Non-Routine Application and Bridge Load Rating Using BrR

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Introduction

- Non-conventional Rating
- Complex Bridge – Stringer Rating
  - Case Study 1 – I-40 Hernando de Soto
- Construction Load Rating
  - Case Study 2 – Utah SLC I-15 SB Widening
  - Case Study 3 – 15 Mile Bridge Demolition

Case Study 1 – I-40 Hernando de Soto

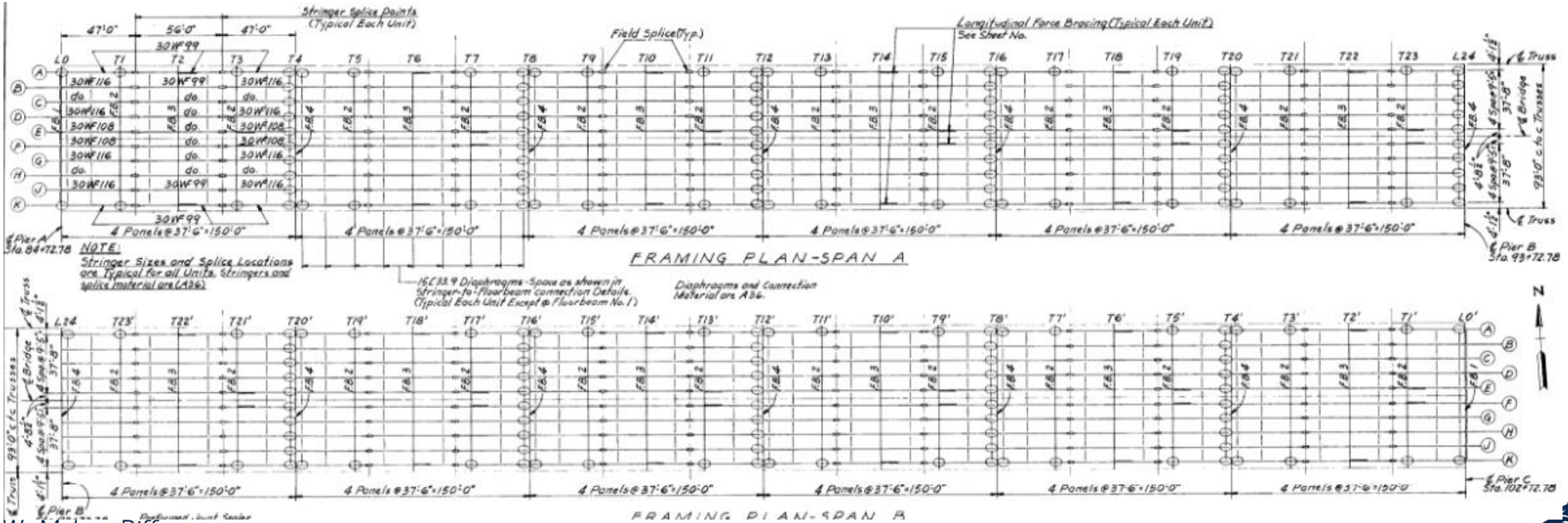
- Hernando de Soto Bridge
  - Carrying I-40 over Mississippi River
- Constructed 1967-1973
- Two 900’ Span Continuous Tied Arch Bridge
- Emergency Repair – Summer 2021
- Post repair load rating

Bridge Load Rating

- Load rate the post repair condition and develop a tool for permit load rating
- Existing 3D model of the continuous tied arch bridge
- Stringer system seismic rehab - 2003
- Load rate stringer system with AASHTOWare BrR (BrR)
  - Efficient and readily accessible
  - Line girder analysis - conservative

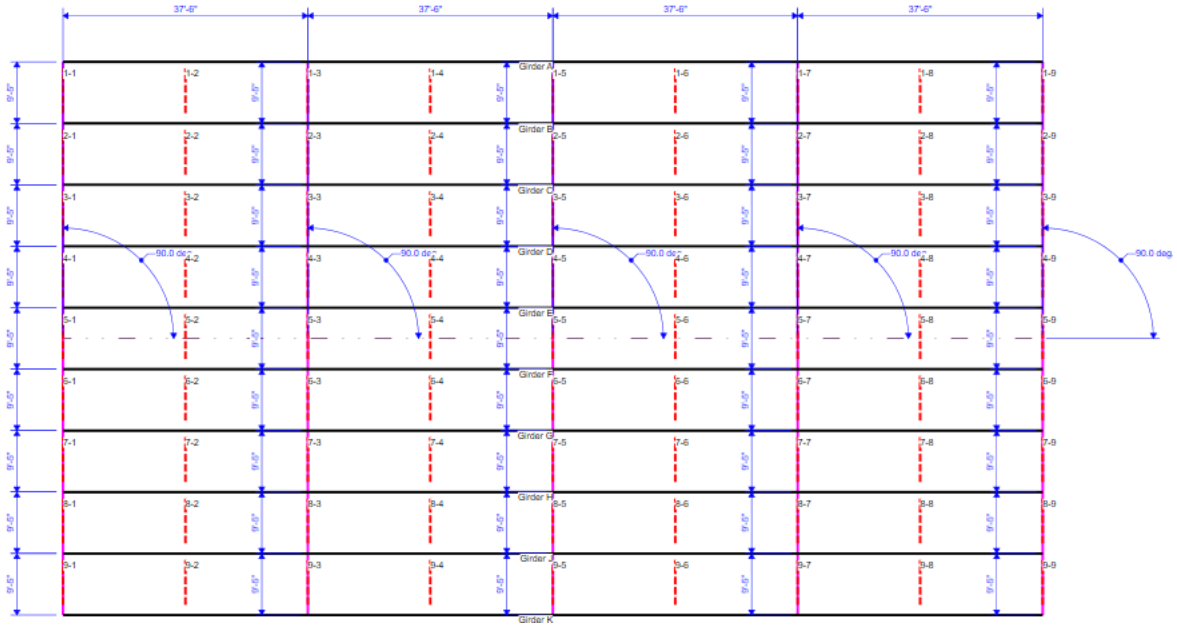
Stringer System

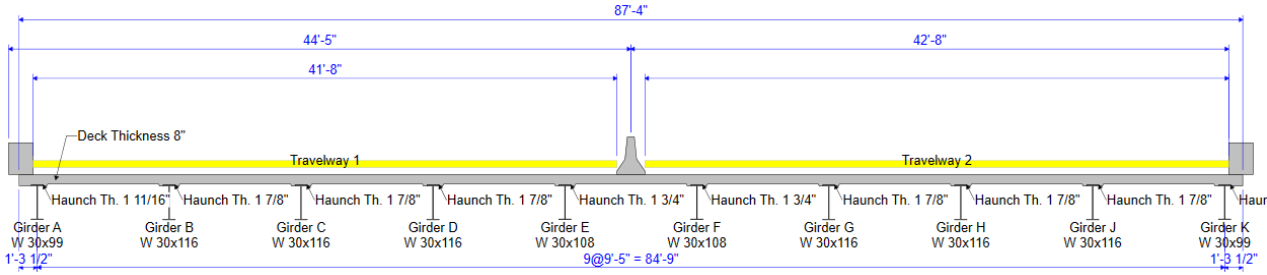
- Floating floorsystem - total 12 units of non-composite stringer system
- 4 panels per unit – 10 stringers. 3 unique stringer lines.
- Rolled sections –WF99, WF 108 and WF 116 (A36)



BrR Model

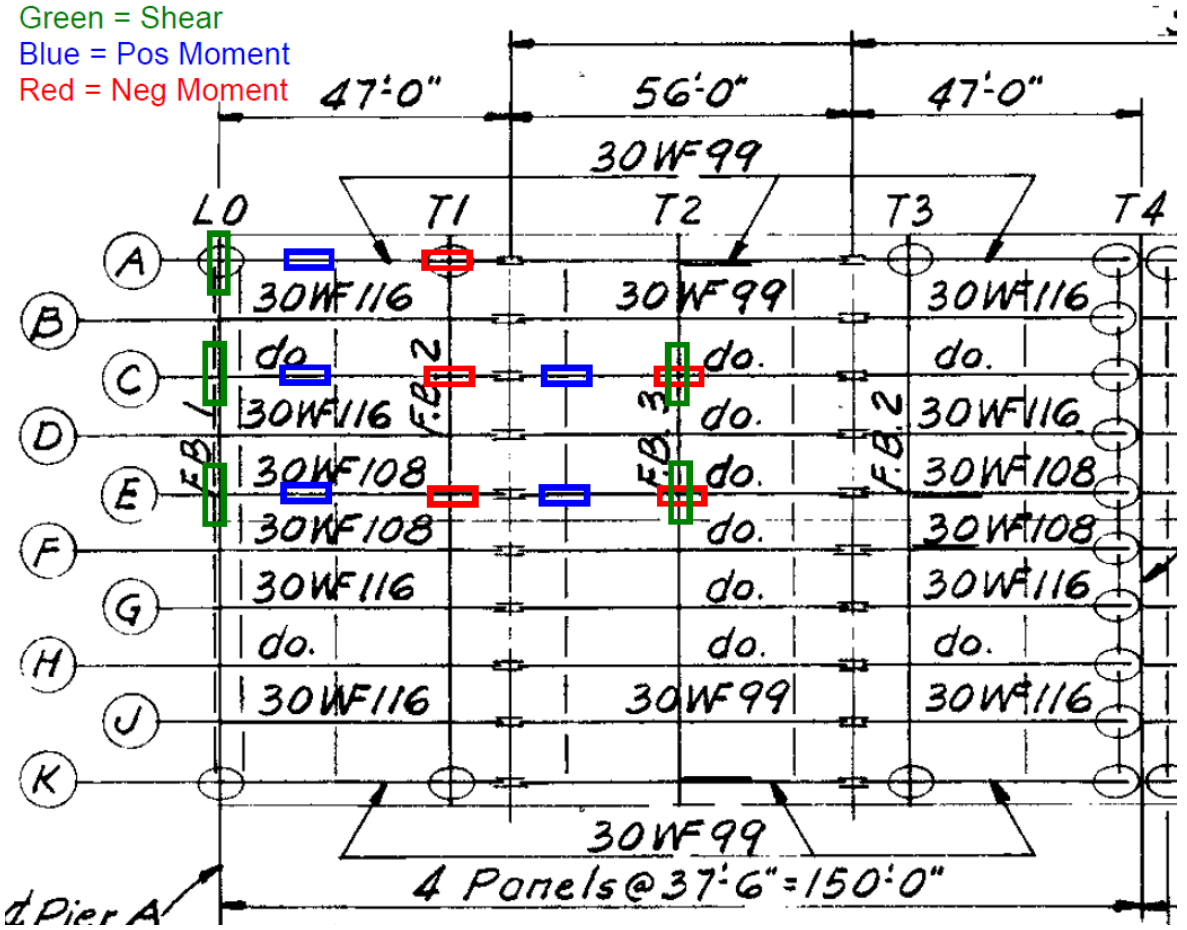
- AASHTO MBE 3rd Edition
- LRFR
- Model in stringer system
- Automated live load distribution factor (LLDF)
- No significant deterioration





Results

- Controlling point of interests of each unique stringer line
- Validated with hand calculation
- Populate capacity and demand into a load rating tool



Lesson and Learn

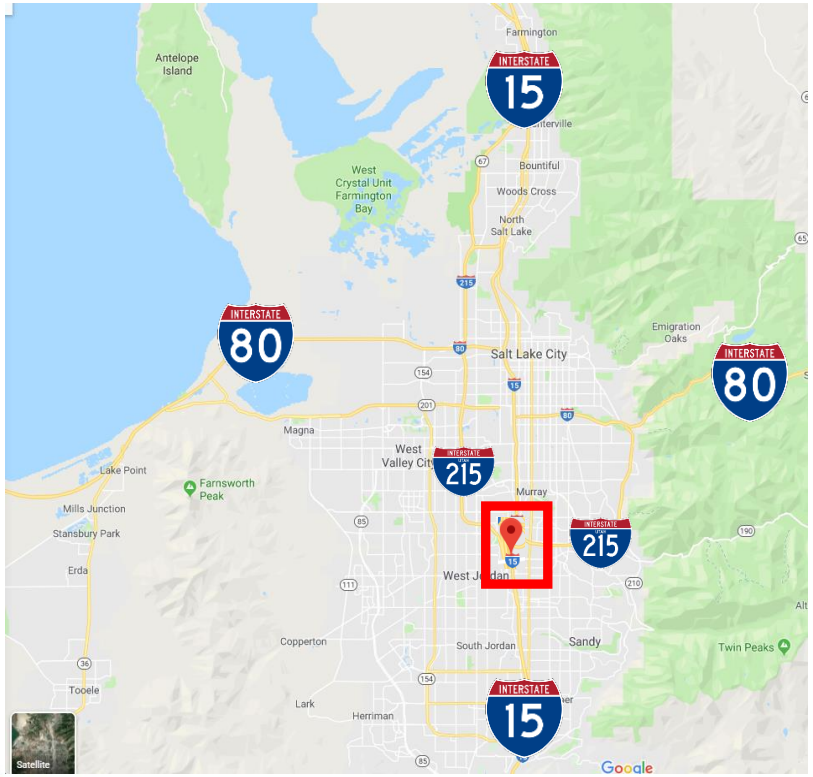
- Early planning
- BrR can be used in complex bridge rating
- Efficient in load rating stringer system
- Comprehensive and accessible results

Case Study 2 - Utah SLC I-15 SB Widening

- Design-Build Project awarded to Ralph L Wadsworth/Michael Baker Team
- Add 1 lane to 14 miles of urban interstate I-15 SB
- Structures Tasks:
  - Replace 2 railroad bridges
  - Widen 8 bridges
  - Narrow 3 corridor (CD) bridges
  - Numerous retaining walls and 24 bridge rehabs

Project Site

- I-15 South
- I-215 to I-15 SB Ramp & CD Road
- High Seismic Zone

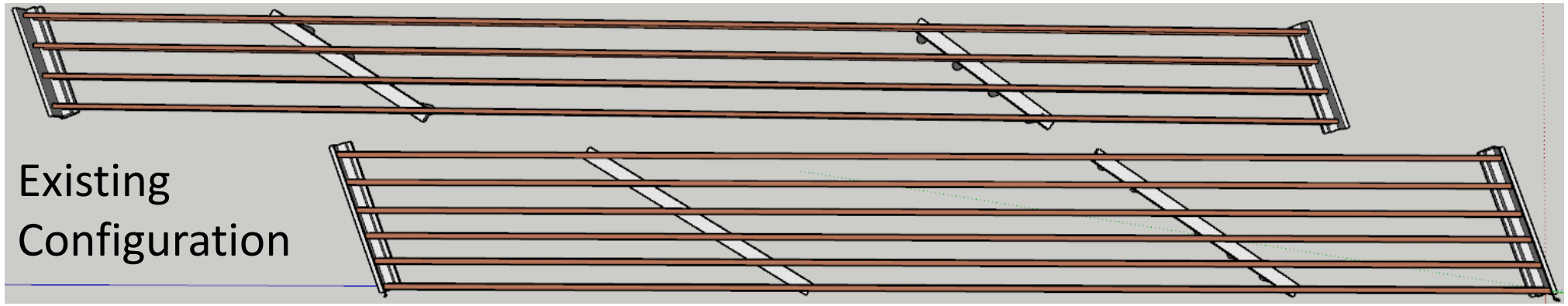


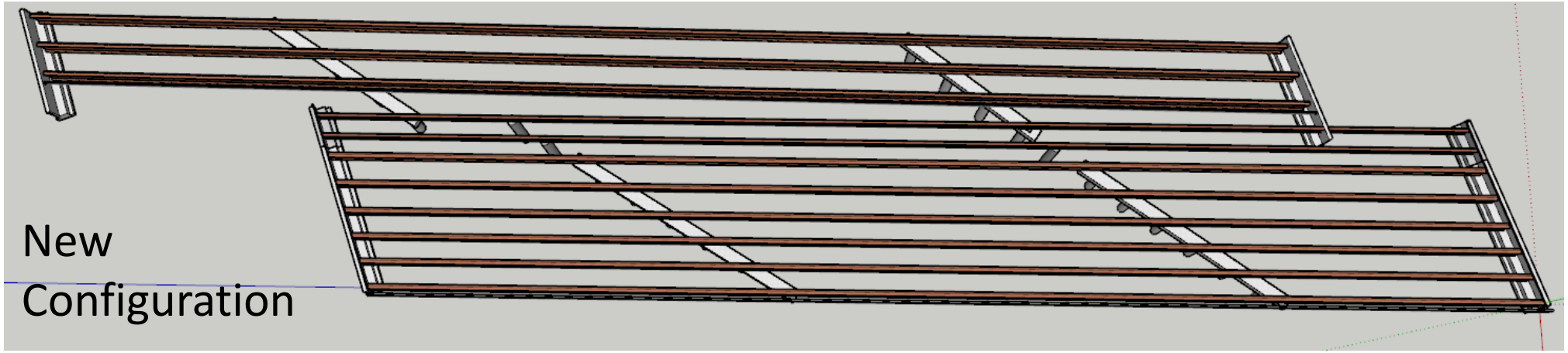
Union Pacific RR (UPRR) Yard

Existing Project Site

Existing Project Site

Widened I-15 Bridge

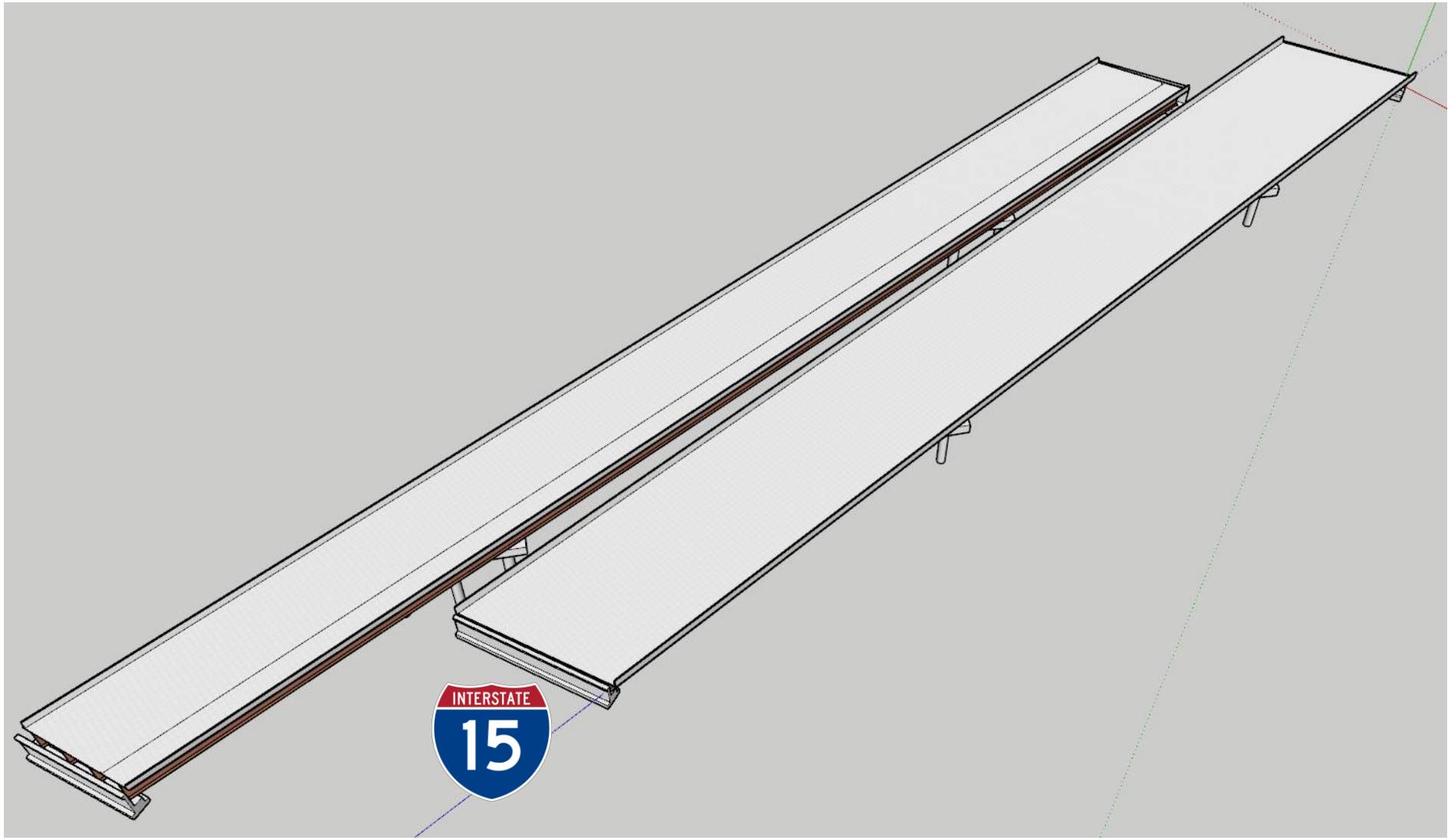




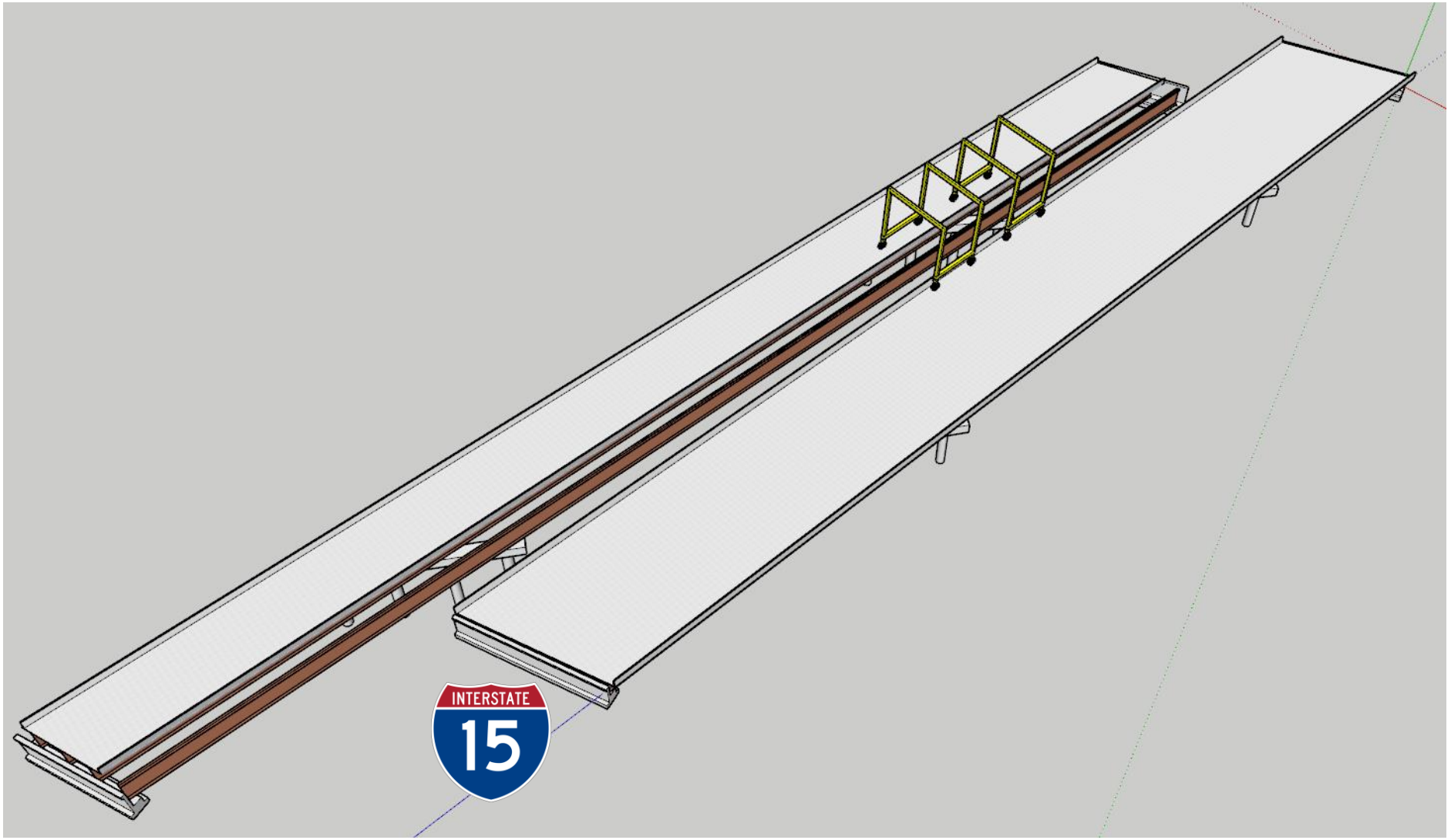
Site Access: Railroad Must Stay Open

- 2 – 40 tons Mi-Jack Cranes
- 1 wheel line on each bridge
- 50 kips/wheel

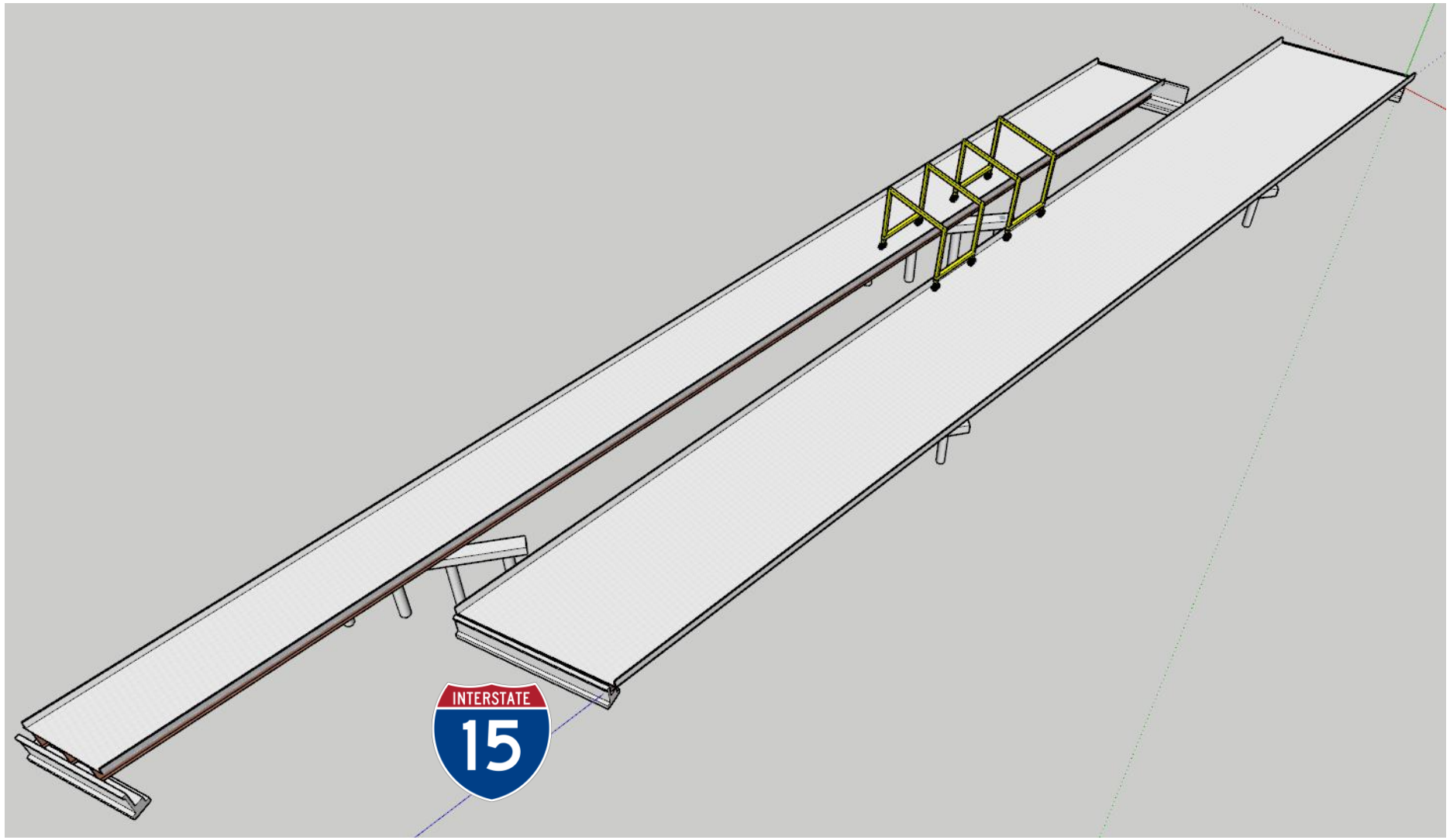
Existing Bridges



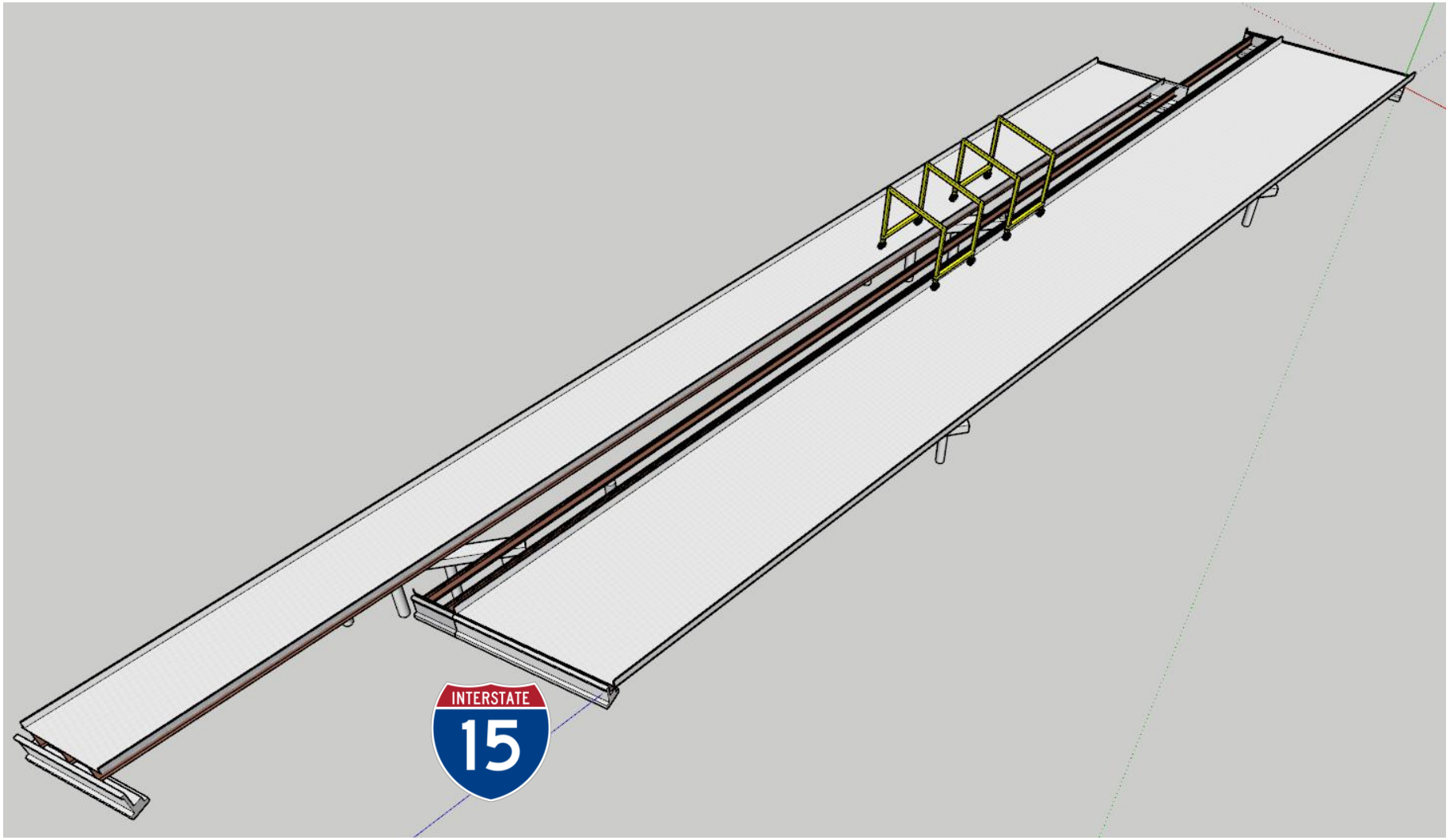
Remove Part of I-215 CD



Remove Part of I-215 CD



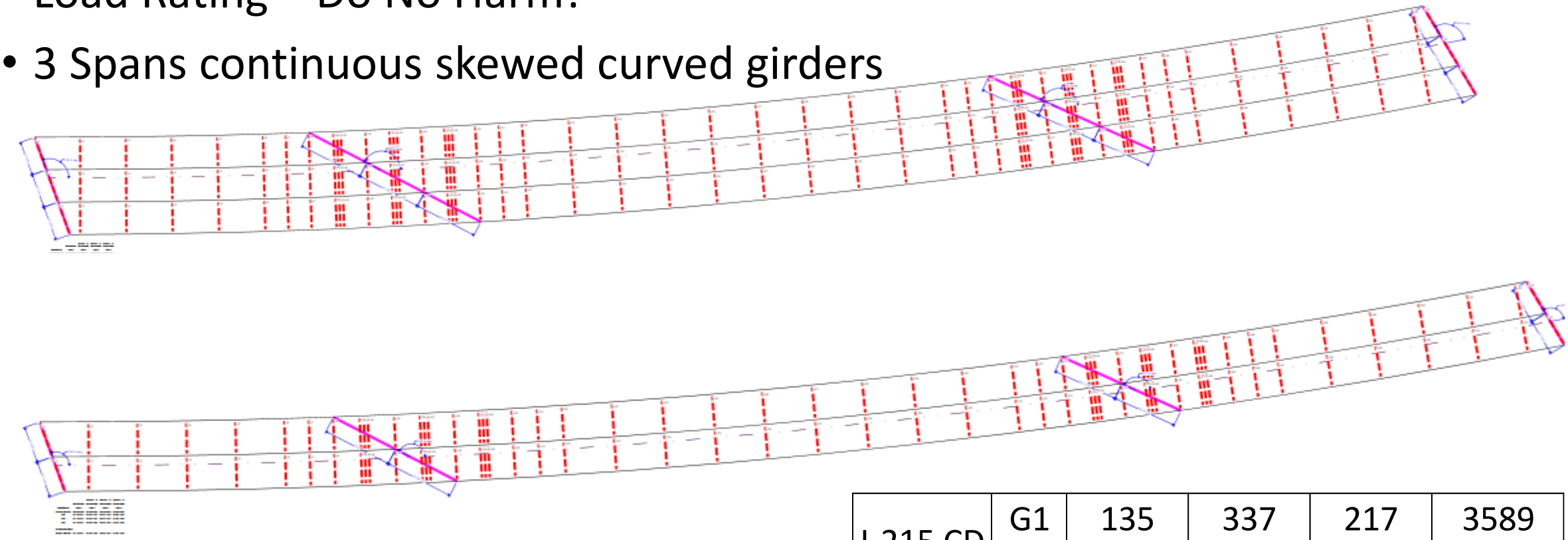
Widened I-15 Bridge



Final Configuration

BrR Model

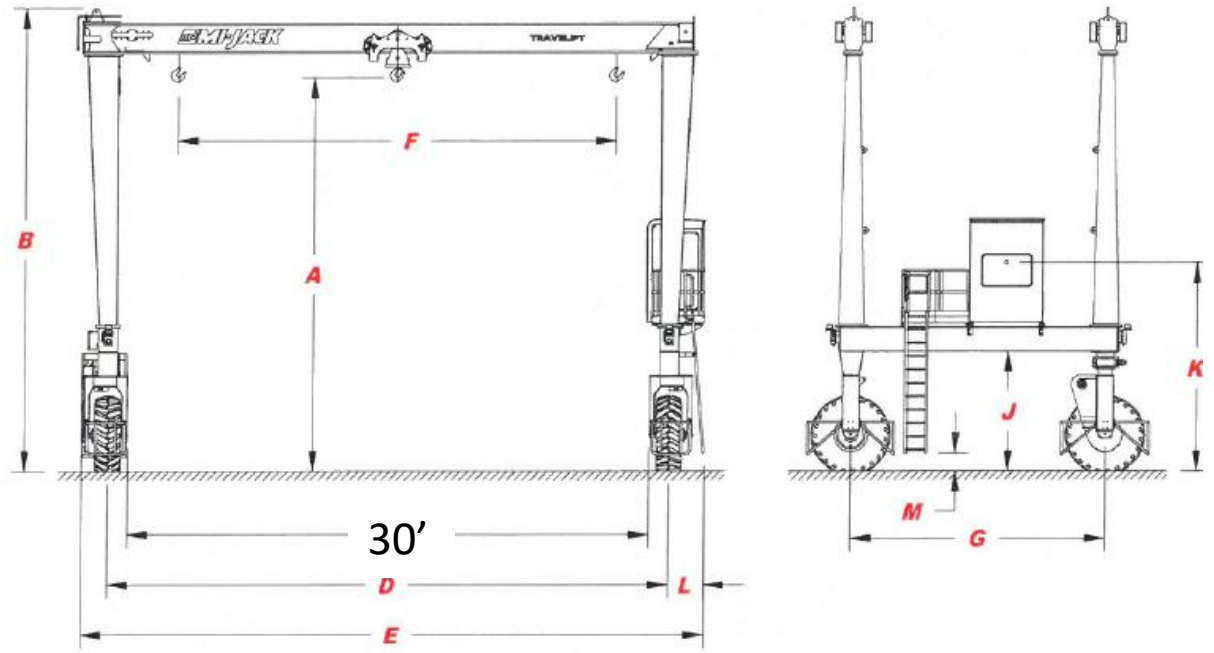
- Load Rating – Do No Harm!
- 3 Spans continuous skewed curved girders

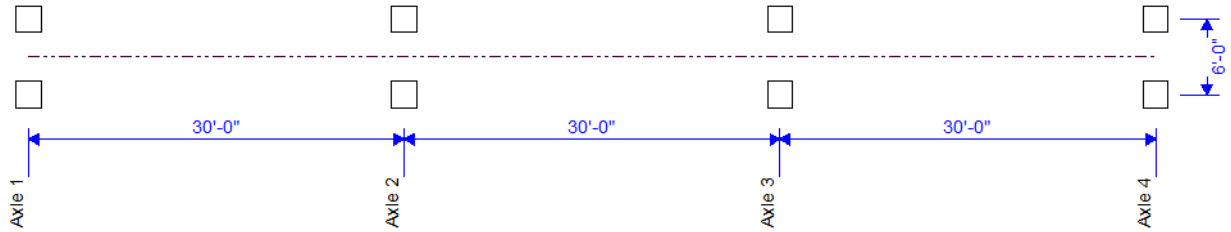


I-215 CD	G1	135	337	217	3589
	G4	203	335	161	3637

40 Tons Mi-Jack Gantry Crane

- 2 gantry cranes - modeled as 4 axles spaced at 30’ apart
- Conservatively assigned 100 kips per axle
- LRFD evaluation:
  - 1.25 DC+1.30 (LL+I)
- Concurrent HL-93 live load
- Full impact
- Yield favorable ratings in the girders and cross frames





Construction

Lesson and Learn

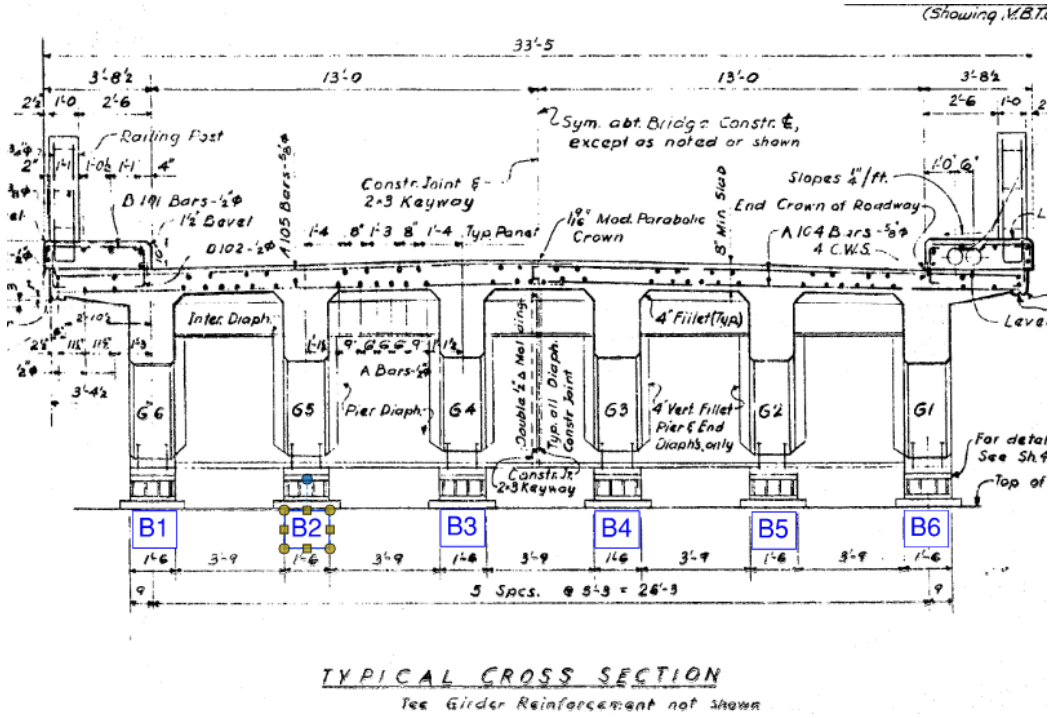
- BrR – alternative option for the construction evaluation
- Understand the capabilities and limitations of BrR
- Efficient post processing
- Communication is critical

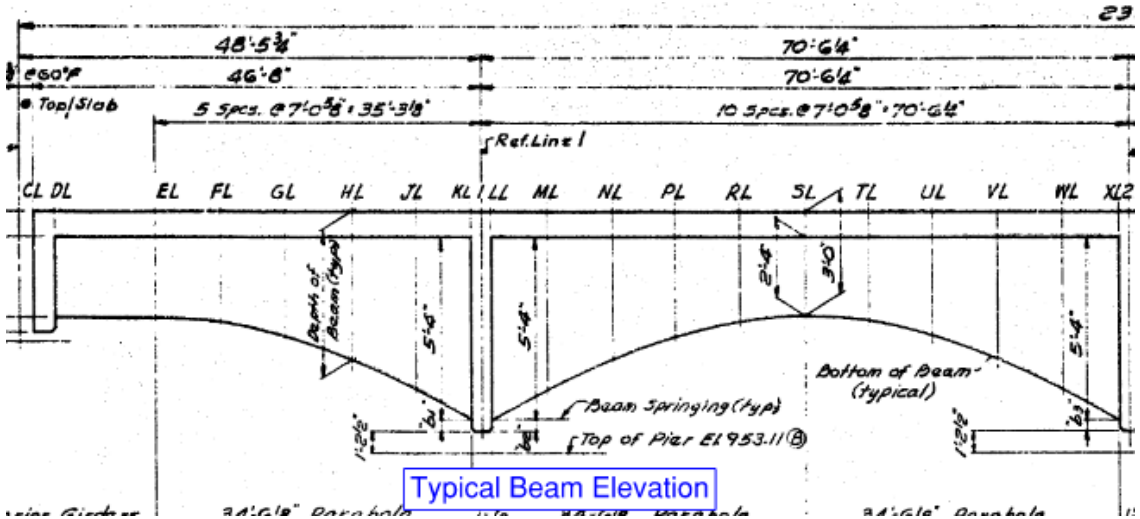
Case Study 3 – 15 Mile Bridge Demolition

- Existing Bridge Information:
  - Carry 15 Mile Road over I-94 EB & WB, and two collector-distributor roads, located at Calhoun County, Michigan
  - Constructed 1960
  - Existing condition: superstructure (Fair, 5) and substructure (Satisfactory, 6)
  - Four span continuous structure, span length 48.5’, 70.5’, 70.5’, 48.5’

Existing Bridge Information

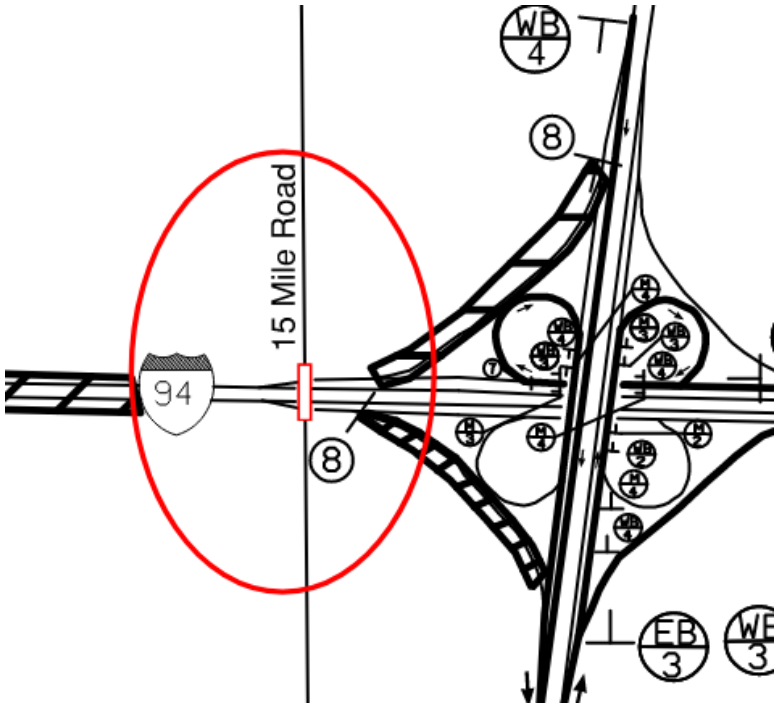
- Reinforced concrete tee beam system

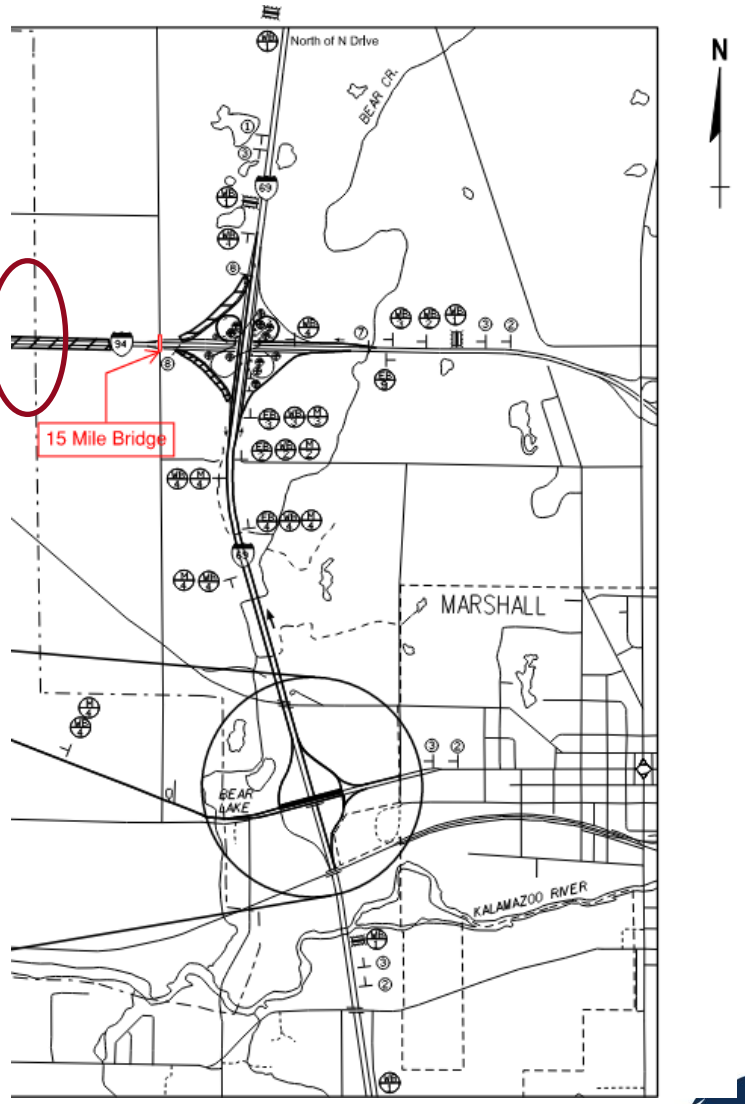




Proposed Project Information

- I-69 Reconstruction Design Build
- From south of I-94 to north of Island Highway
- Existing bridge will be replaced





Why to load rate existing bridge?

- Construction safety and unintentional collapse
- Stability of remaining portion of structure
- Phasing construction for maintenance of traffic
- Protection of existing bridge substructure
- Protection of existing roadway pavement under bridge
- Restricted closure time of I-69 and I-94

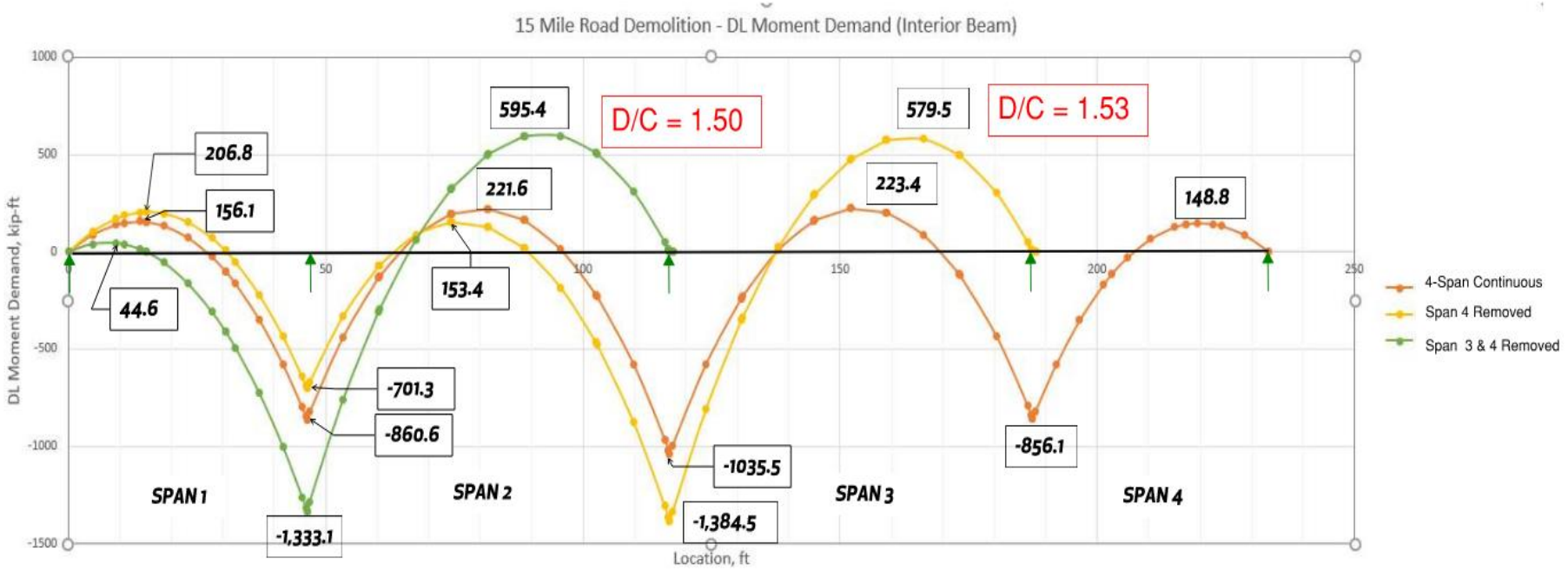
Preliminary Analysis Using BrR

- Removing Span 4

- Removing Span 4 & 3

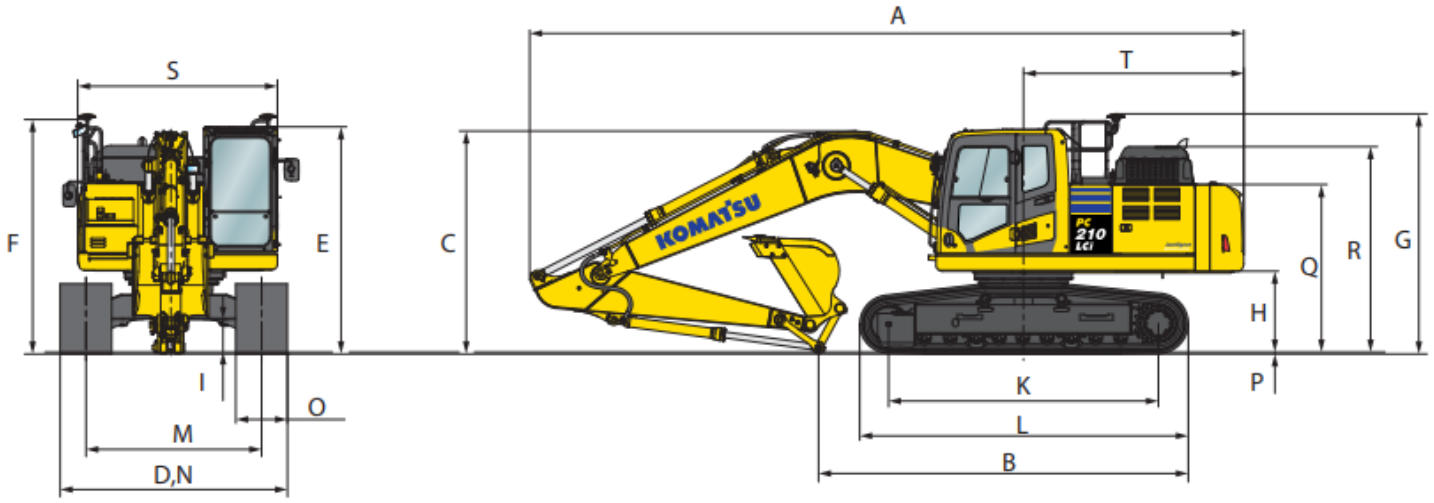
Preliminary Analysis Using BrR

- Evaluate structural strength and stability
- Comparison of beam moment diagrams (dead load only)
- Removal of span could cause other spans to fail



Demolition Equipment

- Multiple hydraulic excavators, on and under bridge
- Use Komatsu 210 for analysis
- Operating weight: 53,882 lbs
- Track length on ground: 12’
- Shoe width: 28”
- Track gauge: 7’-10”



Demolition Method

- Hydraulic Breakers: use boom-mounted excavators to break apart bridge components

(Photo courtesy to Jeremy Curtis)

Analysis of Demolition Stages

- Use BrR to check sufficient strength and stability for each stage of demolition
    - Built a model relatively quick
    - Generate multiple Superstructure definitions to represent demolition stages
    - Analyze non-standard gauge vehicle
    - Specify vehicle path for non-standard gage vehicle
    - Live Load Distribution Factor Analysis using 3D FE analysis

Teamwork and Collaboration

- Owner Michigan DOT review and approval of demolition plans
- Contractor responsibility and preference
- Maintenance of traffic and temporary detour
- Closure time and minimum impact to public

BrR Analysis Procedure

- The evaluation procedure is based on a load rating of the structure throughout the different demolition stages
- The rating methodology: LRFR
- The primary guidelines are LRFD Bridge Design Specifications, 9th Ed. (LRFD Design) and AASHTO Manual for Bridge Evaluation (MBE), 3rd Edition.
- The bridge geometry and reinforcing details are based on original plans.
- No deterioration was considered based on current bridge inspection report.

Load and Load Factors

- The primary load combination used for the evaluation of strength is based on LRFD Design 3.4.2.1:

  1.25 DC + 1.5 DW + 1.5 (LL+IM)

Note: 1.5 load factor for DW is used conservatively (1.25 specified per AASHTO 3.4.2.1) since the overlay thickness is unknown.

Load and Load Factors

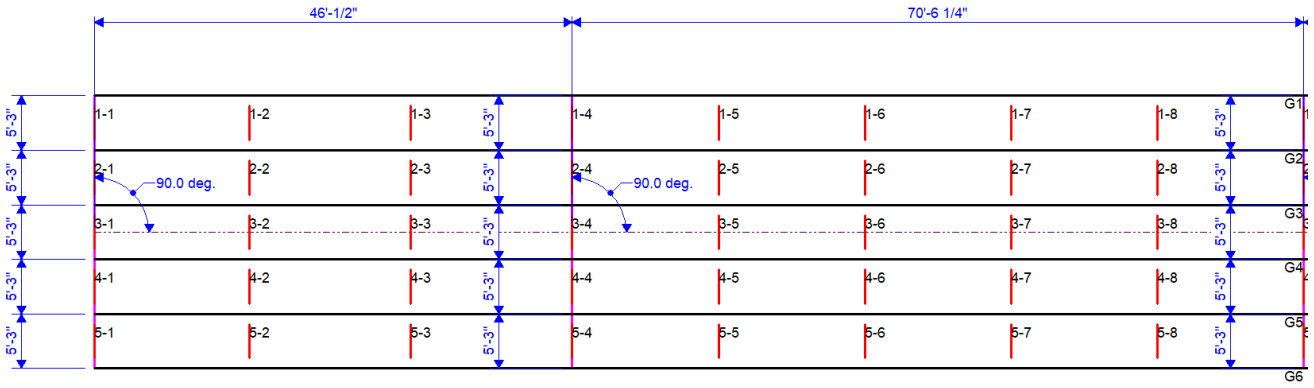
- No significant construction dead loads are anticipated on the structure
- LL using KOMATSU 210 Hydraulic Excavators
- 70%/30% wheel distribution is used to account for lifting/working over the front or over the side for unequal loading between tracks
- Dynamic load allowance of the excavators uses 33% of the total axle weight. The estimated dynamic effect is less than 20% of the axle weight.

Demolition Stage 1

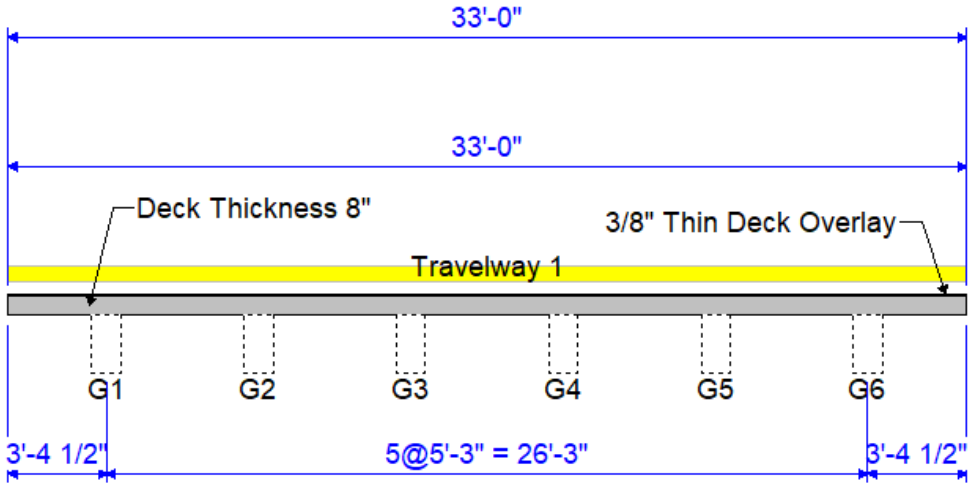
- Demolition Stage 1 to 4 To be completed within 12 hours period, Friday night 8:00 pm to Saturday morning 8:00 am
- Full 12 hours closure of I-94
- Stage 1: removal portion of bridge parapet
- Maximum two excavators can be on the bridge, and minimum 50’ apart must be maintained at all time, measured longitudinally along the length of structure
- The minimum clearance between the edge of track and face of railing shall be 2’ at any time
- Minimum rating factor: 1.329 (controlling member fascia girder, 38.7% span 1)

Demolition Stage 1

- Removal of portion of bridge parapets



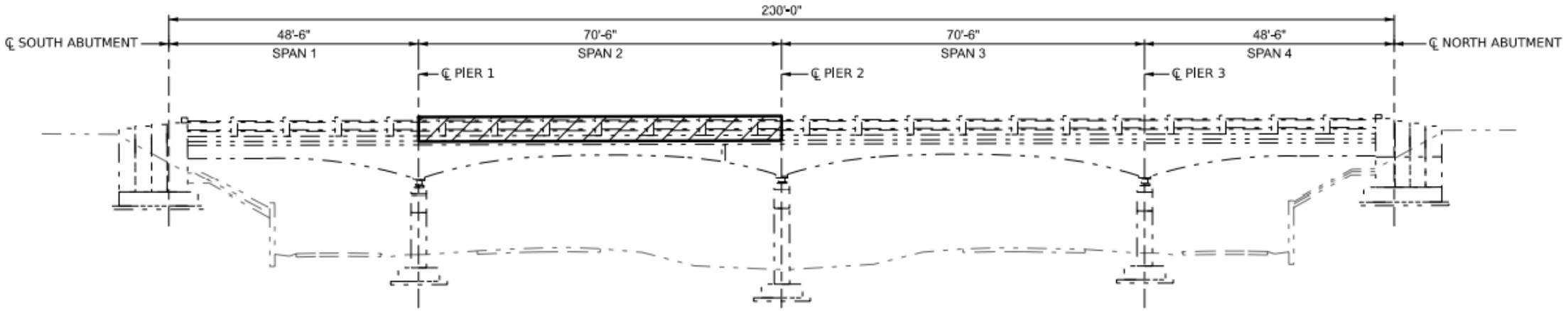
Framing Plan
(Half of Structure)



Typical Cross Section
(Railing Removed)

Demolition Stage 1

- Removal of portion of bridge parapets



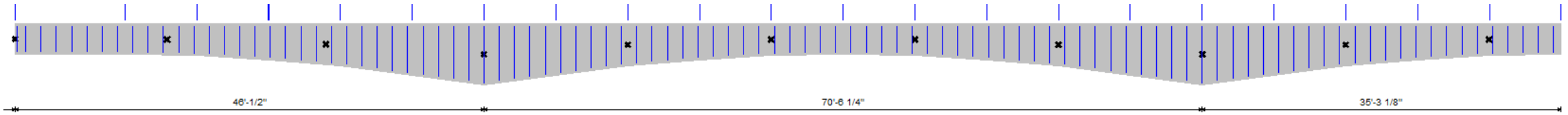
STAGE 1 ELEVATION

Demolition Stage 2

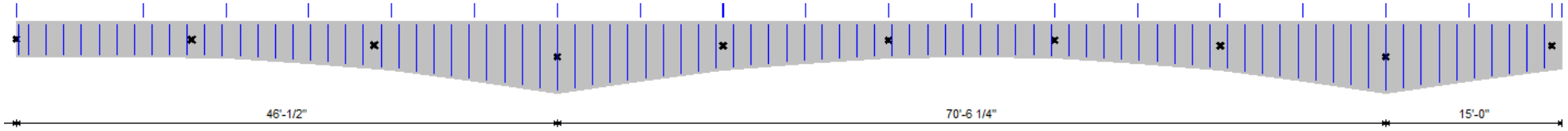
- Remove span 1 (south end span) and portion of Span 2
- Install pavement protection beneath bridge
- Multiple Excavators to work simultaneously on the ground level.
- No live load on top of the bridge and only self weight of structure considered
- Demolish exterior girders along with deck and proceed to the adjacent interior girders
- Maximum overhang 35’ and minimum overhang 15’ at Span 2
- Minimum rating factor: >>1.0 (Controlling member fascia girder, 55% span 3)

Demolition Stage 2

- Girder cantilever end modeled as free end in BrR Member Support



Span 4 Span 3 Half Span 2

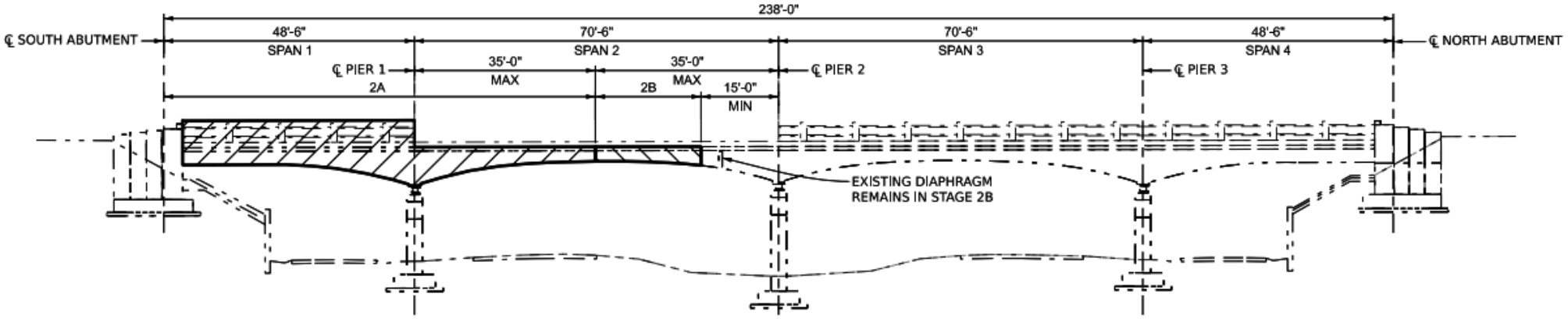


Span 4 Span 3 Remaining 15’ of Span 2

Girder Elevation View

Demolition Stage 2

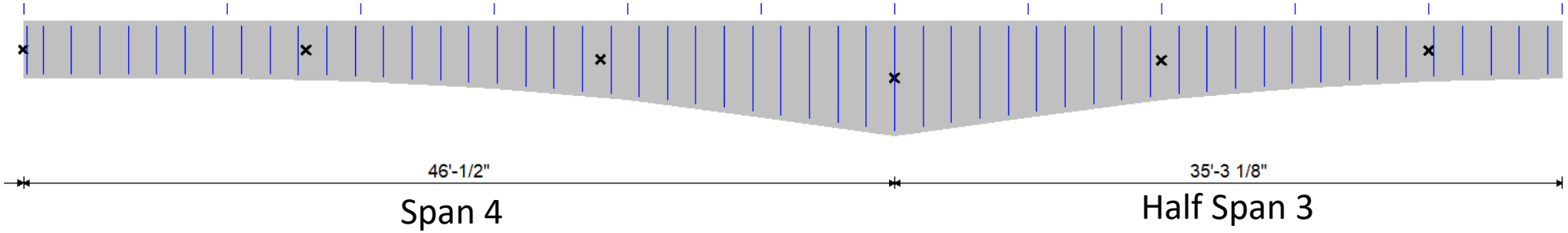
- Remove span 1 (south end span) and portion of Span 2



STAGE 2 ELEVATION

Demolition Stage 3

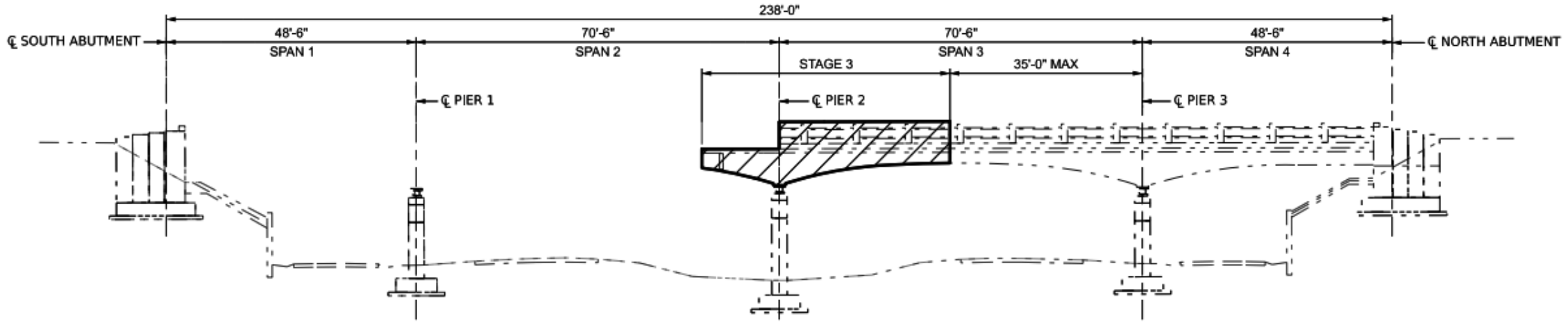
- Remove remaining of span 2 and portion of Span 3
- Maximum overhang 35’ at span 3
- Minimum rating factor: >>1.0 (controlling member fascia girder, 25% span 3)



Girder Elevation View

Demolition Stage 3

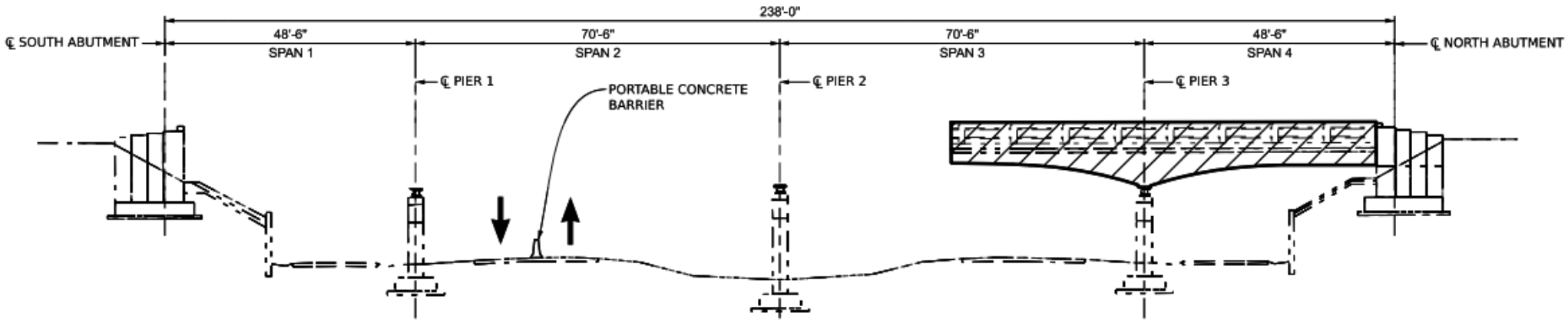
- Remove remaining of span 2 and portion of Span 3



STAGE 3 ELEVATION

Demolition Stage 4

- Remove remaining portion of the structure



STAGE 4 ELEVATION

BrR Load Rating Results Summary

- Provide structural member ratings at different demolition stages
- Evaluate remaining structure stability at different demolition stages
- Provide minimum and maximum removal limits at each demolition stage for contractor options
- Evaluate member capacity for different construction load scenario

Bridge Demolition – Stage 1

- Removal portion of bridge parapets

(Photo courtesy to Jeremy Curtis)

Bridge Demolition – Stage 2

- Removal of span 1 & portion of span 2)

(Photo courtesy to Jeremy Curtis)

Bridge Demolition – Stage 2

- Removal of span 1 & portion of span 2)

(Photo courtesy to Jeremy Curtis)

Bridge Demolition – Stage 3

- Removal remaining of span 2 and portion of span 3

(Photo courtesy to Jeremy Curtis)

Bridge Demolition – Stage 4

- Remove remaining of the structure

(Photo courtesy to Jeremy Curtis)

Bridge Demolition Completed

- I-94 EB

(Photo courtesy to Jeremy Curtis)

Bridge Demolition Completed

- I-94 WB

(Photo courtesy to Jeremy Curtis)

I-94 Open to Traffic at 8:15 am Saturday

- I-94 EB

(Photo courtesy to Jeremy Curtis)

Lesson and Learn

- Follow proper guidance and policy
- Submit early for owner review and approval
- Contractors are the most important part of the demolition execution, from equipment, construction method, schedule, to MOT, keep the communication open
- BrR modeling is relatively faster comparing to a FEM, the time saving is mostly from BrR automated capacity check and load rating

Acknowledgement

- Case Study 1
  - ARDOT and TDOT
  - Michael Baker Project Team
- Case Study 2
  - UDOT
  - Contractor: Ralph L Wadsworth
  - Michael Baker Project Team
- Case Study 3
  - MIDOT
  - Contractor: Anlaan Corporation
  - Michael Baker DB Team

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Thank You!

Questions?

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