

# Construction of the Wichita Riverfront Cable-Stayed Pedestrian Bridges

IBC 07-87

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June 6, 2007

# *Presentation Outline*

- Project Introduction
- Bridge Component Construction & Erection
  - Sand Island & Cofferdams
  - Steel Towers
  - Concrete Deck Segments
  - Cables
- Finite Element Analysis
  - Staged Erection Analysis
    - 3D Modeling
  - Final Photos
- Acknowledgements

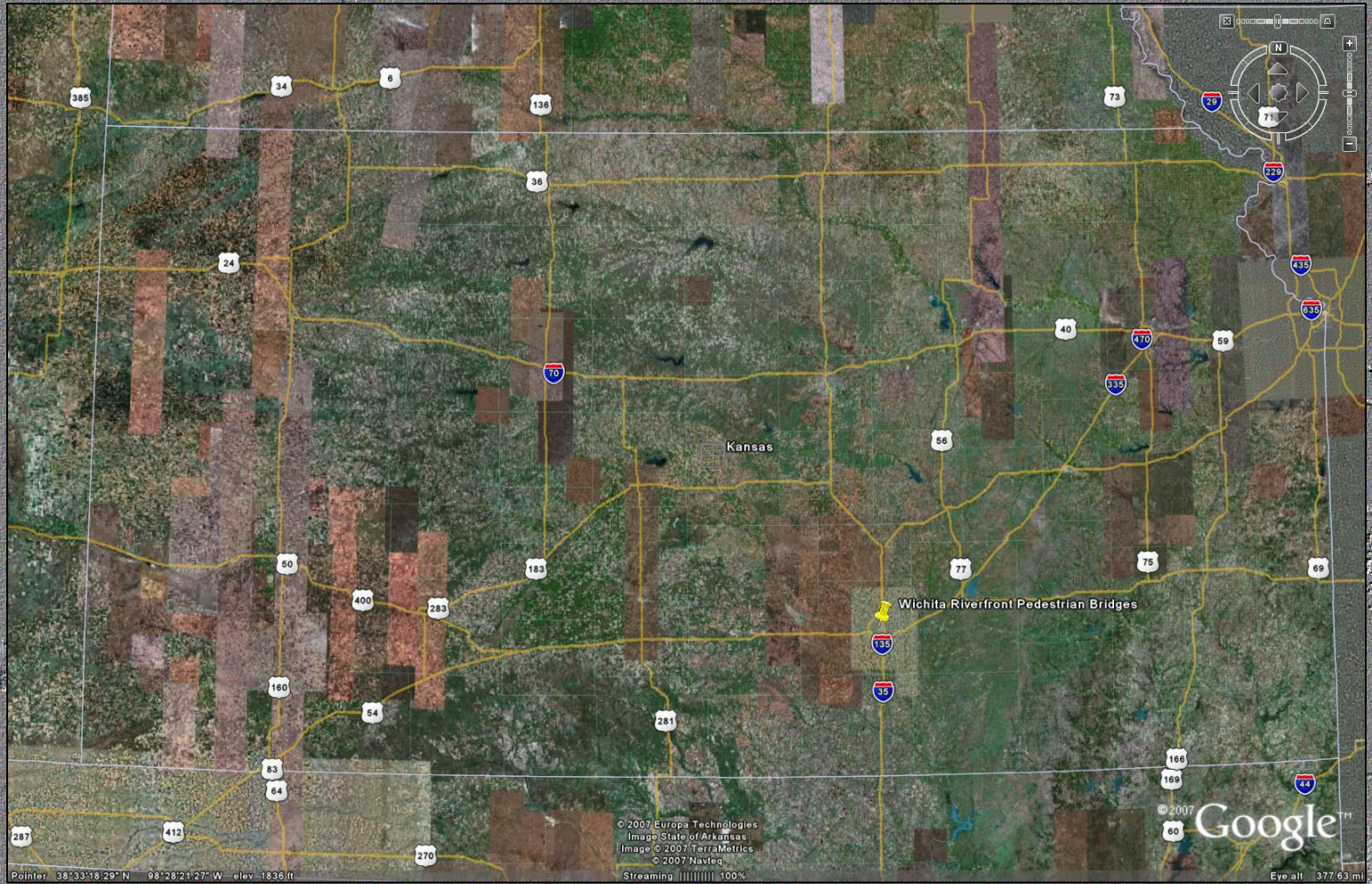




# Project Introduction



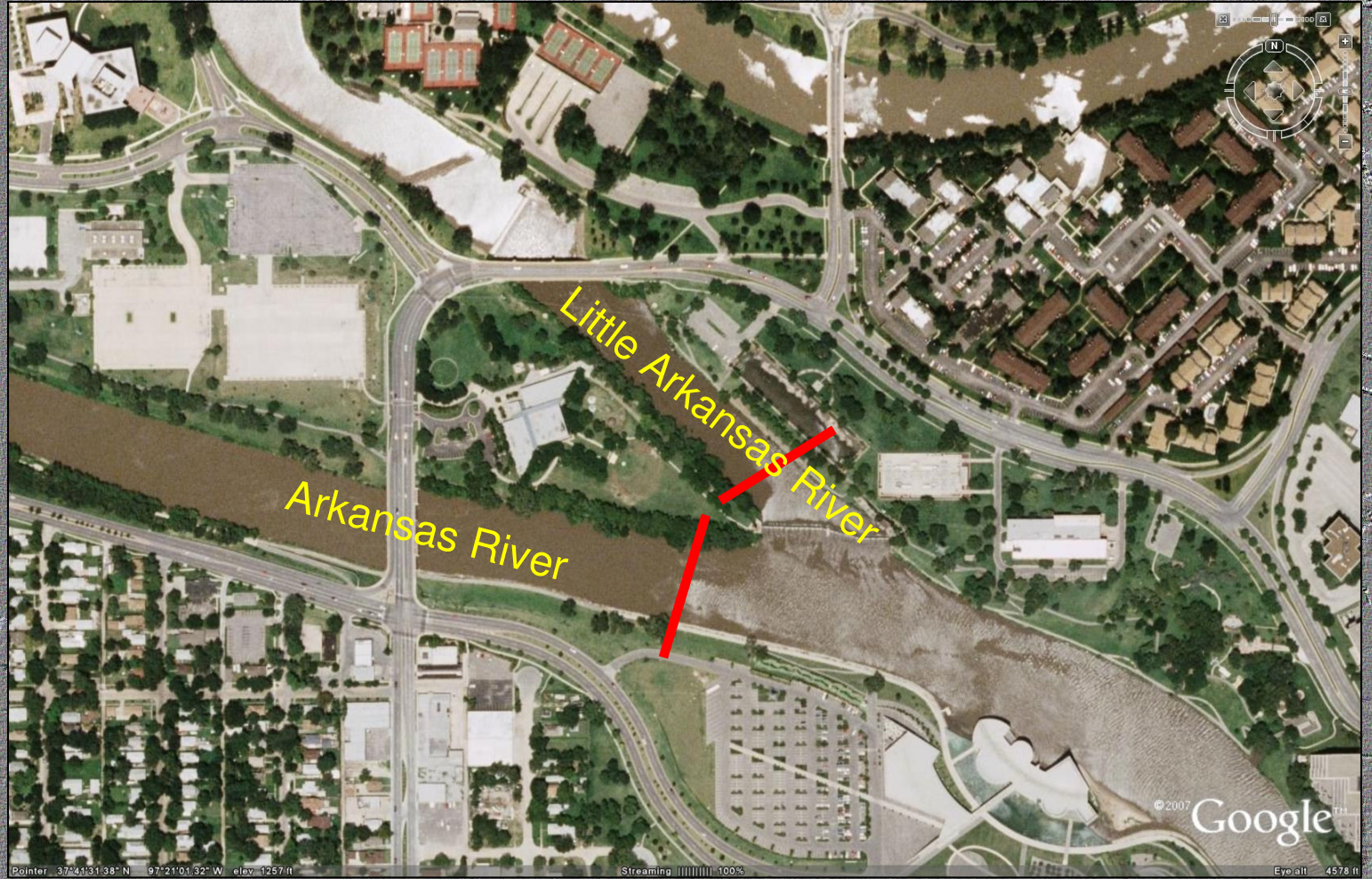
Location



Location



Location



Location



Bridge Site - 2001



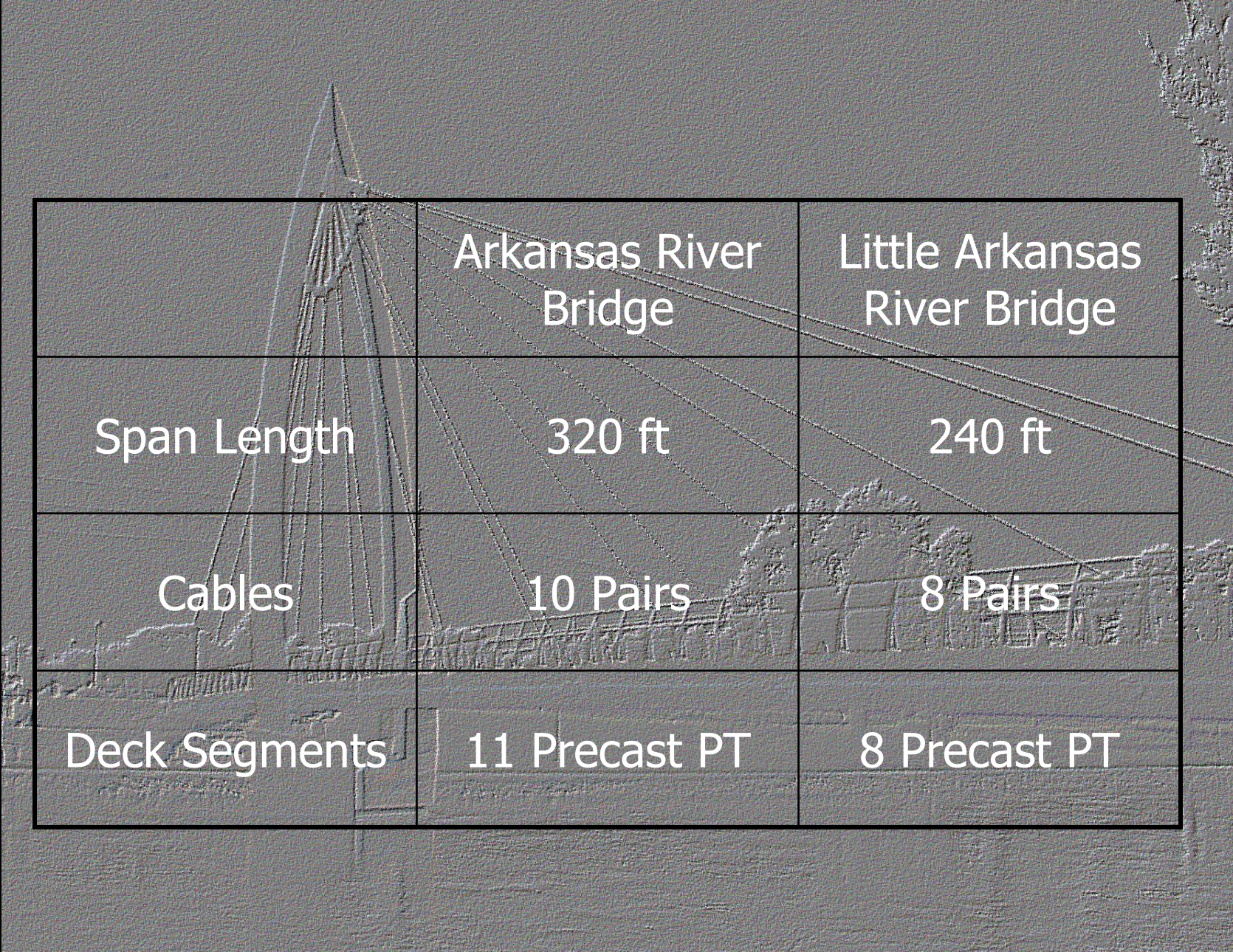


Image courtesy Law Kingdon

Bridge Site – Completed Rendering



# Keeper of the Plains Monument



	Arkansas River Bridge	Little Arkansas River Bridge
Span Length	320 ft	240 ft
Cables	10 Pairs	8 Pairs
Deck Segments	11 Precast PT	8 Precast PT

## Design Summary



# Bridge Component Construction & Erection

## Sand Island & Cofferdams

*Dondlinger & Sons Construction*



# Sand Island Construction

- Deck segmental construction required falsework
- River hydraulics and native materials made this construction technique feasible.
  - Dredged native sand and built-up a large working area.
  - Seasonal river flow and upstream hydraulic stage control made channel constriction an option.
- Fortunately, river flow remained low throughout construction and sand island remained in place.
- Minimal environmental impact since all materials were native to the river.

# Sand Island Construction



Sand Islands

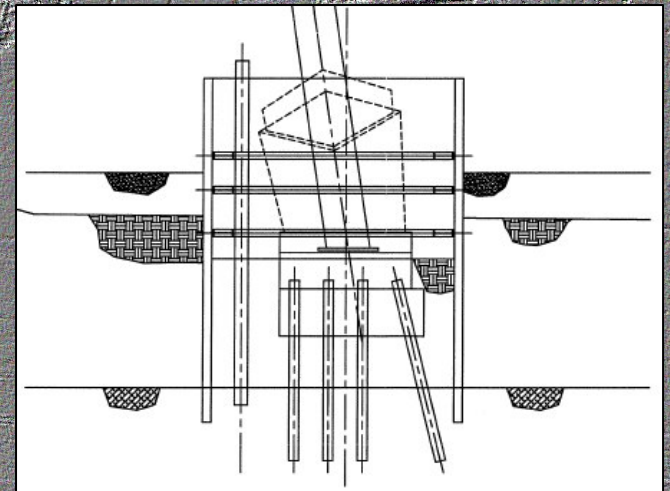
# Sand Island Construction



Sand Islands

# Cofferdam Construction

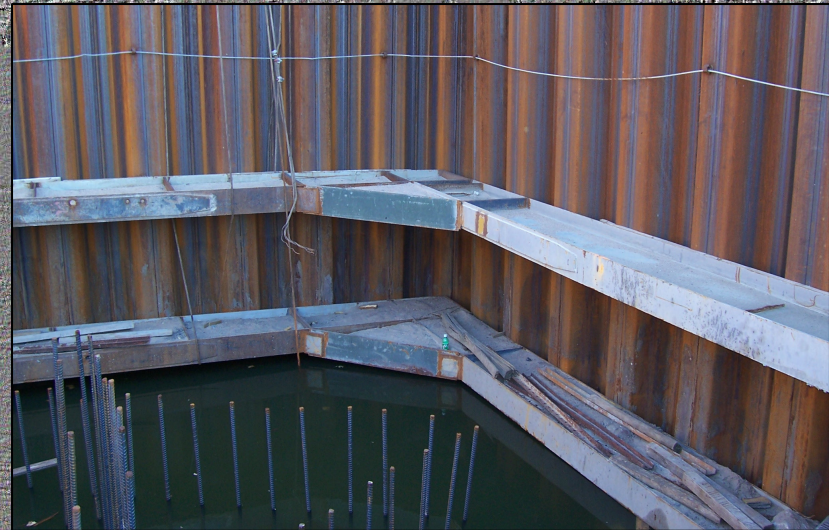
- Cofferdams were required to construct the tower base and foundation.
- Cofferdams provided access for:
  - Construction of large pile-supported tower footings
  - Setting steel tower leg base
  - Construction of unique CIP concrete tower base



Cofferdams



# Cofferdam Construction



# Bridge Component Construction & Erection

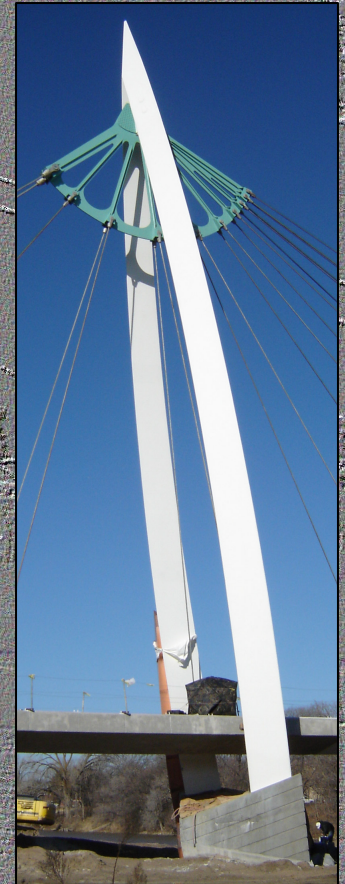
## Steel Towers

*Fabrication by PDM Bridge*



# Steel Tower Design Features

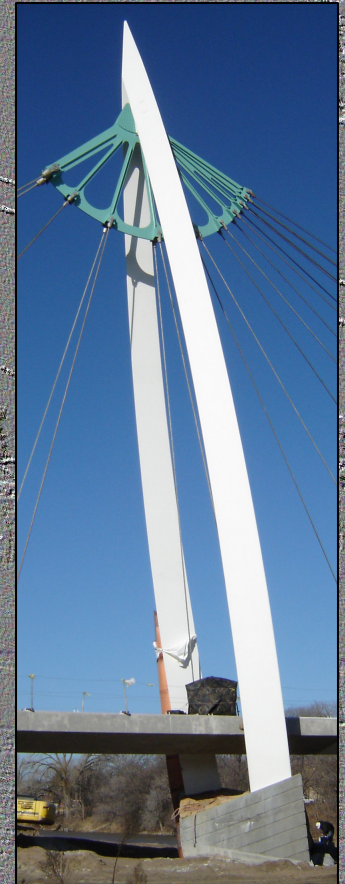
- 125' tall "leaning" back at 8.5°
- Similar geometry for both bridges
- Triangular tapered cross-section
  - Triangle face dimension tapers from 5'-0" to approximately 3'-9"
  - Typical plate thickness = 2"
- Comprised of tower legs and Upper Cable Anchorage
- Partial Penetration Weld connects legs and Upper Cable Anchorage



Steel Towers

## Steel Tower Design Features (cont.)

- Tower Legs
  - “Banana” shaped (tapered and curved)
  - Length = 110'
  - Weight = 60 Tons
- Upper Tower Segment & Upper Cable Anchorage
  - Unique geometry
  - Approximately 25' x 30'
  - Weight = 60 Tons



Steel Towers

# Tower Legs - Fabrication



Fabrication by PDM Bridge



# Upper Cable Anchorage - Fabrication



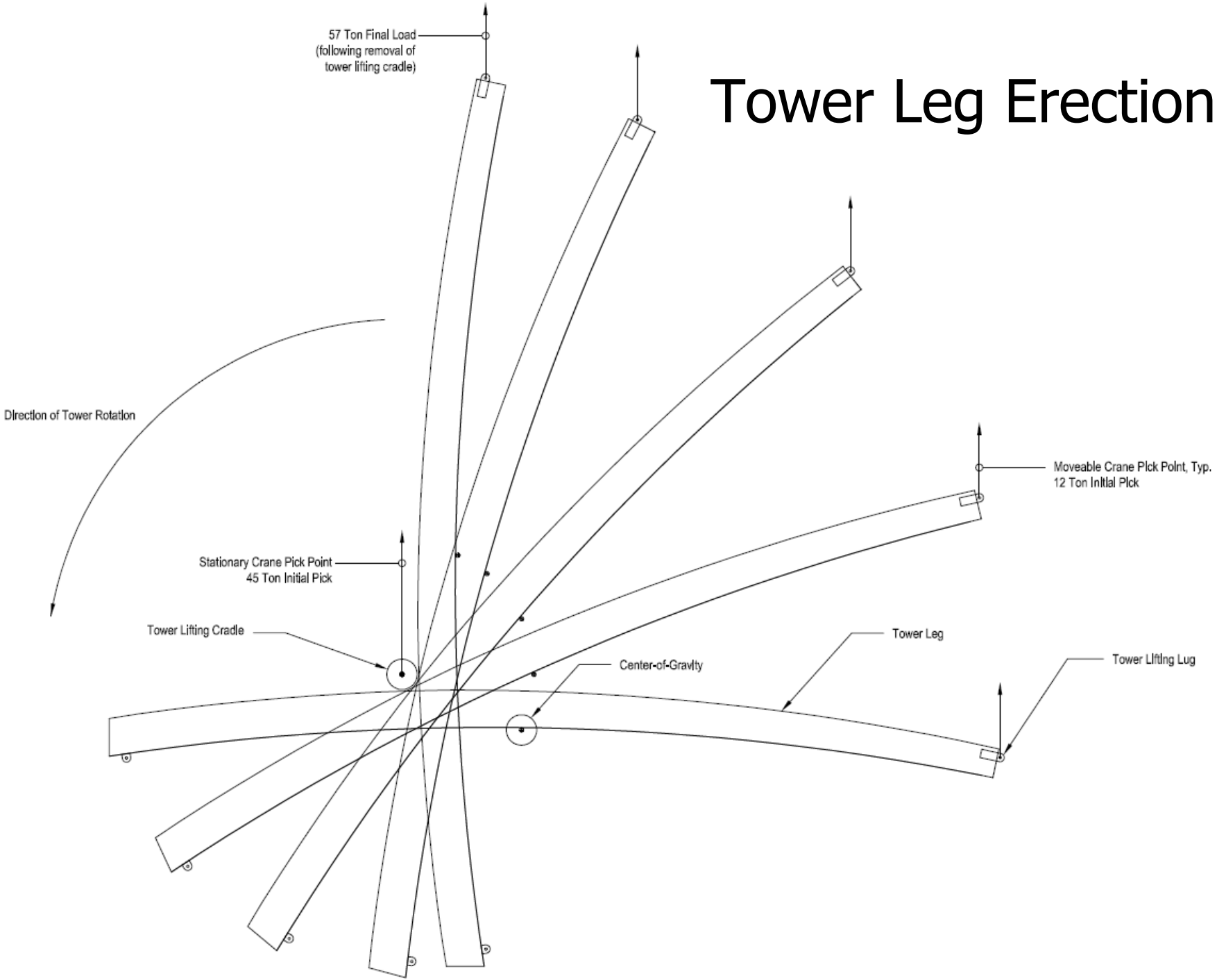
Fabrication by PDM Bridge



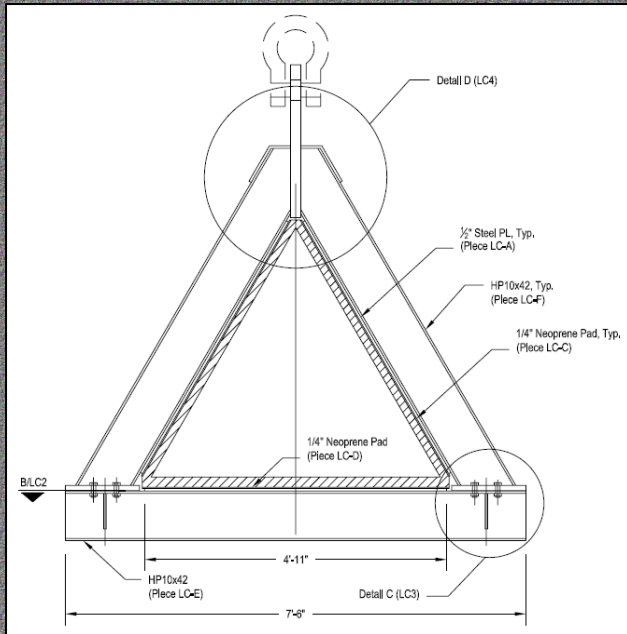
## Tower Leg Erection

- Unique geometry – “Banana”
  - CG location within curve
  - Smooth shape – difficult to pick
- Two-crane pick
  - Pick flat from truck
  - Rotate up
  - Pull bottom into “leaning” geometry
- Designed & fabricated a custom lifting assembly

# Tower Leg Erection







Tower Lifting Cradle

# Tower Leg Erection



# Tower Leg Erection



# Tower Leg Erection



# Tower Leg Erection

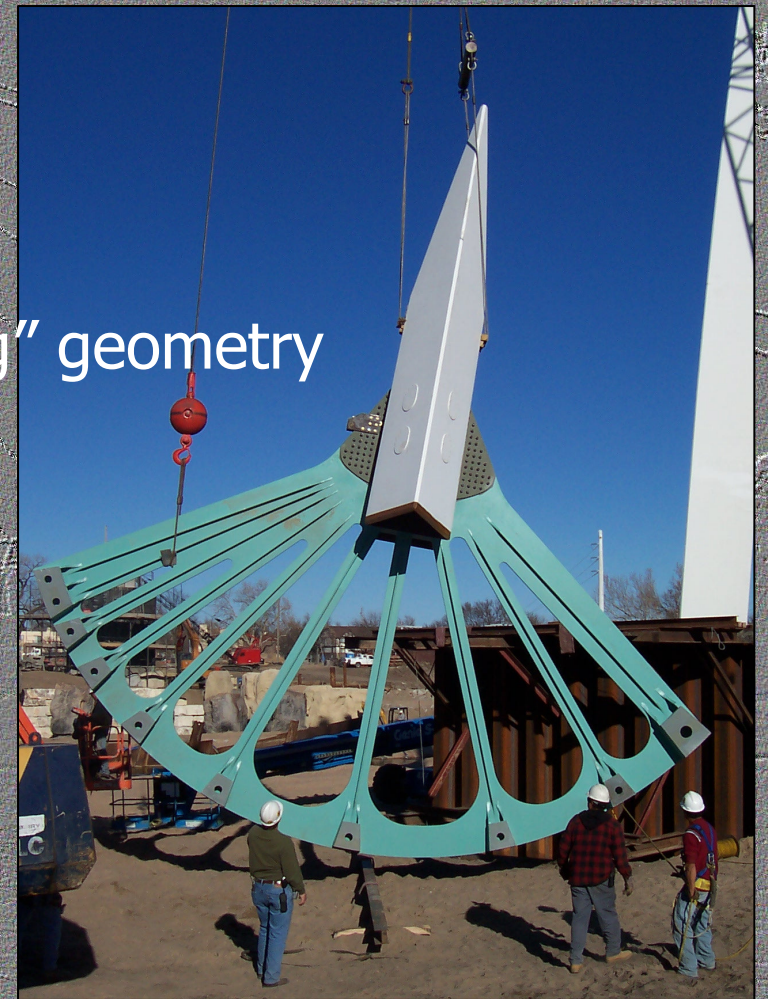
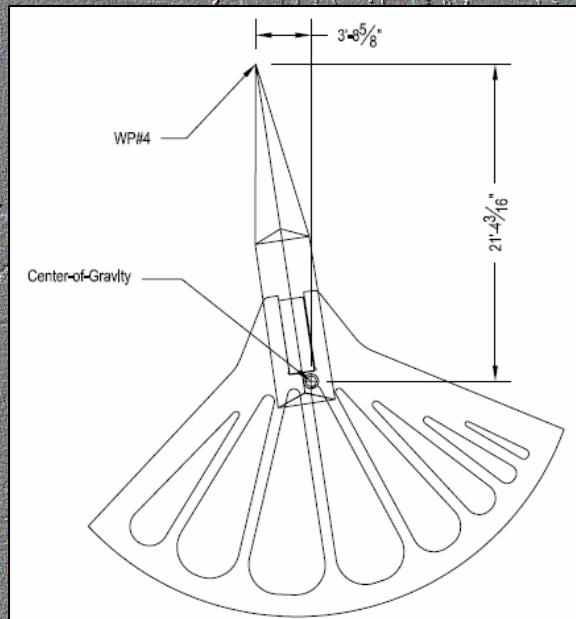


# Tower Leg Erection



# Upper Tower & Anchorage Erection

- Unique geometry
- Single-crane pick
  - Pick from falsework
  - Pull bottom into “leaning” geometry



Steel Towers

# Upper Tower Erection





# Upper Tower Erection



# Completed Tower





# Bridge Component Construction & Erection

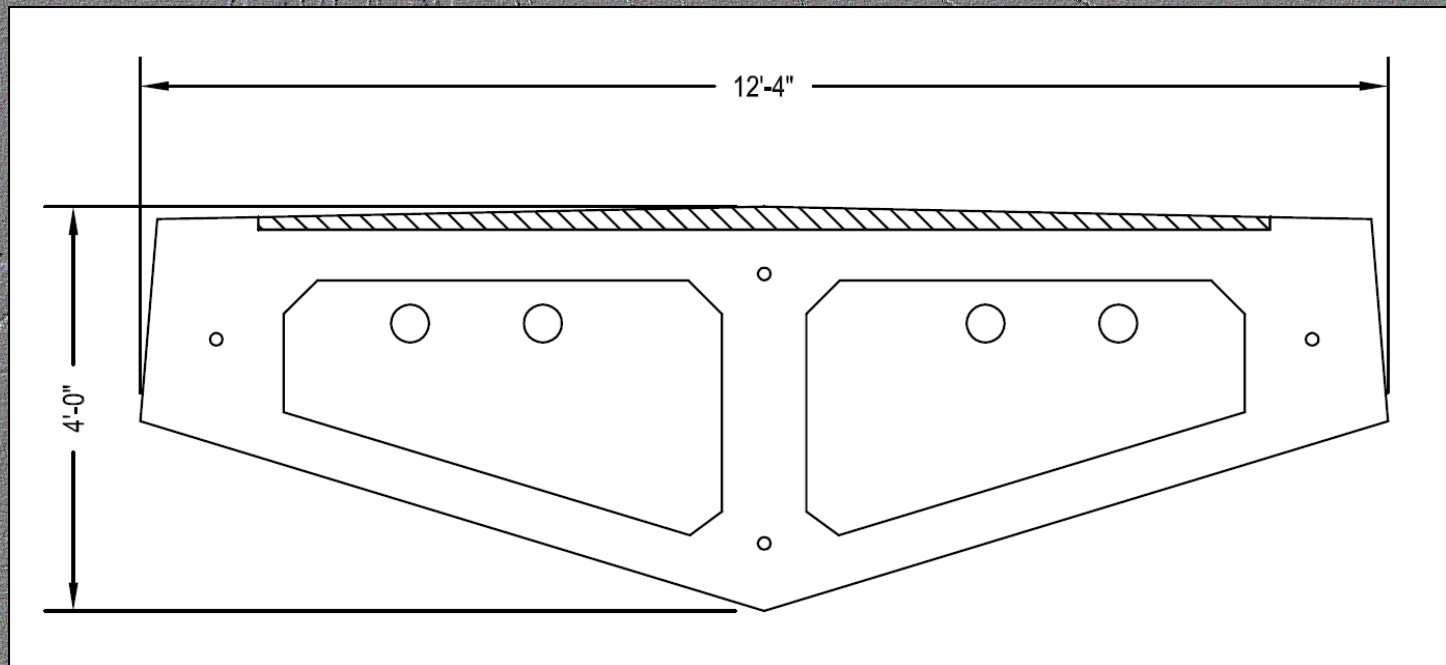
## Concrete Deck Segments

*Fabrication by Coreslab Structures, Inc.*

**CORESLAB<sup>®</sup>  
STRUCTURES**

# Concrete Deck Segment Dimensions

- Two-cell hollow trapezoidal section
- 12'-4" wide x 4'-0" deep x 32' long
- Typical Segment Weight = 55 Tons



Deck Segments

# Deck Segment: 3D Rendering

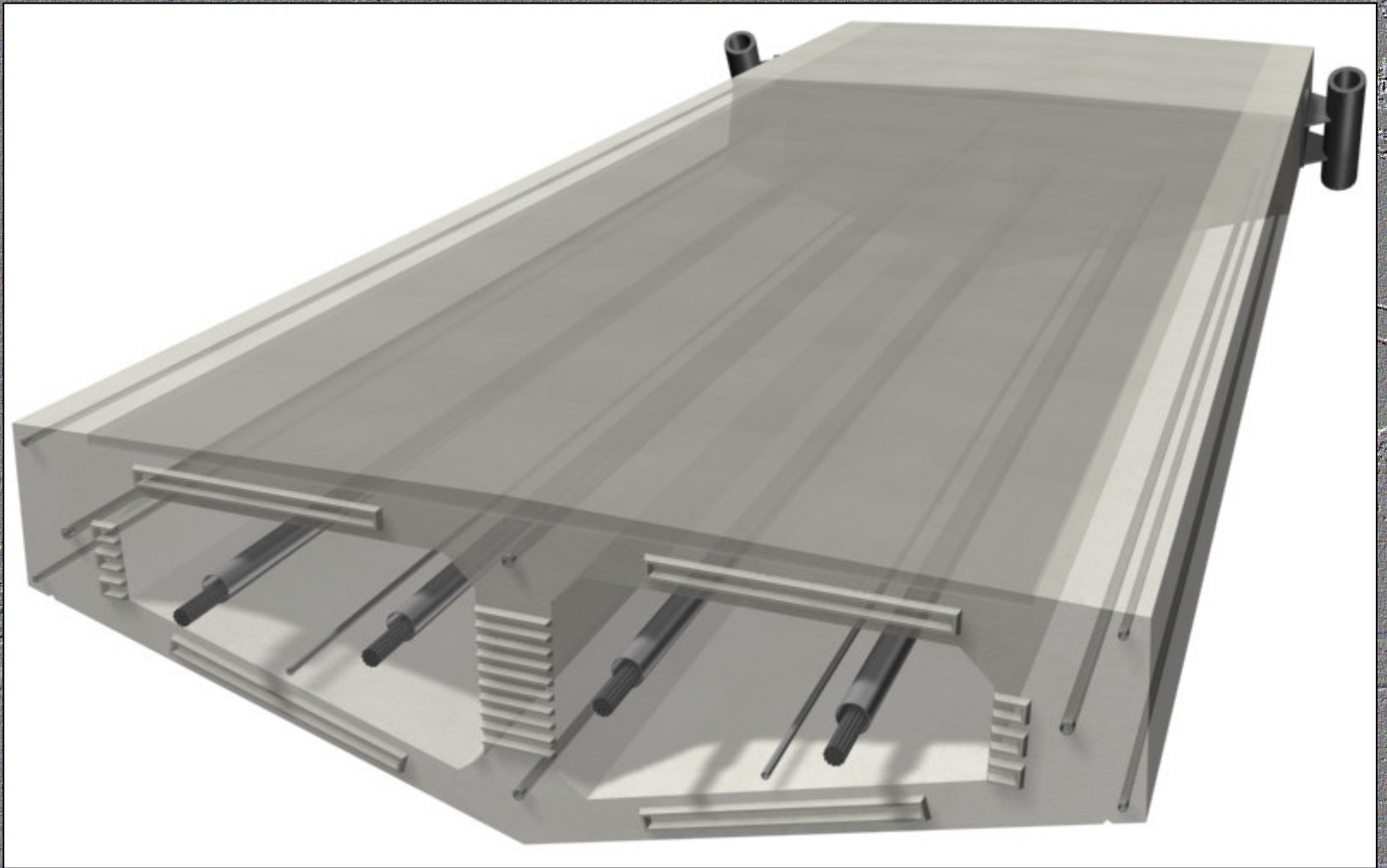
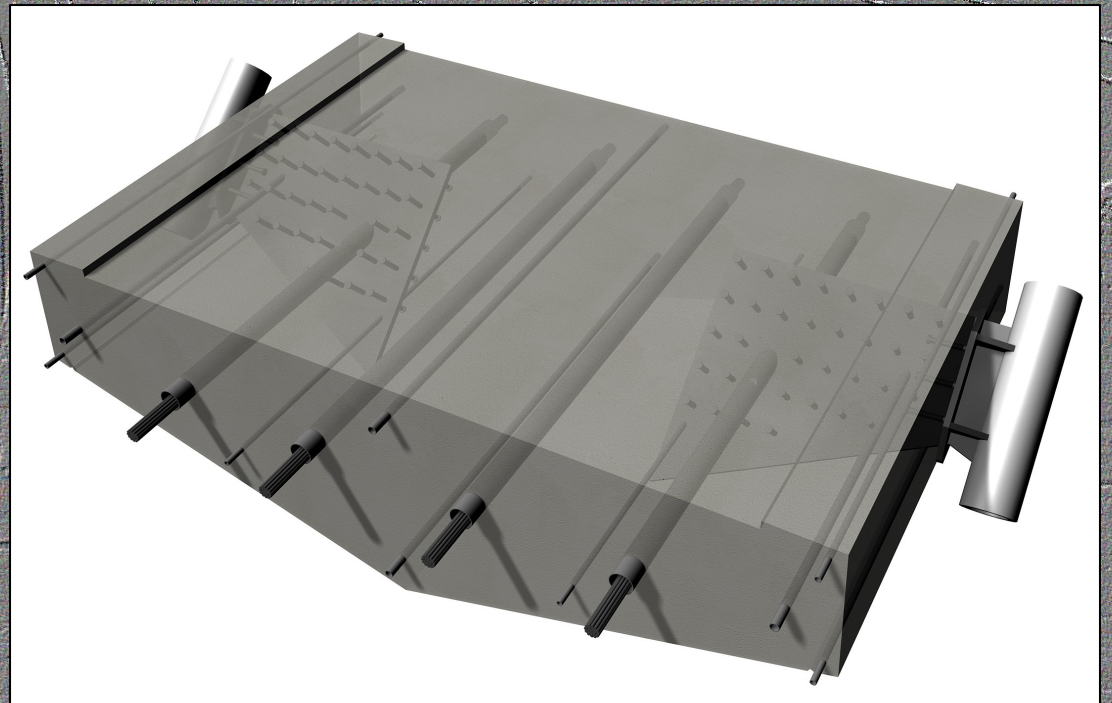
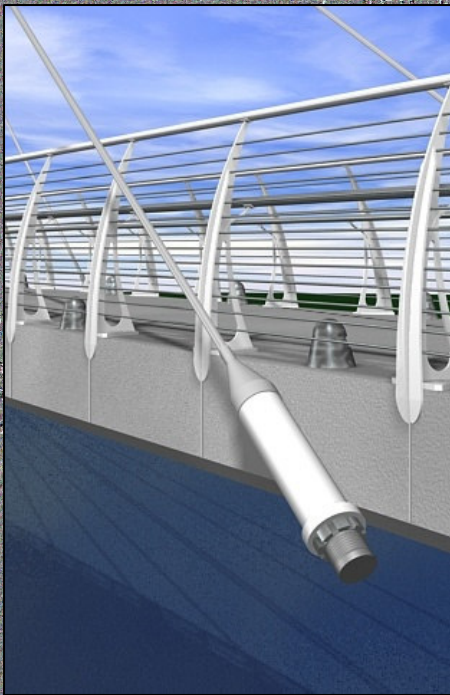


Image courtesy HNTB Corporation

## Deck Segments

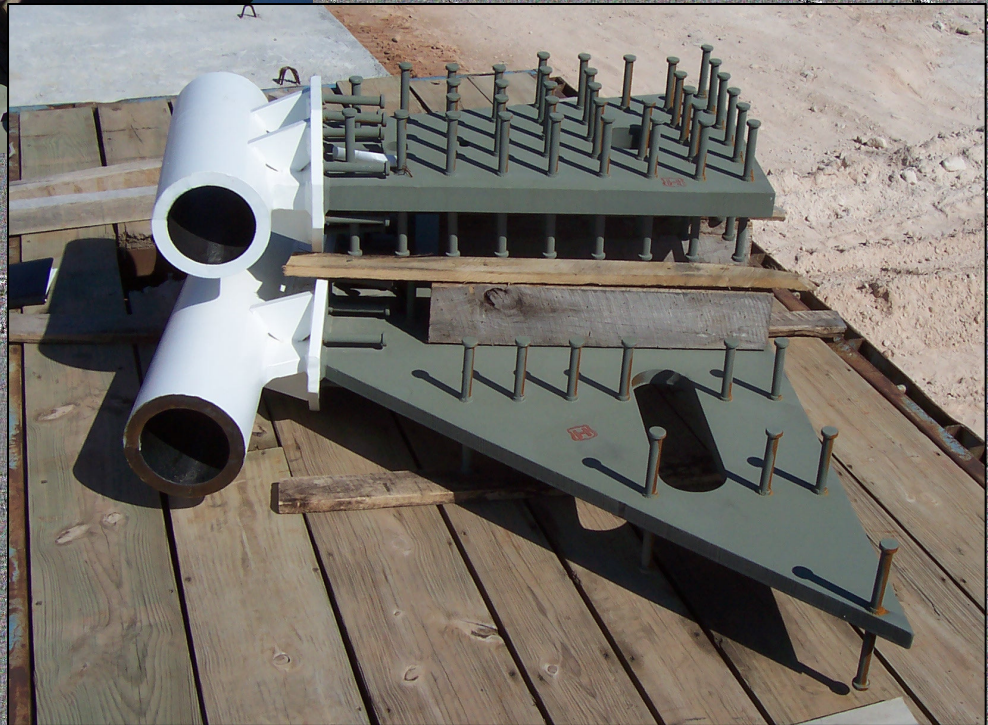
# Cable Connection Details

- Include lower cable attachment assembly
  - Embedded anchor plate & steel pipes
  - Anchor plates must accommodate PT



Images courtesy HNTB Corporation

Deck Segments



Cable Anchors

# Concrete Deck Segments



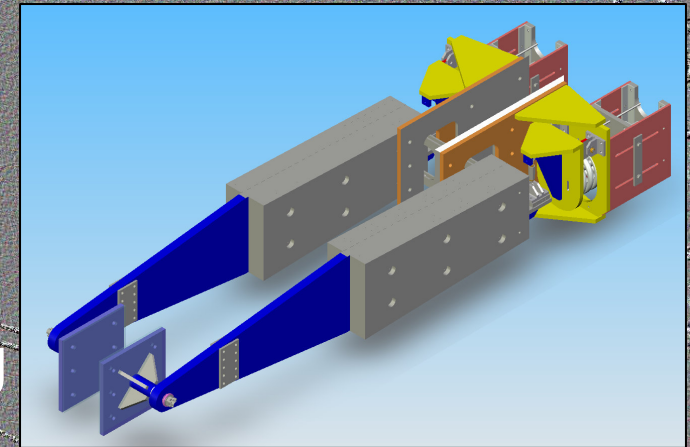
Precast fabrication by Coreslab Structures (Oklahoma City)

**CORES LAB**  
**STRUCTURES**



# Tuned Mass Dampers

- 2 TMDs @ Each Bridge
- Controls bridge vibrations
- Tuned per dynamic testing



Dynamic testing and TMD design / fabrication by Motioneering, Inc.

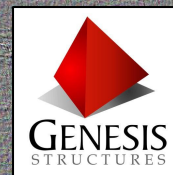


# Tuned Mass Dampers

# Bridge Component Construction & Erection

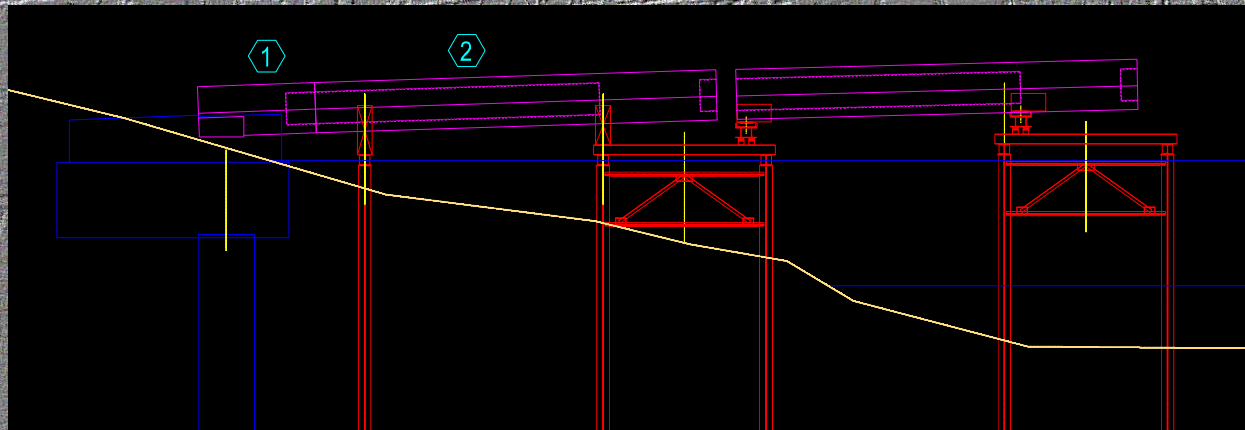
## Falsework

*Designed by Genesis Structures*



# Deck Falsework

- Temporary structures designed to support the deck segments during construction
- Required to accommodate longitudinal motion
  - Decks placed then rolled into final position
  - Specially-designed saddle



Deck Falsework

# Deck Falsework



# Deck Panel Placement



# Deck Panel Placement



- Post-Tensioning

- (4) 1" Diameter Grade 150 Bars @ 77 kips each
- (4) 19-Strand tendons (Gr. 270) @ 835 kips each

**Need more photos or info**

Deck post-tensioning by VSL, Inc.



Deck Post-Tensioning

# Bridge Component Construction & Erection

## Cables

*Fabrication by WRCA  
Castings & Fittings by CBSI, Inc.*





## Cable Details

- ASTM A586 Structural Strand
  - 2" Diameter Typical
  - 3 3/8" Diameter at end cables
- Fixed-length cables
  - Open-strand bridge sockets @ top
  - Type 7 adjustable sockets @ bottom
- Cable installation & Tensioning
  - Initial install operation & tension to small value
  - Second pass tension to planned values

# Cable Fabrication



Type 7 socket



Open strand socket



Cable fabrication by WRCA. Castings furnished by CBSI, Inc.

# Cable Installation & Tensioning





# Finite Element Modeling

## Staged Erection Analysis

*Software by*

**LUSAS**

# Staged Erection Model

- Global structural model to analyze construction activities & bridge effects
  - Staged construction
  - Vertical (compression-only) falsework for liftoff
  - Post-tensioning
  - Creep
  - Shrinkage
  - Cable tensioning sequence

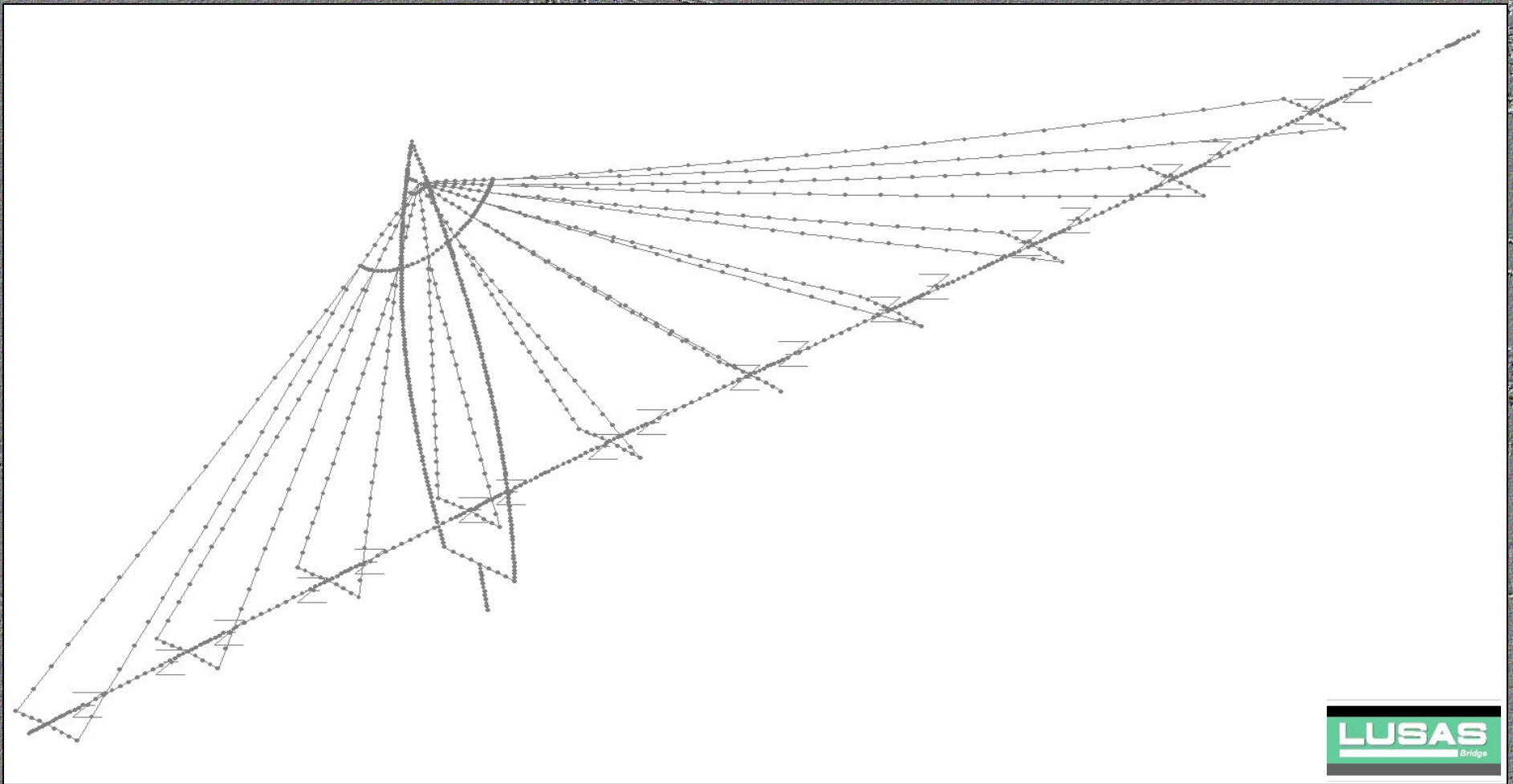
Finite Element Analysis

## Staged Erection Model (cont.)

- Results
  - Verification that construction activities do not overstress the structure
    - Tower
    - Deck
    - Cables
  - Revised camber diagram
  - Anticipated deflections
  - Falsework reactions for design
  - Specific cable tensioning sequence

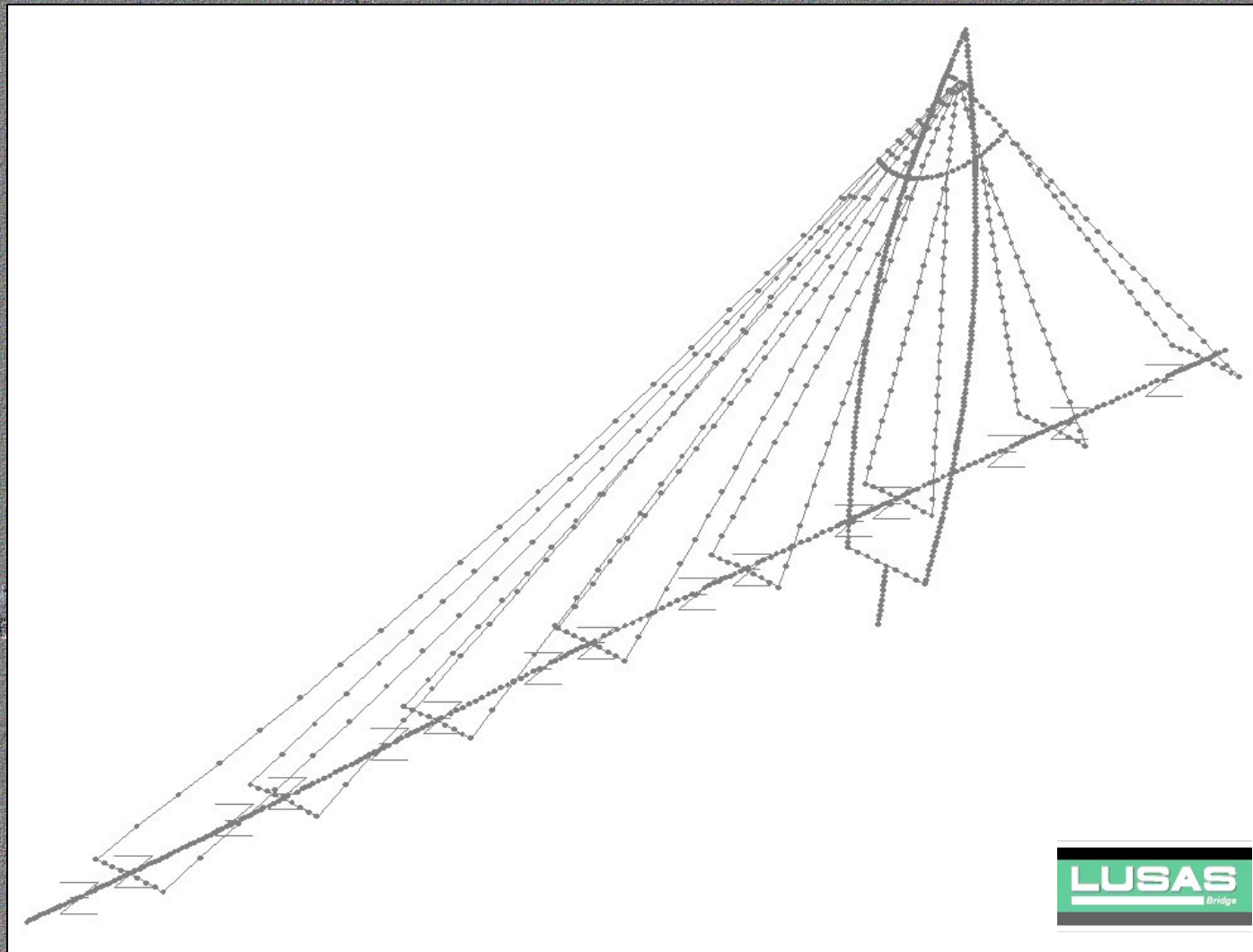
Finite Element Analysis

# Staged Erection Model



Arkansas River Bridge

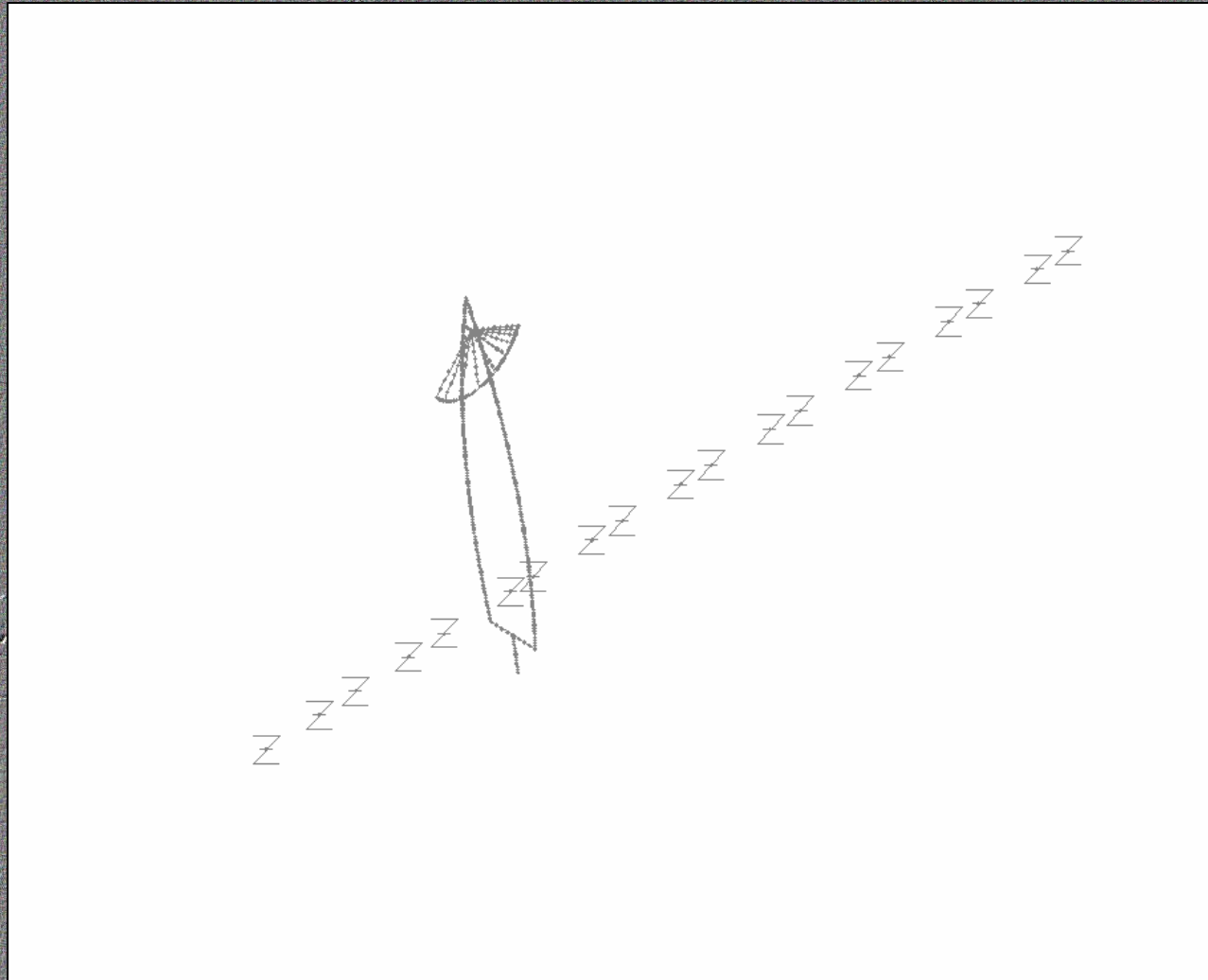
# Staged Erection Model



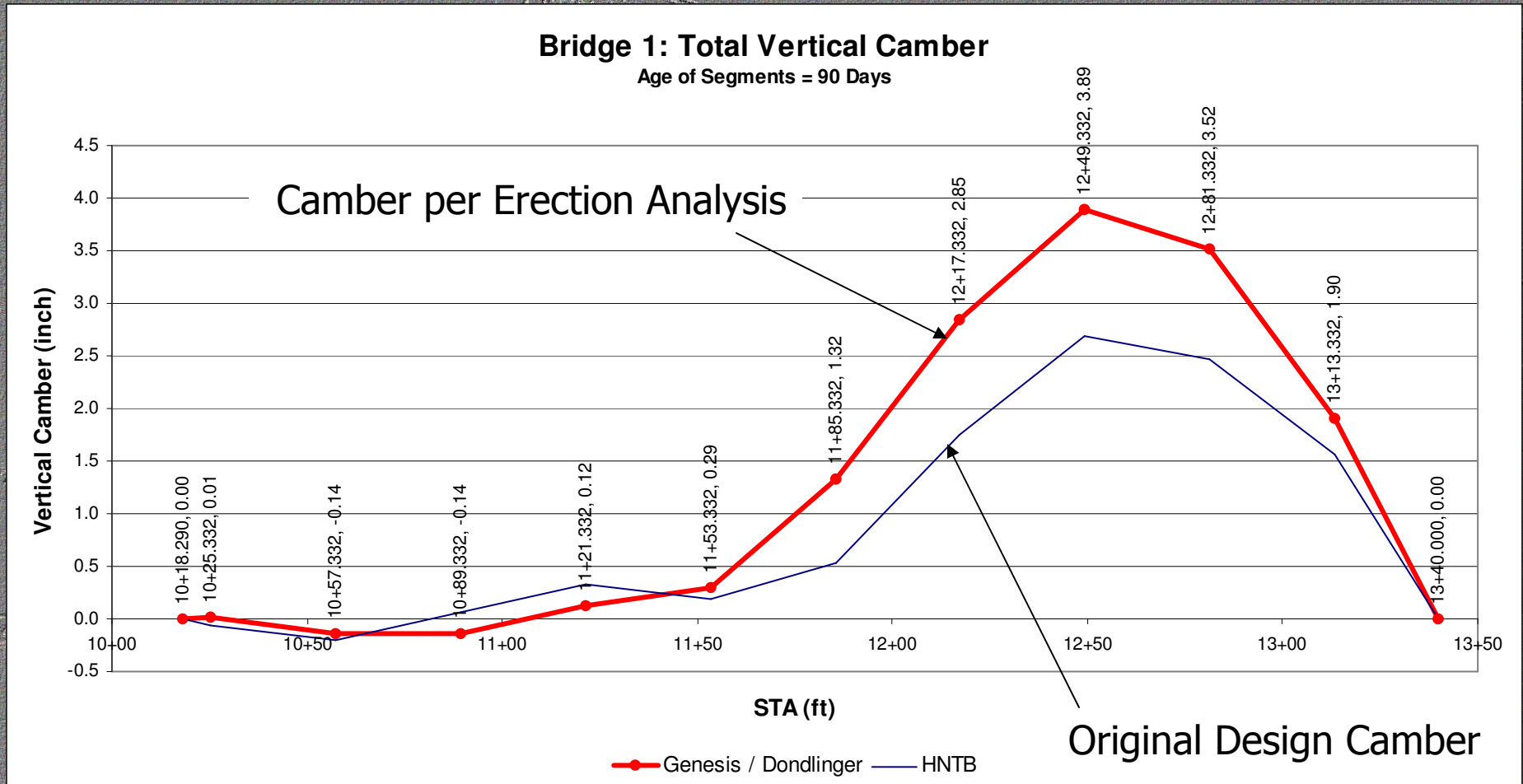
Little Arkansas River Bridge



# Staged Erection Model - Video

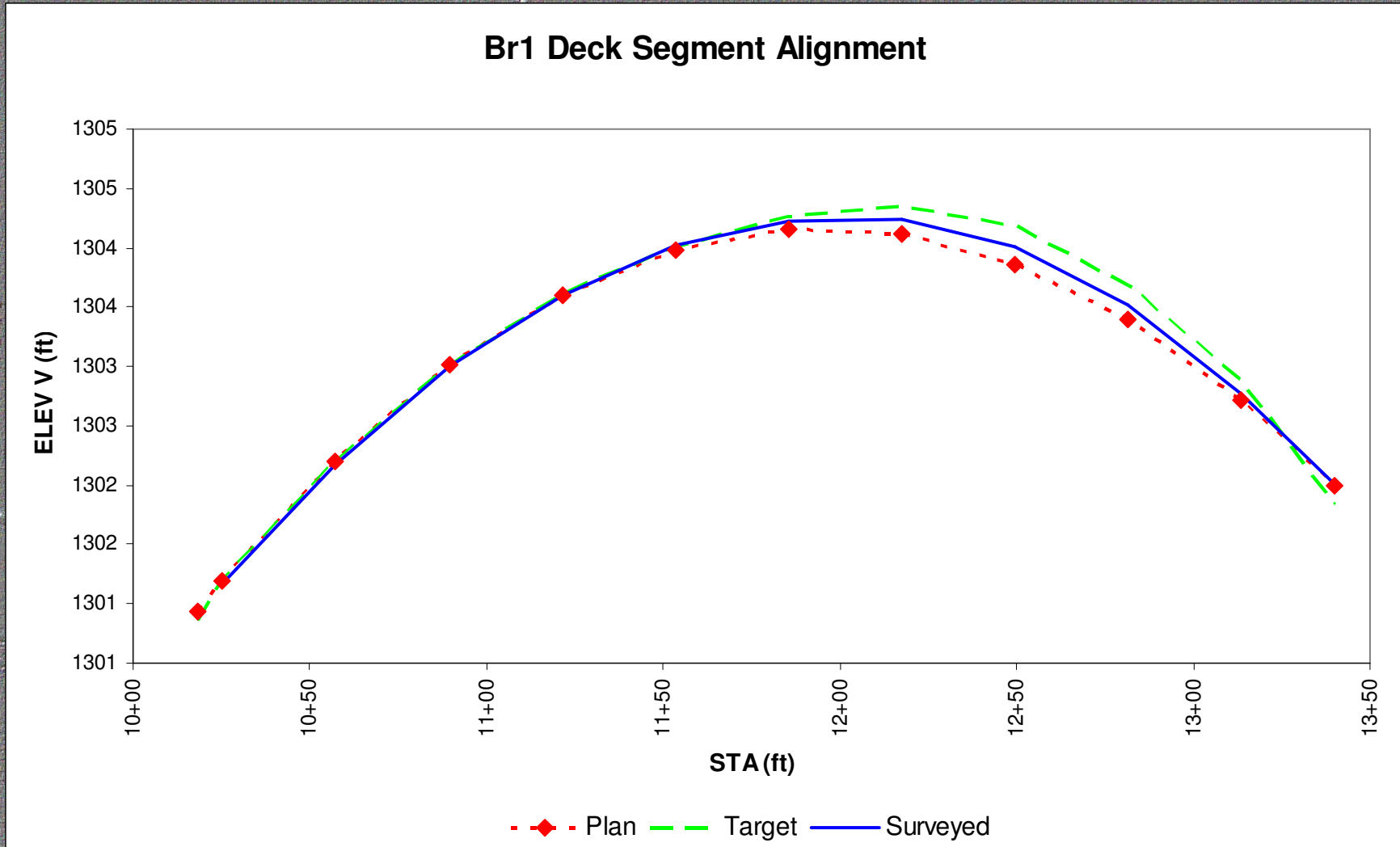


# Results: Deck Geometry



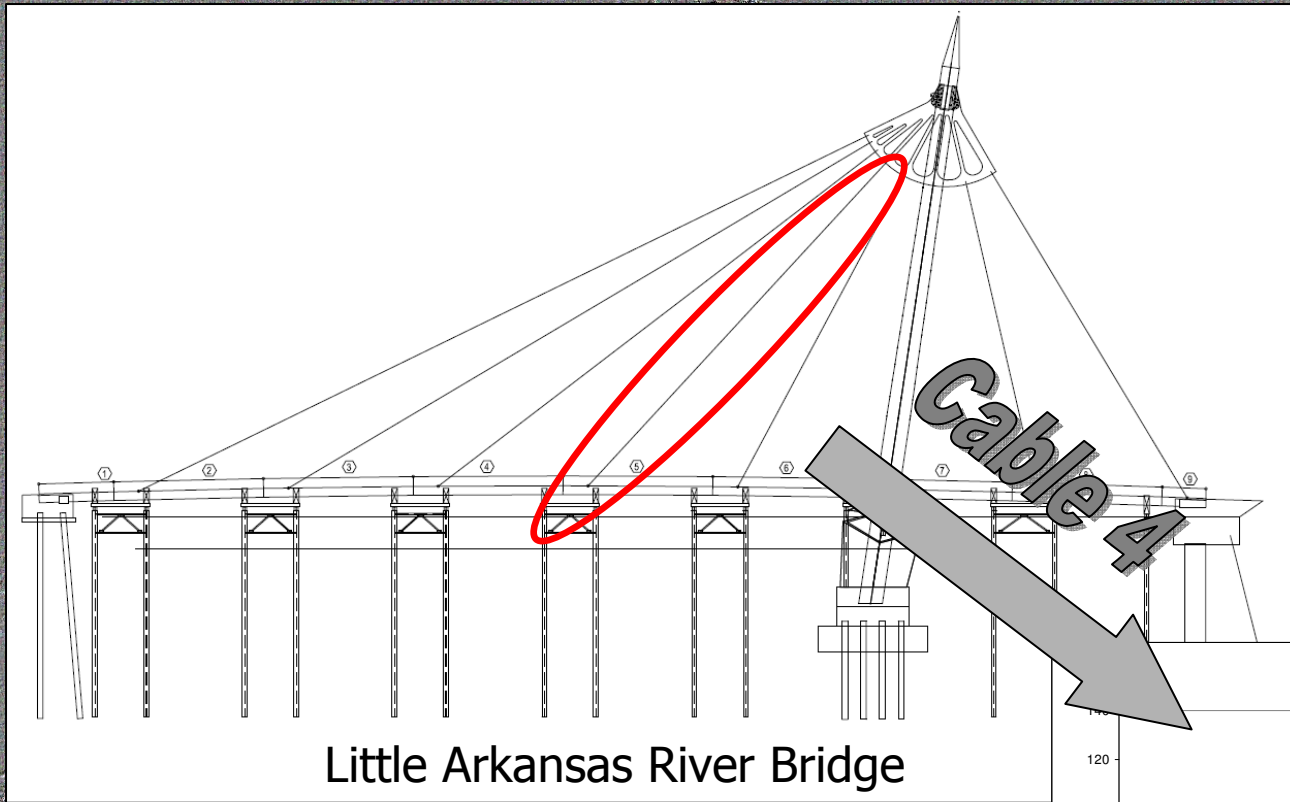
Camber Diagram - Arkansas River Bridge

# Results vs. As-Built: Deck Geometry

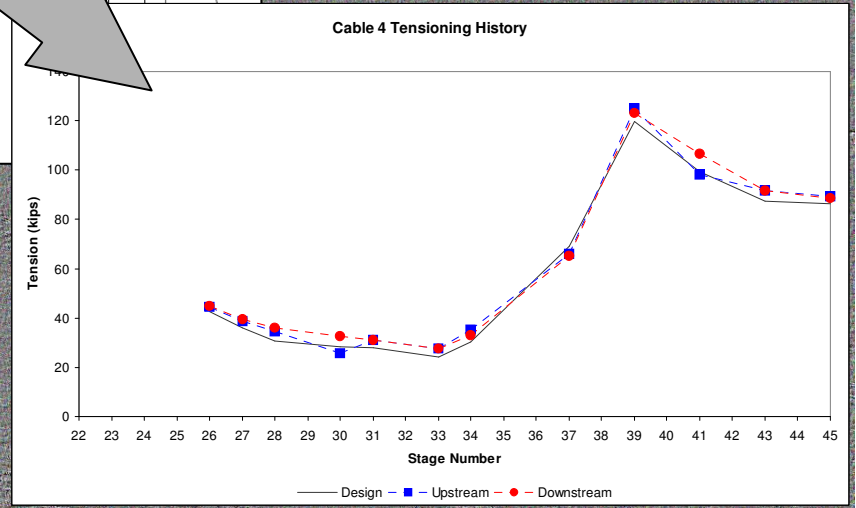


Deck PGE - Arkansas River Bridge

# Results: Cable Tension

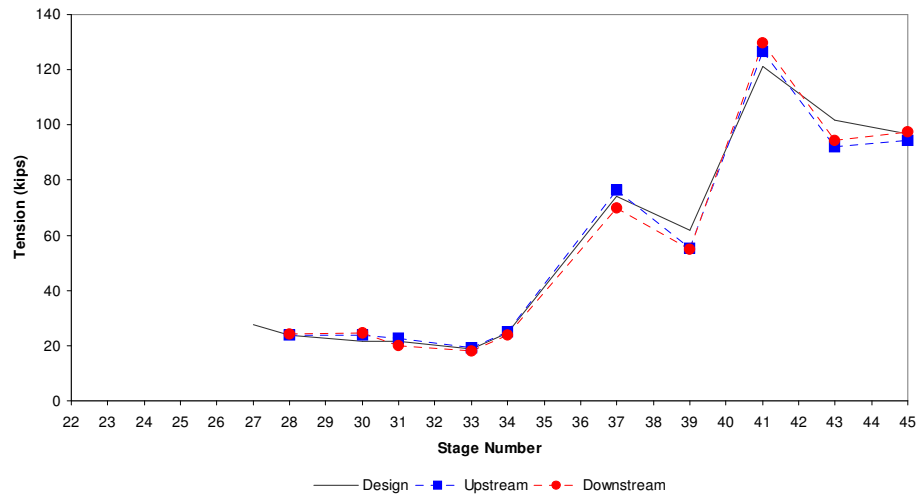


Little Arkansas River Bridge

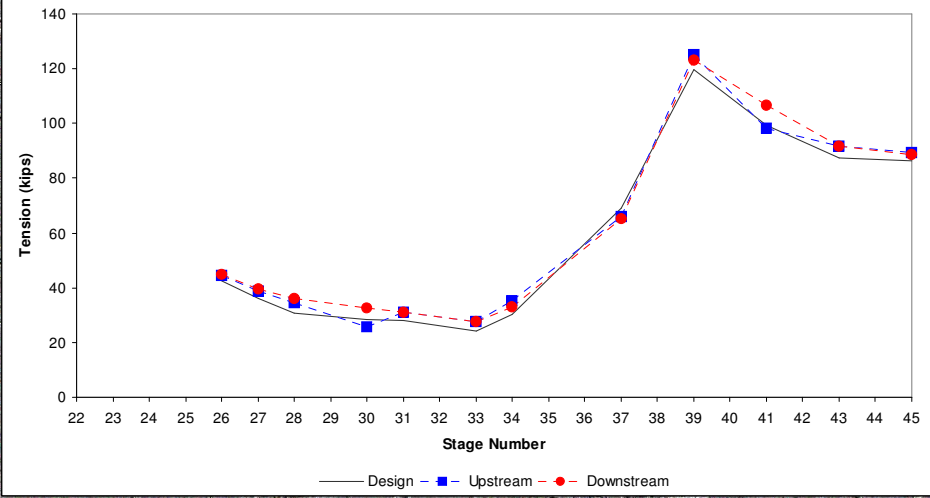


# Results: Cable Tension

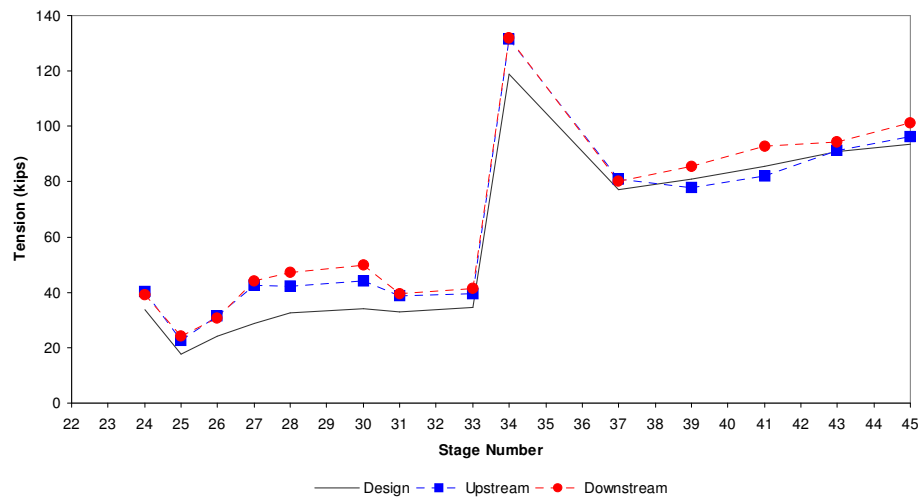
### Cable 3 Tensioning History



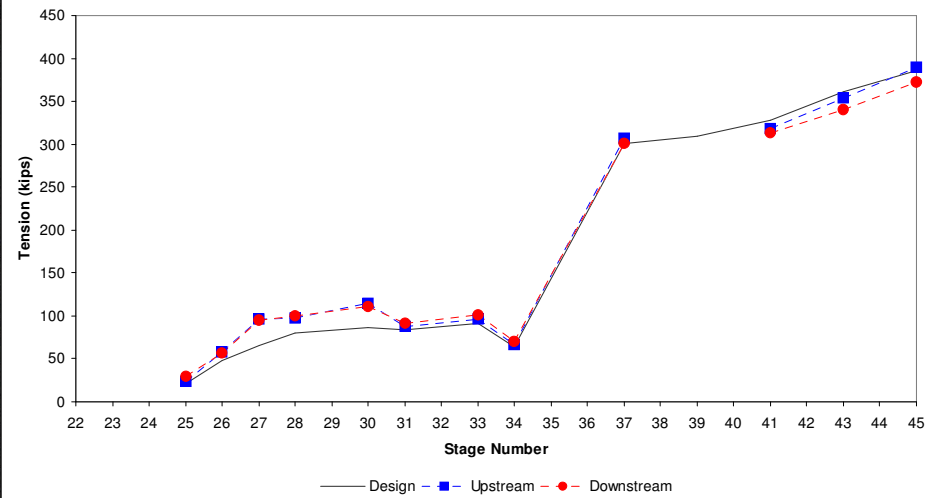
### Cable 4 Tensioning History



### Cable 7 Tensioning History



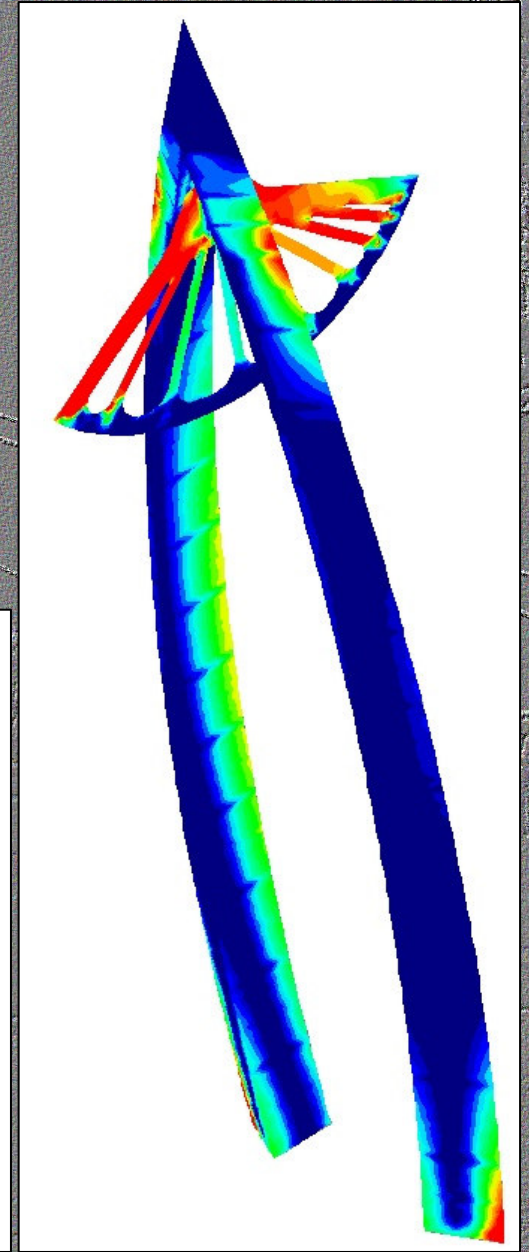
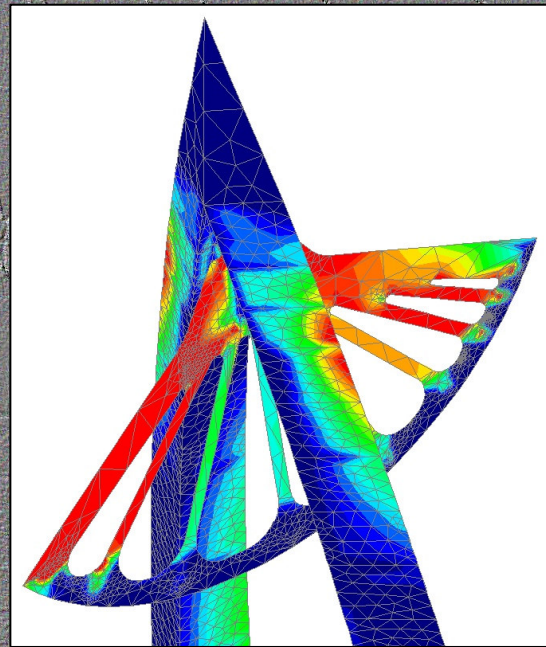
### Cable 8 Tensioning History



## 3D Analysis

- Tower stress analysis
  - Investigate high stress at top welds
  - Loading due to cable forces
  - Shell elements

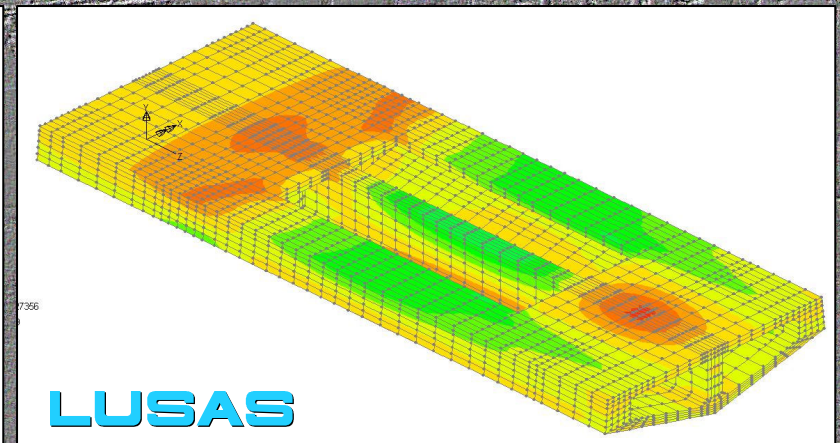
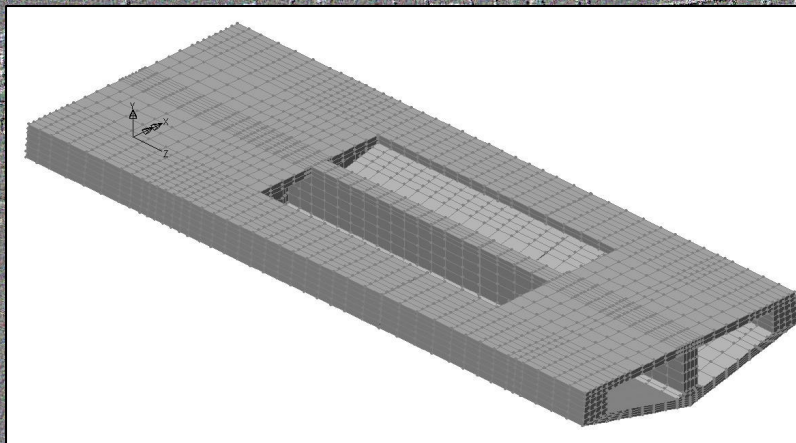
LUSAS



Finite Element Analysis

# 3D Analysis

- Deck Segment Analysis
  - Investigate stress transition through deck openings
  - Deck openings for TMDs
  - Lifting stress analysis
  - Solid stress elements



Finite Element Analysis



Final Photos





Final Photos

# Acknowledgements

*Owner:*

City of Wichita, Kansas



*General Contractor:*

Dondlinger & Sons Construction



# Acknowledgements (cont.)

## Construction Team

- *Cable Suppliers:* CBSI, Inc. & WRCA
- *Precaster:* Coreslab Structures (Oklahoma City)
- *Dynamics & TMDs:* Motioneering, Inc.
- *Steel Fabricator:* PDM Bridge
- *Post-Tensioning:* VSL
- *FE Program:* LUSAS
- *Erection Engineer:* Genesis Structures



## Design Team

- *Engineer-of-Record* HNTB Corporation
- *Project Architect* Law Kingdon

