



ABC of Detroit's Network Tied Arch using SPMTs

May 18th, 2023



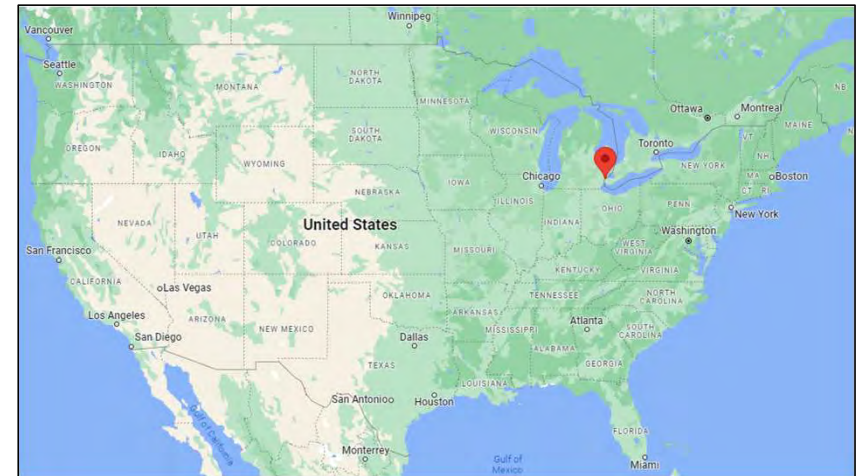
I-94 MODERNIZATION PROJECT



Presentation Agenda



- Welcome & Introductions
- Site Constraints
- Bridge Design
- ABC Alternatives
- Bridge Construction Engineering
- Bridge Move
- Q&A



Project Location – Detroit, Michigan

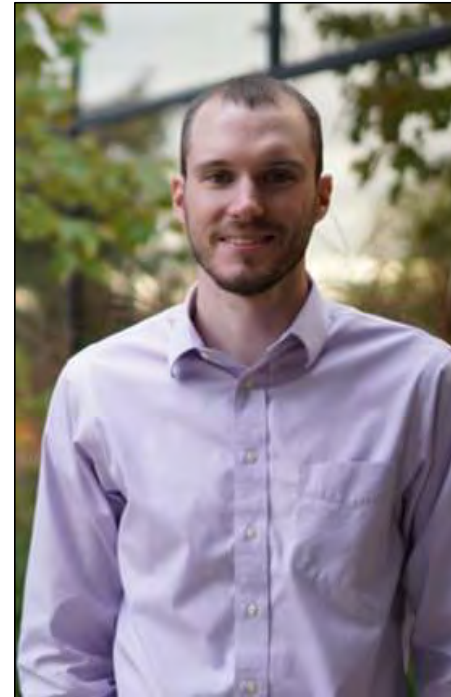
Welcome and Introductions



Mike LaViolette, PE, P.Eng.
National Bridge
Practice Leader



John Belcher, PE
Statewide Bridge
Construction Engineer



Matt Longfield, PE, SE
Michigan Bridge
Section Manager





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Concept Inception & Background

Arch Bridge Concept Inception



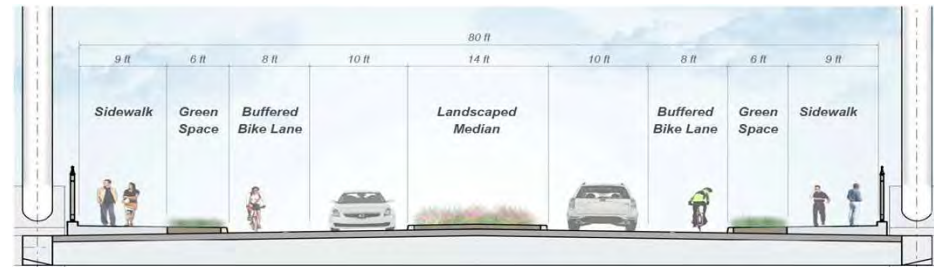
- MDOT's Advance Bridge Program Goals:
 - Replace 8 bridges in poor condition in advance of the full corridor construction.
 - Evaluate the feasibility of using Accelerated Bridge Construction (ABC) methods
 - Construct a signature structure in the corridor



Arch Bridge Concept Inception



- I-94 and 2nd Ave. Project Goals:
 - Minimize impact to I-94 traffic
 - Minimize throw-away work
- Community Connector:
 - WSU campus
 - Significant stakeholder involvement
 - Bicycle and pedestrian access
 - Aesthetics and green space
 - Lighting is a key element



Why Did MDOT Choose Tied Arch Design?



- This design provides flexibility:
 - Eliminates a center pier in the median and a relocated future pier
 - Accommodates the new freeway design and future construction
 - Shallow structure depth reduces profile grade increase on 2nd Avenue
 - Self-propelled modular transporters (SPMTs) and launching can be used



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Bridge Design

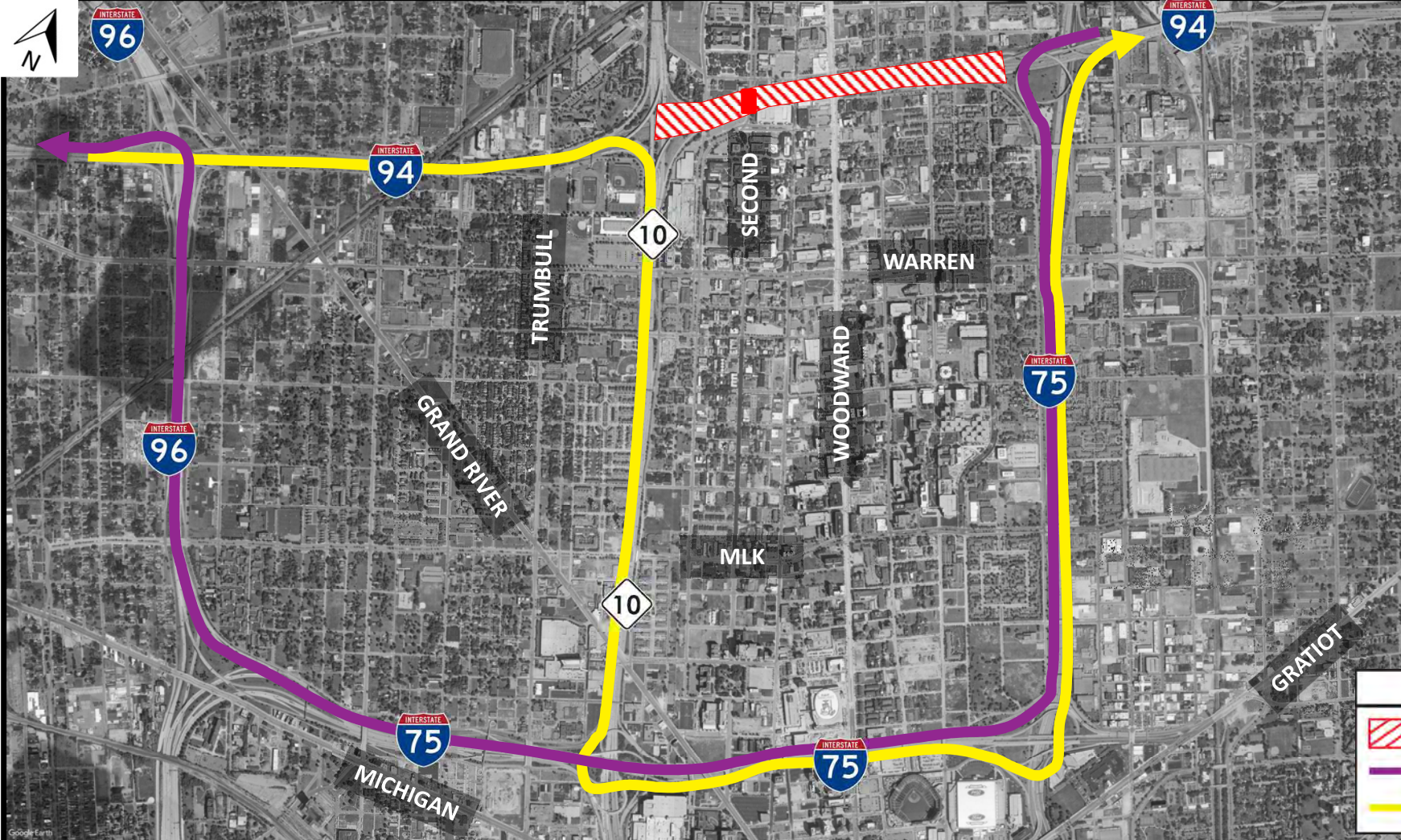
Site Constraints and Staging Area






I-94 Viewpoint at Second Avenue



I-94 Full Closure Detour Route



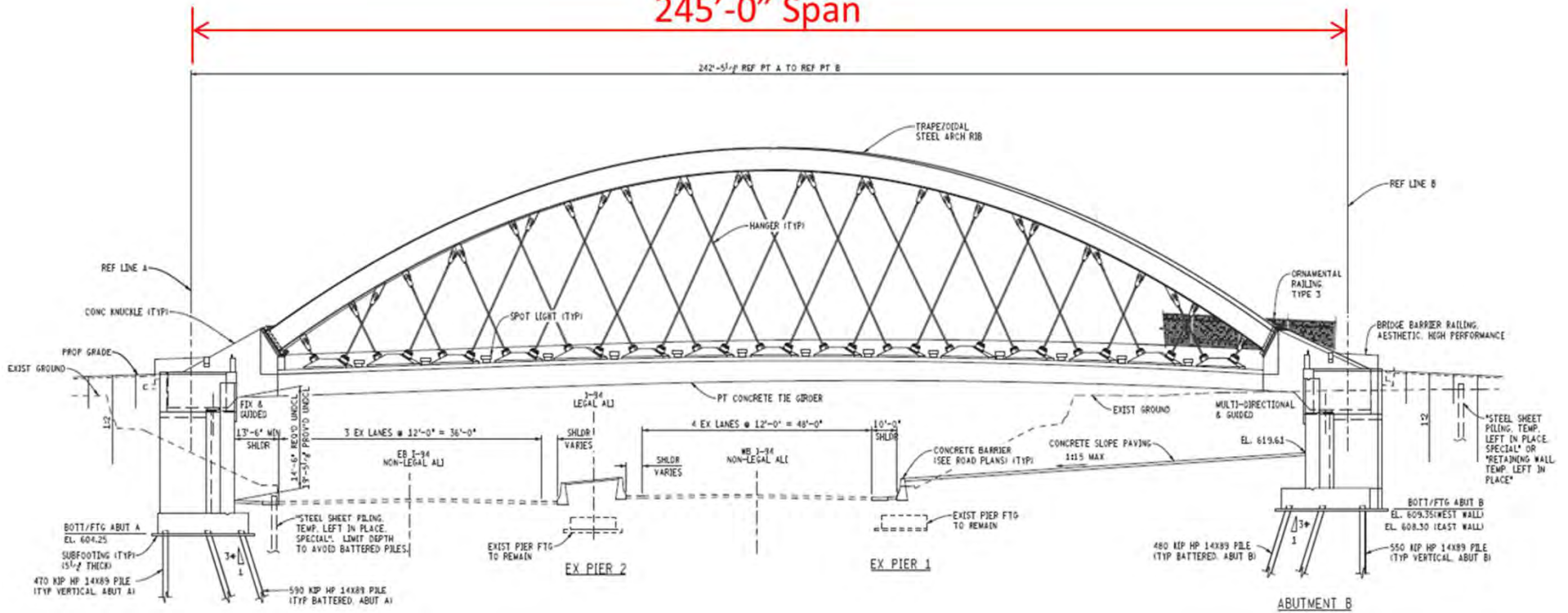
LEGEND

-  WORKZONE
-  DETOUR: WESTBOUND
-  DETOUR: EASTBOUND

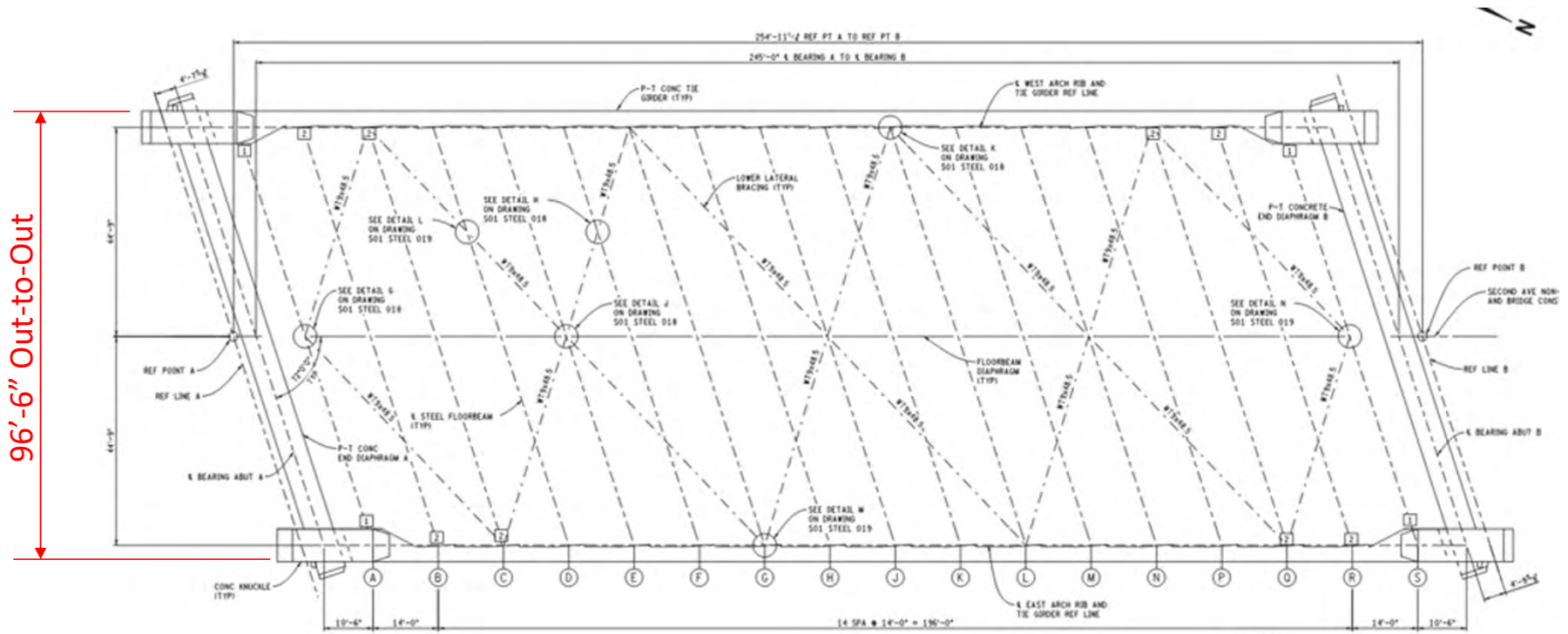
Second Avenue Bridge – Network Tied Arch



245'-0" Span



Framing Plan

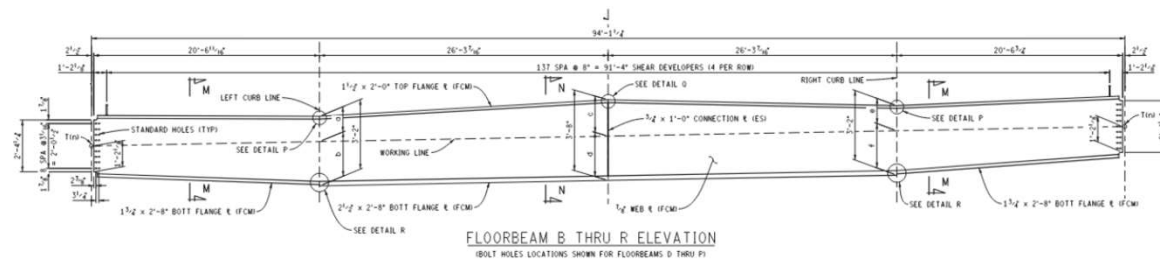


Skewed 18 degrees and asymmetrical vertical curve

Skewed? Vertical Curve? We do that all the time

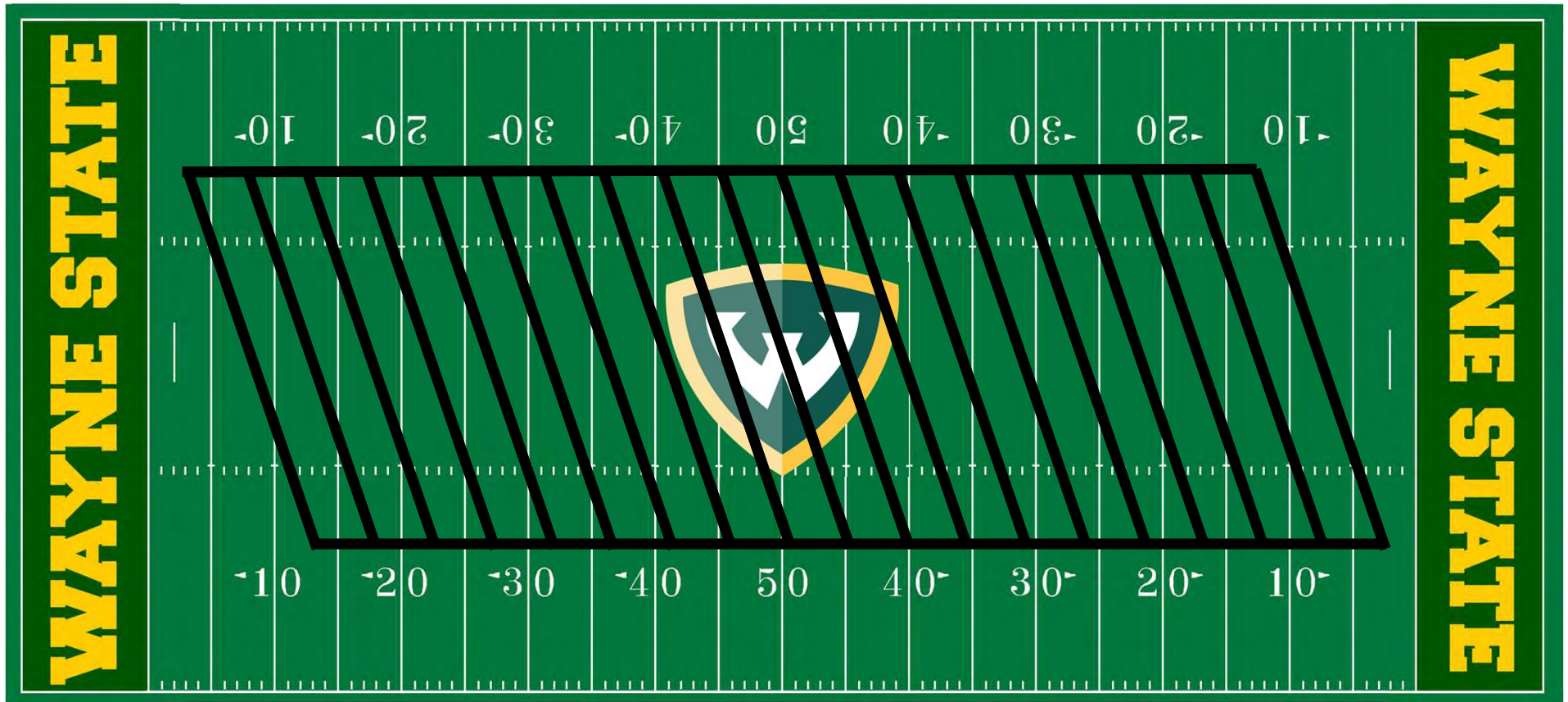


- Geometry
 - Variable floorbeam dimensions
- ABC Construction
 - Each corner at different elevation as skeleton is lifted and launched
- Aesthetics
 - Lateral bracing between arch ribs gives a warped appearance



Naruse Okumatsushima Bridge, Japan

Second Avenue Bridge Size Comparison



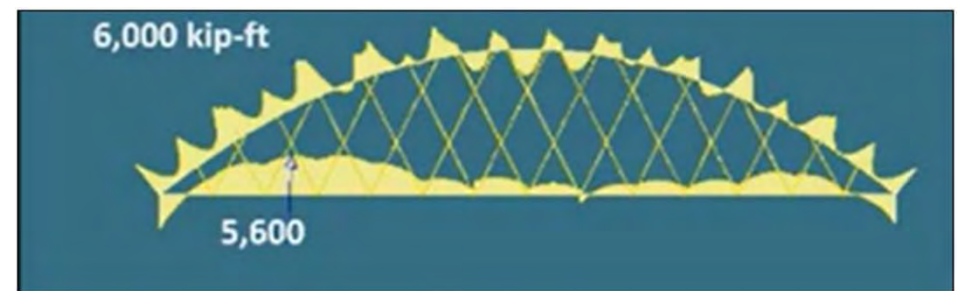
Second Avenue Bridge – Network Tied Arch



Network Arch Advantages

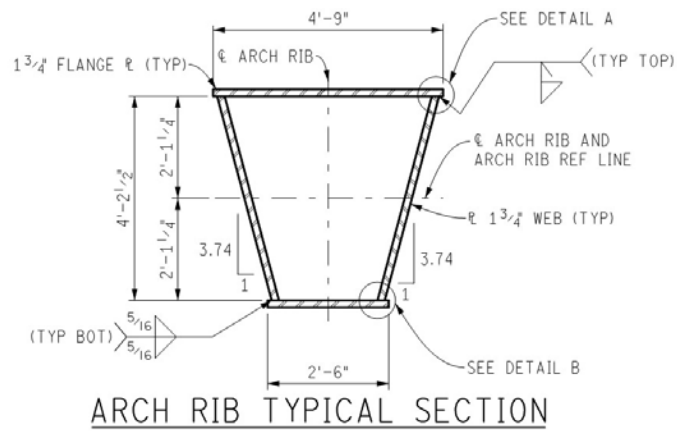


- Clear span does not require proposed pier construction affecting traffic on I-94
- Network arch is more efficient than traditional tied arch structure
- Inclined hangers greatly reduce arch rib moment and shear forces
- Increased stiffness vs. vertical hangers
 - Dead and live load deflections approx. 1/10 of vertical hanger systems
- Increased Redundancy



Credit – Gregor Wollman - HNTB

Arch Rib Details



Hangers

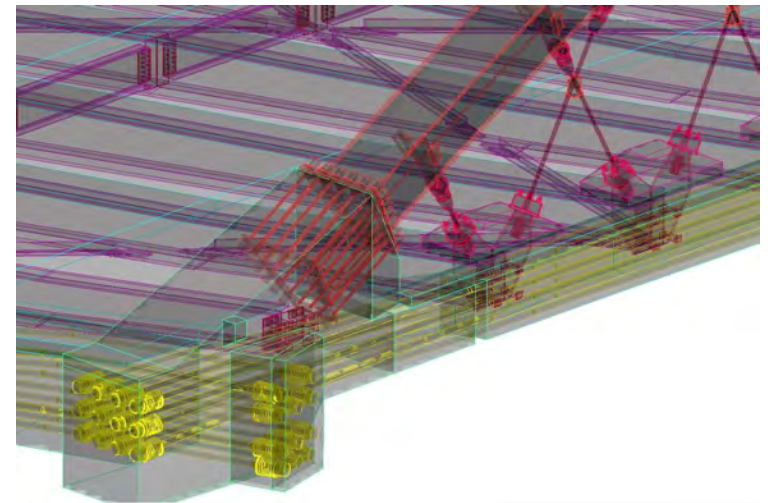
- 3 1/8" dia. ASTM A586 Structural Strand
- Class A Coating Inner Wires
- Class C Coating Outer Wires



Concrete and Post-Tensioning Details



- Tie Girders ($f'c = 8$ ksi):
 - 12 – 19 strand tendons (0.6" dia.)
- End Diaphragms ($f'c = 6.5$ ksi):
 - 11 – 19 strand tendons (0.6" dia.)
- Knuckle Base Plate:
 - 20 - 1 3/8" Grade 150 PT Bars





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Construction Engineering

ABC Alternatives Considered



- Offsite full assembly and SPMT move
- Offsite skeleton assembly and SPMT move
- Arch rib panel construction



ABC Alternative Chosen



- The bridge skeleton was assembled in a Wayne State University parking lot 500 feet from final location.
- The bridge foundation and abutment walls were constructed simultaneously – reducing impacts on I-94 traffic.



Industry Outreach During Structure Study Phase



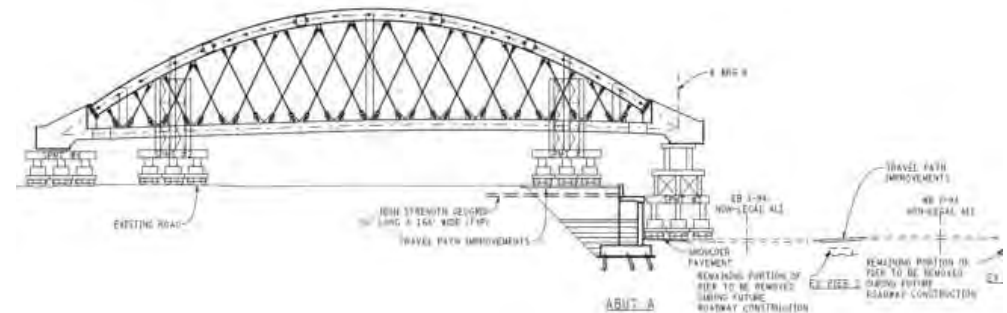
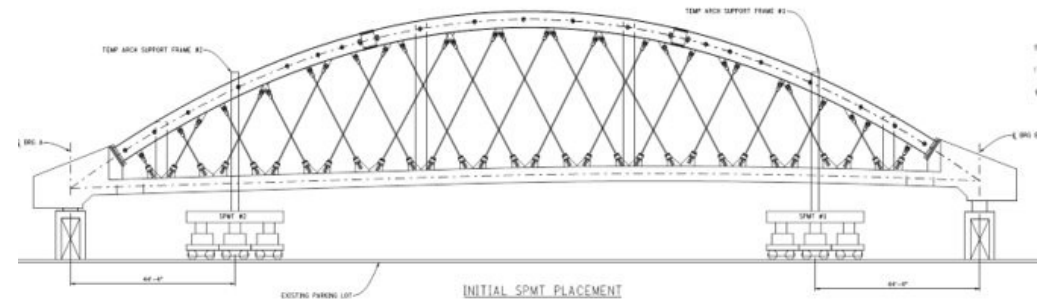
- First web meeting – designer presentation on project constraints
- Series of confidential, one-on-one meetings with individual heavy-lift contractors
- Identify feasible bridge move methods
- Establish basis of design



Assumed Erection Analysis



- Design phase assumed an erection sequence based on industry outreach
 - SPMT's located inboard of knuckles
 - Handoff to SPMT's for I-94 launch
 - Temporary end diaphragms
 - Used to approximate locked-in construction stresses
 - Drove permanent structure geometry
- Special provision requiring contractor to furnish analysis and erection plan consistent with means and methods



Proposed Erection Analysis



- SPMT's located under each knuckle along CL Bearing
- End diaphragms poured prior to move
- Skidding system to transfer bridge to SPMT's on I-94
- Erection plans and calculations totaled nearly 1,700 pages



Analysis Reviewers



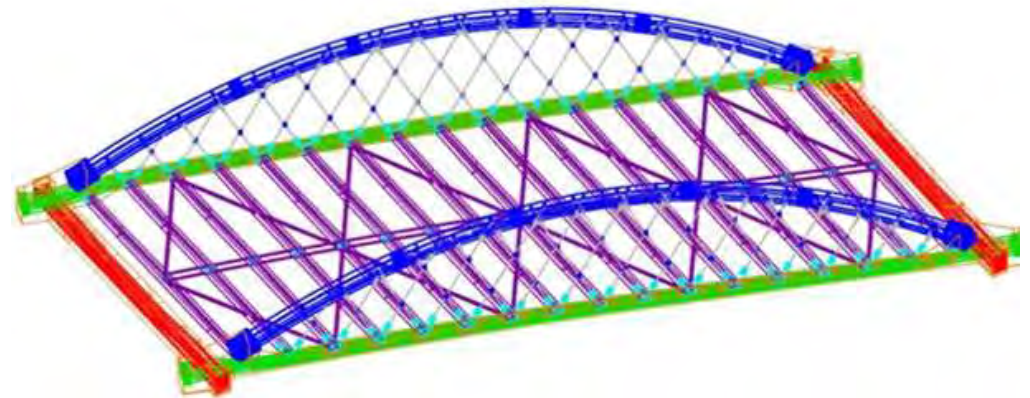
- Many sets of eyes utilized to review erection and move analysis
 - Engineer of Record
 - MDOT construction and materials staff
 - Independent Peer Review Engineer
- Collaborative effort with Erection Engineer to reduce risk and resolve concerns
- Collective team effort invaluable to success of project



Finite Element Modeling



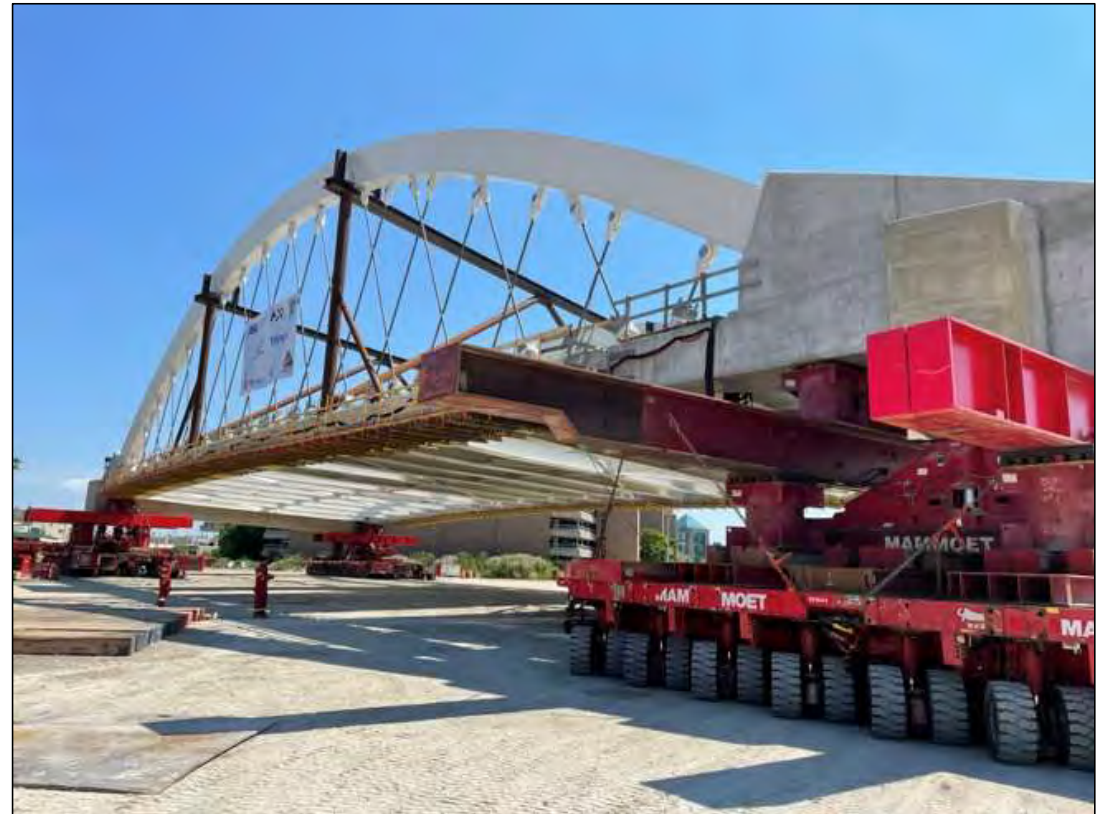
- Total of three independent models and calculations developed
 - Erection Engineer
 - Engineer of Record
 - Independent Peer Review Engineer
- Regular team meetings to discuss findings throughout project
- Concurrence between models obtained prior to acceptance



Bridge Move Preparation



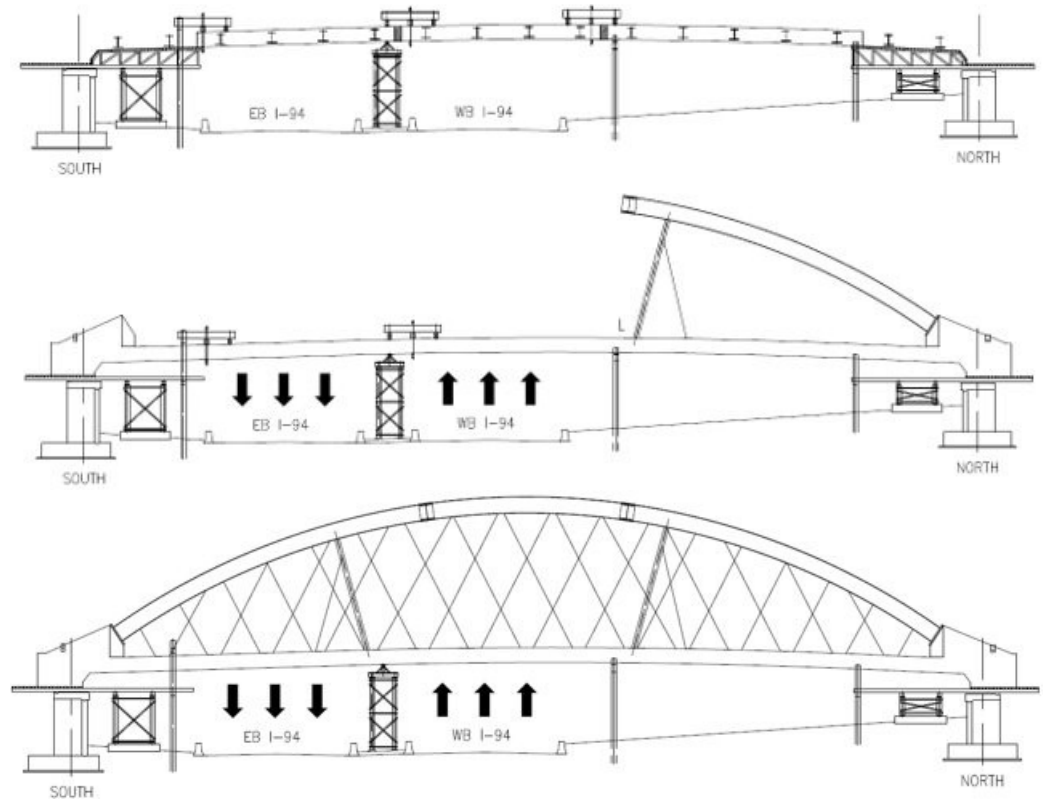
- Document developed with:
 - Move Procedure
 - Schedule
 - Safety Procedures
 - Communication Plan / Contact Info
 - Equipment
 - Drawings
 - SPMT Calculations
 - Monitoring Plan
 - Crowd Control Plan
- Pre-move meeting one month prior with stakeholders and Contractor



Value Engineering Concept (Proposed)



- Alternative ABC concept to build superstructure in-place with spliced, precast tie girder segments
- Full freeway closures comparable to SPMT concept
- Ultimately not accepted due to substantial re-design of superstructure
- Outside the box thinking valuable to ABC projects



Bridge Monitoring During Move



- Combination of robotic total station survey and electrified wires
- Structure movement limits established with adjust/stop values
 - Bridge designed to accommodate 3" out-of-plane movement at any corner
 - 2" limit used in field to make adjustments
- Communication plan with Erection Engineer and Contractor in-place throughout move

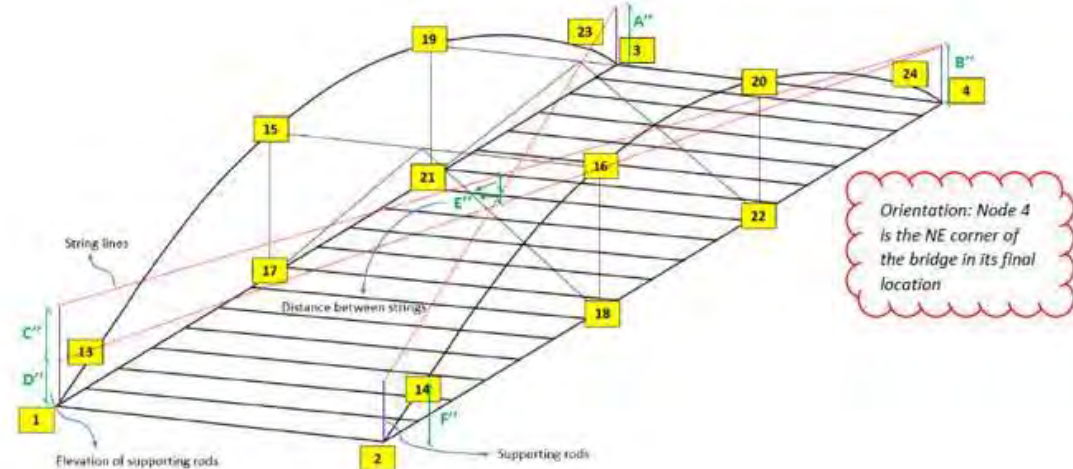


Figure 3 – Electrified string lines



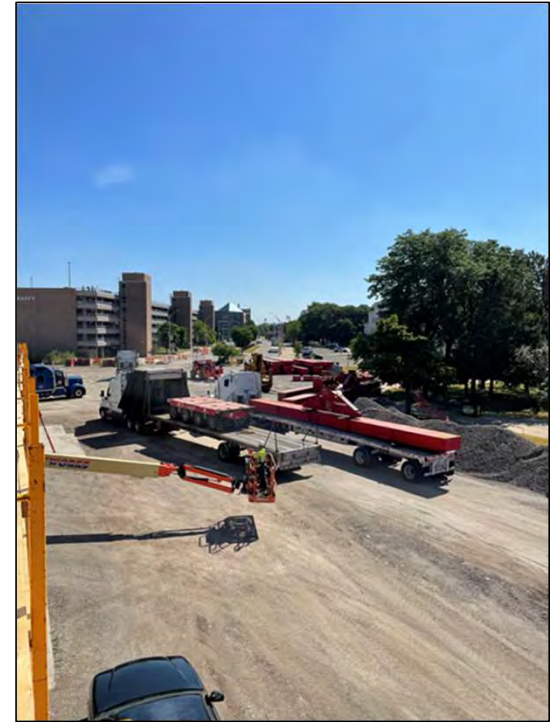
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Bridge Construction & Move

Hanger Adjustments/Verifications (July 6th & 7th, 2022)



Heavy Movers Arrive (July 6th-8th, 2022)



Initial Lift and Temp Support Removal (July 14th, 2022)



Initial Lift and Temp Support Removal (July 14th, 2022)



Initial Lift and Temp Support Removal (July 14th, 2022)



Azobe or Ekki wood (Africa)

Initial Lift and Temp Support Removal (July 14th, 2022)



Prep Sole Plates and Mobilize SPMTs (July 15th, 2022)



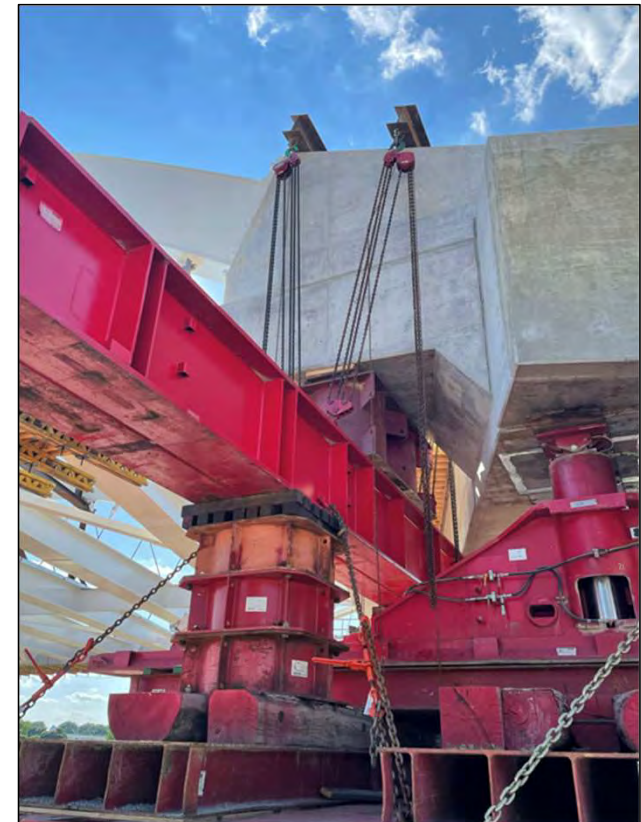
Prep Sole Plates and Mobilize SPMTs (July 15th, 2022)



Loading SPMTs (July 16th, 2022)



Final Preparation for Move (July 18th, 2022)



Final Preparation for Move (July 18th, 2022)



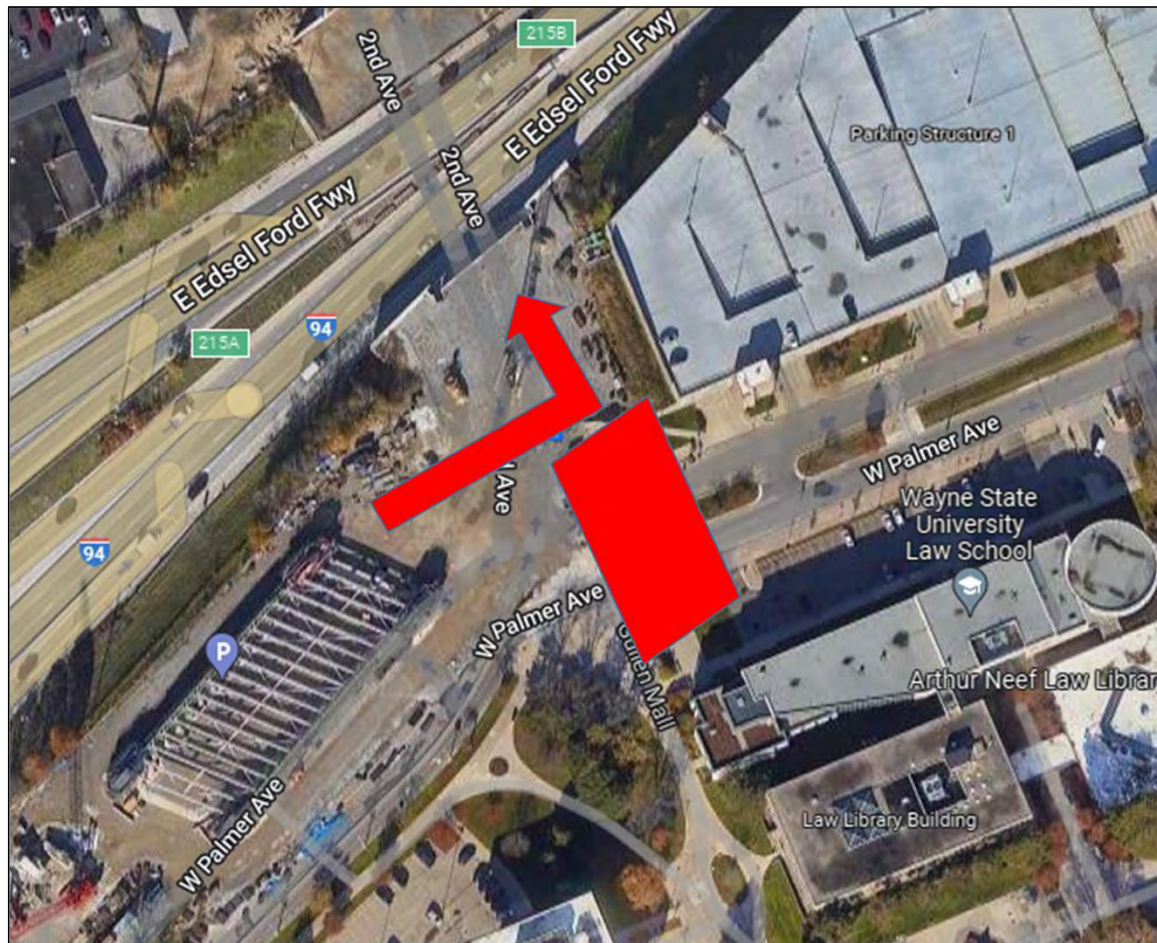
- Monitoring System:
 - Wires
 - Prisms
 - Total Station



First Move (July 19th, 2022)



First Move (July 19th, 2022)



First Move (July 19th, 2022)



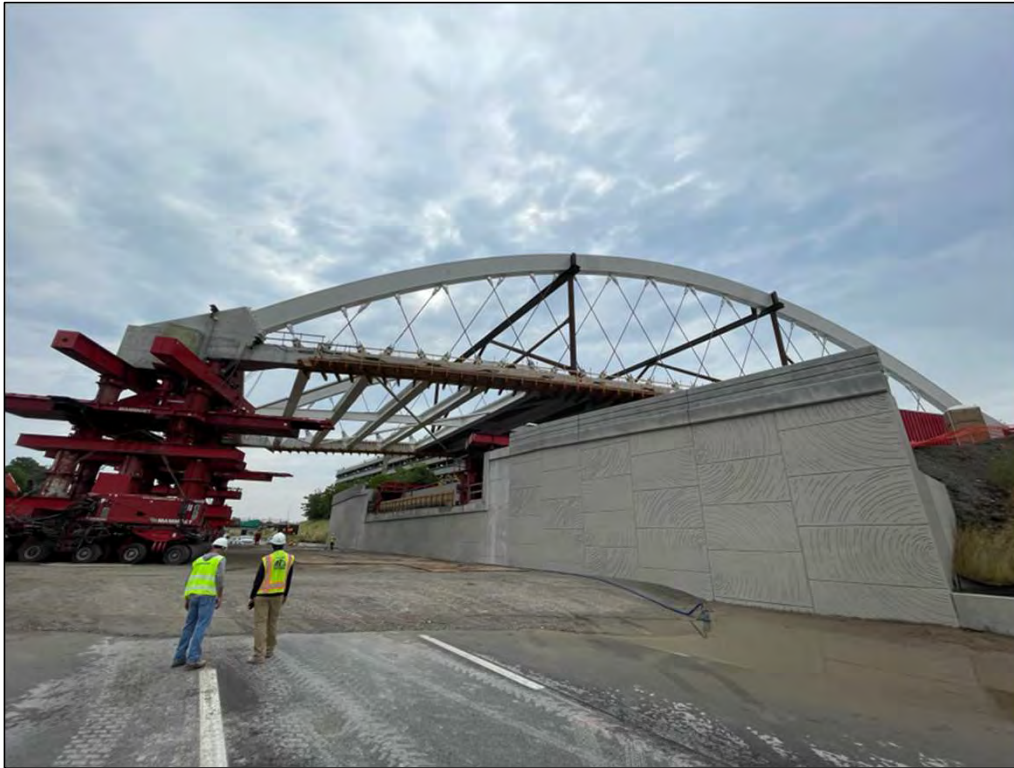
The Handoff (July 23rd, 2022)



The Handoff (July 23rd, 2022)



Crossing I-94 (July 24th, 2022)



Crossing I-94 (July 24th, 2022)



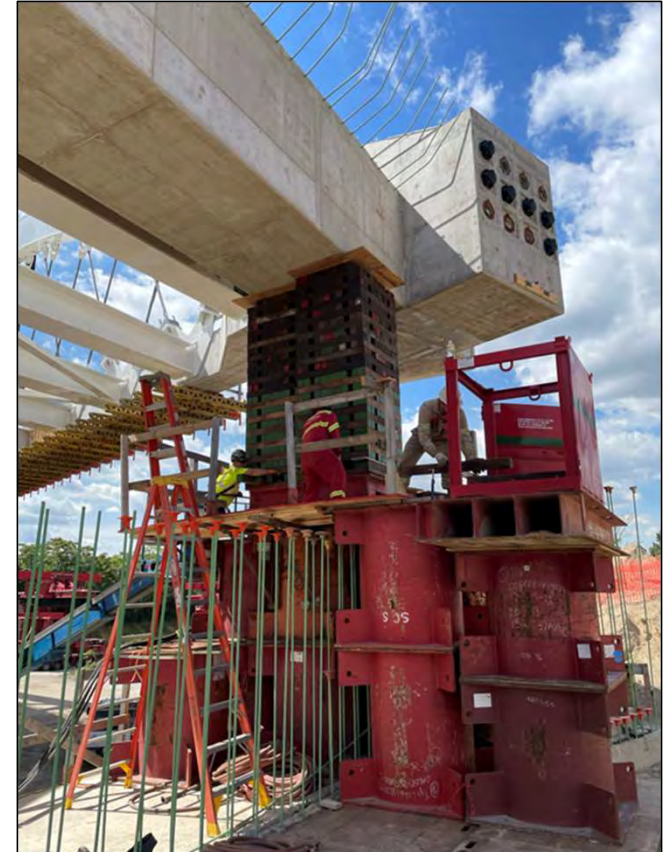
Transfer to Abutments (July 25th, 2022)



Transfer to Abutments (July 25th, 2022)



Remove SPMTs and Begin Lowering (July 26th, 2022)



Remove SPMTs and Begin Lowering (July 26th, 2022)



Lowering to Bearings (July 27th, 2022)



Lowering to Bearings (July 27th, 2022)



Lowering to Bearings (July 27th, 2022)



Welding the Bearings (July 28th, 2022)



Key to Success



End Diaphragm Signing



Timelapse Video of Bridge Move





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Conclusions

Conclusions and Lessons Learned



- ABC projects – especially for a complex bridge – can be done using D/B/B but might be a better fit for alternative delivery such as CMGC
- Constructing a mock-up of complex components provides opportunity to address challenges prior to work on permanent structure
- Independent peer review of complex bridge designs is invaluable
- Collaboration between MDOT, design team and contractor remain key to successful project

Conclusions



Conclusions





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Q & A Session