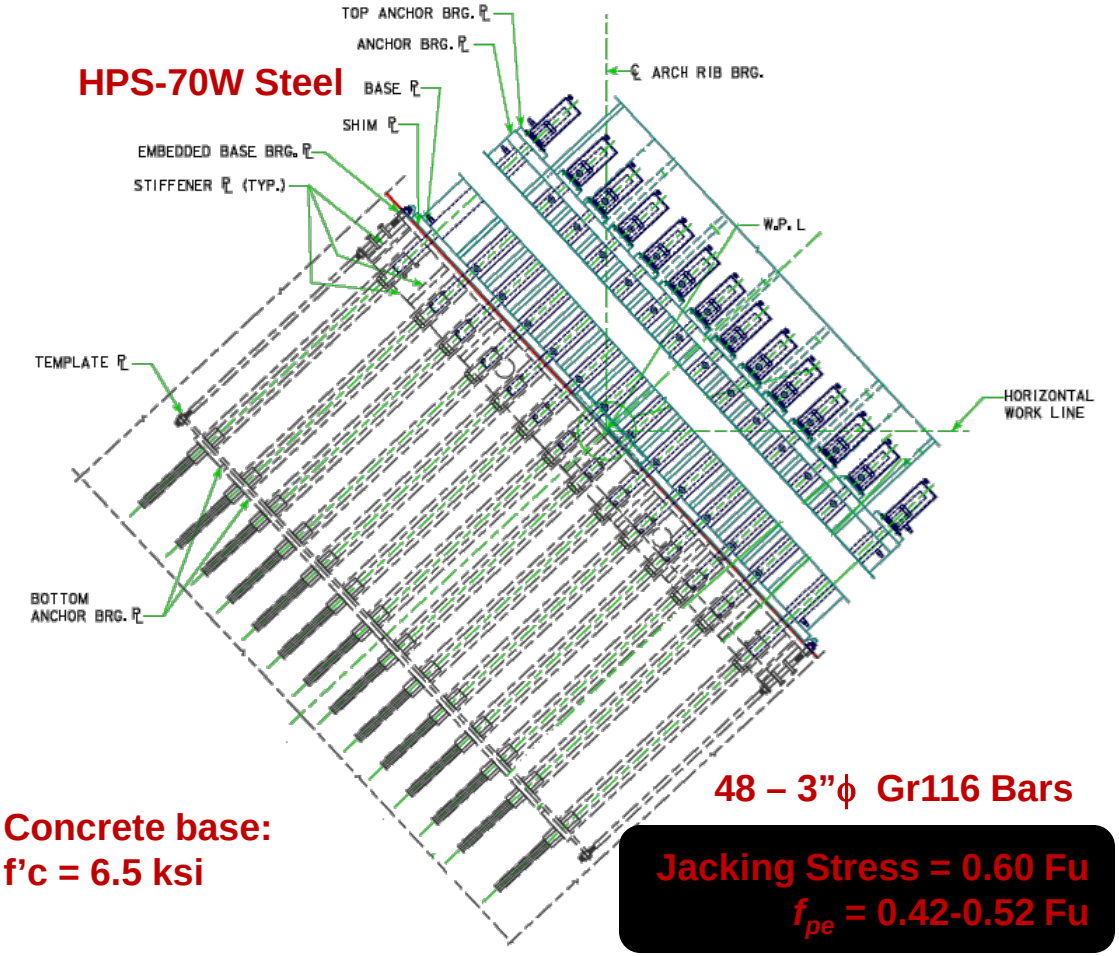


MODJESKI and MASTERS
Experience great bridges.

ARCH SPAN – ARCH RIB ANCHOR BOLTS

Arch Steel/concrete Interface Connection





HPS-70W Steel

48 – 3”ϕ Gr116 Bars

Concrete base:
f’c = 6.5 ksi

Jacking Stress = 0.60 Fu
f_{pe} = 0.42-0.52 Fu

ARCH SPAN – ARCH RIB ANCHOR BOLTS

- 48 bolts at 8 locations = 384 anchor bolts
- Original design: Epoxy coated and grout
- Began research for stainless steel in January 2015
- Phase 1: literature review
- Phase 2: laboratory testing

ARCH SPAN – ARCH RIB ANCHOR BOLTS

- Phase 2: laboratory testing

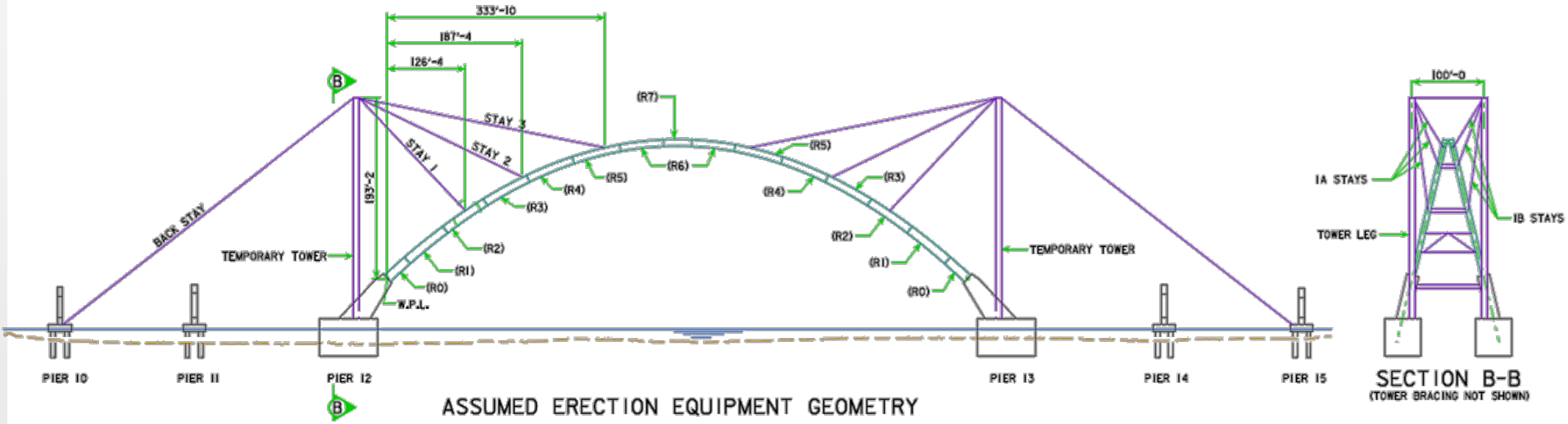
- Ductility
- Stress relaxation
- Toughness
- Machinability
- Tensile strength

Threshold galling stress
Critical pitting temperature
Stress corrosion cracking
Hydrogen embrittlement
Aqueous corrosion resistance

CORRIDOR – BRIDGE DECK REINFORCEMENT

- 100 year life comparison: epoxy vs stainless steel
- Life Cycle Cost Analysis completed
- User delay evaluation completed
- Stainless steel reinforcement is cost competitive!

ARCH CONSTRUCTION SEQUENCE



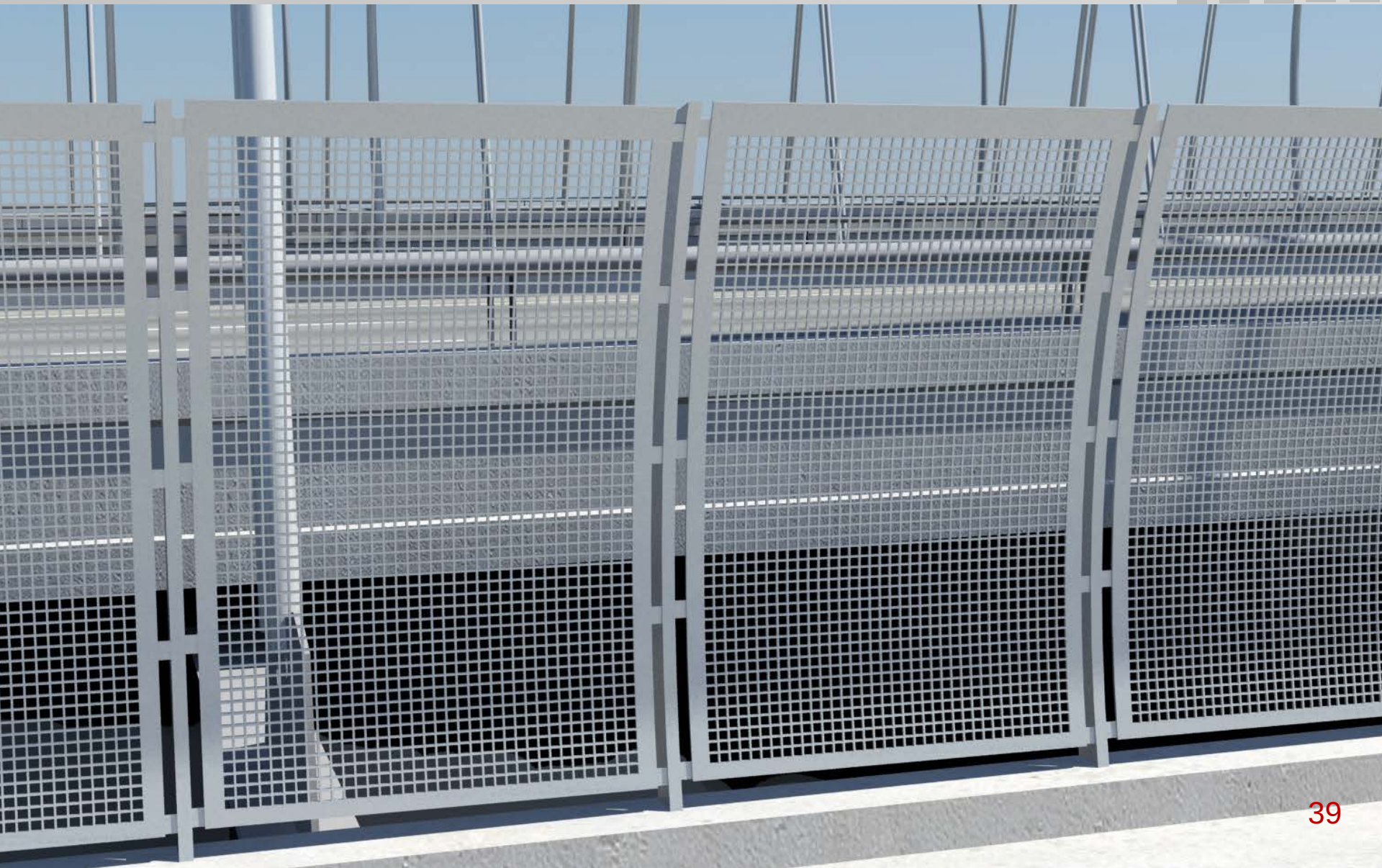
APPROACH SPANS AND VIADUCT PIERS

MULTI-USE TRAIL

MULTI-USE TRAIL – PEDESTRIAN OVERLOOK

MULTI-USE TRAIL – RIVER SIDE RAILING

MULTI-USE TRAIL – ARCH SIDE RAILING



BETTENDORF LET-DOWN STRUCTURE

IDENTITY ELEMENTS

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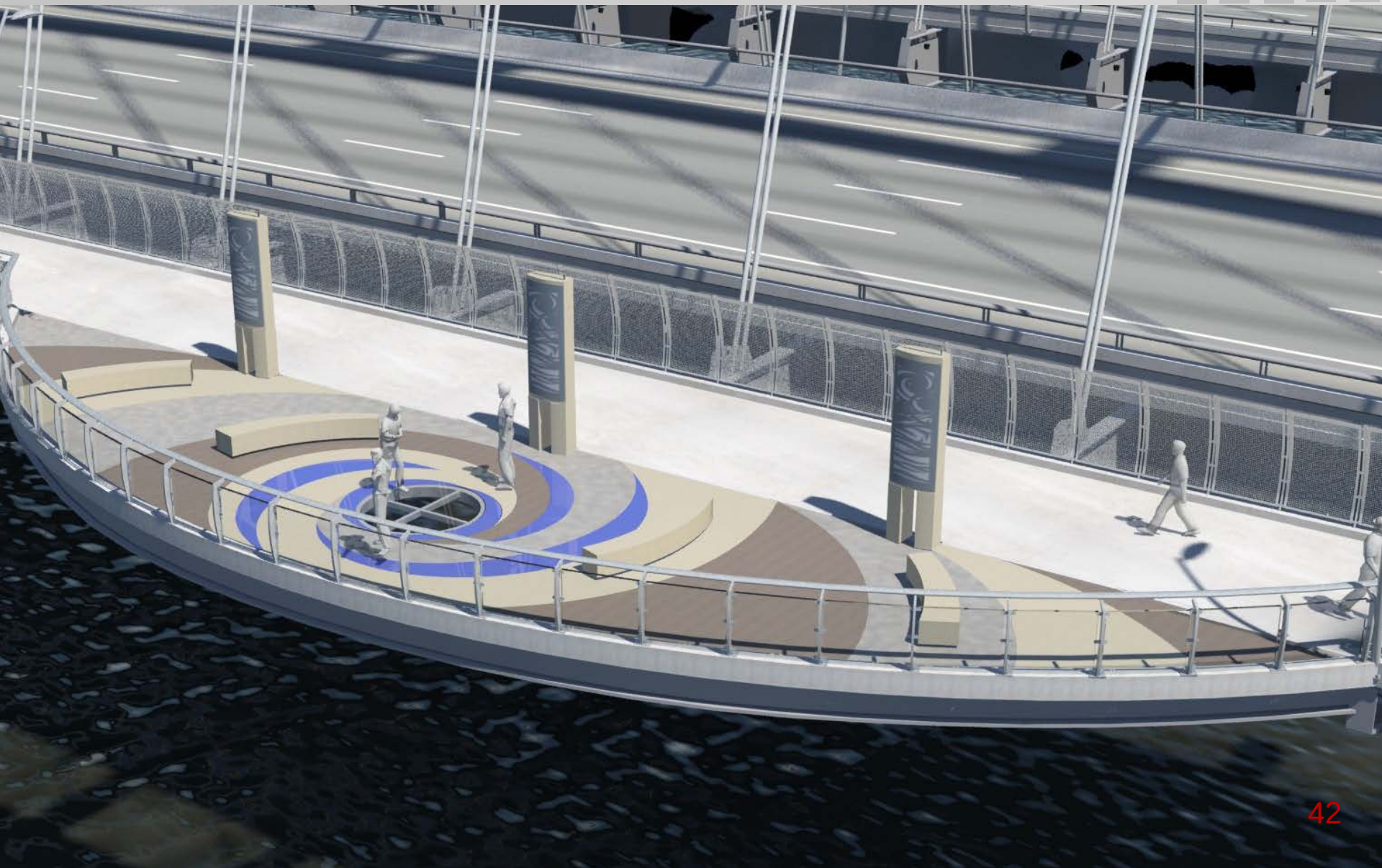


ARCH SPAN – AESTHETIC LIGHTING

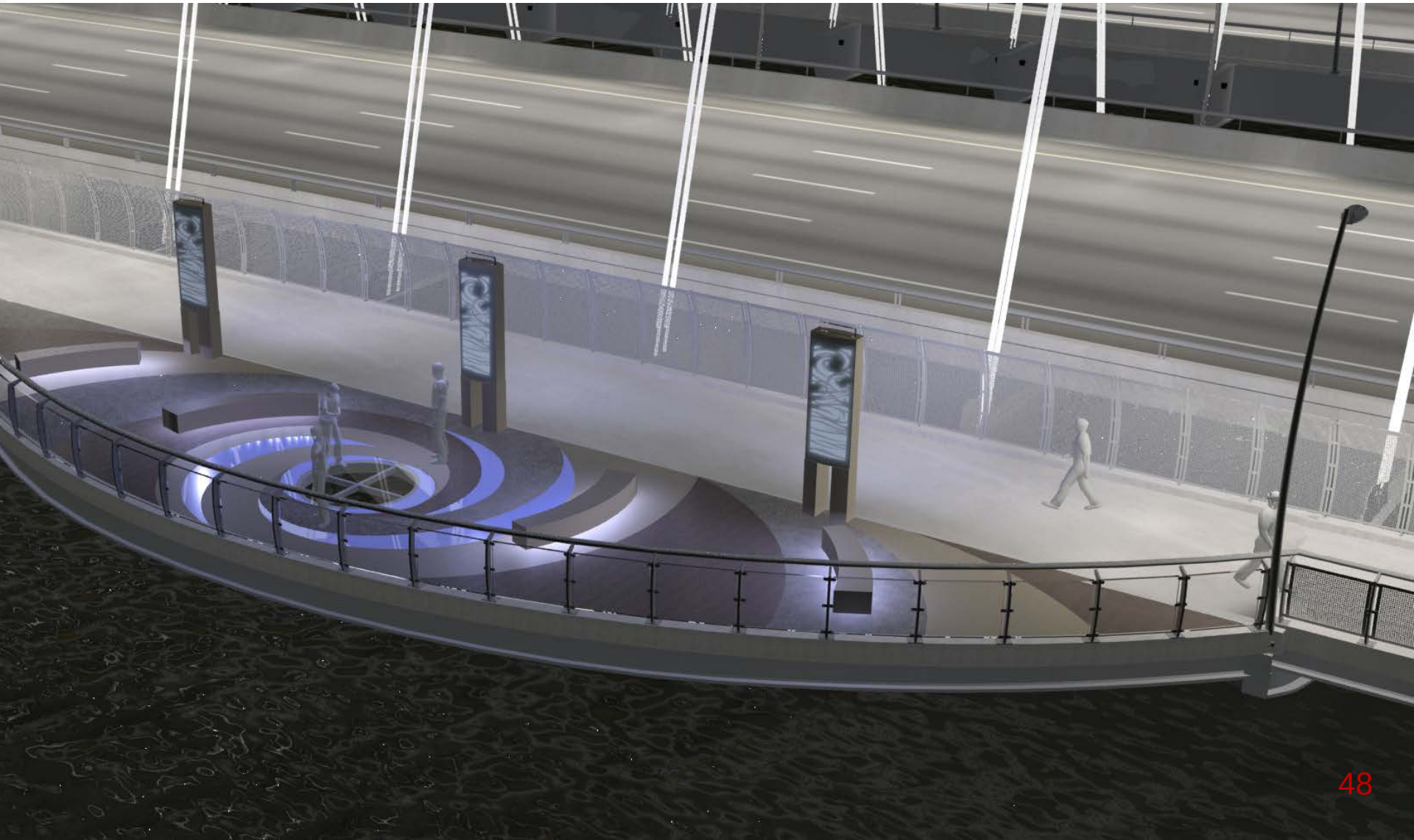
ARCH SPAN – AESTHETIC LIGHTING

ARCH SPAN – COLOR CHANGING LIGHTING

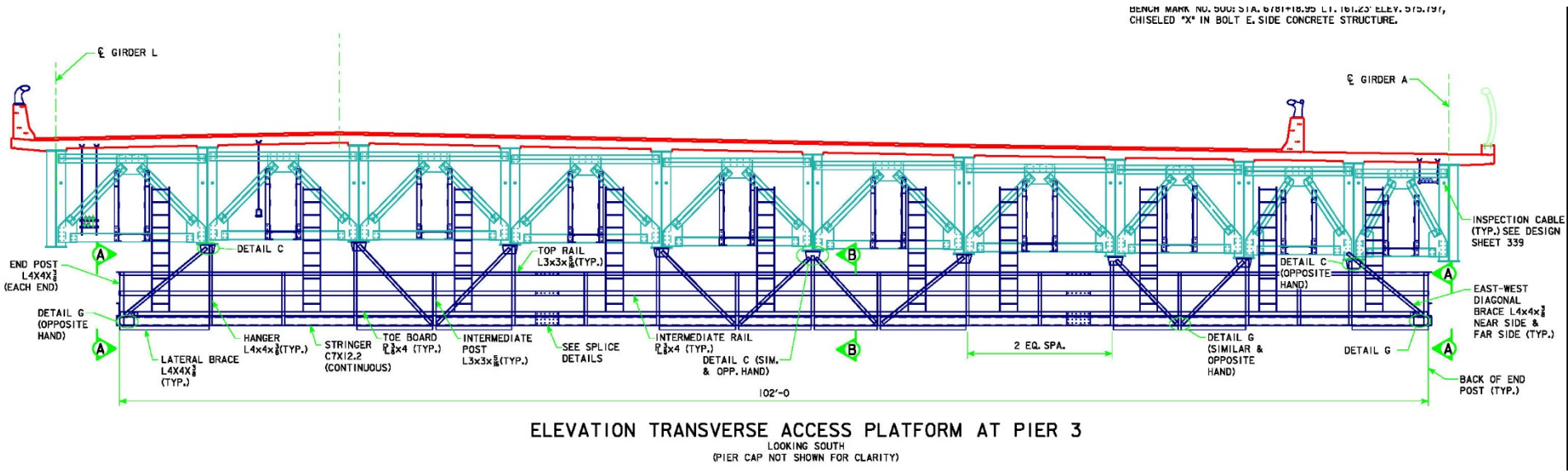
PIER LIGHTING

MULTI-USE TRAIL LIGHTING

PEDESTRIAN OUTLOOK LIGHTING



MAINTENANCE – INSPECTION WALKWAYS



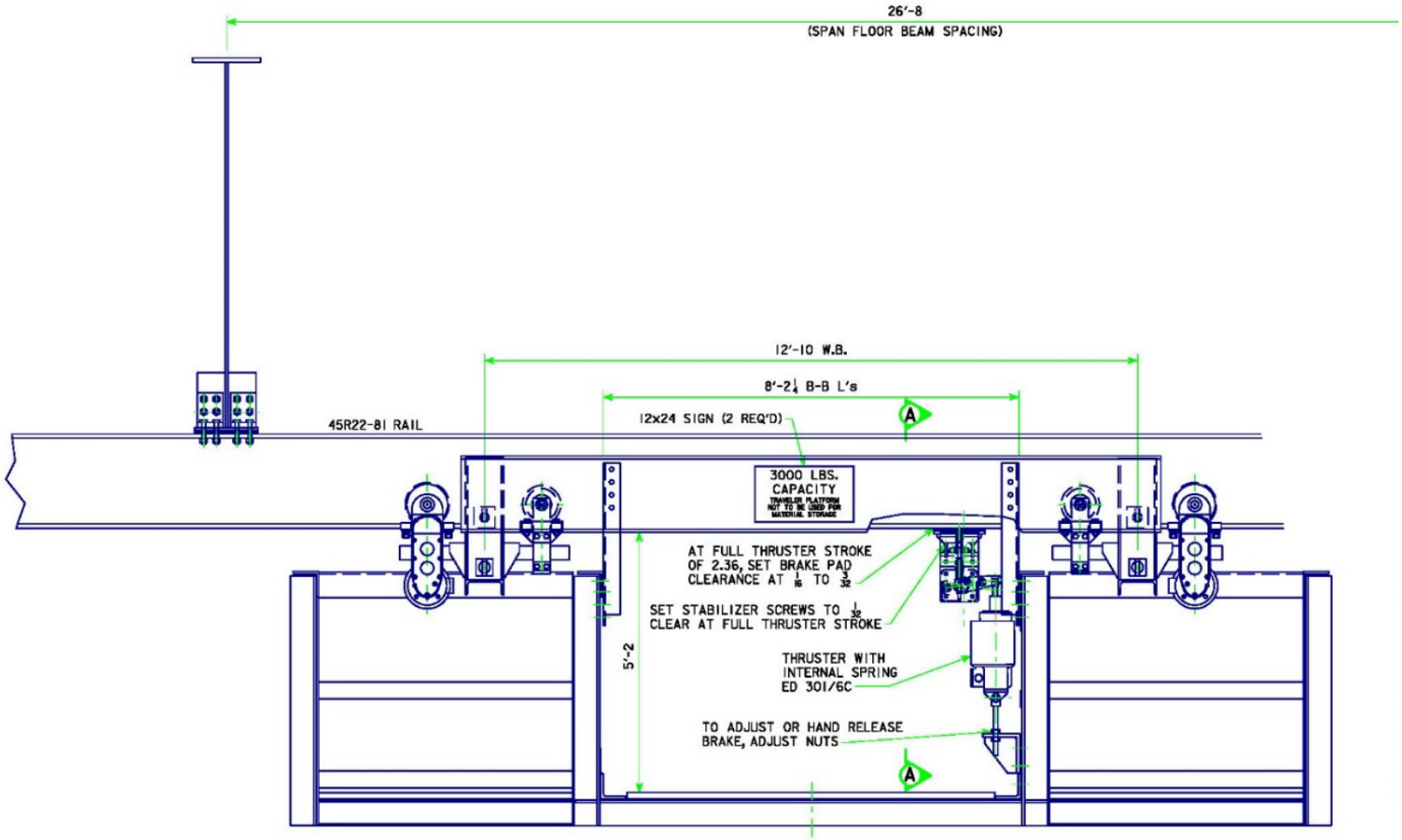
ELEVATION TRANSVERSE ACCESS PLATFORM AT PIER 3
LOOKING SOUTH
(PIER CAP NOT SHOWN FOR CLARITY)

- Walkways in every girder bay of **Approach Spans**
  - Walkways supported by cross frames
  - Move between girder bays via transverse access platforms
  - Maintenance waterline in every girder bay

MAINTENANCE – INSPECTION TRAVELER

- Inspection traveler in the **Arch Span**

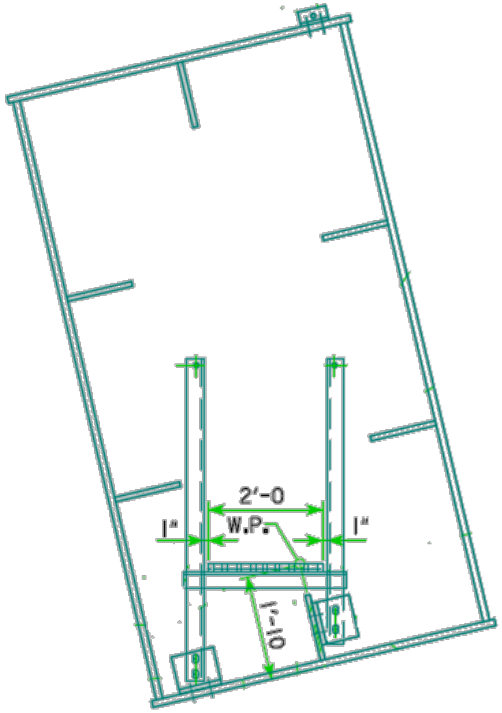
MAINTENANCE – INSPECTION TRAVELER

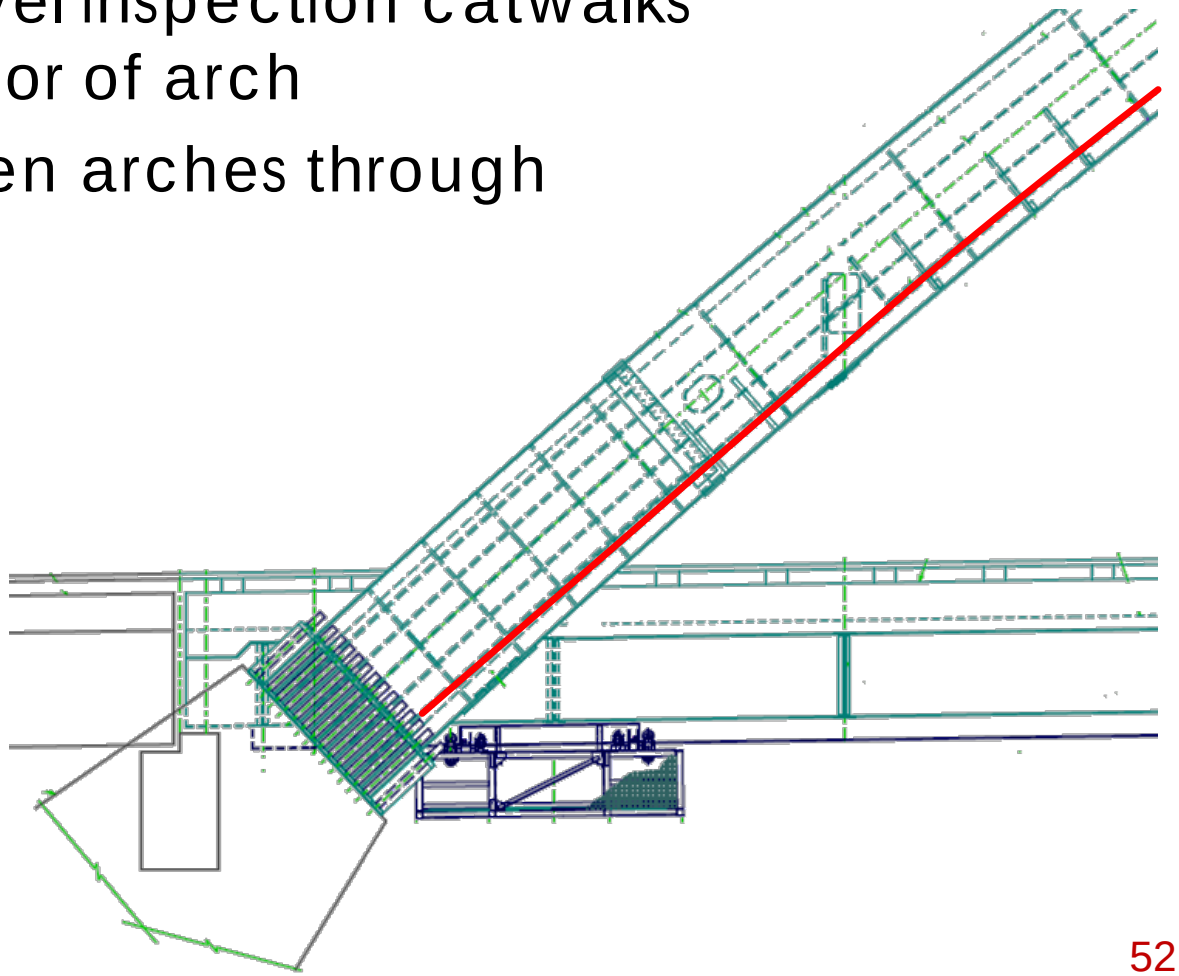


- Inspection traveler in the **Arch Span**

ARCH SPAN - SUPERSTRUCTURE

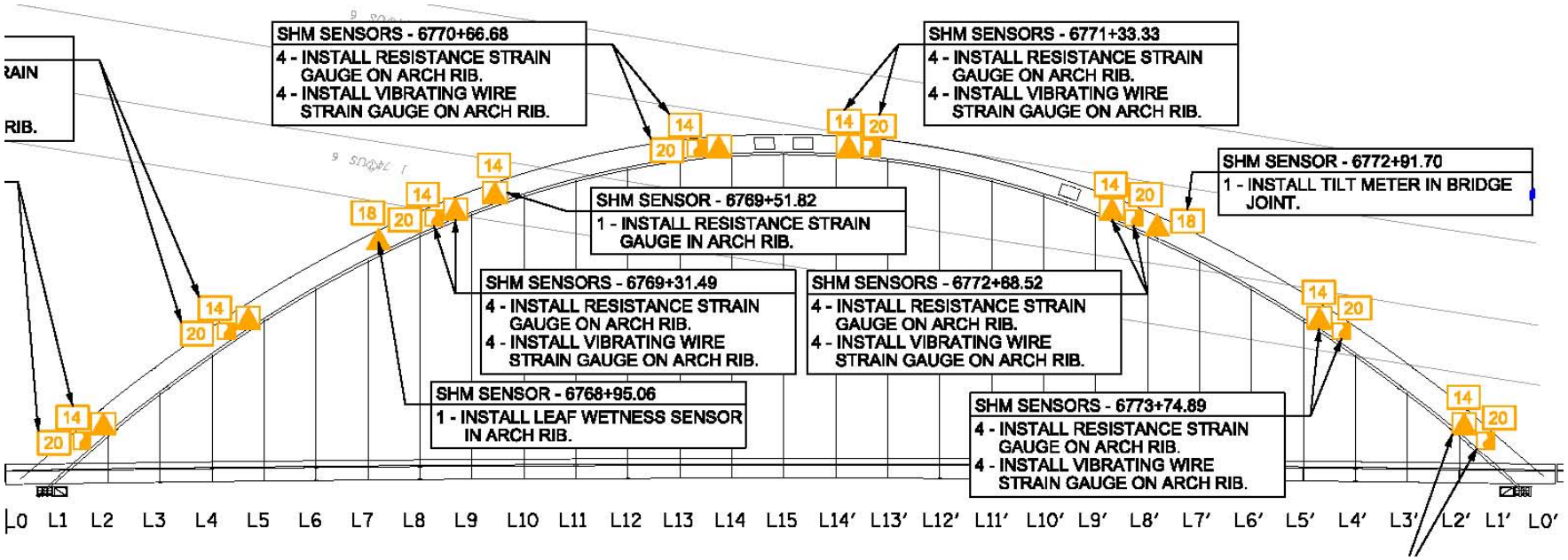
- Arch Rib Walkway:
  - Transversely level inspection catwalks full length interior of arch
  - Access between arches through bracing struts





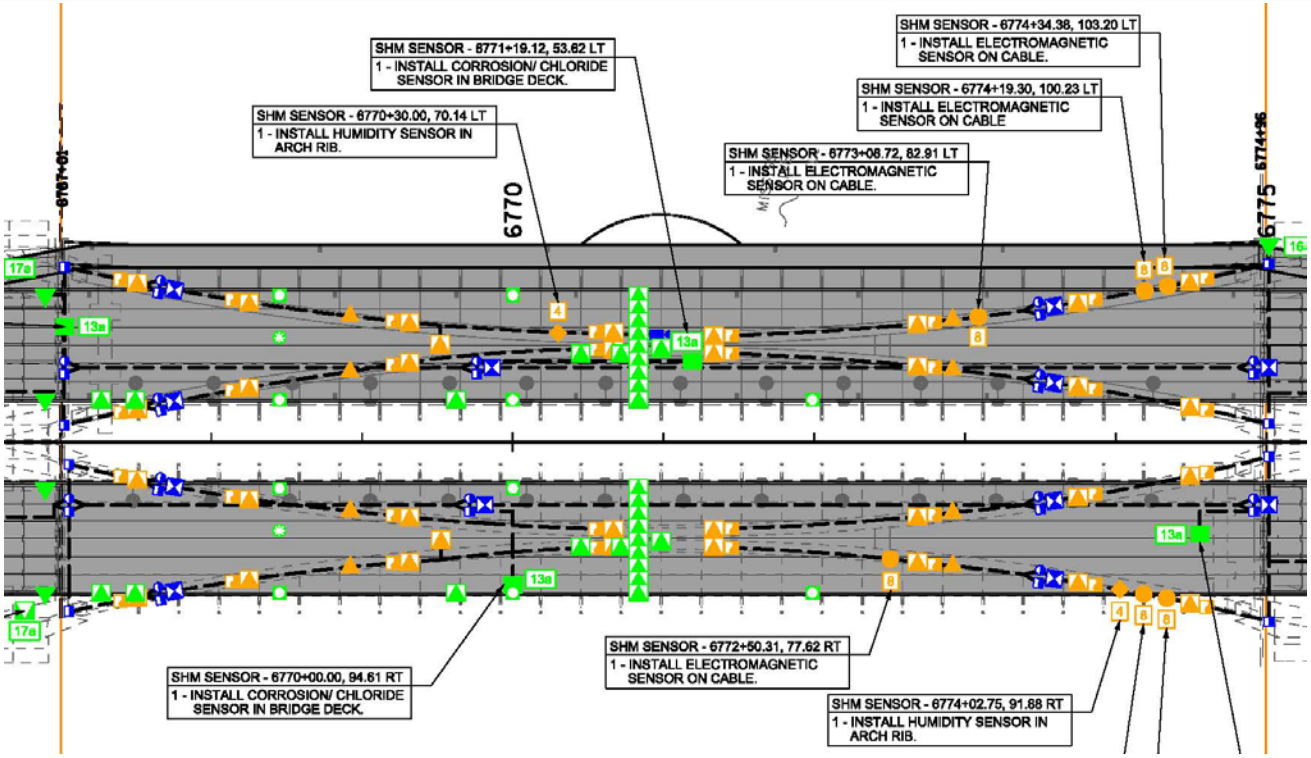
ITS/STRUCTURAL HEALTH MONITORING/SECURITY

- Total cost of SHM system is estimated at $3.5 million



- Slow speed, long-term strain measurements
- Live load strains
- Moisture sensors in arch ribs
- Change of rotation at arch piers
- Superstructure vibrations
- Temperature gradient

ITS/STRUCTURAL HEALTH MONITORING/SECURITY



- Deck chloride sensor
- Electromagnetic sensor on cable
- Displacement at expansion joint locations
- Relative movement between stiffening girders and pier crossbeams
- Security cameras

DEMOLITION

DEMOLITION

Fort Steuben Bridge Demolition: February 21, 2012 - 7:15 AM

THANK YOU!