# Design and Construction of the St. Anthony Falls Bridge (I-35W)

Tom DeHaven - FIGG

# I-35W Collapse August 01, 2007

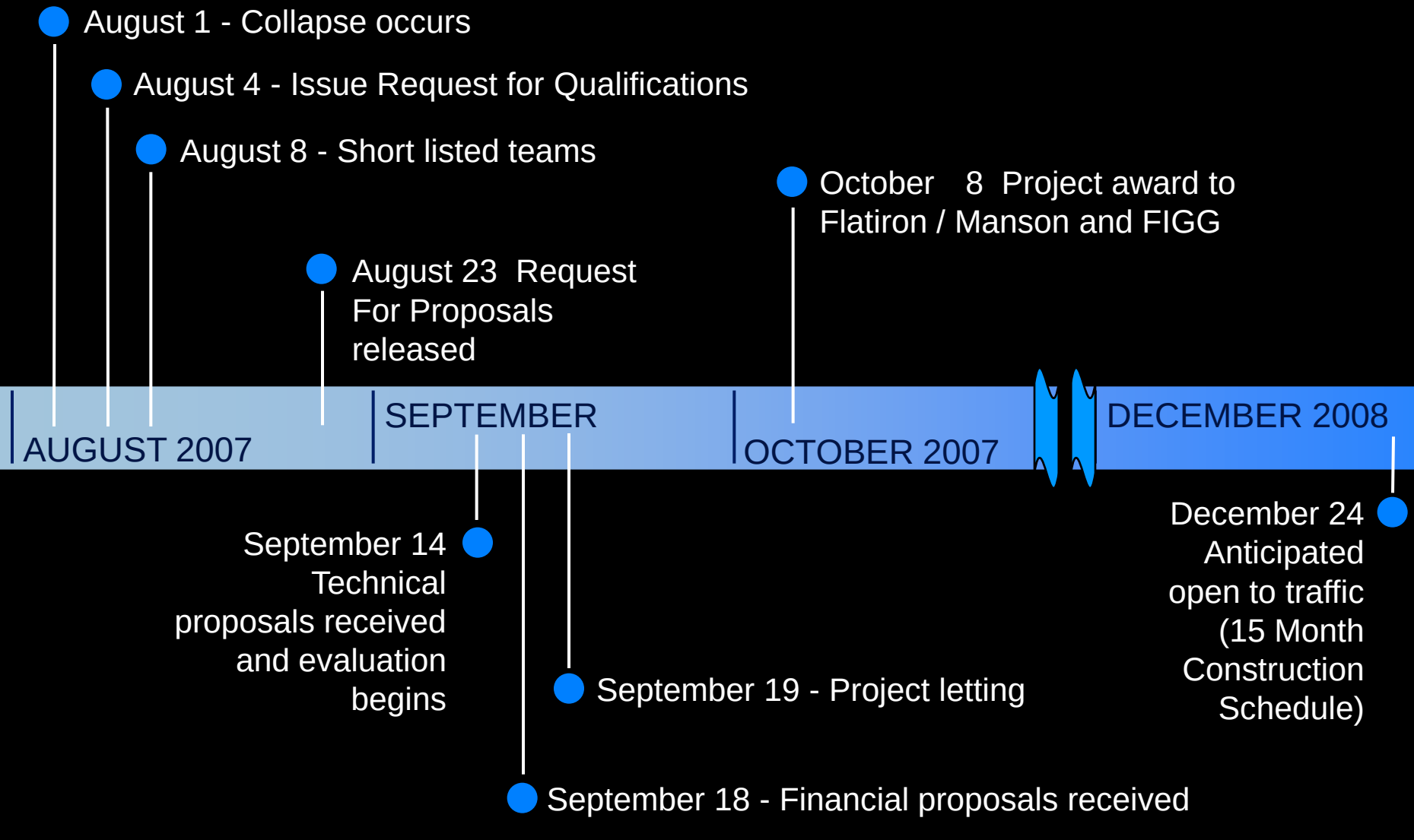
# New bridge needed quickly

141,000 cars a day used the bridge
One of the busiest bridges in
Minnesota

·Close to major traffic areas
U of M
Downtown Minneapolis

·$400K a day in road users costs

# Design Build on Accelerated Schedule



## Owner

Minnesota Department of Transportation

FLATIRON MANSON

## Contractor

Flatiron Constructors, Inc.
Manson Construction Co. – Johnson Bros.

FIGG

## Designers

FIGG Bridge Engineers • TKDA • Oslund and Associates • Braun Intertec Corp.

# Design Build Proposal

August 8 - FMJV/FIGG shortlisted

August 23 Final RFP

September 14 – Technical Proposals submitted

37 Days

# What happened in those 37 days

Weekly Meetings between MnDOT and each short-listed Team

Confidential

Developed a Relationship

Increased Contractor's Comfort

# New St. Anthony Falls Bridge

## GOALS

- Safety
- Quality
- Aesthetics
- Public Relations
- Enhancements
- Environmental Compliance
- Time and Budget

# What happened in those 37 days

FMJV/FIGG Team deciding on Bridge type and erection method

- Steel and Concrete alternates priced
- Availability of Materials
- Erection Plans developed

# What happened in those 37 days

FMJV/FIGG Team selected Concrete Bridge with both CIP and precast elements

Concrete was available and allowed FMJV to control their own destiny

Allowed exceeding 100 yr design life with HPC

Availability of Materials and labor was good

Erection Plans incorporated ideas from FIGG and FMJV

# What happened in those 37 days

FMJV/FIGG Team concerns

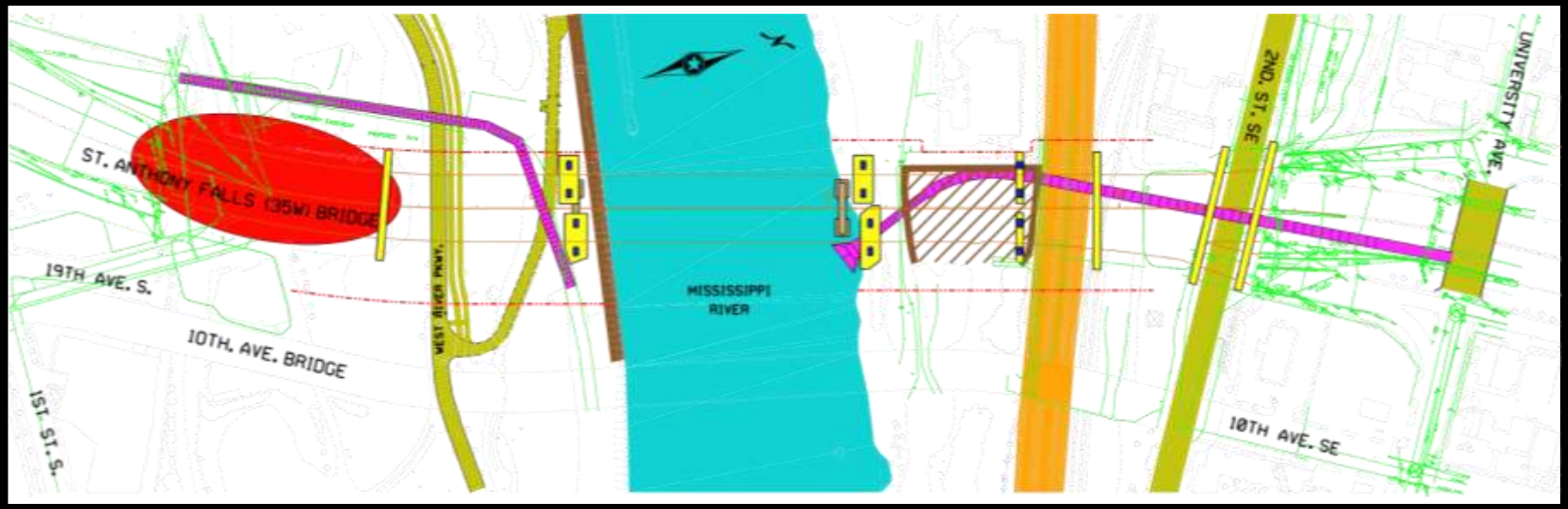
- No Local Labor Agreement
- Weather
- Unknowns from Site

# Design and Construction Challenges

**Get Foundations Started ASAP**
- Required Preliminary Superstructure Design

**Cold Weather Protection**
- Heating and Housing

**Site Geometric Constraints**
- Contaminated Soils
- In-place Storm Sewers and Utilities
- Historic Wall



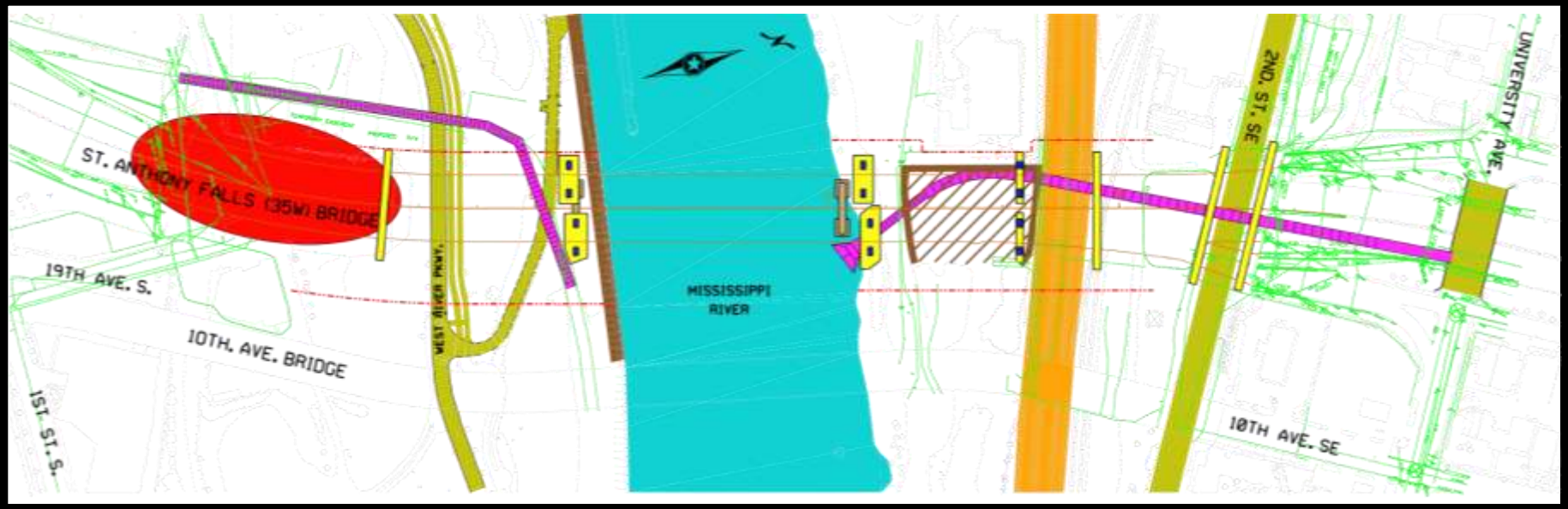
# Design and Construction Challenges

**Drilled Shaft**

- Upper layer of soft sandstone
- Artesian Conditions
- Load Test Required
- No piers in river

**Design for future LRT addition**

- Added a week before RFP released
- Developed Criteria for LRFD Methodology

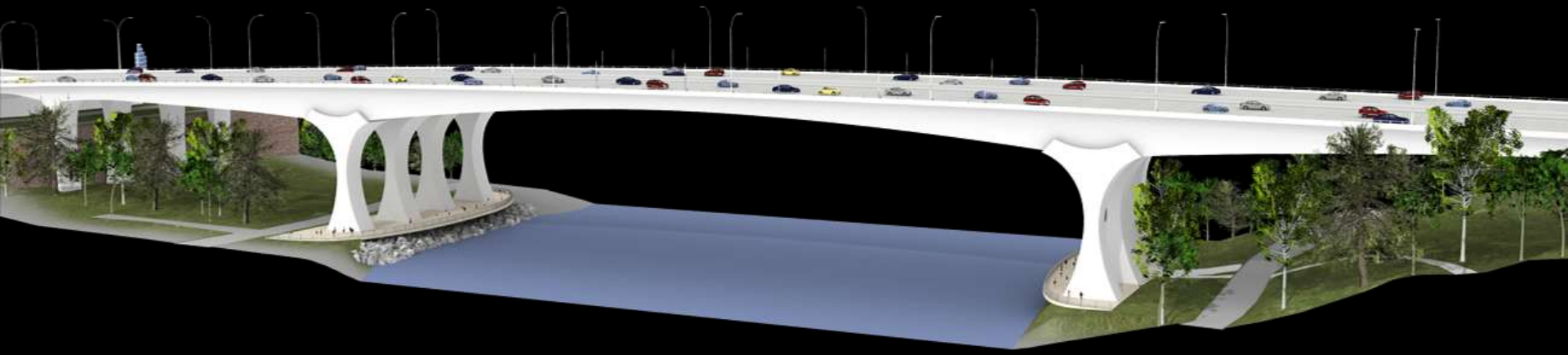


# Bridge Description

Bridge reflects series of modern arch forms – Elegant simplicity

Four-span bridge approximately 1,218’ long

504’ main span over Mississippi River



# MnDOT's Actions led to Project Success

Delivered on all commitments they made

Shared their DB expertise

Staffed project with highly experienced, decisive staff

Encouraged OTS reviews

Reviewed all submittals within 7 days and averaged 2 days

# MnDOT's Actions led to Project Success

Made Quality Manual a living document that was improved as the project progressed

Instituted "Hold Points" in QA/QC activities to assure Quality

Involved all stakeholders and got their input while eliminating all "red tape". No voice was discounted.

# FHWA's Actions led to Project Success

Full-time Bridge Engineer- Romeo Garcia

Gathered expertise from national experts on any issue

Brought in experts to share ideas from past DB projects

- Silica Fume

- Health Monitoring

- Quality Programs

- Drilled Shafts

# Other Actions led to Project Success

Labor Agreement with the Building trades

Efficient Labor force

Unaffected by cold weather

Selecting Cemstone to supply concrete mixes, expertise and concrete

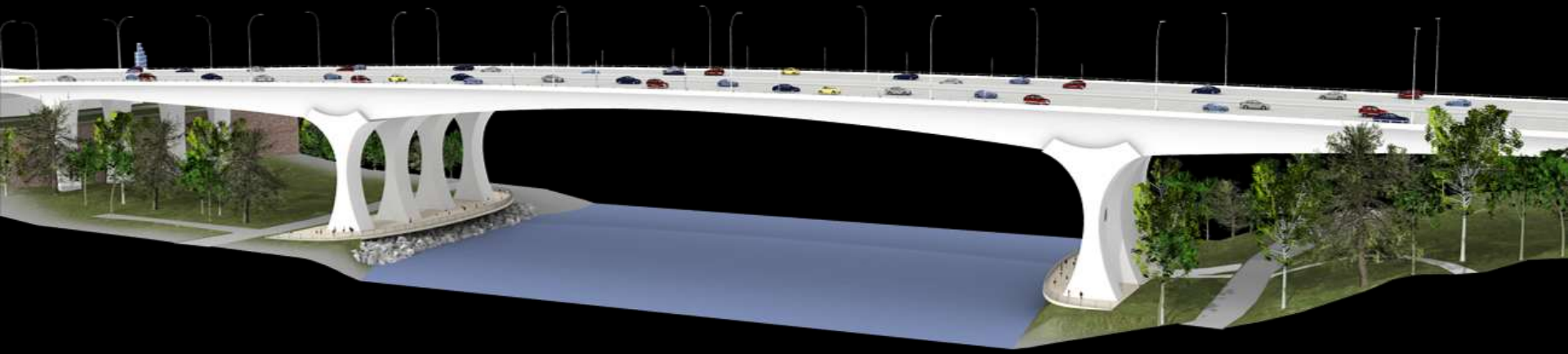
"Amazing! We just met with a concrete supplier who can actually provide answers and not just excuses" – J. Barton- FMJV Superintendent

# Long-term Durability and Corrosion Protection

Develop design features to ensure superior durability

Exceed requirements of successful and proven Mn/DOT bridge standards

Ultimate goal: 100 year service life (Mn/DOT standard is 75 years)




# High Performance Concrete

Mix designs are tailored for each project element

The bridge superstructure, deck, footings, and drilled shafts all use concrete mixes with compressive strengths higher than required by design

# High Performance Concrete

Superior Compressive Strength

Low Permeability

High Freeze-thaw Resistance

Good Workability

# High Performance Concrete

Life 365 was used to estimate the time to corrosion

Developed by ACI Committee 365

Estimates for the mixes are:

| | |
|---|---|
| Drilled Shafts | – 118 years |
| Footings | – 131 years |
| Piers | – 119 years |
| Substructure | – 115 years |
| Superstructure | – 171 years |

# High Performance Concrete

All mixes include additives - silica fume and fly ash to reduce permeability and thermal cracking

Estimated chloride permeability is low - averaging 750 coulombs at 28 days. Actual Measured was an average of 250 coulombs.

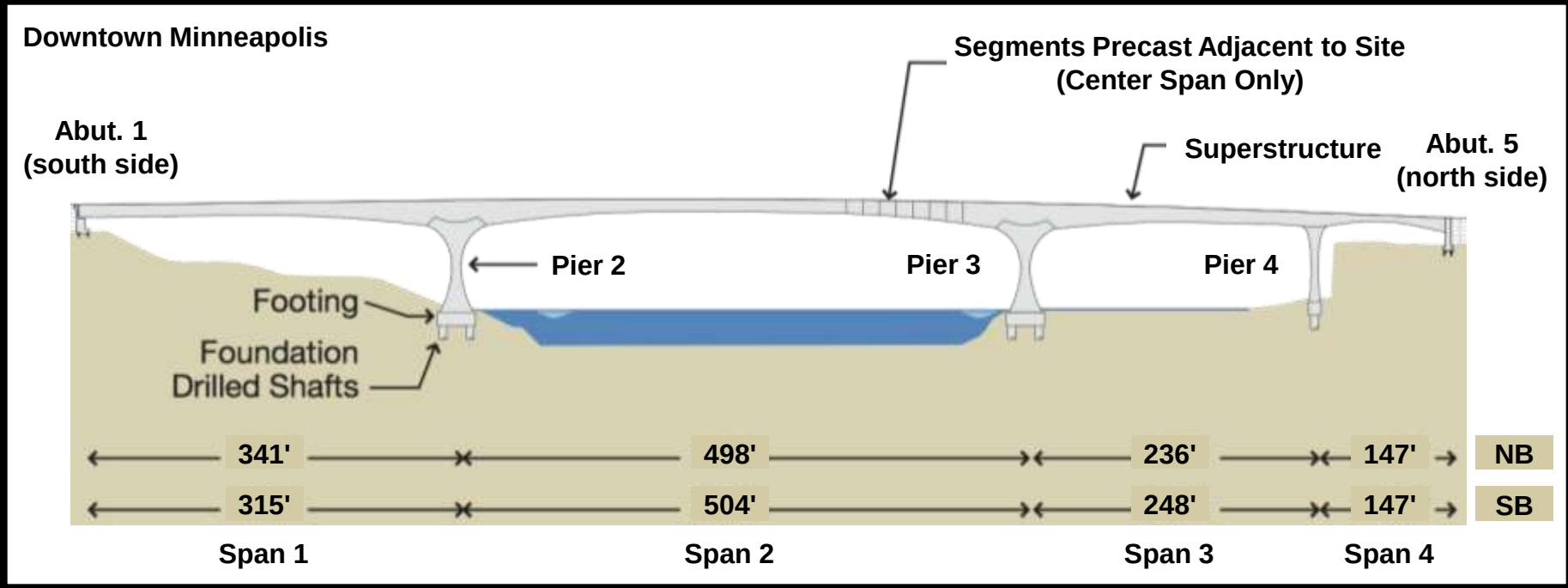
Low shrinkage property of less than 0.021% - decreasing the potential penetration of contaminants

# Bridge Description

Variable depth superstructure
- 25' over piers
- 11' span 1 and 3 ends and midspan
- 6' span 4 midspan

Concrete piers supported by footings / drilled shafts socketed into rock

Expansion taken at abutment 1 and pier 4 (integral deck at abutment 5)



# Mini Case Study – Drilled Shafts

## Main Pier Footings

- Span extensive storm drains
- Some locations straddle existing foundations

## Main Pier Foundations

7' and 8' diameter drilled shafts
100' long with socket into bedrock
Slurry method with SC concrete

# Drilled Shaft Issues

- Required Load Test in relatively unknown material
- Critical Path item
- First drilled Test hole found Artesian condition

- Led to major meeting with all parties to decide how to proceed

  -MnDOT, FHWA, Owner's Experts, FMJV, Braun, Case Foundations, and FIGG

  -Will a shorter Shaft reach capacity?

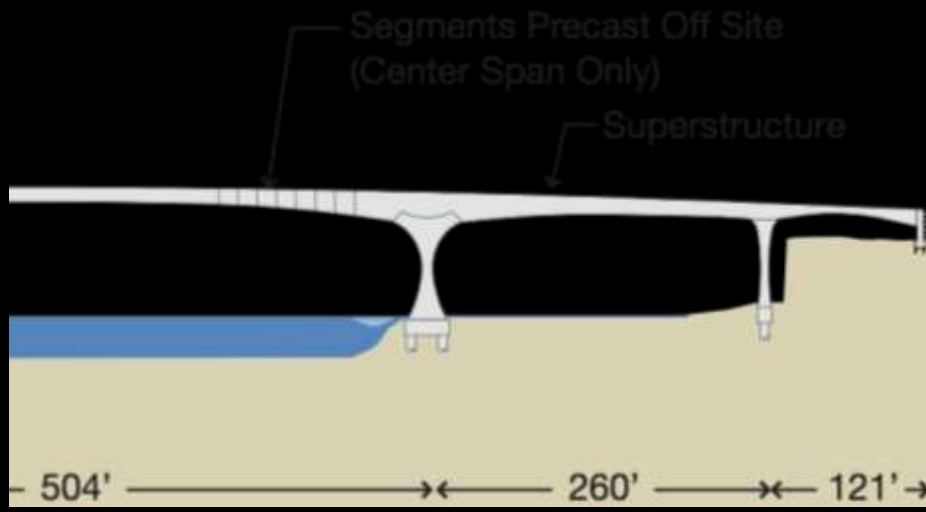
# Drilled Shaft Issues

- Drilled Second Test Shaft above artesian
- Used 4 O-cells for skin friction and only one to estimate end bearing
- Used self-consolidation concrete

- Test Shaft exceeded design by 20%
- 1st Production shaft at Contract Day 50

# Stream lined Review

- OTS Review (Over the Shoulder)
- Historic Wall protruded out 20’.  Pier 4 and entire design affected
- Shared information with MnDOT as solution was developed.
- Result: improved solution and stream lined review




# Project Enhancements

# Multiple Levels of Redundancy

Two bridges, each with two box girders

Hundreds of high-strength steel strands embedded in each box girder

Pier under each box girder

Multiple drilled shaft foundations socketed into bedrock

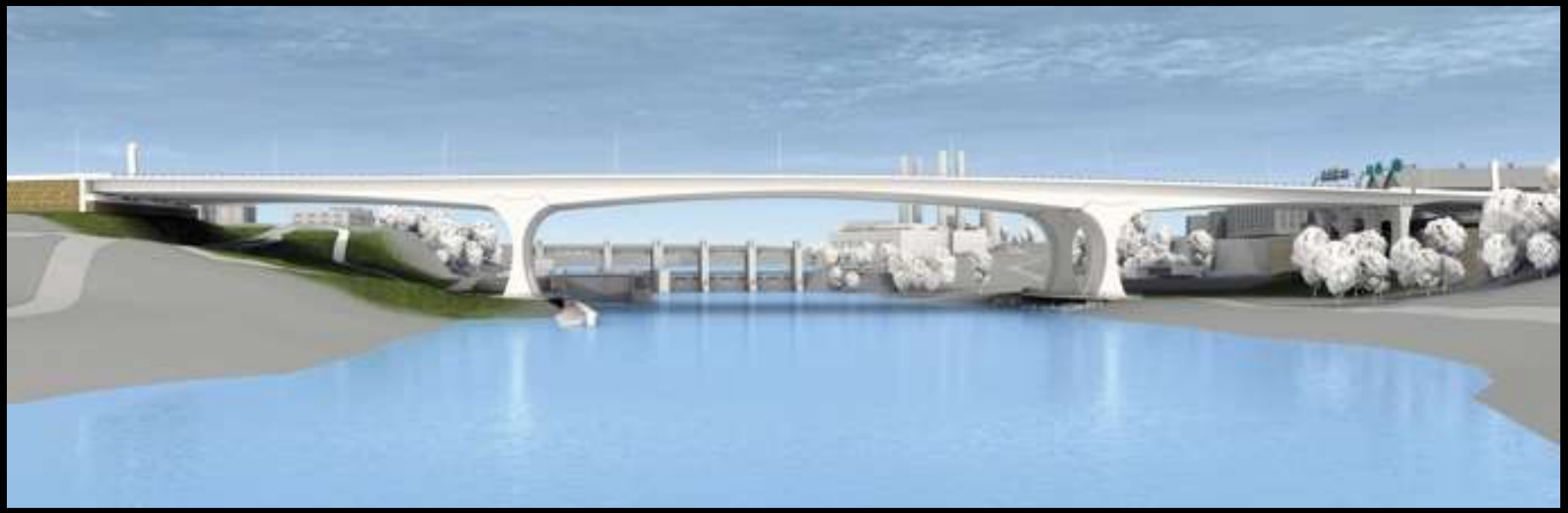
# Corrosion Protection Strategies

Include corrosion resistant design details

Utilize high performance materials

Provide multiple layers of protection of key structural elements

Provide high quality construction



# Post-tensioned Concrete Bridge

Bi-directional prestressing of the concrete deck to reduce the potential for cracking

Minimum 250 psi residual compression  in the longitudinal direction of the deck

Zero tension criteria in the transverse direction of the concrete deck under full load

# Corrosion Resistant Design Details

Integral Wearing Surface - monolithic application of additional concrete above what is required structurally

Additional concrete precompressed both directions with deck PT

4.5" clear cover to top deck reinforcing and prestressing

Top 0.5" reserved for deck milling and profiling

# Reinforcing and Prestressing Steel

Epoxy coated reinforcing used at all locations, except drilled shafts

Prestressing steel is protected by the concrete, plastic or galvanized ducts and high performance grout

Hardware and other steel components that are embedded in the concrete are galvanized or epoxy coated

# Corrosion Protection of Post-tensioning Strand Systems

High Performance Concrete provides a dense, barrier with low permeability

Post-tensioning ducts – corrugated plastic in the top slab, high-density polyethylene for external tendons, and galvanized steel corrugated duct for all other locations

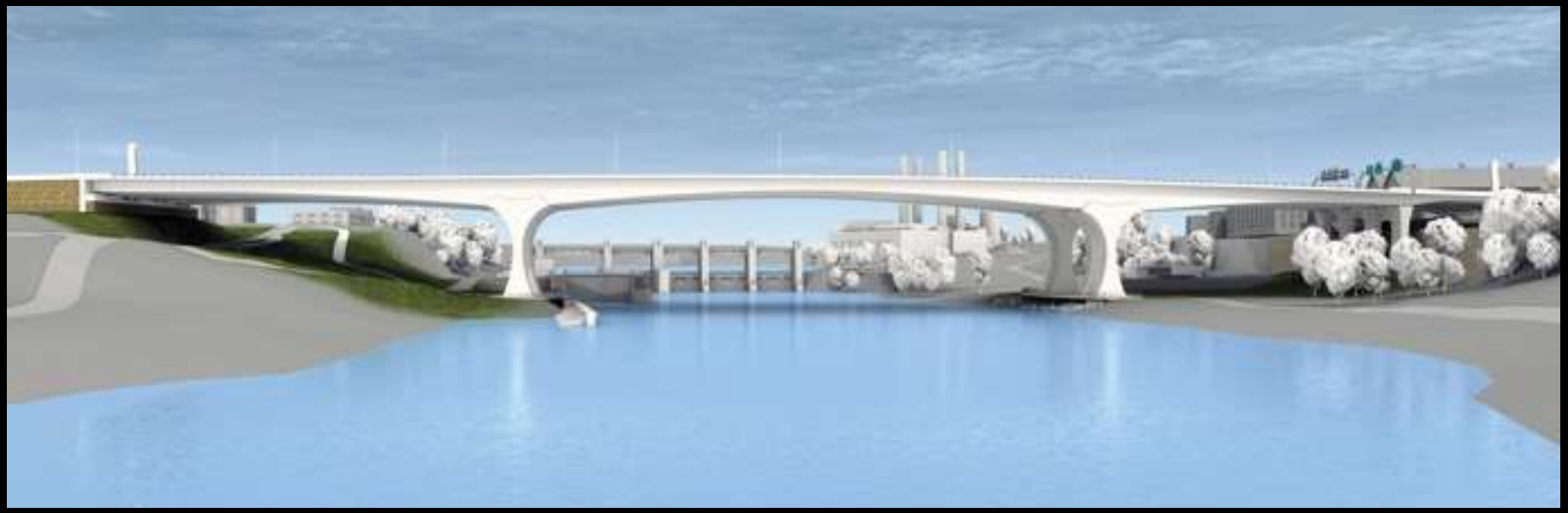
Enhanced cementious prepackaged grout with Thixotropic Properties

# Health Monitoring "Smart Bridge" Systems

Integrated Bridge Sensor Monitoring System

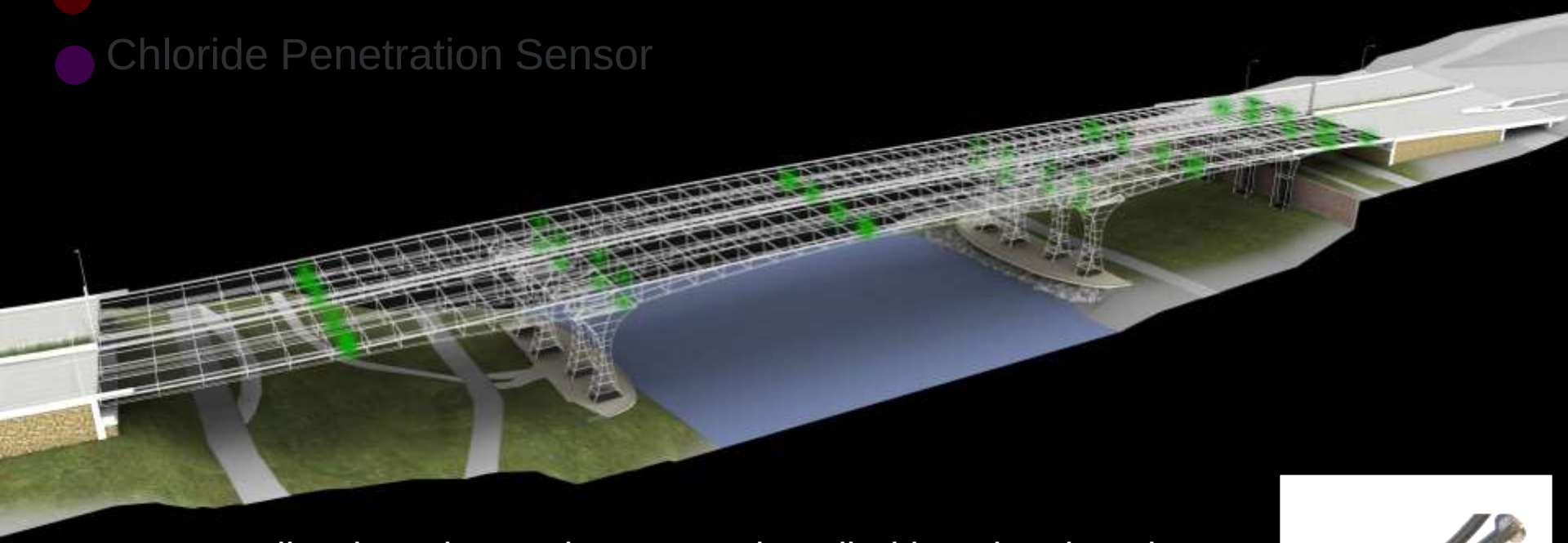
Record of structural behavior (structure monitoring)

Control of the automated anti-icing system



# Sensors for Structural Behavior

- Vibrating Wire Strain Gauge with Temperature Reading
- Linear Potentiometer
- Accelerometer
- Chloride Penetration Sensor



Vibrating wire strain gauges, installed in select locations, will measure how the bridge is resisting loads and also the temperature of the concrete

# Sensors for Structural Behavior

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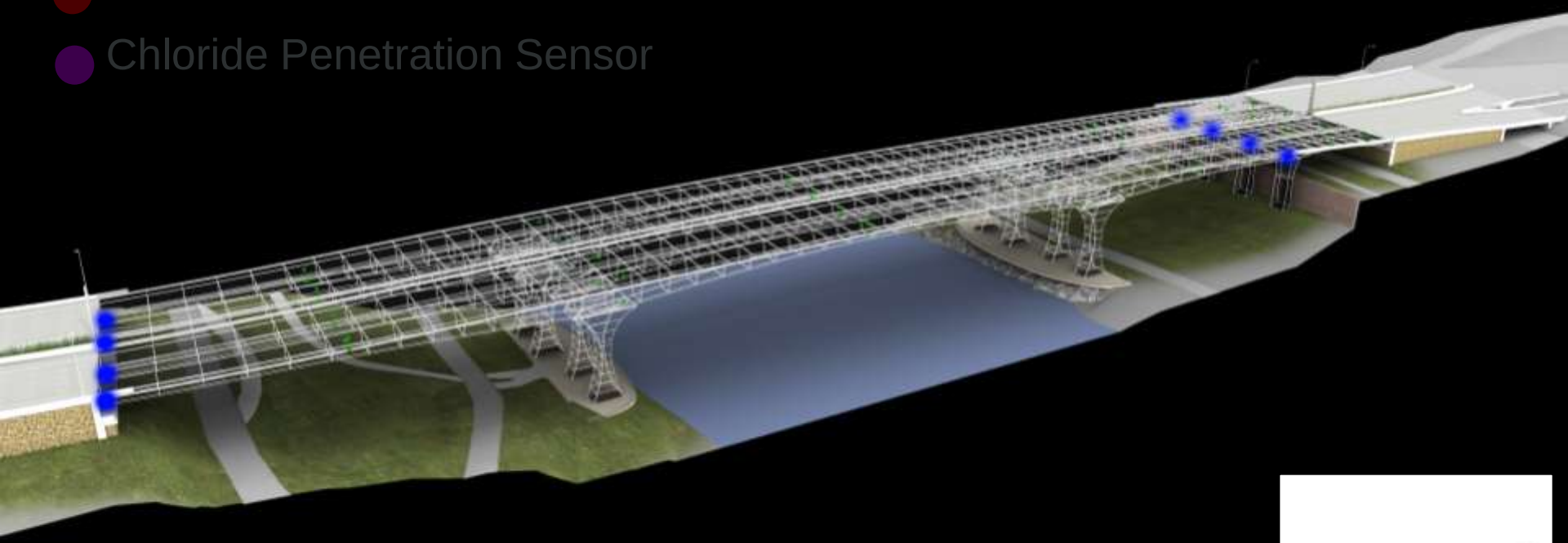

Placed at expansion joints and bearings to measure bridge movements which can be compared to expected values

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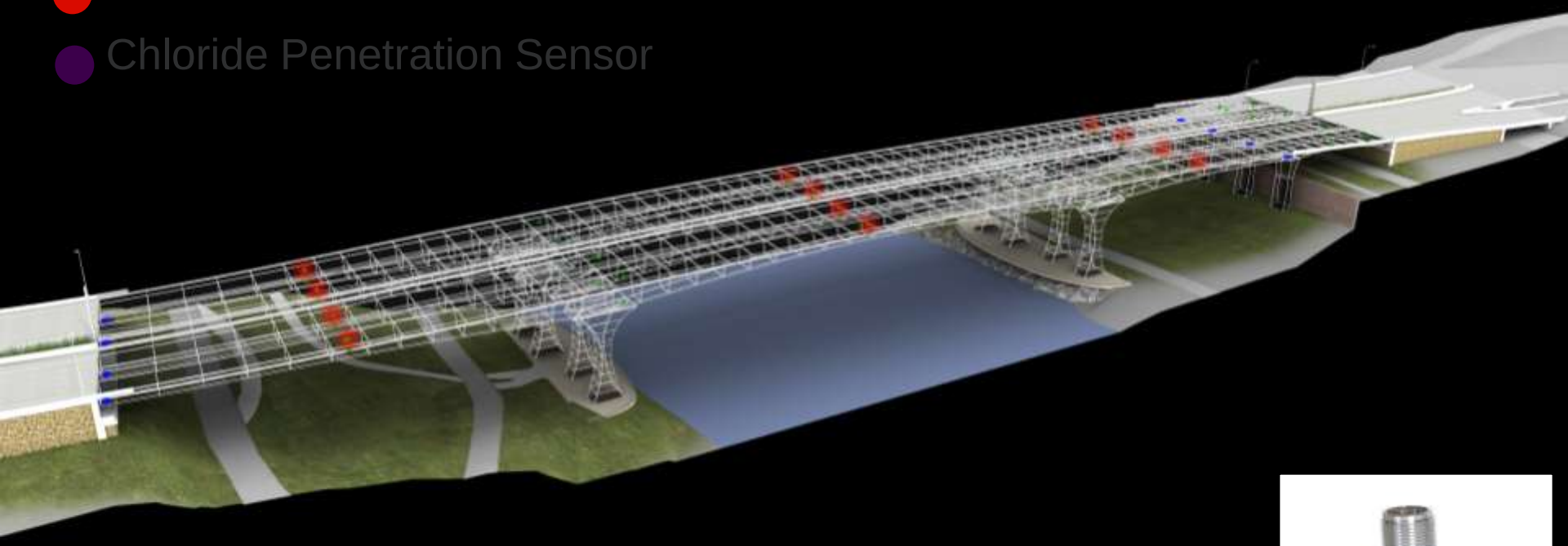

Accelerometers monitor bridge deflections under loads

# Sensors for Structural Behavior

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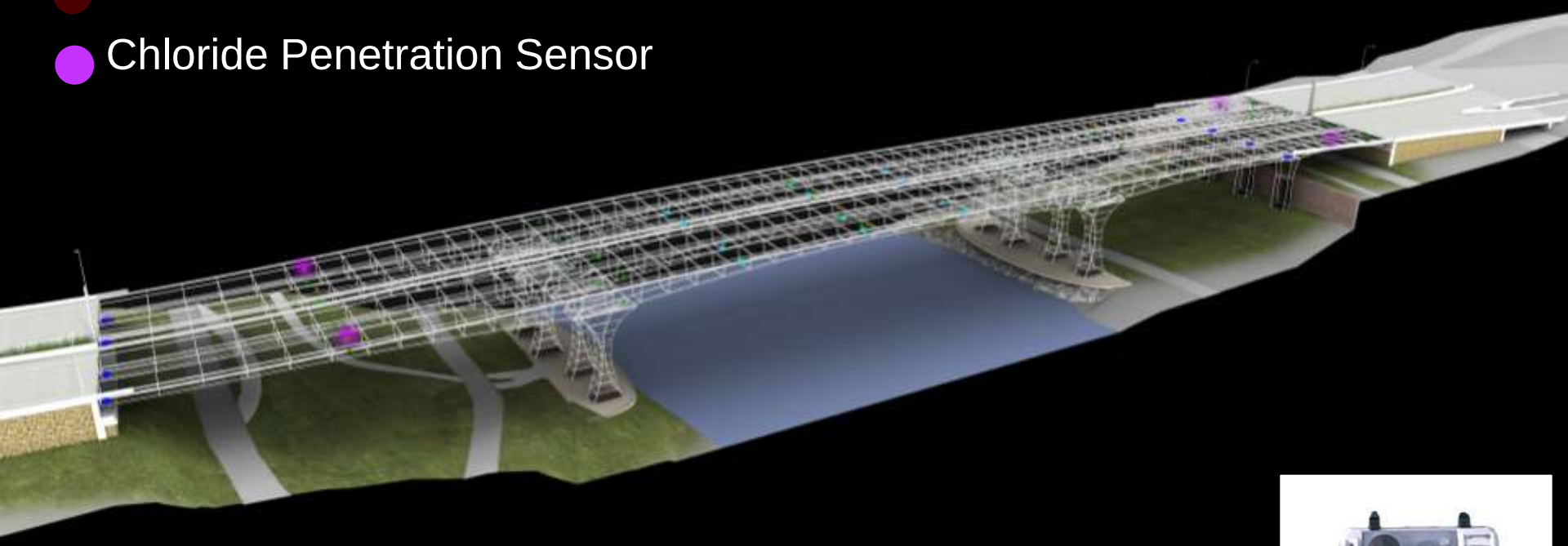
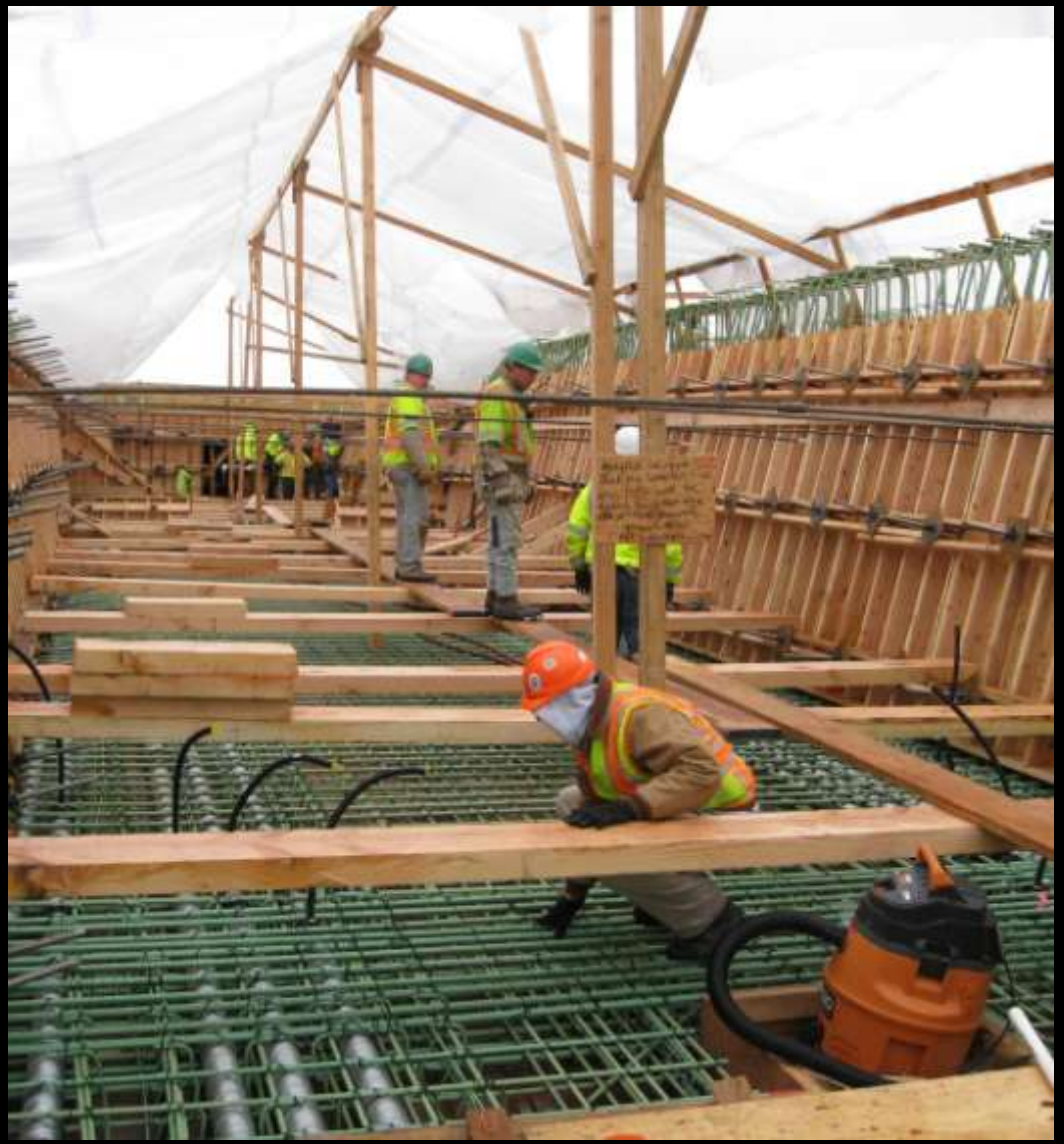


Monitor levels of chlorides in the concrete deck to assist with maintenance activities


PROJECT CONSTRUCTION

# Goal:
# Work everywhere Possible at the same time



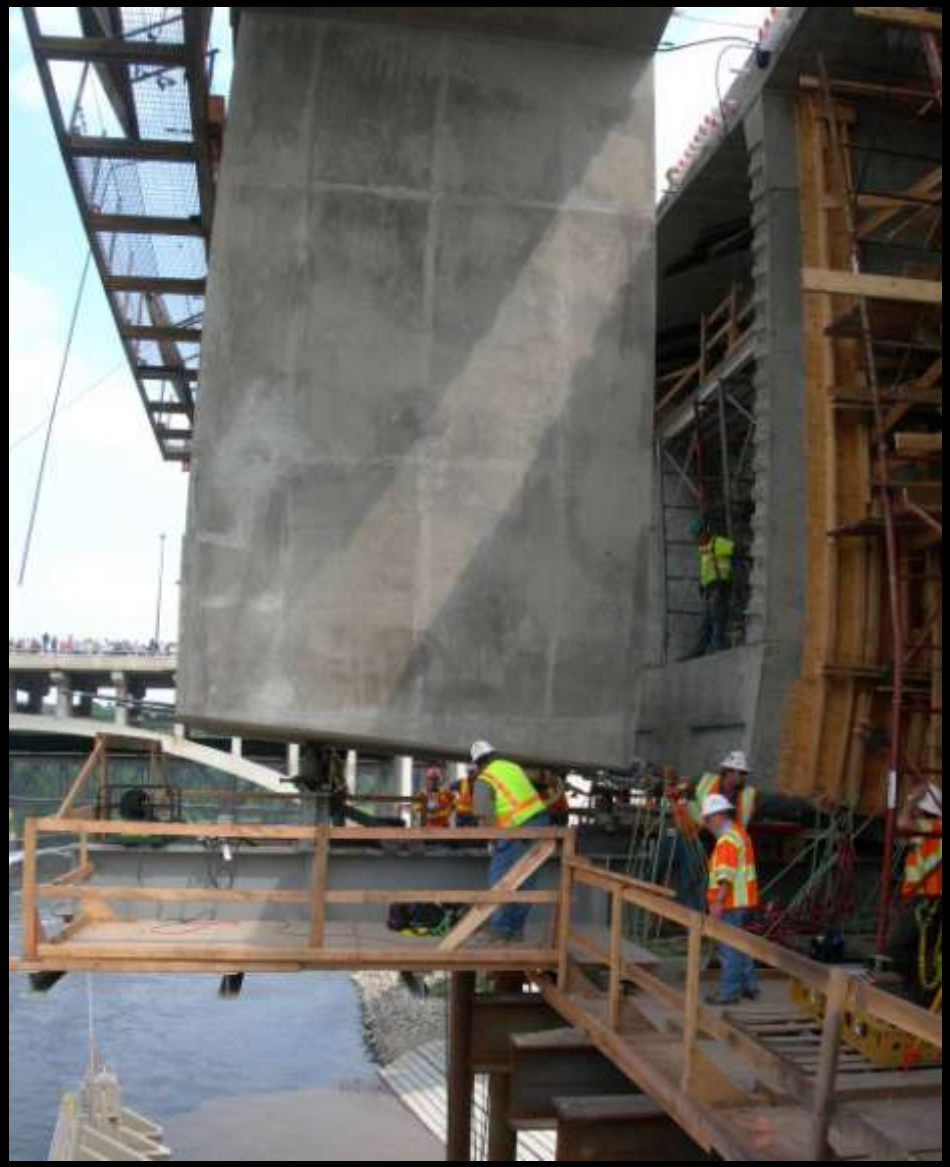
## Superstructure

25' to 11' high CIP box girders (back spans)
25' to 11' high precast segments (main span)
Back spans and main span cast simultaneously

# Superstructure
# (back spans on falsework)

## Superstructure
## (main span – precast segments)
## (casting yard – longline casting)

All 8 headings cast simultaneously
Longline casting method
Heated enclosures



Segment lengths - 13.5' to 16.5'
Weights - 380 kips to 216 kips
15 segments per cantilever

Superstructure
(main span – precast segments)
(unidirectional cantilever)

## Spans 1 and 3

CIP casting complete
Longitudinal span PT stressing complete
Currently supported on falsework

## Span 2
## (precast main span)

- Precasting is complete
- 120 precast segments were placed in 47 days
- Placed up to 6 per day

## Span 2

Precast Segment Erection

## Span 2

Cantilever Erection

- Monuments at bridge Ends

- Monuments with Aesthetic lighting

# I-35W Progress

## Project Milestones

*Taking on the many challenges of building the new I-35W Bridge on an accelerated schedule has provided an opportunity to show the world—because the world was watching—how a city can triumph over tragedy.*

*– Peter F. Sanderson, Flatiron-Manson Project Manager*

First Sidewalk Superintendent Talk conducted by Peter Sanderson

First drilled shaft installed; reinforcing is shown being prepared for the shafts

**Design Started 10/8/07**

**Construction Started**

| | | | | | | |
|---|---|---|---|---|---|---|
| DATE | 10/15/07 | 10/24 | 11/1 | 11/10 | 12/4 | 1/12/08 |
| DAYS | 0 | 9 | 17 | 26 | 50 | 89 |
| TEMP | 52/47°F | 53/38° | 58/32° | 45/33° | 20/14° | 26/17° |

Community design charette

Test shaft drilled

Last drilled shaft installed

# I-35W Progress

First footing poured

Falsework construction began

Coldest day:
Low -14 Wind chill -36

First pier form removed

| 1/15 | 1/23 | 1/28 | 1/30 | 2/10 | 2/23 | 2/25 |
|---|---|---|---|---|---|---|
| 92 | 100 | 105 | 107 | 118 | 131 | 151 |
| 22/-5° | 3/-9° | 43/24° | -2/-14° | -4/-14° | 32/11° | 37/22° |

First pier poured

First segment, or box girder, cast

Last footing poured

# I-35W Progress


First box girder segment transported to Bohemian Flats

First concrete placed in Spans 1 and 3

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DATE | 3/14/08 | 4/2 | 5/1 | 5/7 | 5/25 | 5/31 | 6/6 | |
| DAYS | 151 | 170 | 198 | 205 | 223 | 229 | 235 | |
| TEMP | 40/27°F | 43/24° | 68/47° | 66/49° | 84/61° | 79/56° | 75/64° | |

Road deck concrete placement for spans over land started

First box girder segment placed

Last box girder segment cast

# I-35W Progress

Roadway concrete paving began

Last box girder segment erected

Northbound bridge cantilevers connected

| 6/16 | 6/30 | 7/10 | 7/16 | 7/24 | 8/1 |
|---|---|---|---|---|---|
| 245 | 259 | 269 | 275 | 283 | 291 |
| 73/52° | 83/59° | 85/63° | 85/63° | 84/68° | 87/66° |

Actual Opening 9/15
Day 336

Original Completion Date; design and build in fifteen months

Bridge casting in "Snowbound" white began

Southbound bridge cantilevers connected

Construction stopped at 3:00 p.m. for six hours in remembrance of August 1, 2007, 6:05 p.m.

Dedication & opening (eleven months)

# I-35W Progress

5-5-08

6-18-08

FIGG Creating Bridges as Art

# I-35W Progress



5-5-08

7-14-08

# I-35W Progress

May 2008

Open to Traffic Sept 2008

# I-35W Progress
# Open to Traffic September 15,

# New St. Anthony Falls Bridge

## GOALS

- Safety
  - No Lost time Accidents
- Quality
  - Detailed QC in Design and Construction
- Aesthetics
  - Award winning
- Public Relations
  - Exceptional in all aspects
- Enhancements
  - Eliminated Roadway exceptions, HP Concrete, Smart Bridge, LED Lights, etc
- Environmental Compliance
  - Throughout construction
- Time and Budget
  - About 3 months early and no extra cost

# FIGG Recommendations for DB Projects

- Mandate weekly meetings during RFP process
- Mandate OTS reviews and compel Owner/Designer Interaction
- Eliminate "red tape" delays all agencies should be as responsive as they were on I35W
- Encourage Innovation- HPC, silica fume mixes, LED lighting, etc

# I35W St. Anthony Falls Bridge Success

## TEAM EFFORT

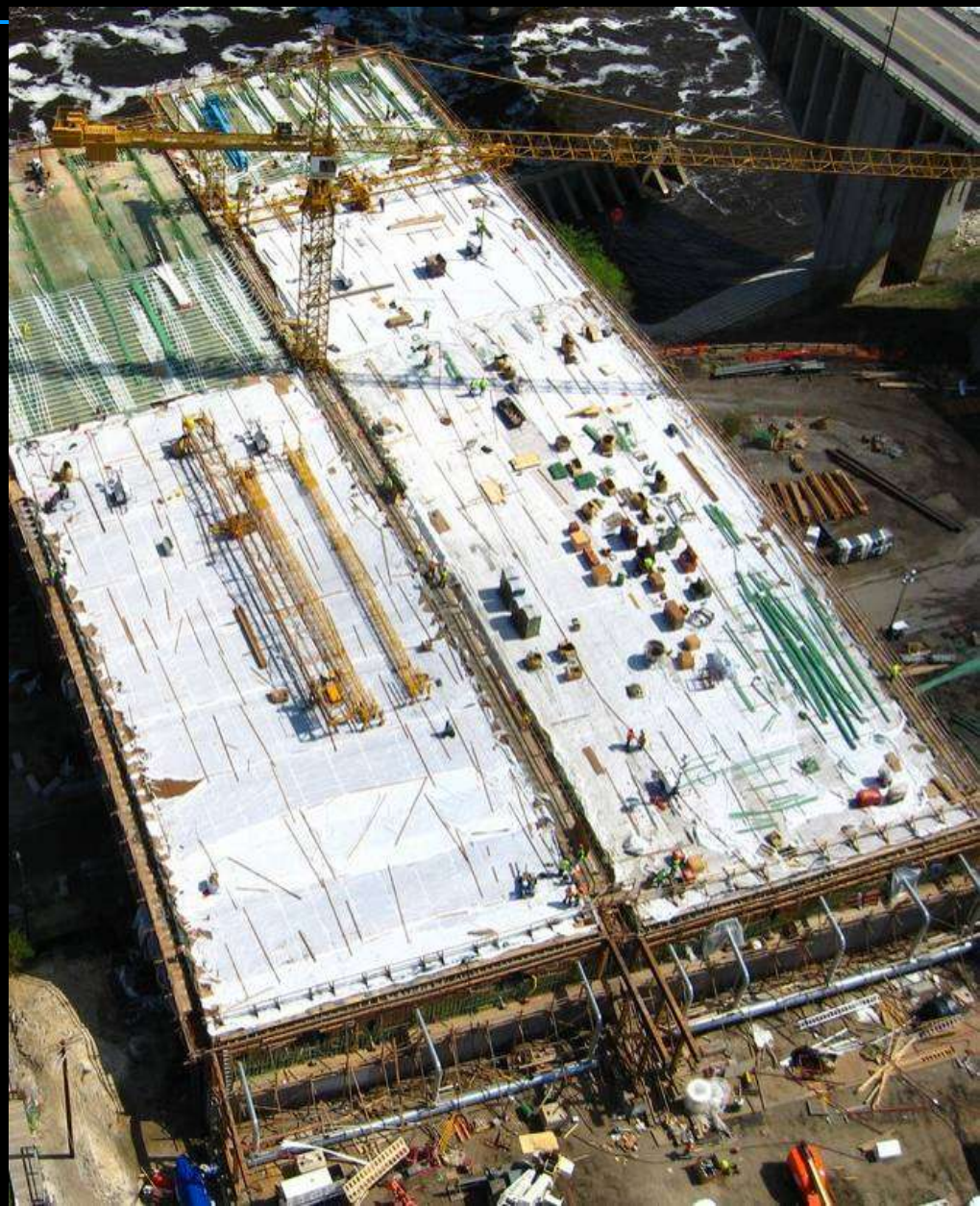
MnDOT and FHWA Professionalism

Local Union Labor

**Achieved High Quality and Safety** with an accelerated schedule

# Special Recognition and Thanks

- TKDA
- Braun-Intertec
- Aetos Aerial Images



# I35W St. Anthony Falls Bridge Questions