I-74 over the Mississippi River

Design and Construction of Arch Foundations

104th Transportation and Highway Engineering Conference

Presented by: Andrew J. Keaschall, PE, SE, Alfred Benesch & Company

February 27th, 2018

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- Cities,, and Rock Island Counties

OWNERS AND KEY STAKEHOLDERS

IOWA DOT

Illinois Department of Transportation

U.S. Department of Transportation
Federal Highway Administration

Bettendorf IOWA
a premier city

CITY OF MOLINE ILLINOIS

City of Davenport

Scott County

Rock Island County

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DESIGN TEAM

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MODJESKI and MASTERS

whks
engineers + planners + land surveyors

ILLUMINATIONARTS

Terracon

AMERICAN
SURVEYING & ENGINEERING, P.C.

ITERIS

SHIVEHATTERY
ARCHITECTURE + ENGINEERING

FLUIDCLARITY

CONSTRUCTION ENGINEERING AND INSPECTION

HNTB

Missman, INC.
Professional Engineers & Land Surveyors

QUIGG ENGINEERING INC
Certified DBE/WBE

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GEC TEAM

amec foster wheeler

KNIGHT
Engineers & Architects

Hutchinson TECHNOLOGY

HRG
HRGreen

RMCA
R.M.CHIN & ASSOCIATES, INC.

IMAGES INC

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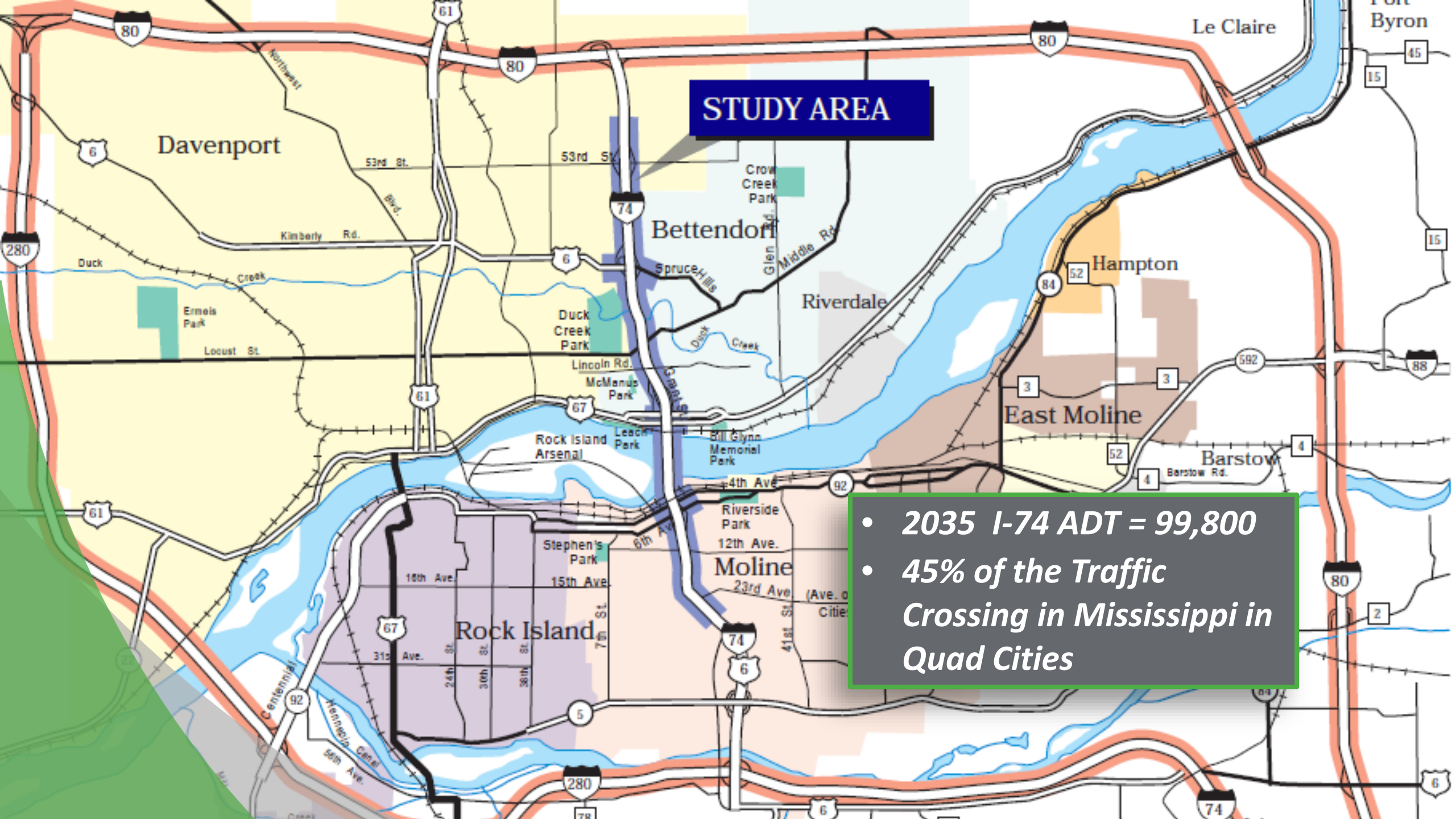
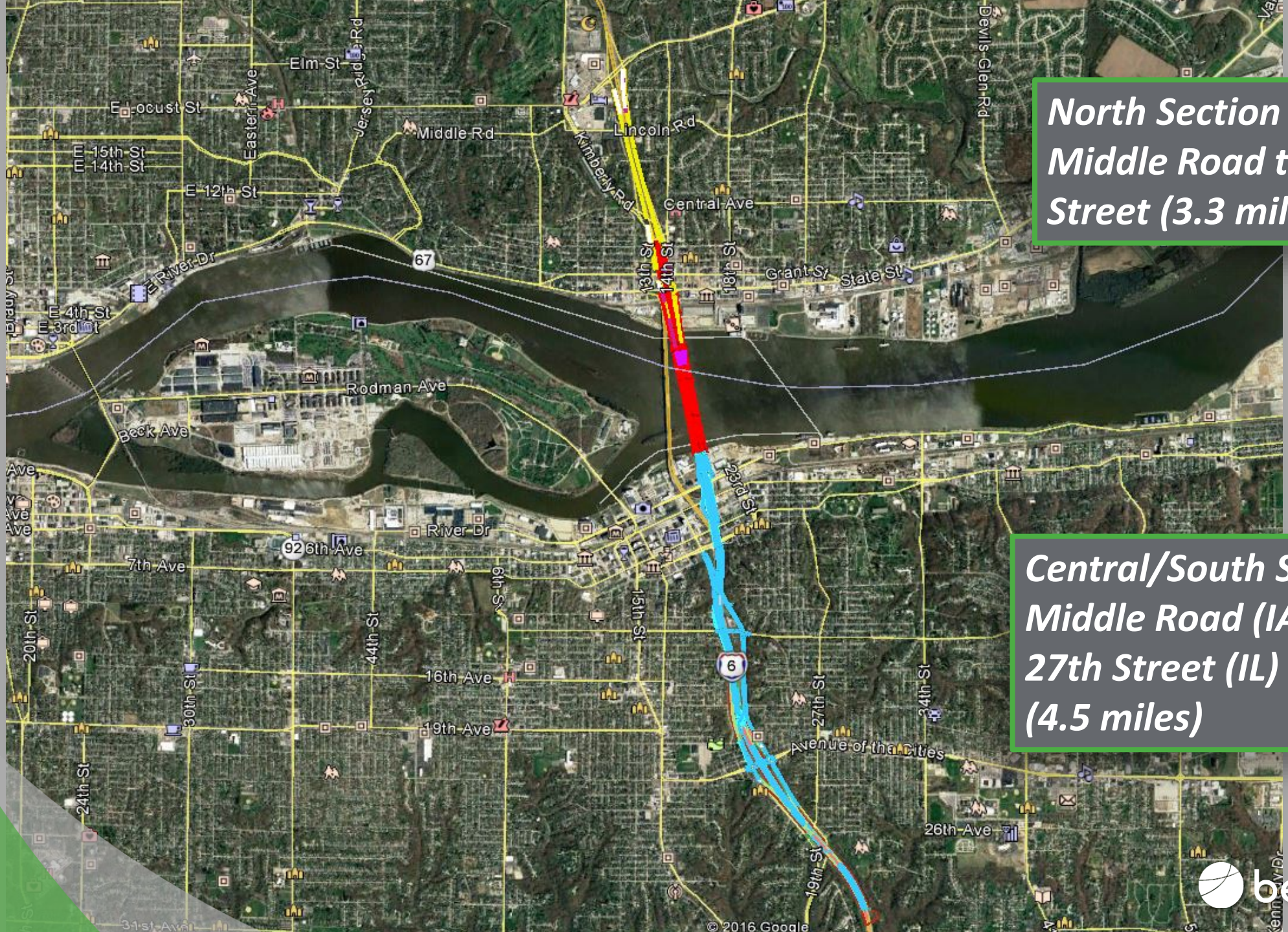
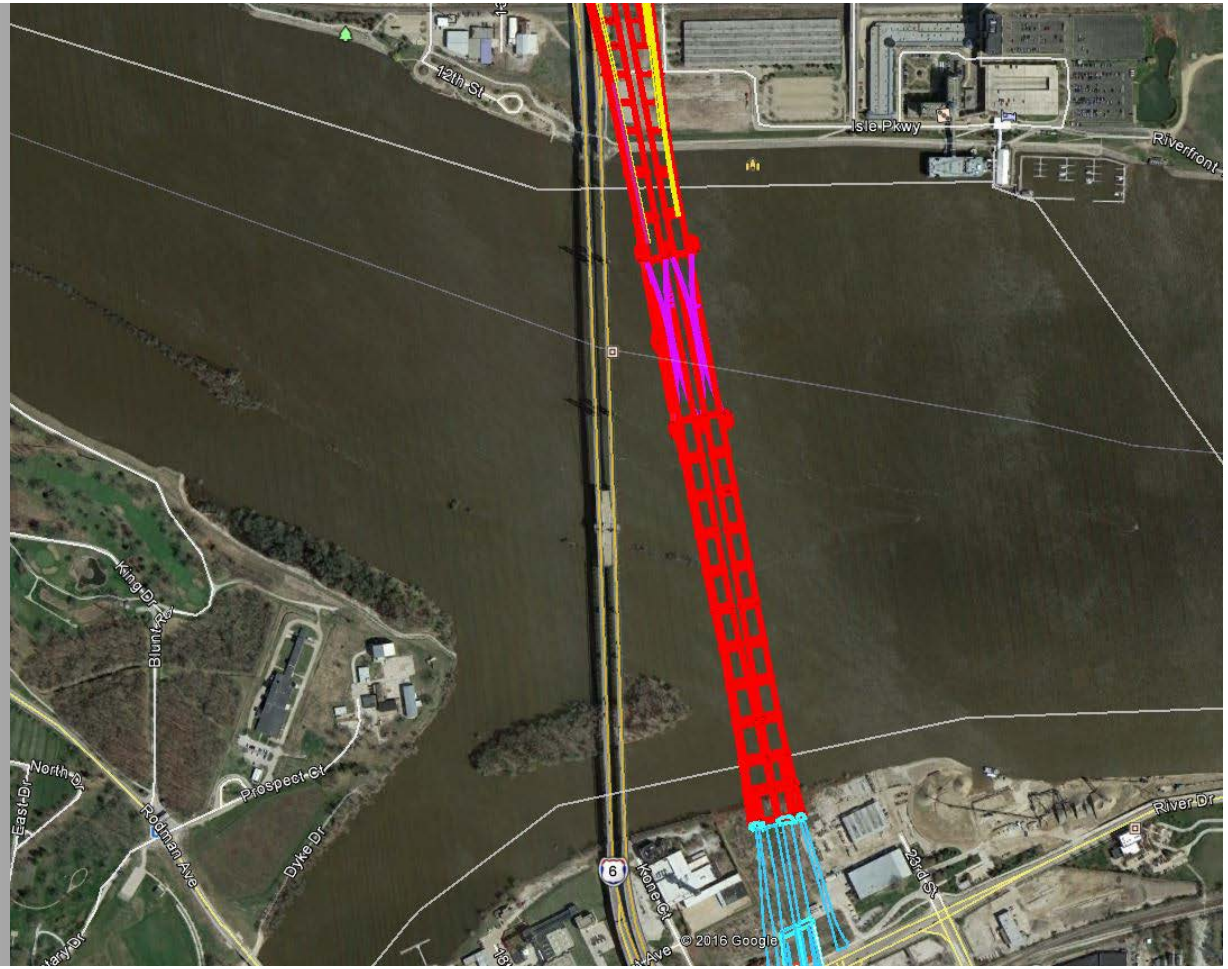


- *2035 I-74 ADT = 99,800*
- *45% of the Traffic Crossing in Mississippi in Quad Cities*


North Section – Middle Road to 67th Street (3.3 miles)
Central/South Section - Middle Road (IA) to 27th Street (IL) (4.5 miles)
Elm St
E Locust St
Middle Rd
Lincoln Rd
Kimberly Rd
Central Ave
E 15th St
E 14th St
E 12th St
E River Dr
67
E 4th St
E 3rd St
Rodman Ave
Beck Ave
River Dr
6th Ave
7th Ave
16th Ave
19th Ave
Grant St
State St
Avenue of the Cities
26th Ave
6
92
© 2016 Google

MISSISSIPPI RIVER SPANS

- “Bank-to-bank” is about 3,300 feet
- Plate Girder approach spans north and south of the Main Span
- Shallow Water on the Illinois side
- Clear distances between existing and proposed structure
  - 60’ at north (Iowa) end
  - 600’ at south (Illinois) end



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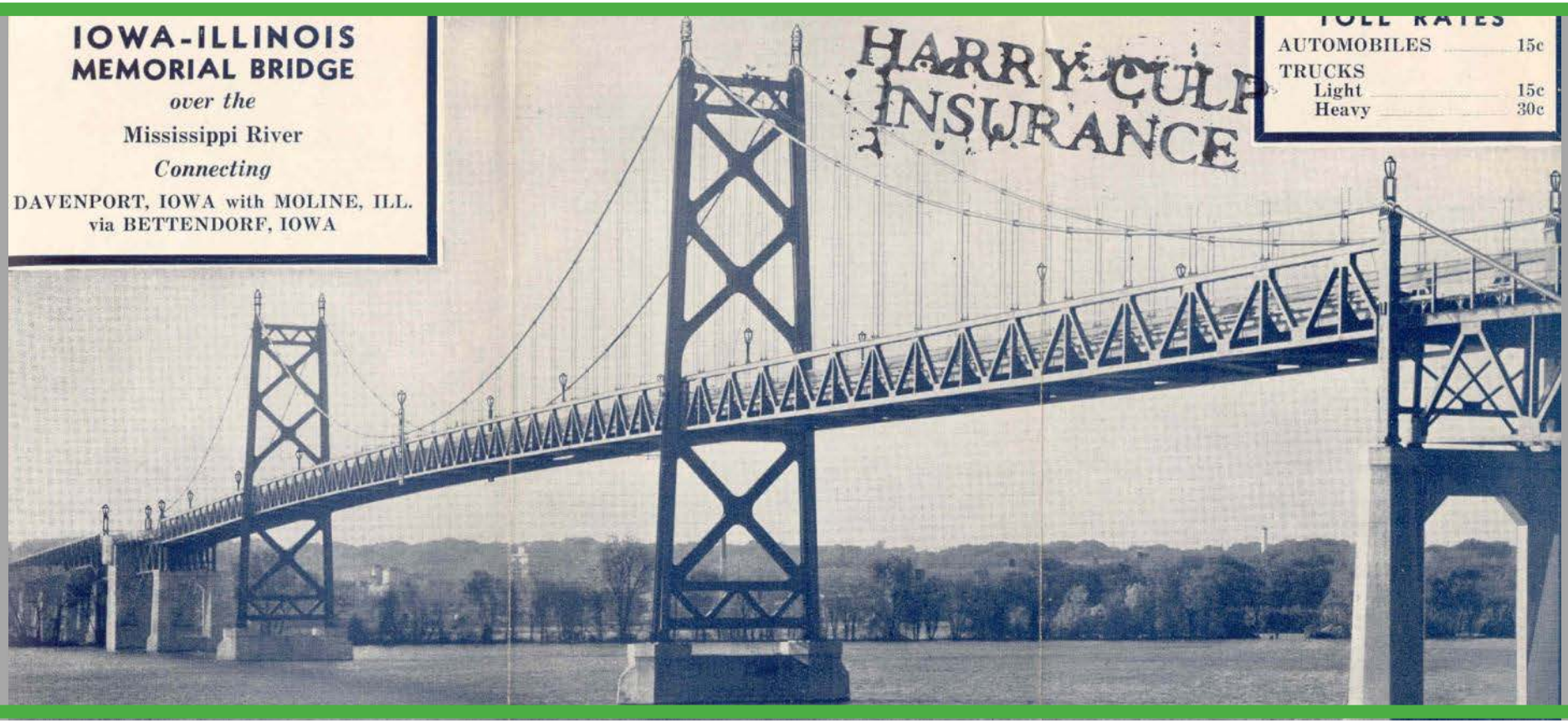
EXISTING NORTHBOUND BRIDGE



- Open to Traffic in 1935 – 15 Cent Toll
- Construction Cost - $1.5 Million

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EXISTING NORTHBOUND BRIDGE

1930's

Source: *Upper Mississippi Valley Digital Image Archive*

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EXISTING NORTHBOUND BRIDGE

1930’s

EXISTING SOUTHBOUND BRIDGE

Southbound Bridge
Construction in 1959

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EXISTING BRIDGES

Twin Suspension Bridges Converted to I-74 in 1970's

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EXISTING BRIDGES

PROPOSED BRIDGES

Twin Basket Handle
True Arches

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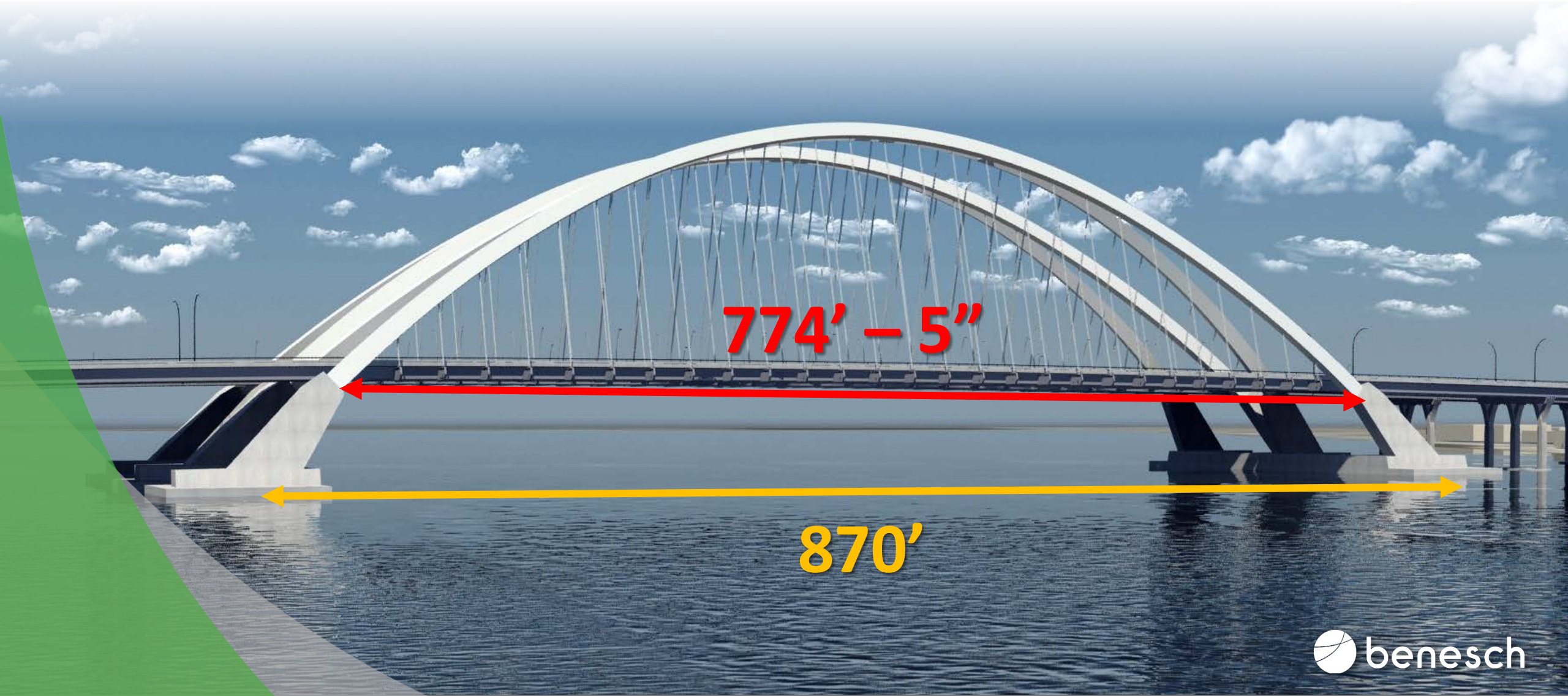
PROPOSED BRIDGES

ARCH SPAN – SUPERSTRUCTURE



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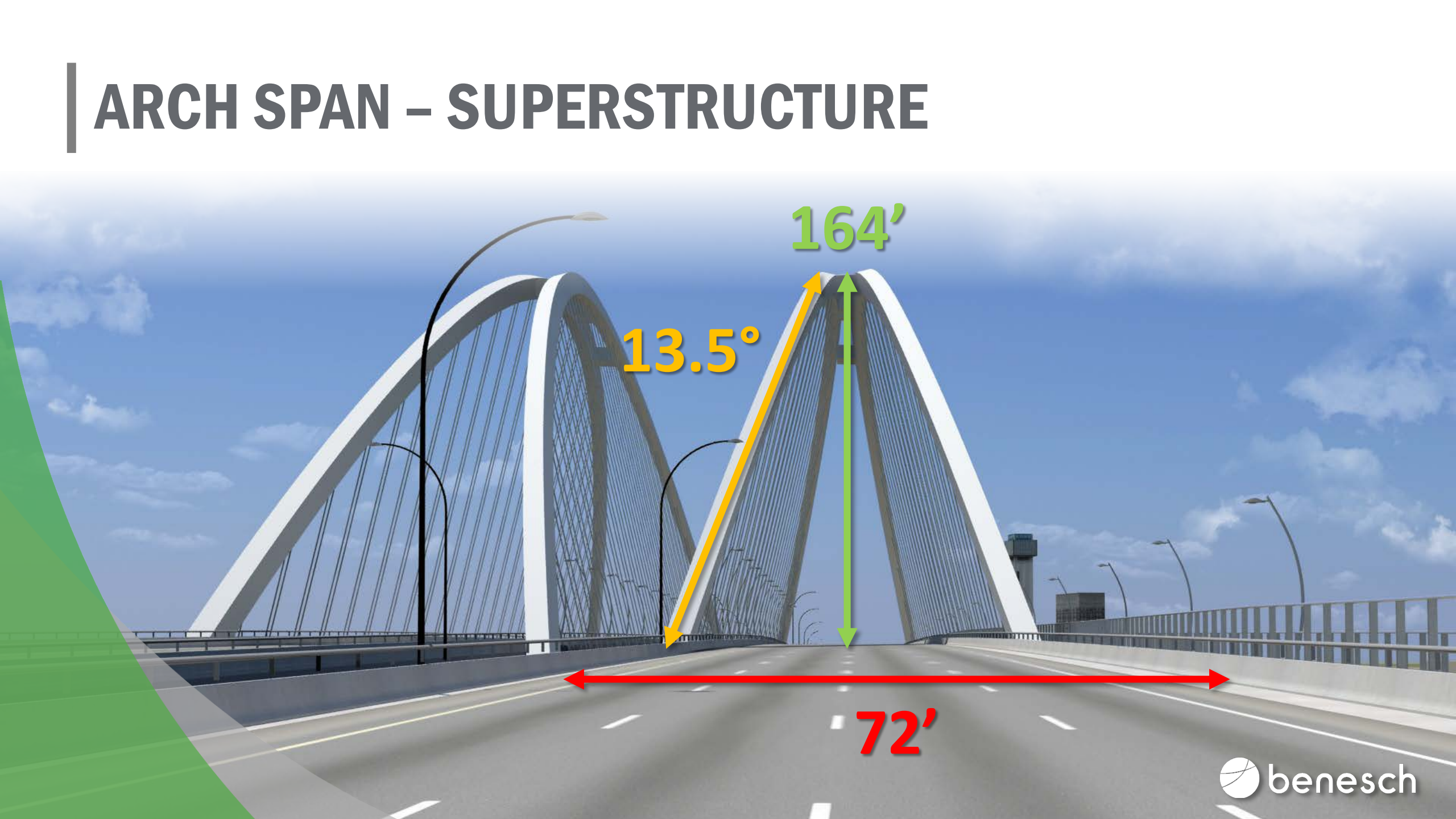
ARCH SPAN – SUPERSTRUCTURE



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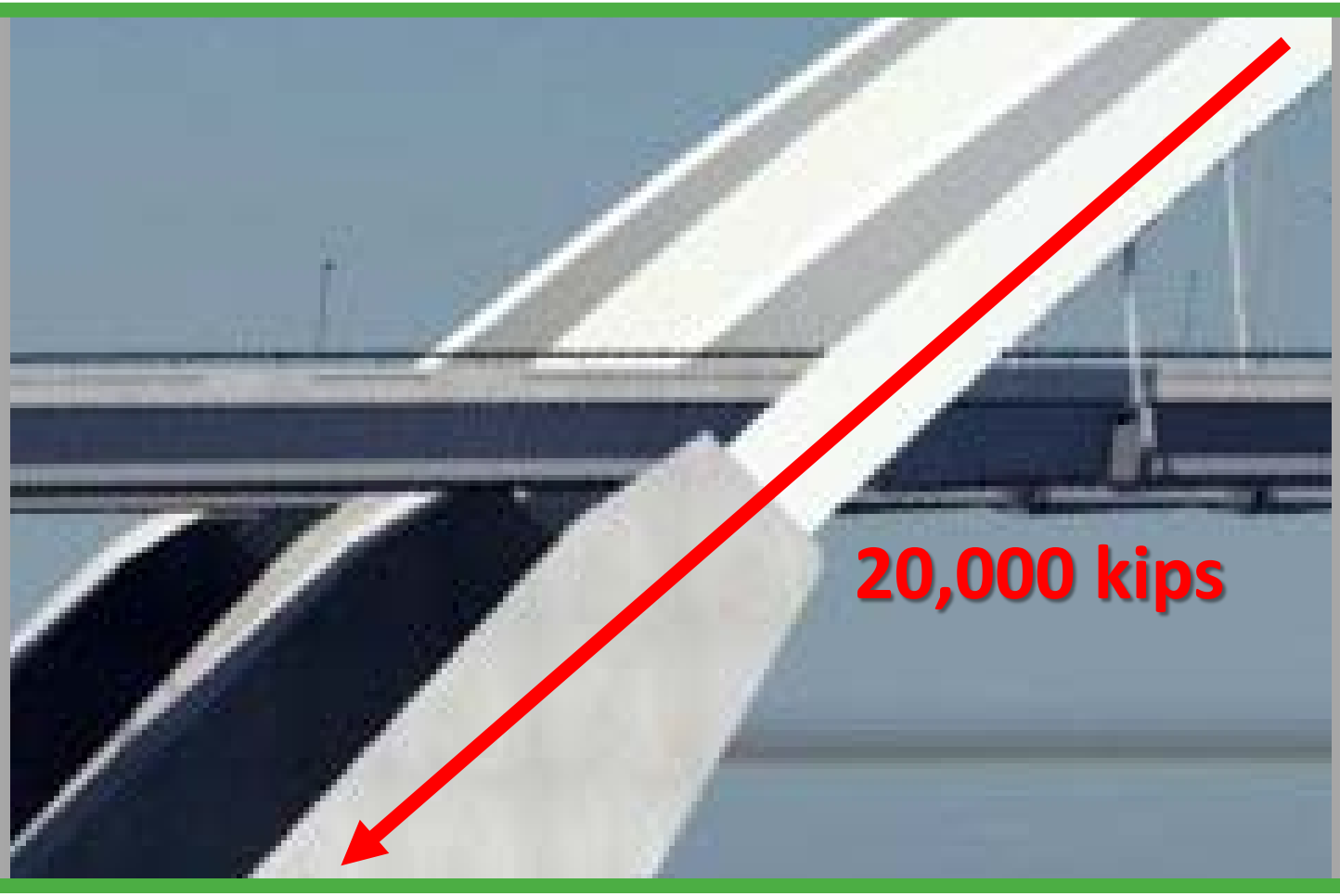
ARCH SPAN – ANCHORAGE



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FOUNDATION DESIGN APPROACH

Pat Tillman Memorial Bridge at Hoover Dam Bypass

- True Arch Foundation (Main) Objectives
  - Support Vertical Loads
  - Resist Thrust

Photo *Courtesy of Wikipedia*

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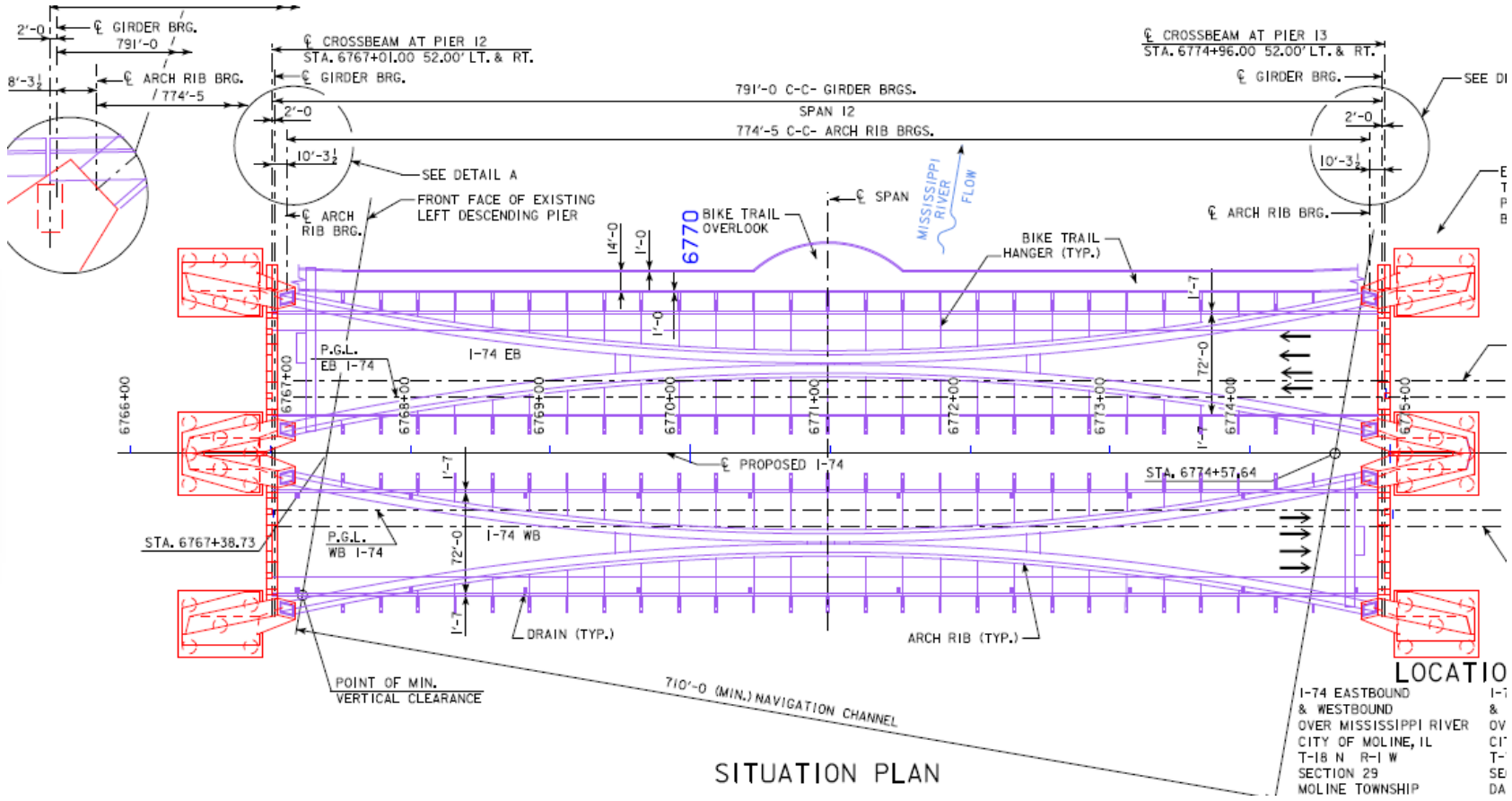
FOUNDATION DESIGN APPROACH

Six individual Foundation Elements (middle ribs share a foundation element



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FOUNDATION DESIGN APPROACH

- ***Preliminary Plans proposed two foundation alternates***
  - Drilled Shafts with Waterline Cap
  - Spread Footing on Rock

- ***Site Specific Challenges***
  - Variability in the rock type and quality
  - Relatively flat riverbed
  - Minimal (if any) soil overburden
  - Bedding planes within the limestone

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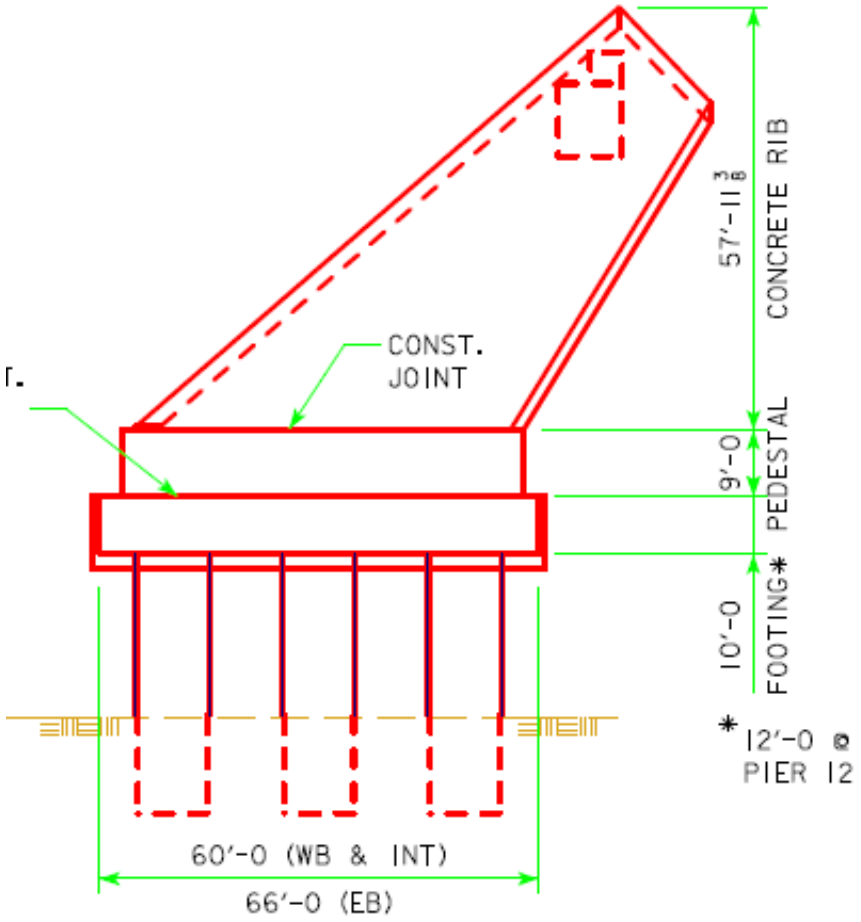
DRILLED SHAFT ALTERNATE

- ***Challenges***
  - Need to control shaft deflection to ensure proper arch behavior
  - Very high sustained shear and flexure loads for the life of the structure
  - Creep was a concern
  - Shaft sizes and layout ended up being impractical



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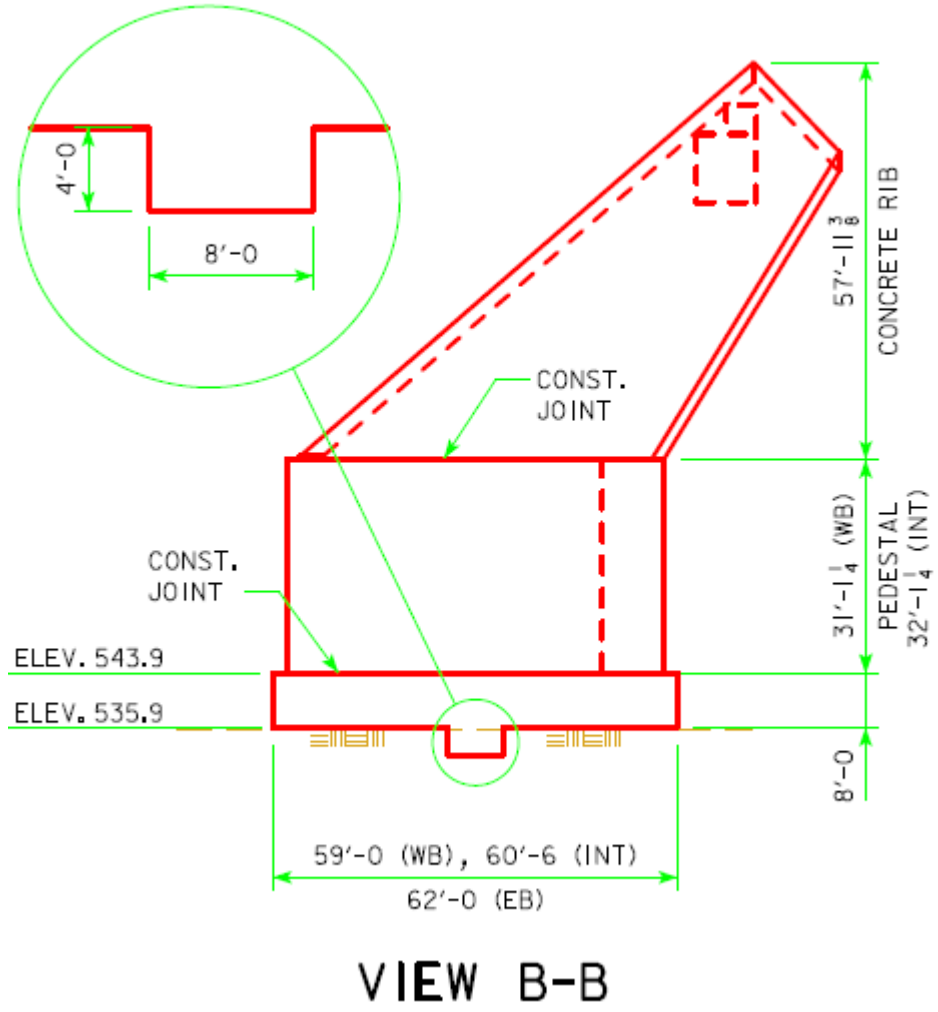
SPREAD FOOTING ALTERNATE

- *Challenges*
  - Variability in Rock quality
  - Bedding planes in limestone could “slide”
  - Uneven bearing capacity across the area of footing
  - Must be cast “in the dry” in order to achieve desired behavior



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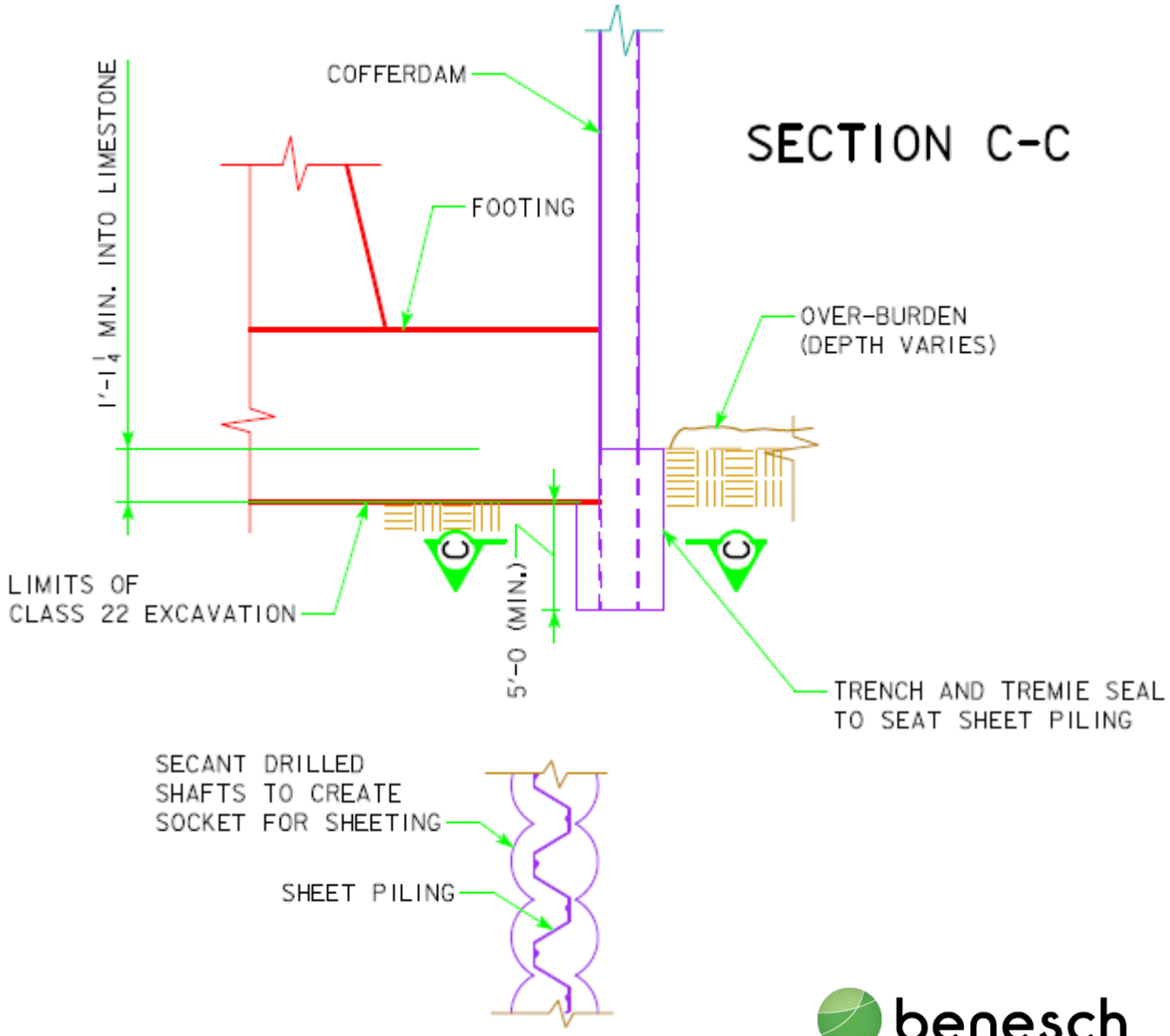
SPREAD FOOTING ALTERNATE

- Ability to cast the footing in the dry created concerns
- Rock Grouting was not recommended as the pressures could actually fracture the rock instead of strengthen and seal
- Perimeter cutoff wall would be required to inhibit flow into the footing area.
- Cost of cut-off wall was substantial and required significant rock drilling



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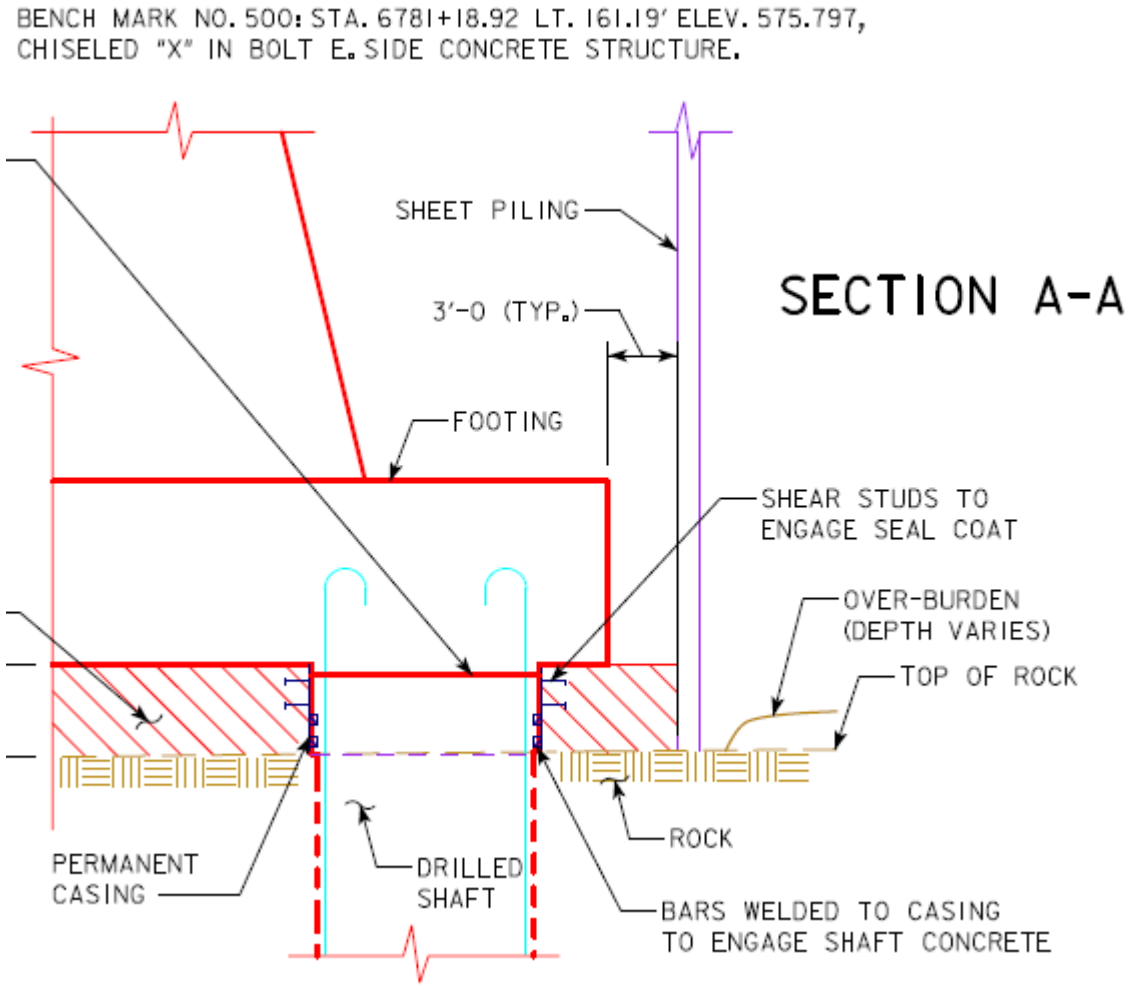
HYBRID FOOTING ALTERNATE

- "Re-purposed" the rock drilling such that it could be part of the permanent load path
- Maintain the footing as near as possible to the riverbed
- Shaft height is significantly less than the waterline footing option
- Allows for use of more conventional cofferdam (although there is still no overburden)
- Created two fully adequate load paths for the thrust forces (shafts, and interface friction)



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HYBRID FOOTING ALTERNATE

- ***Step 1:*** Remove loose rock and soil in the area of the shafts and footing
- ***Step 2:*** Place Drilled Shafts. Casing will extend above river elevation, but top of shaft is near bedrock
- ***Step 3:*** Construct cofferdam
- ***Step 4:*** Remove loose material and place seal coat
- ***Step 5:*** Dewater cofferdam, trim casings and prep bottom of footing
- ***Step 6:*** Form and pour footing

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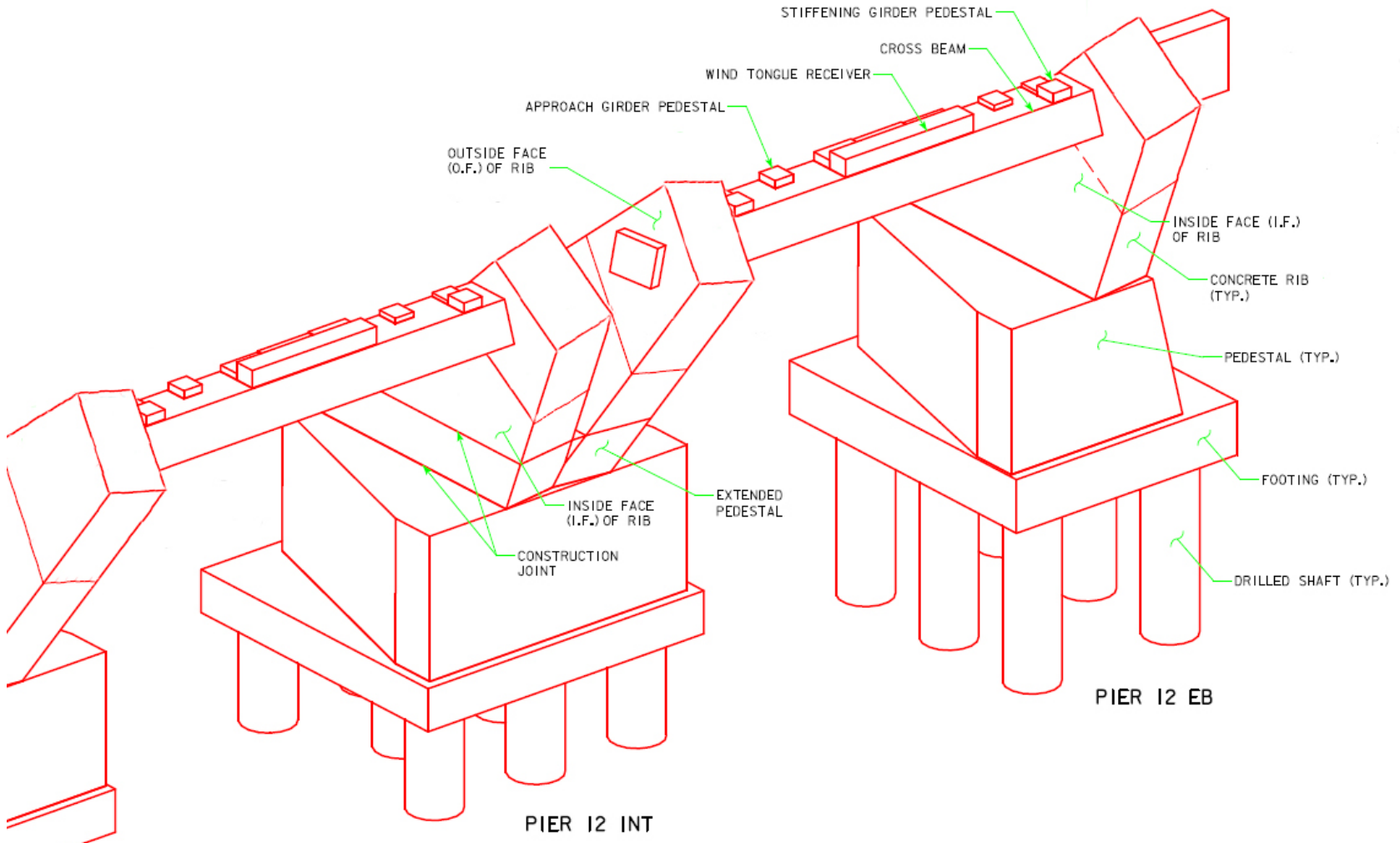
ARCH SPAN – HYBRID FOUNDATION



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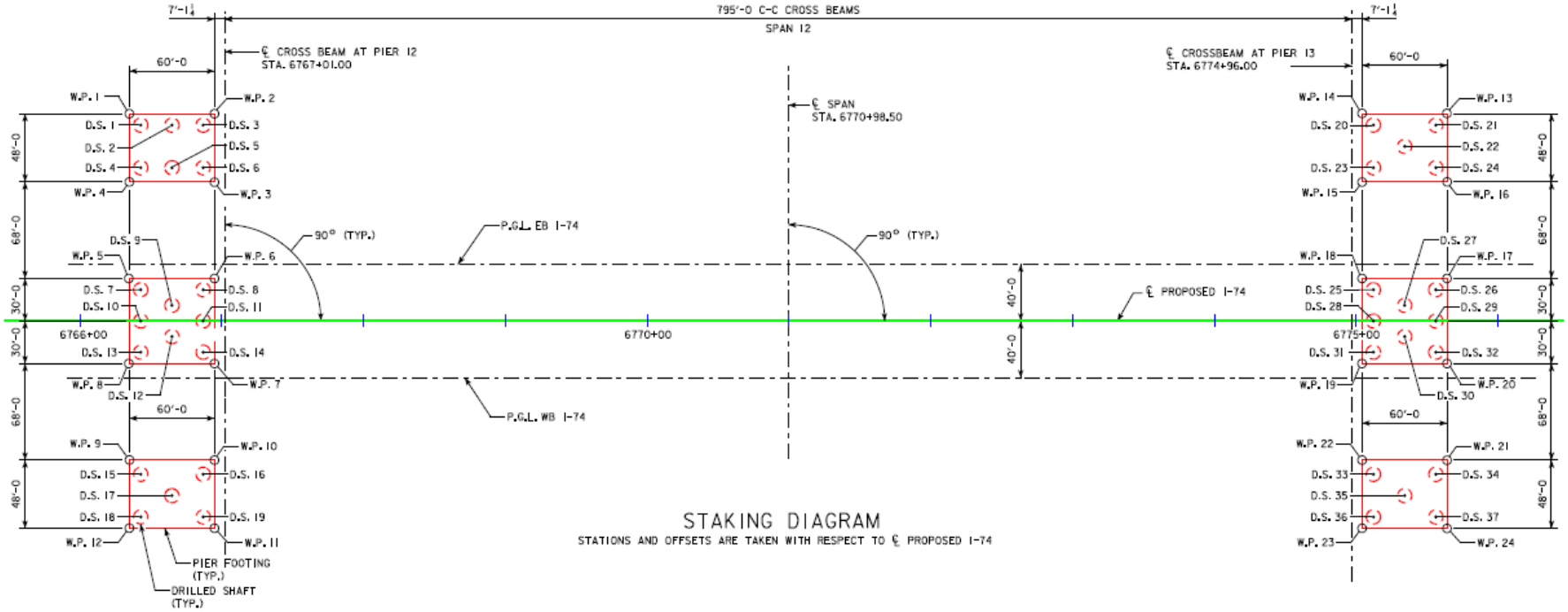

- A total of 37 shafts for the 6 individual foundation elements
- Each Shaft is 10’ in diameter with 9.5’ diameter rock sockets
- Top of shaft is near bedrock
- Length of shafts varies from 22’ to 36’

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BID OPENING APRIL 25, 2017

- Iowa used an “Optional Tie” between the approach spans and the Main Span.
- Five bidders submitted for the combined work for the approach spans and the main span.

Bidder Name	DBE	Bid Amount
LUNDA CONSTRUCTION CO.	5.09%	$322,067,927.86
WALSH CONSTRUCTION CO II, LLC & AMERICAN BRIDGE CO I-74, JV	5.09%	$357,790,073.13
TRAYLOR BROS., INC & MASSMAN CONSTRUCTION CO., JV	5.05%	$368,425,183.25
KRAEMER AMES OBAYASHI, JOINT VENTURE	5.01%	$375,790,068.16
JOHNSON BROS CORP & RENDA CONTRC., JV	5.42%	$416,249,971.17

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REMOVE LOOSE ROCK AND SOIL

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REMOVE LOOSE ROCK AND SOIL

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PLACE DRILLED SHAFTS

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PLACE DRILLED SHAFTS

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PLACE DRILLED SHAFTS

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PLACE DRILLED SHAFTS

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CONSTRUCT COFFERDAM

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CONSTRUCT COFFERDAM

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PLACE SEAL COAT

PLACE SEAL COAT

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DEWATER AND PREPARE BASE

DEWATER AND PREPARE BASE

FORM AND POUR FOOTING

FORM AND POUR FOOTING

FOUNDATION CHALLENGES

- Variability in Rock Quality and top of rock elevation
- Differing depths required to set the permanent casing
- “Cavern” at one drilled shaft (subsequently filled with concrete and re-drilled)
- Soft Spot near pier 13WB (same pier as the cavern)

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CURRENT STATUS

- All 37 main span foundation shafts have been placed
- Cofferdams in placed at 5 locations
- Seal coats installed at 4 locations
- Footing installed at one location

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Design and Construction of Arch Foundations

THANK YOU!

QUESTIONS?

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APPROACH SPANS AND VIADUCT PIERS

At Normal Pool River Levels

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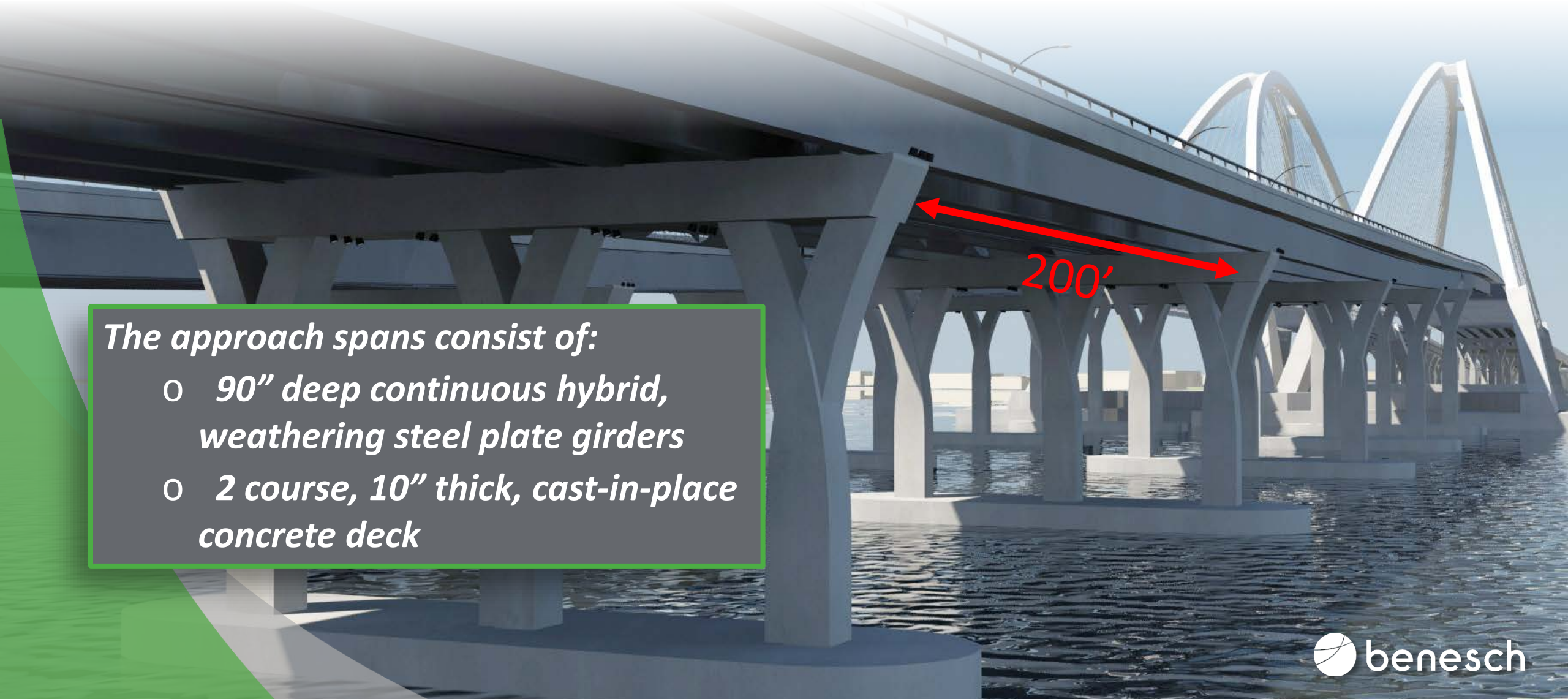
APPROACH SPANS



The approach spans consist of:

- *90” deep continuous hybrid, weathering steel plate girders*
- *2 course, 10” thick, cast-in-place concrete deck*

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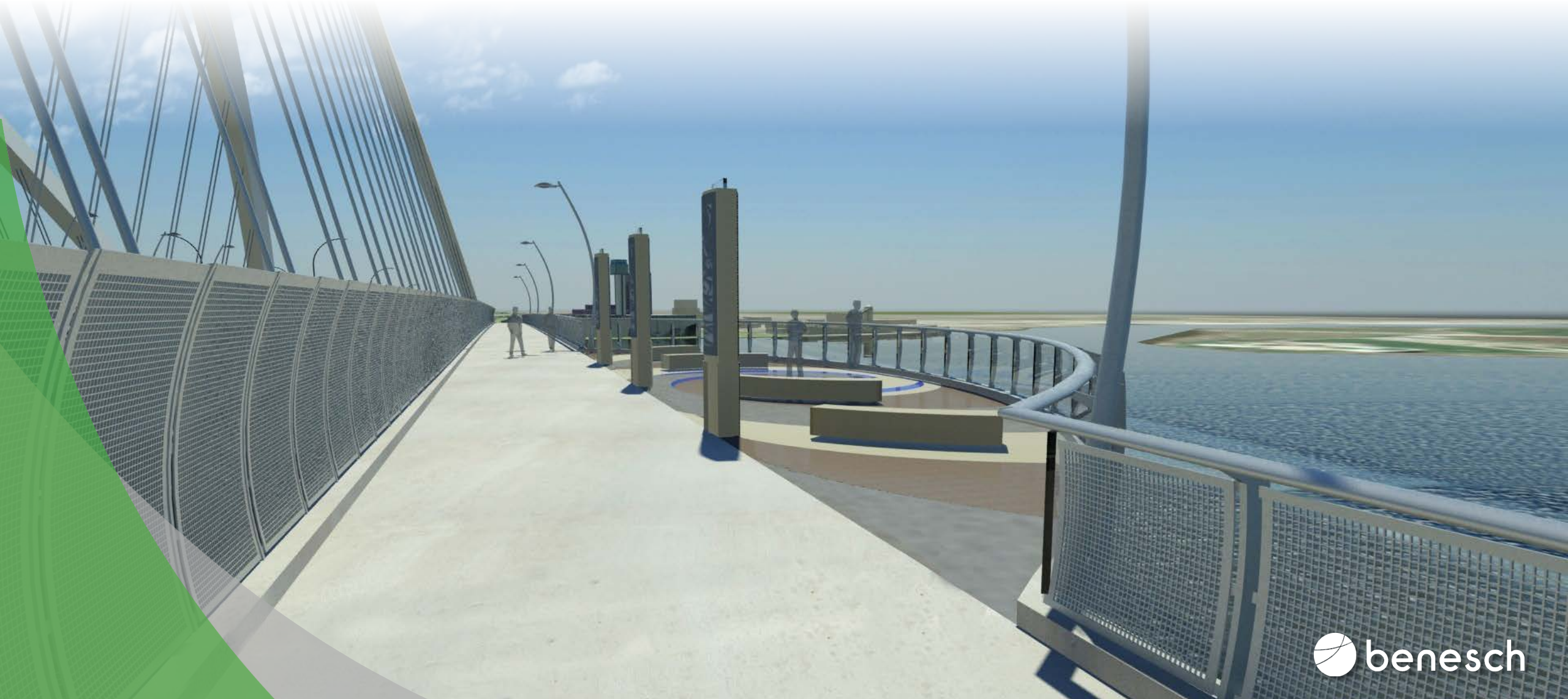
MULTI-USE TRAIL – PEDESTRIAN OVERLOOK



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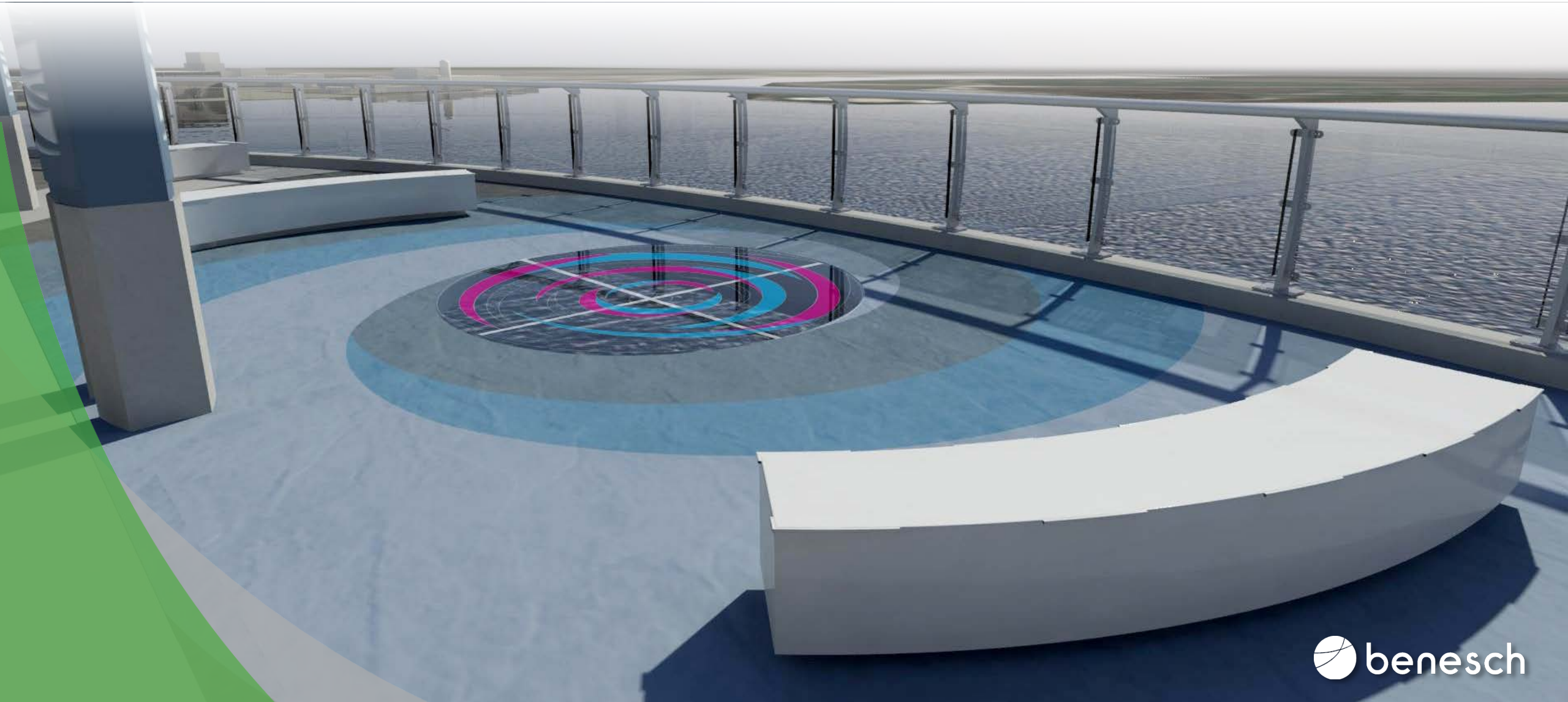

BETTENDORF LET-DOWN STRUCTURE

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ARCH SPAN – AESTHETIC LIGHTING

ARCH SPAN – AESTHETIC LIGHTING

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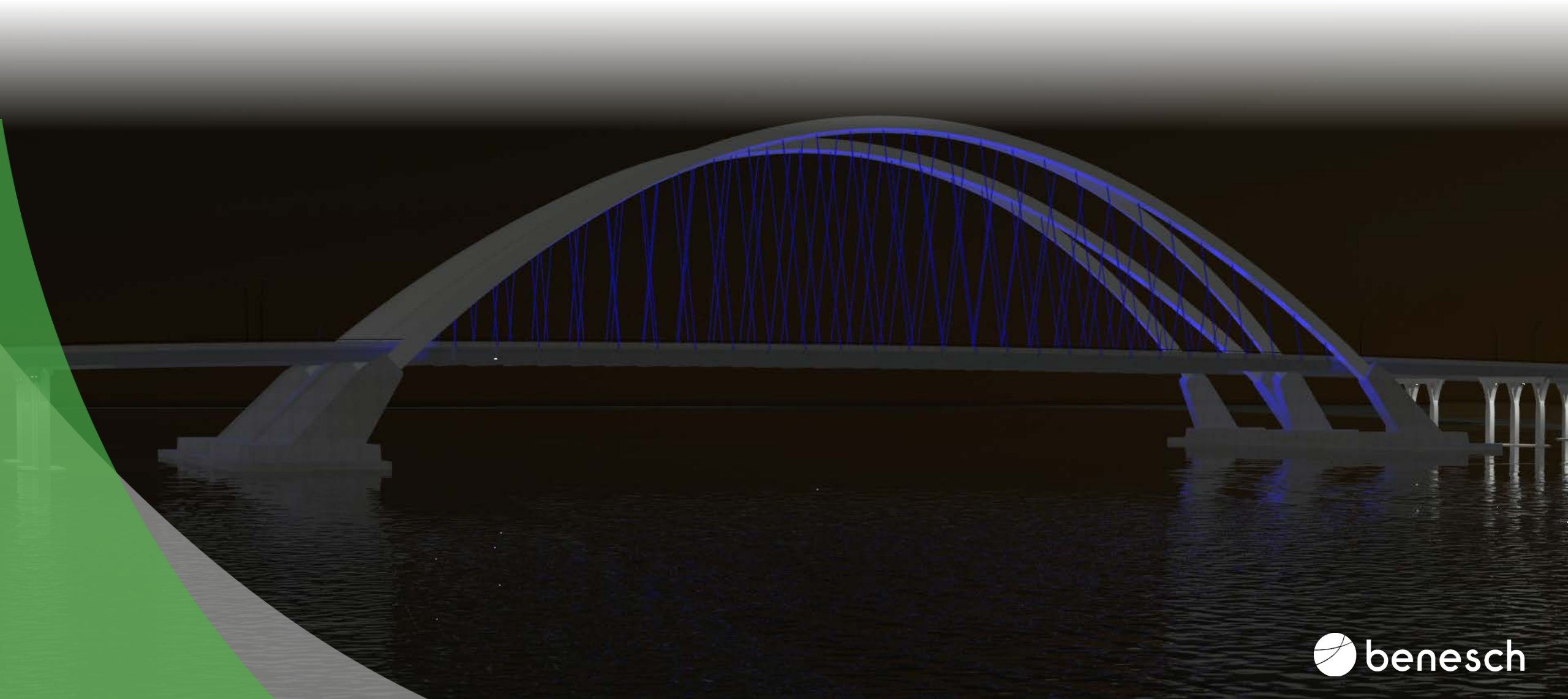
ARCH SPAN – COLOR CHANGING LIGHTING



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ARCH SPAN – COLOR CHANGING LIGHTING

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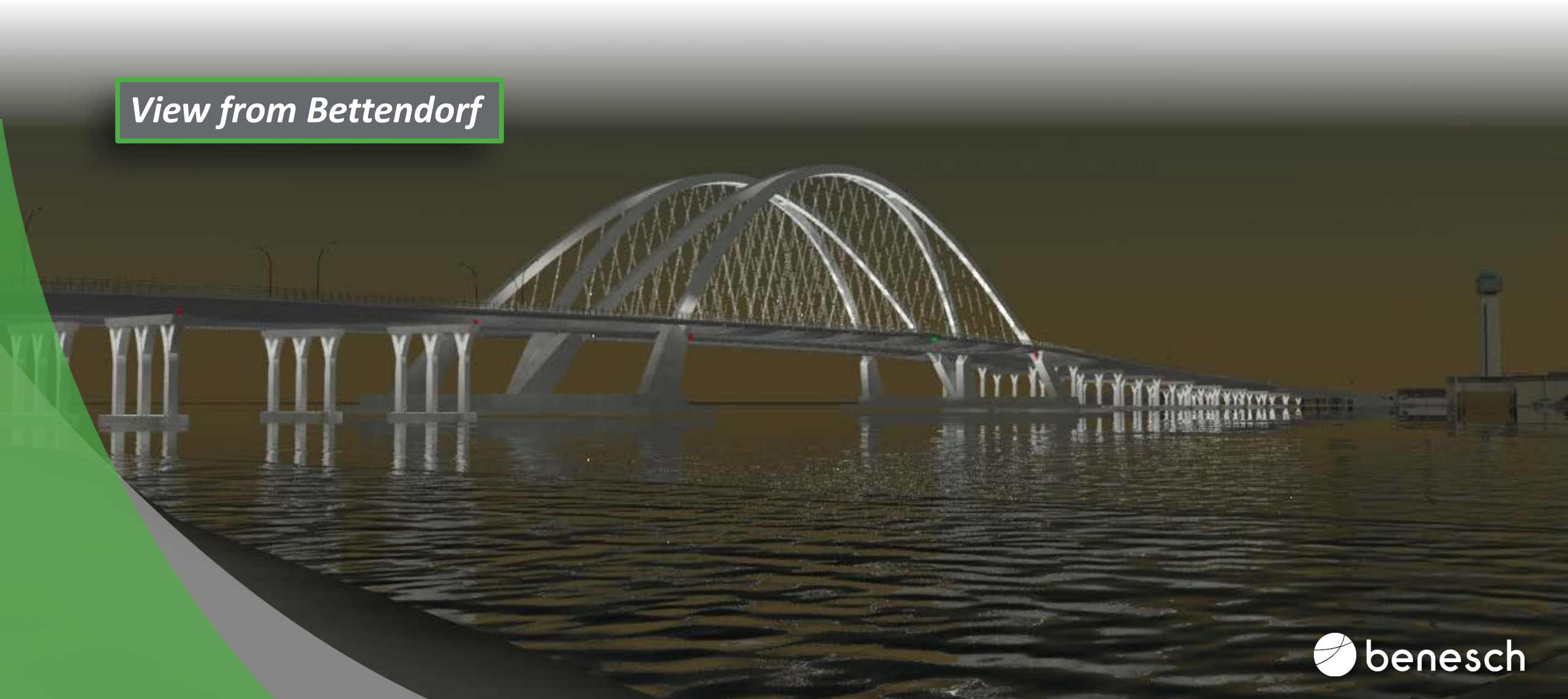
PIER LIGHTING

AESTHETIC LIGHTING – RIVER SPANS



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THANK YOU!

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