MIDASoft Webinar | March 18, 2015

# Load Rating and Rehabilitation of the New River Gorge Bridge


**Presenter:**

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**Project Manager:**

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CELEBRATING 100 YEARS 1912 ~ 2012

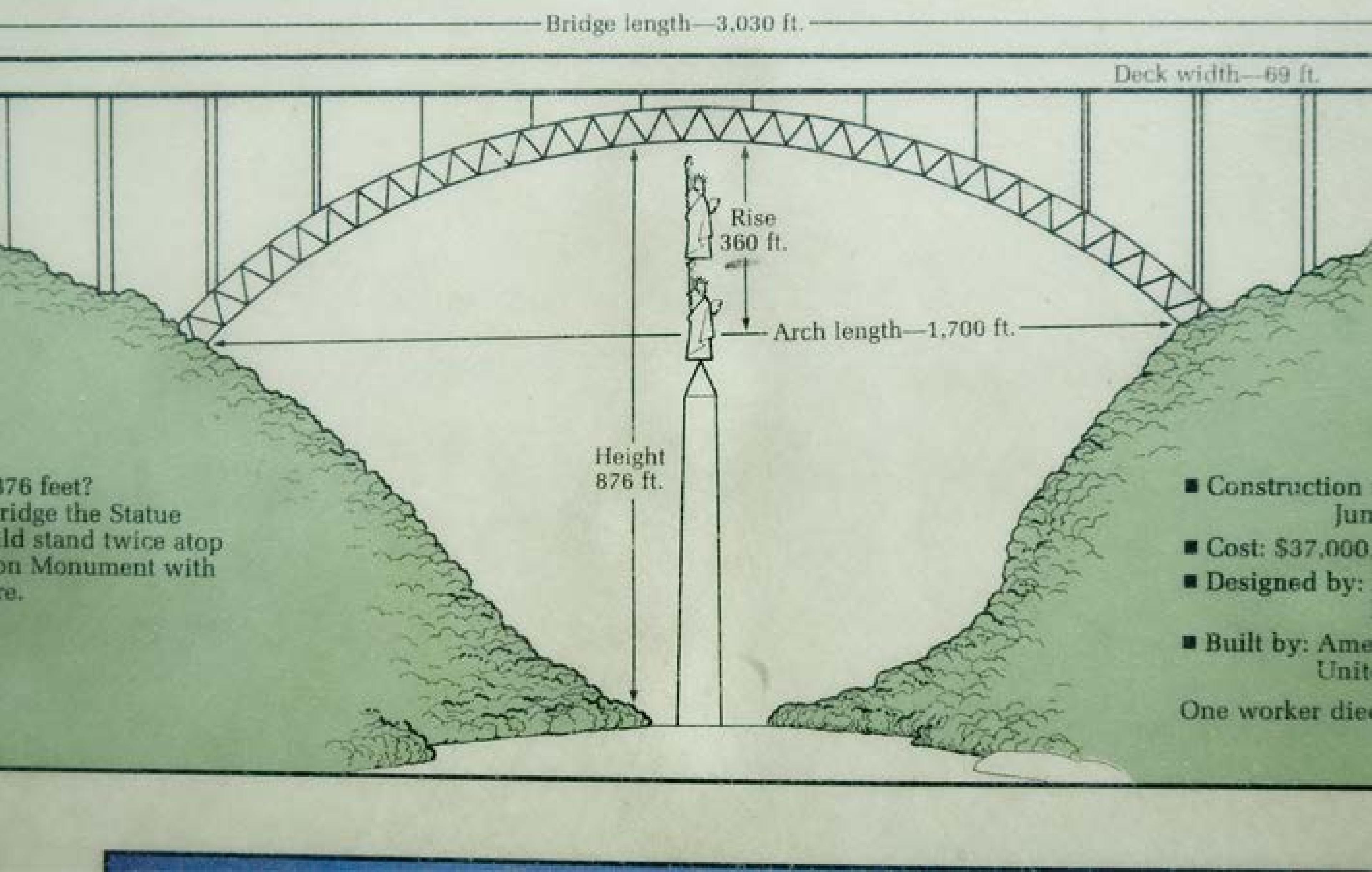
BURGESS & NIPLE
Engineers ■ Architects ■ Planners

STATE OF WEST VIRGINIA DEPARTMENT OF TRANSPORTATION

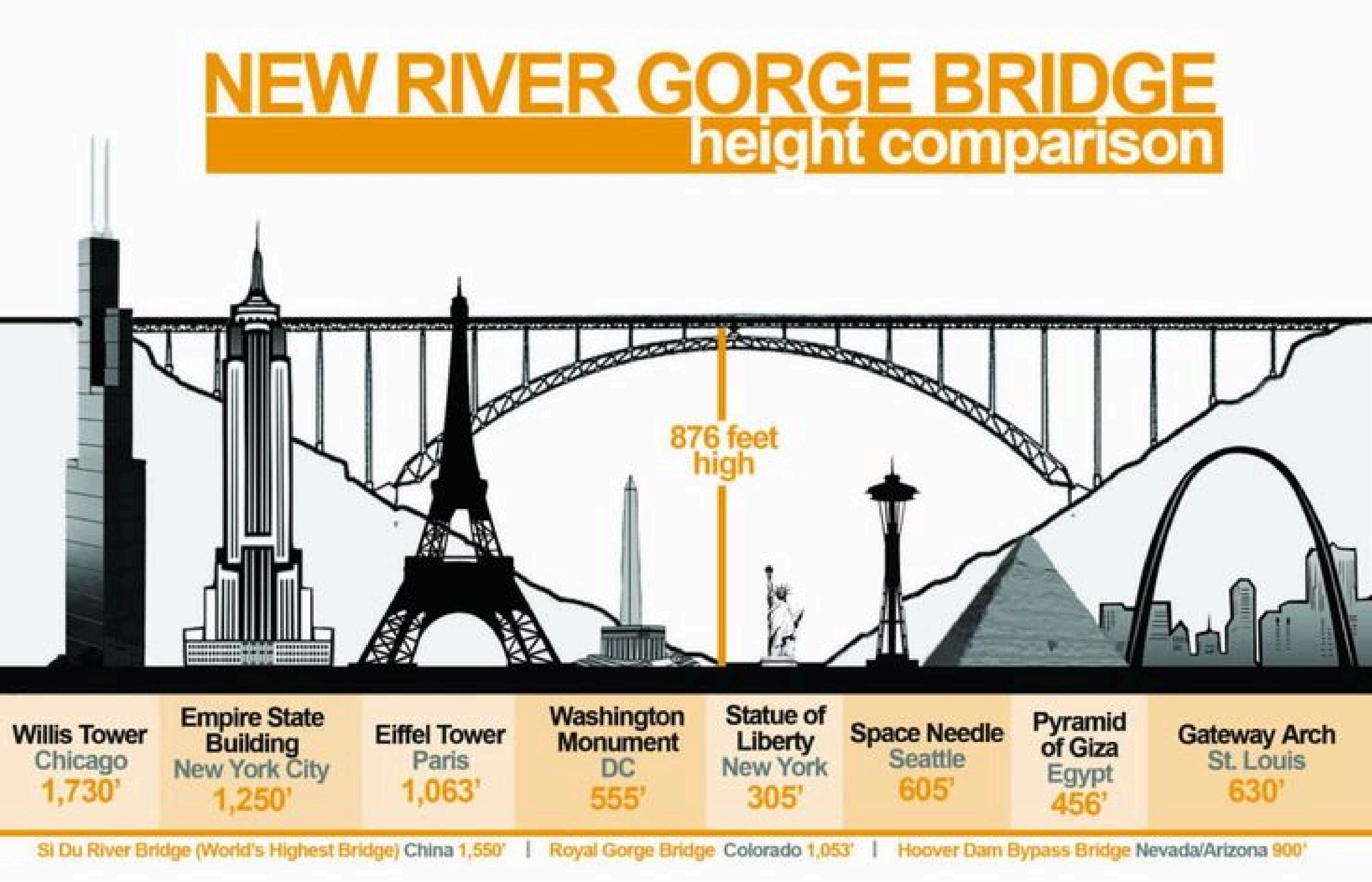
# The New River Gorge Bridge

- Owned by WVDOT
- Constructed June 1974 – October 1977
- Main Span Length:  1,700 ft
- Overall Length:  3,031 ft
- Height above the New River:  876 ft
- Longest Steel Arch Bridge in the Western Hemisphere
- Added to the National Register for Historic Structures in 2013

# How high is the bridge?

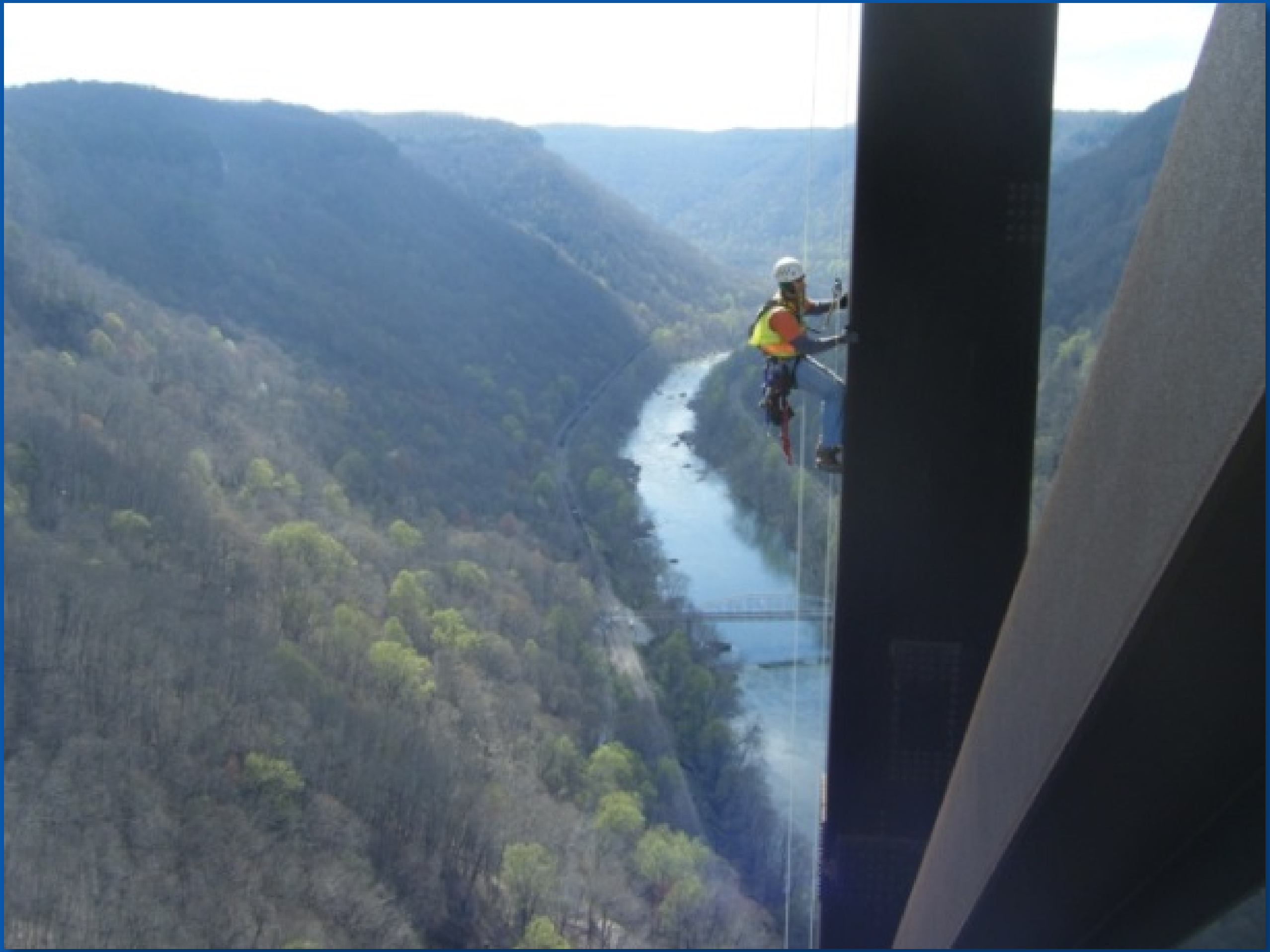


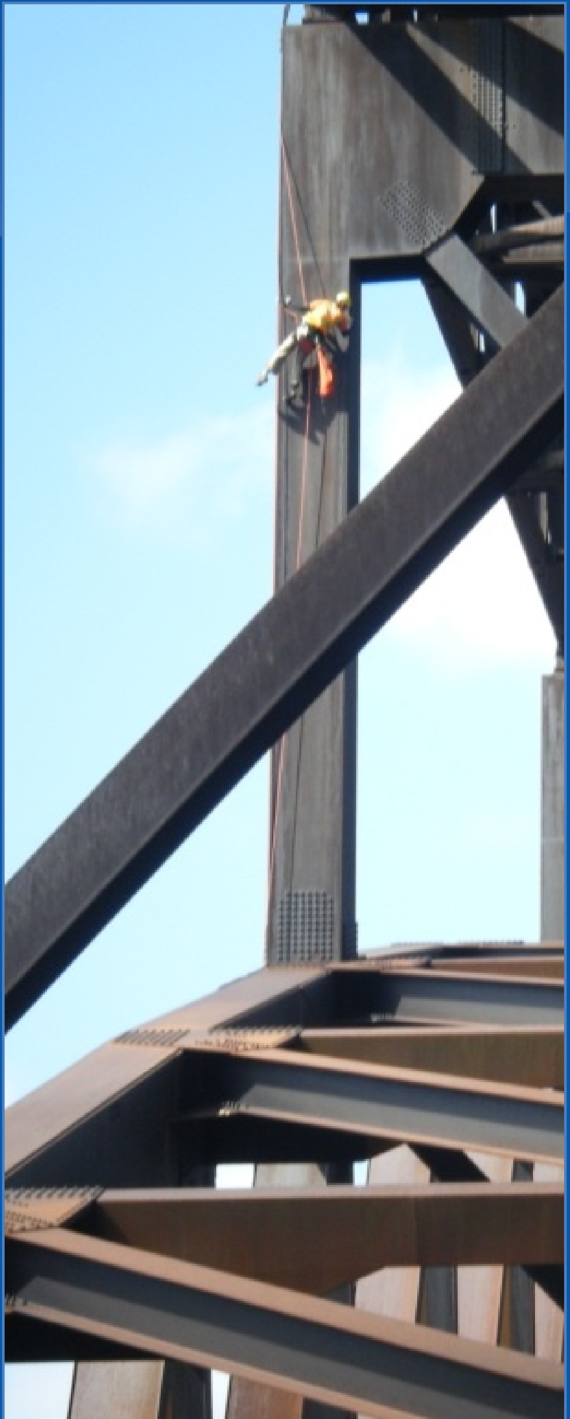
# How high is the bridge?



# Inspection:

- Burgess & Niple has been inspecting the bridge since 2008.
- The inspection team uses a combination of climbing and access equipment.





# Load Rating Scope:

- Load rate all primary bridge members
- Load rate all primary member connections, including gusset plates and splices
- Include wind and temperature effects in the rating
- Perform the rating for HS20 design load, 5 West Virginia legal loads, and 4 Coal Resource Transportation System (CRTS) trucks
- Include all member losses and deficiencies recorded during inspections in the rating calculations

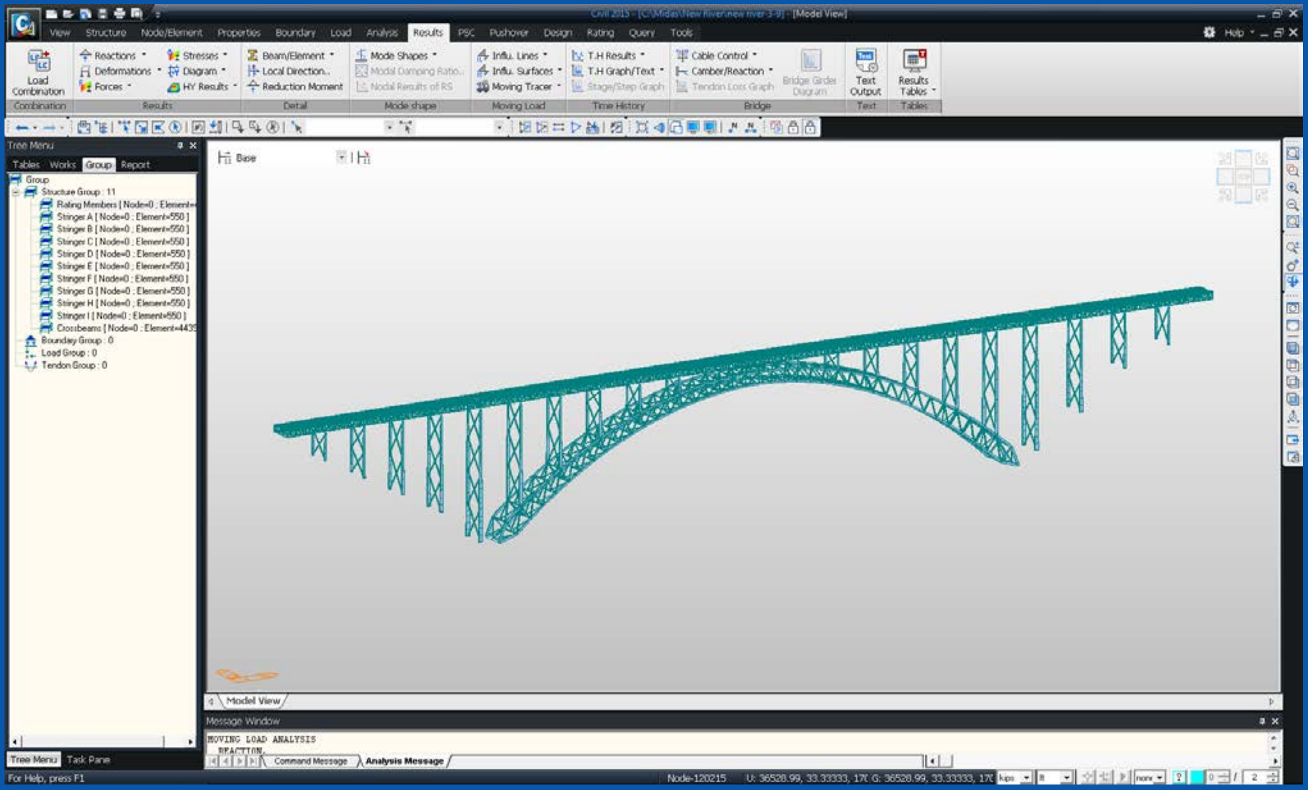
⇒ 4500+ members
⇒ 871 gusset plates
⇒ 1034 non-gusset connections

# Load Rating Challenges:

- Modeling – How many and what type of analysis models are needed?
- Data management – How do we collect and use data consistently and efficiently?
- Capacity and rating – How do we use collected data (section properties, connection geometry, losses) to calculate capacity and ratings for 4500 members and 1900 connections?

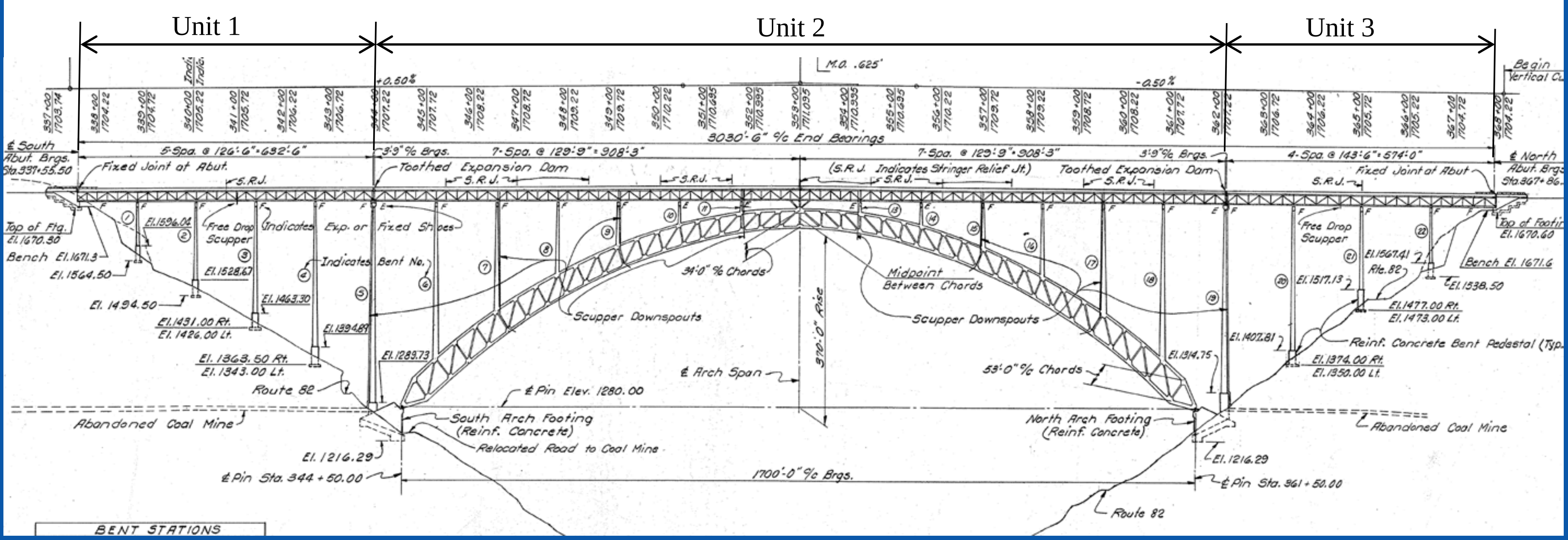
# Modelling:  Midas Civil

- Main model for the bridge was created using Midas Civil
- This model would be used to calculate dead load, live load and temperature forces for all members except the stringers
- A second version of the main model will be created to calculate wind forces using geometrically nonlinear analysis
- Stringers will be handled separately using a calculated distribution factor for live load

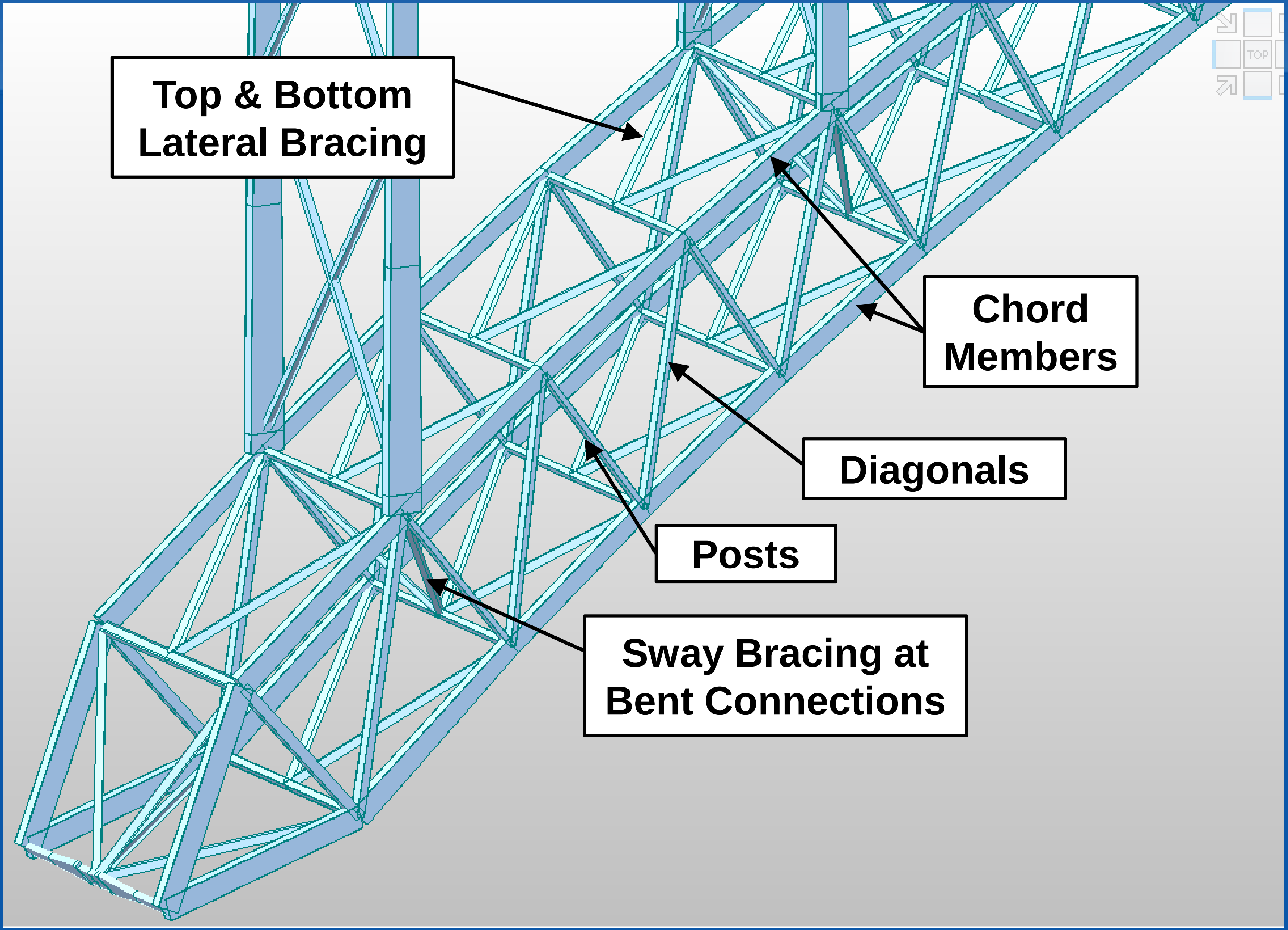


# Configuration of the structure:

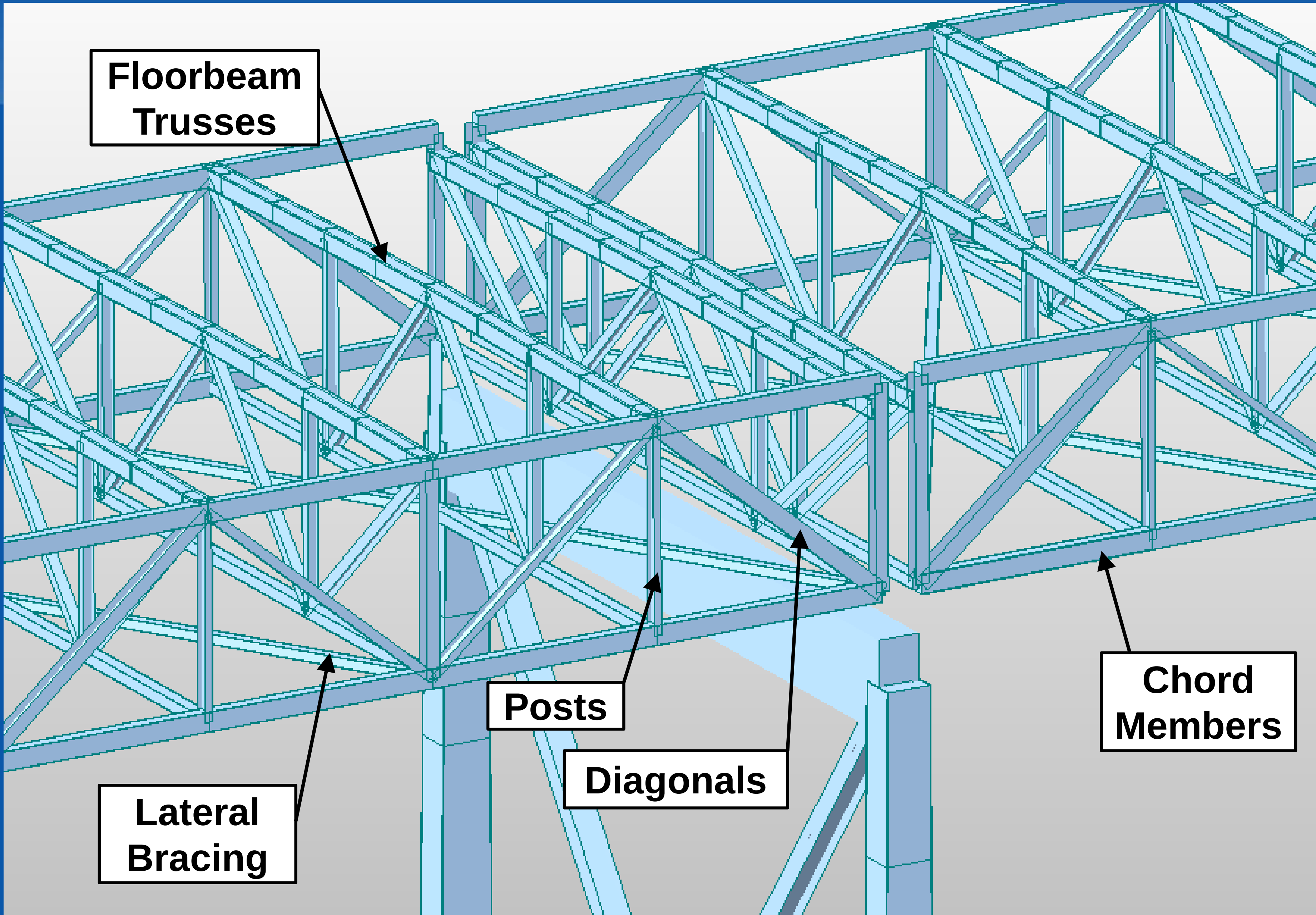
- 3 Units, with expansion joints at bent 5 and bent 19
- Longitudinally fixed at the abutments
- Unit 1 and 3 bents fixed at the base
- Unit 2 bents treated as pin-pin



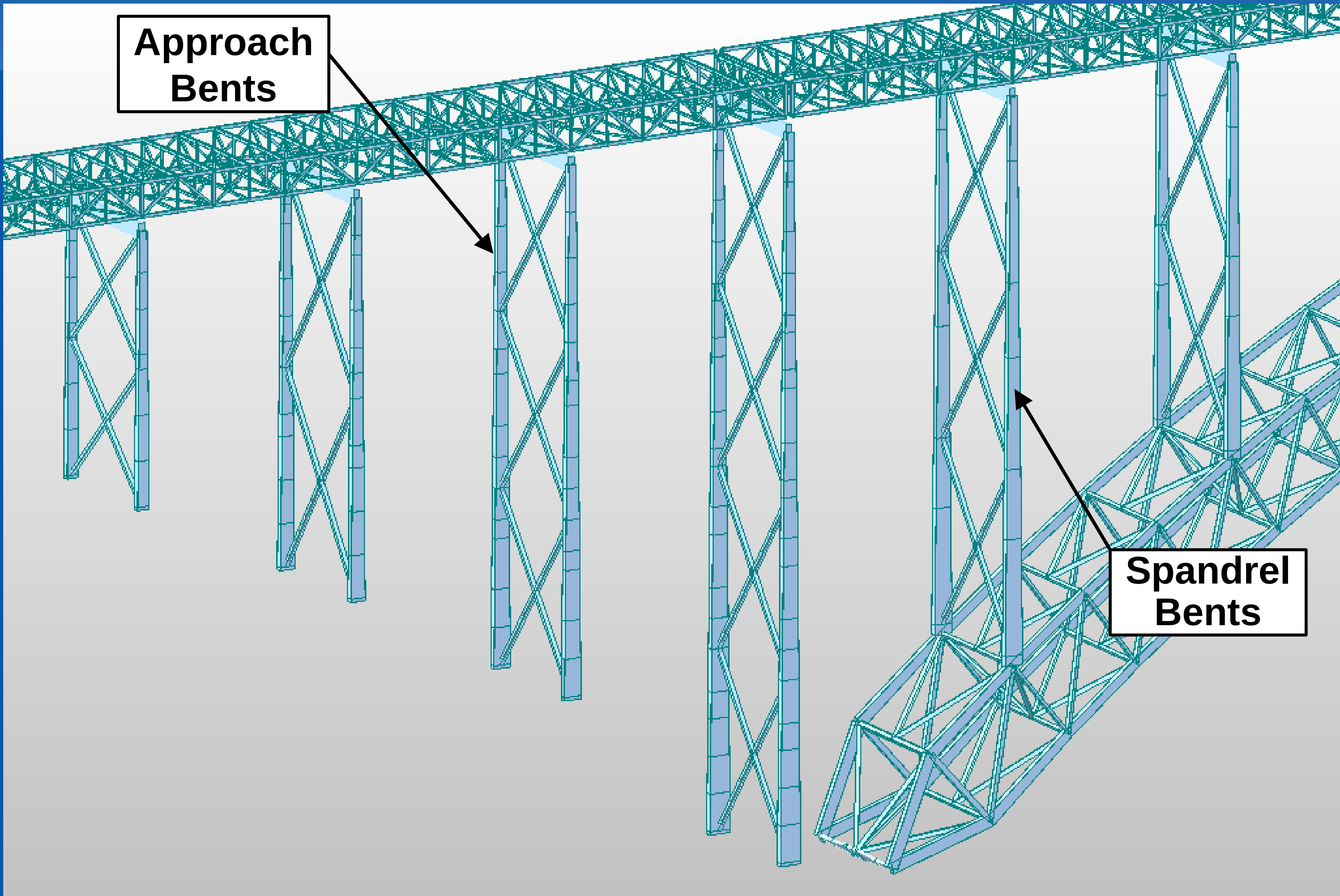
# Model Configuration – Arch Truss



# Model Configuration – Deck Truss



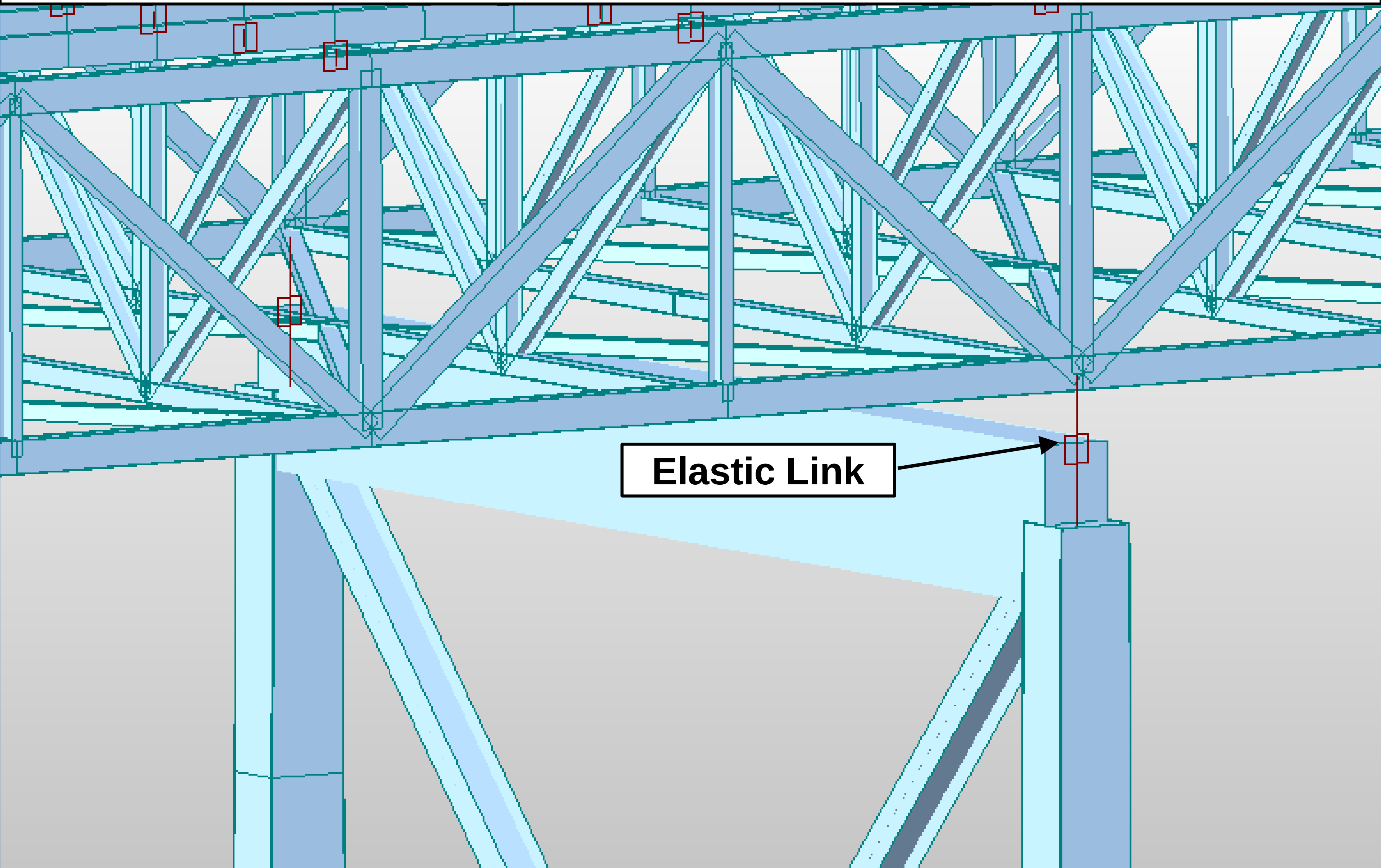
# Model Configuration – Bents

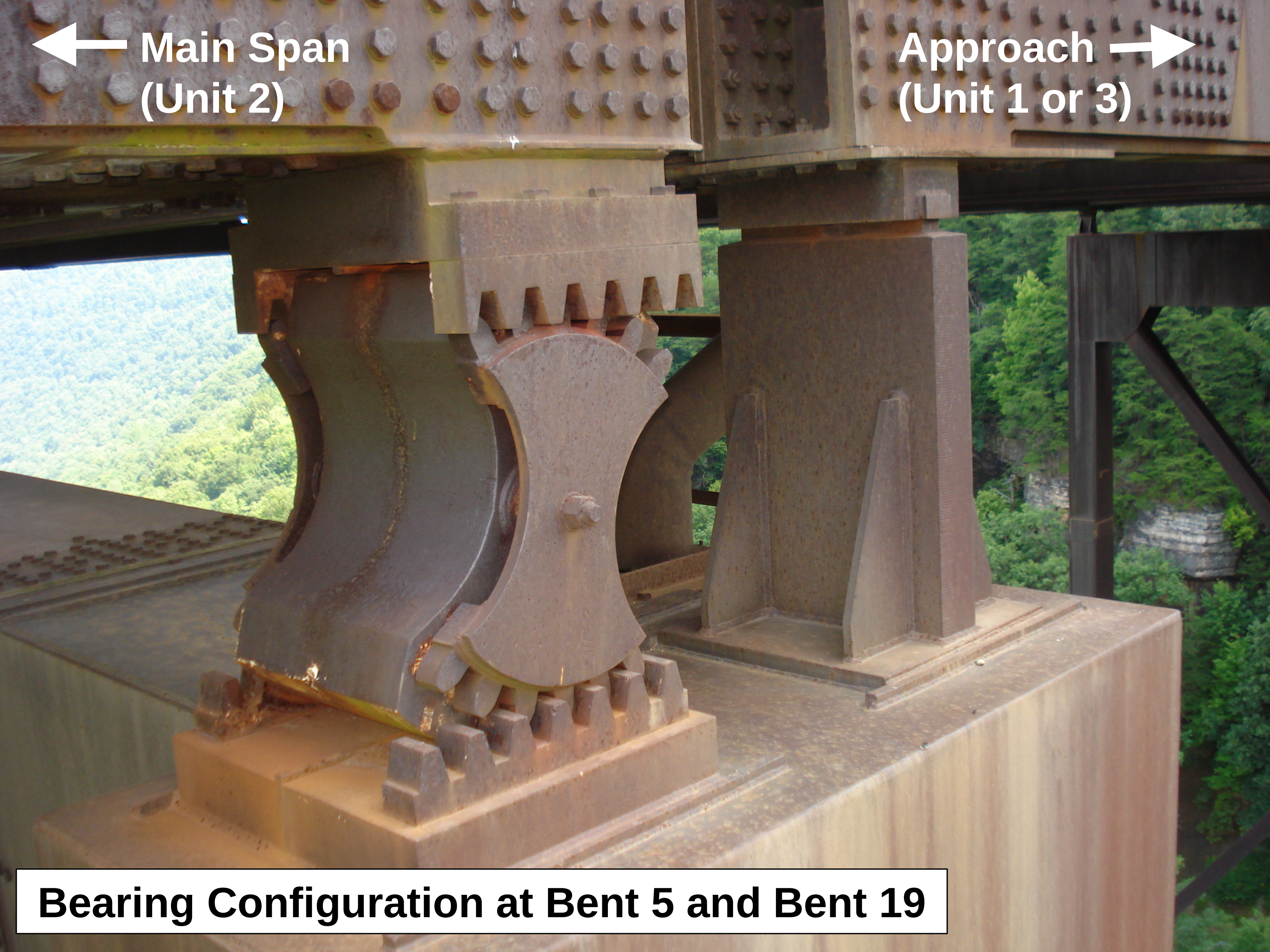


Typical bearing condition at top of bent

**Typical Bent Bearings:**

- **Bent bearings were modeled using elastic links.  Links were released for rotation at the top node.**

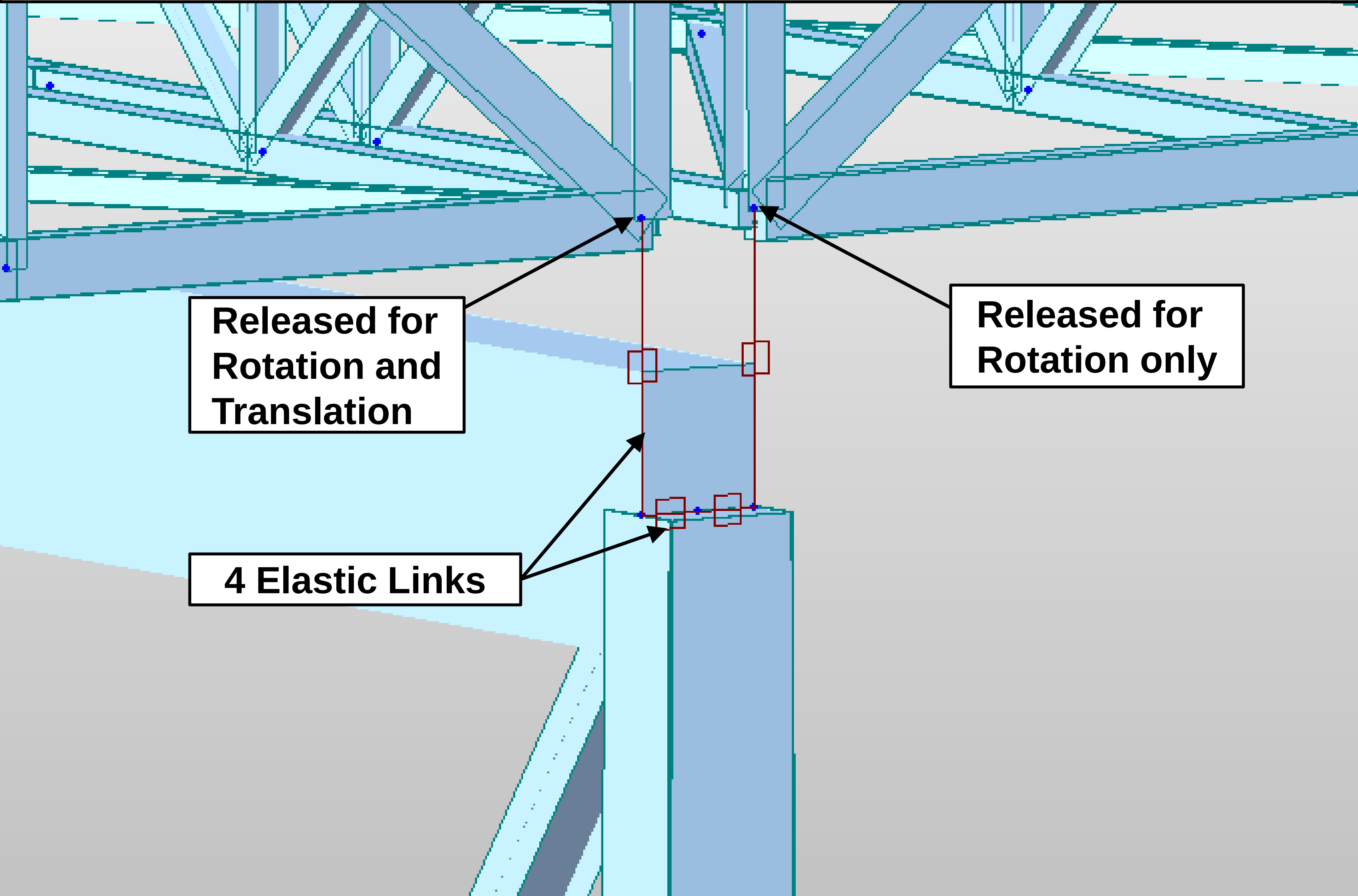





Bearing Configuration at Bent 5 and Bent 19

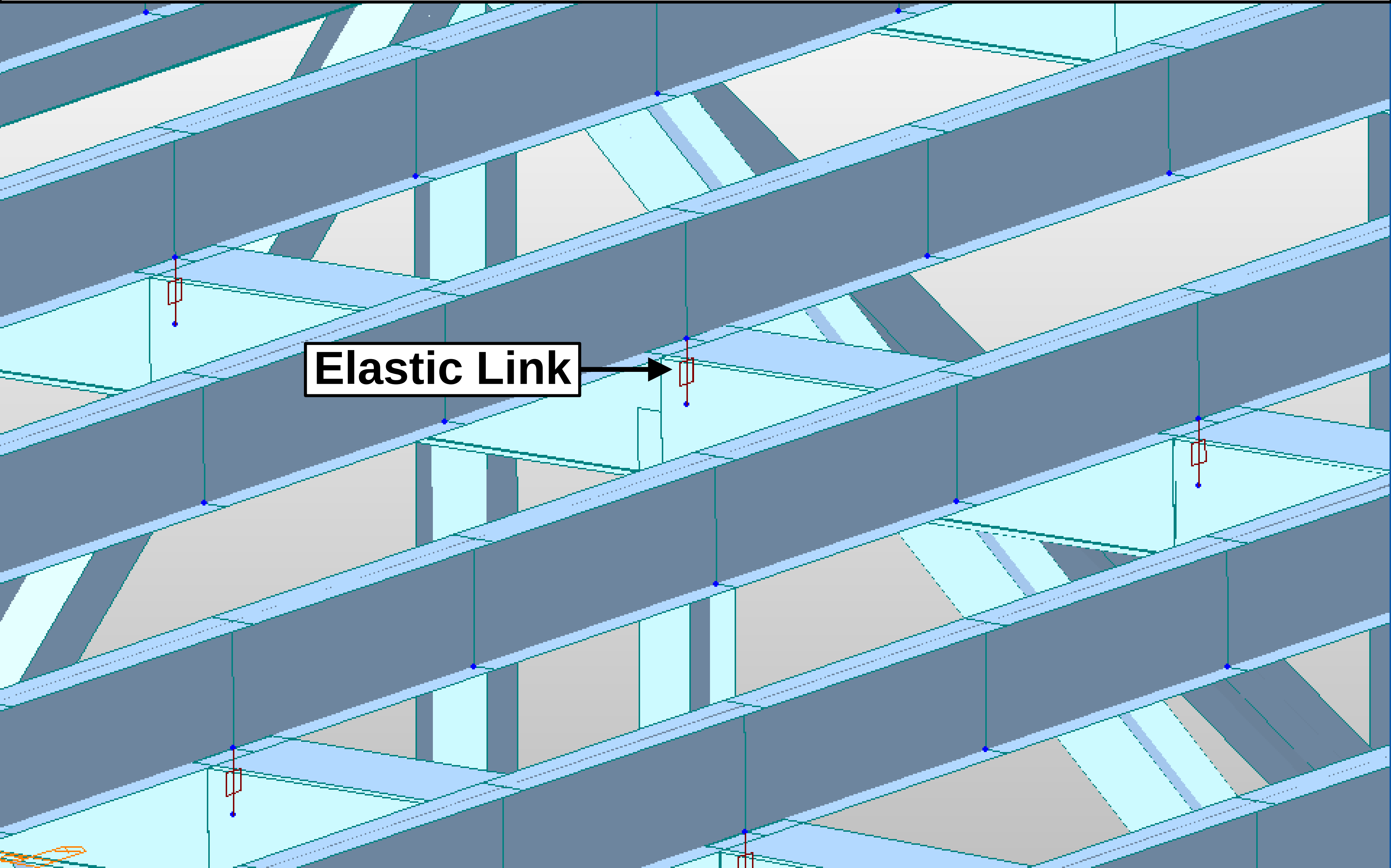
**Bents 5 & 19 (Expansion bearing locations):**

- **A series of 4 links is used to connect the truss bearings to the bent cap.**



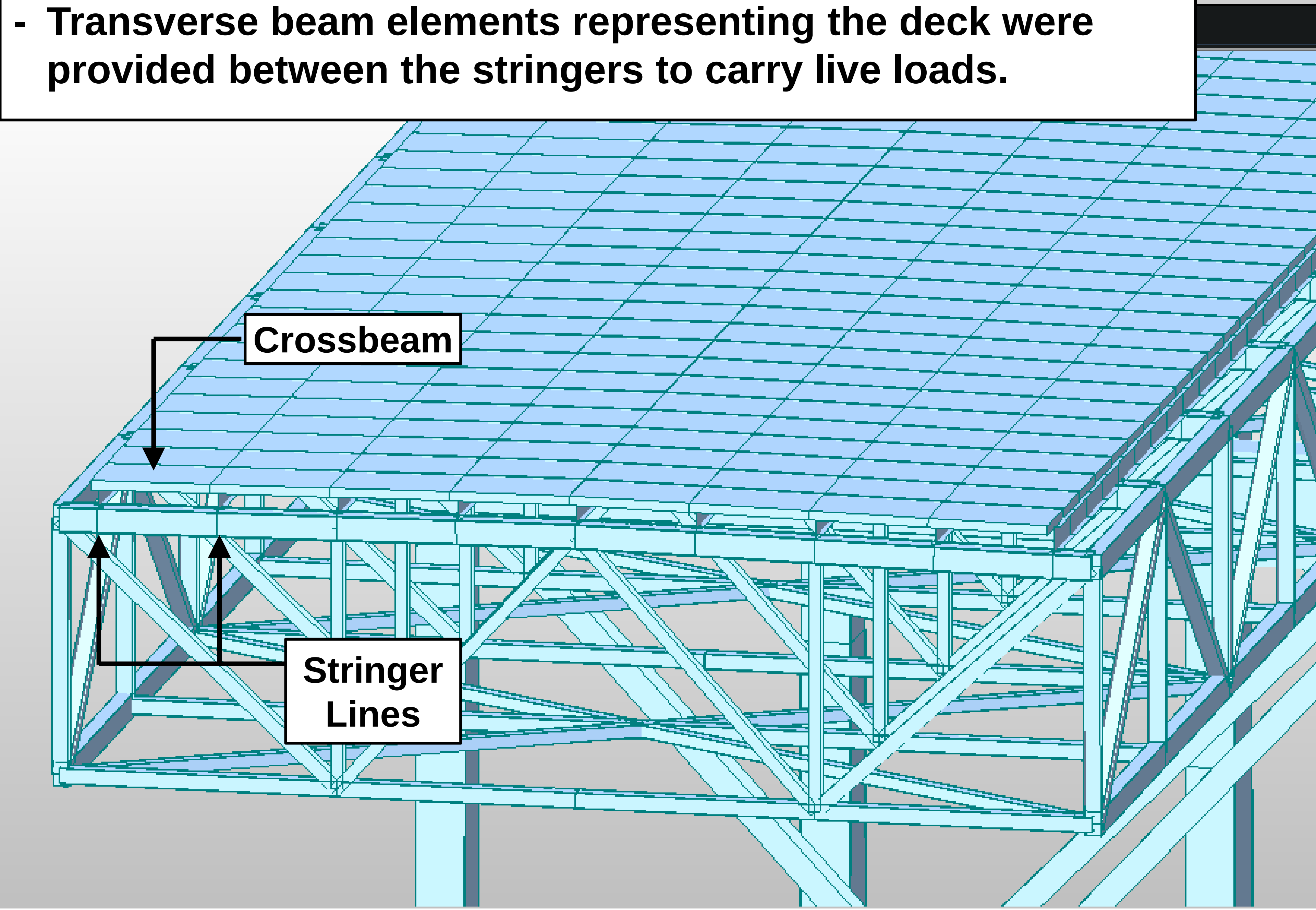
**Stringer to Floorbeam Connections:**

- **Elastic Links released for rotation at the top node. Member ends are released for translation at deck joint locations.**



**Deck Crossbeams:**

- Transverse beam elements representing the deck were provided between the stringers to carry live loads.



# Live Load Cases:

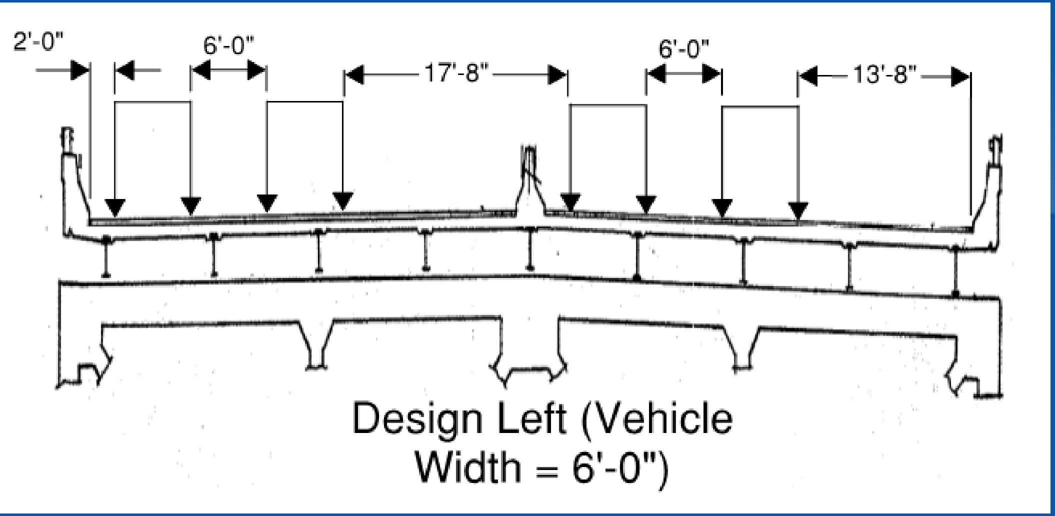
- 24 Lane Locations
- 55 Moving Load Cases

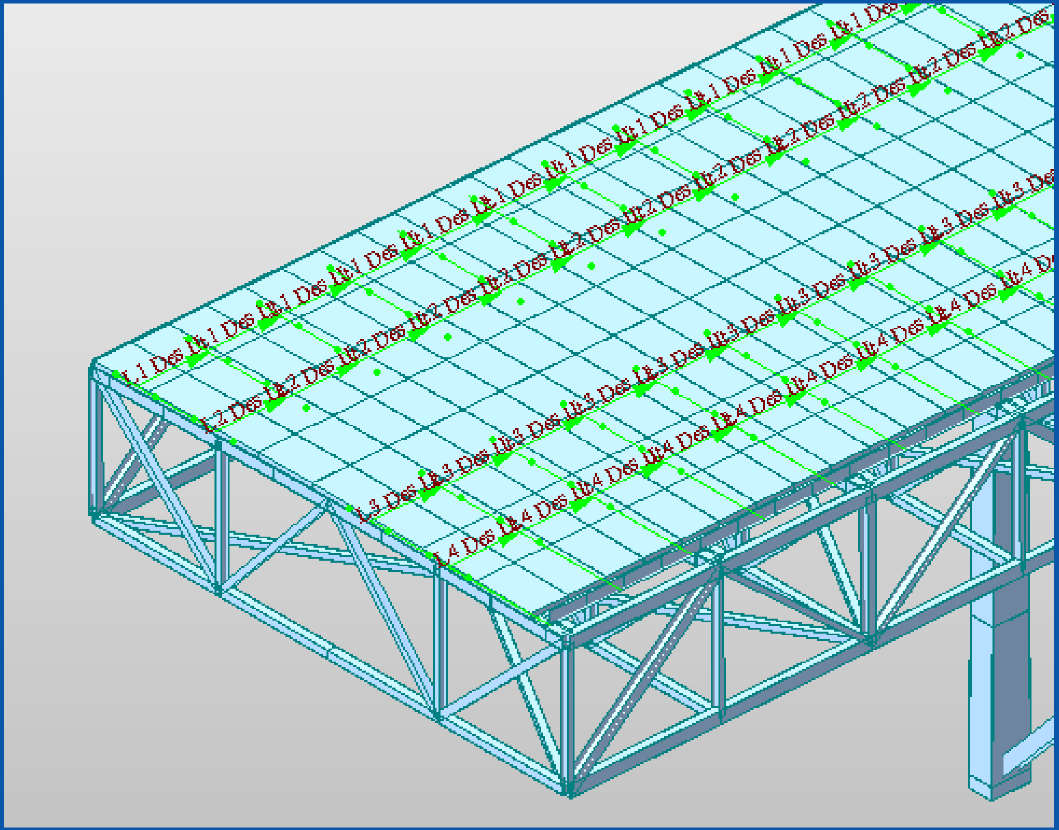
Traffic Line Lanes : 24

- Traffic Line Lane 1 [ L1 Des Lt ]
- Traffic Line Lane 2 [ L1 Des P3 ]
- Traffic Line Lane 3 [ L1 Des P4 ]
- Traffic Line Lane 4 [ L1 Des Rt ]
- Traffic Line Lane 5 [ L1 Legal Lt ]
- Traffic Line Lane 6 [ L1 Legal Rt ]
- Traffic Line Lane 7 [ L2 Des Lt ]
- Traffic Line Lane 8 [ L2 Des P3 ]
- Traffic Line Lane 9 [ L2 Des P4 ]
- Traffic Line Lane 10 [ L2 Des Rt ]
- Traffic Line Lane 11 [ L2 Legal Lt ]

Moving Load Cases : 55

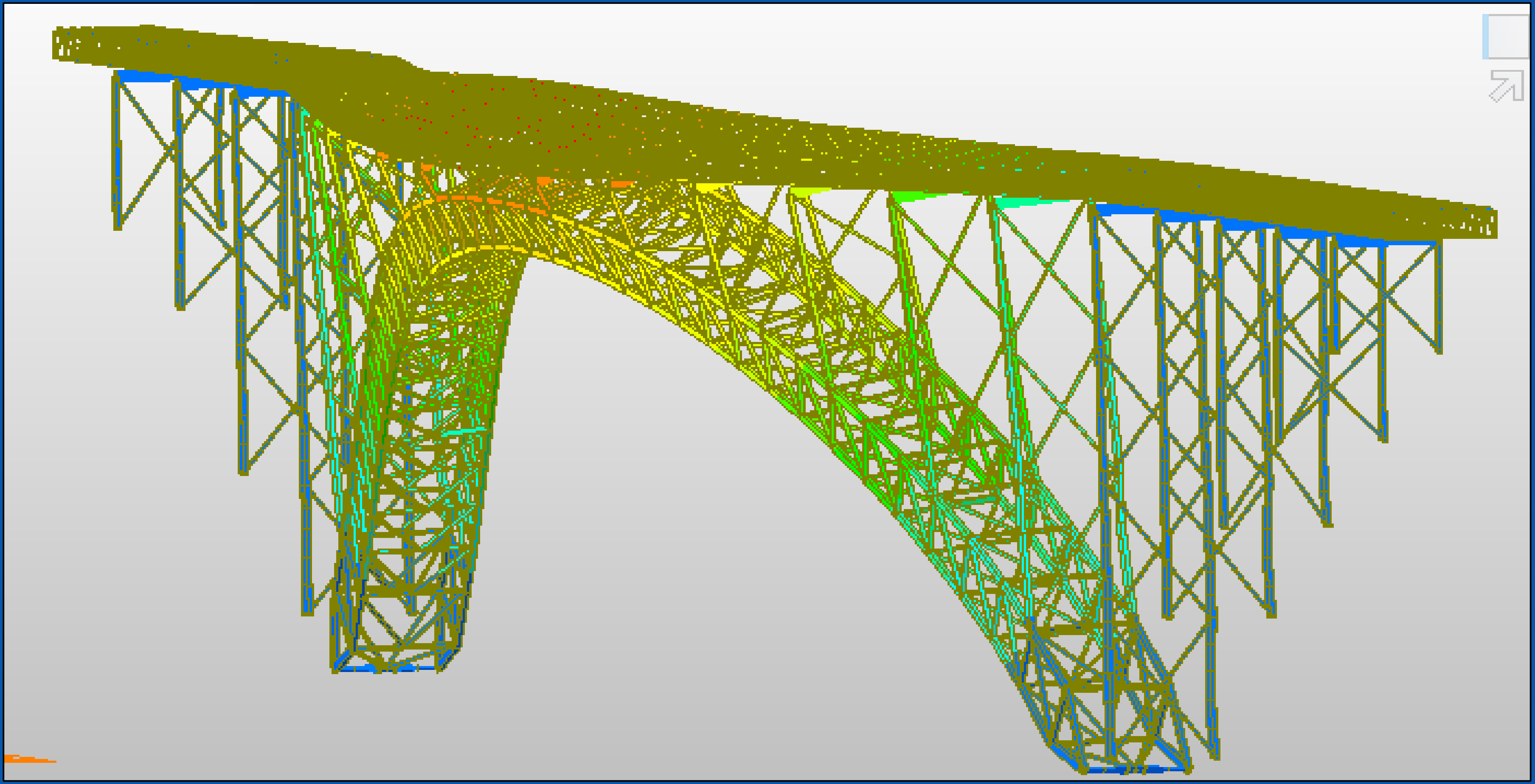
- Moving Load Case 1 [ HS20 (Design) ]
- Moving Load Case 2 [ HS20 (Legal) - Lane 1a ]
- Moving Load Case 3 [ HS20 (Legal) - Lane 1b ]
- Moving Load Case 4 [ HS20 (Legal) - Lane 2 ]
- Moving Load Case 5 [ HS20 (Legal) - Lane 3 ]
- Moving Load Case 6 [ HS20 (Legal) - Lane 4a ]
- Moving Load Case 7 [ HS20 (Legal) - Lane 4b ]
- Moving Load Case 8 [ H20-44 - Lane 1a ]
- Moving Load Case 9 [ H20-44 - Lane 1b ]
- Moving Load Case 10 [ H20-44 - Lane 2 ]
- Moving Load Case 11 [ H20-44 - Lane 3 ]
- Moving Load Case 12 [ H20-44 - Lane 4a ]
- Moving Load Case 13 [ H20-44 - Lane 4b ]



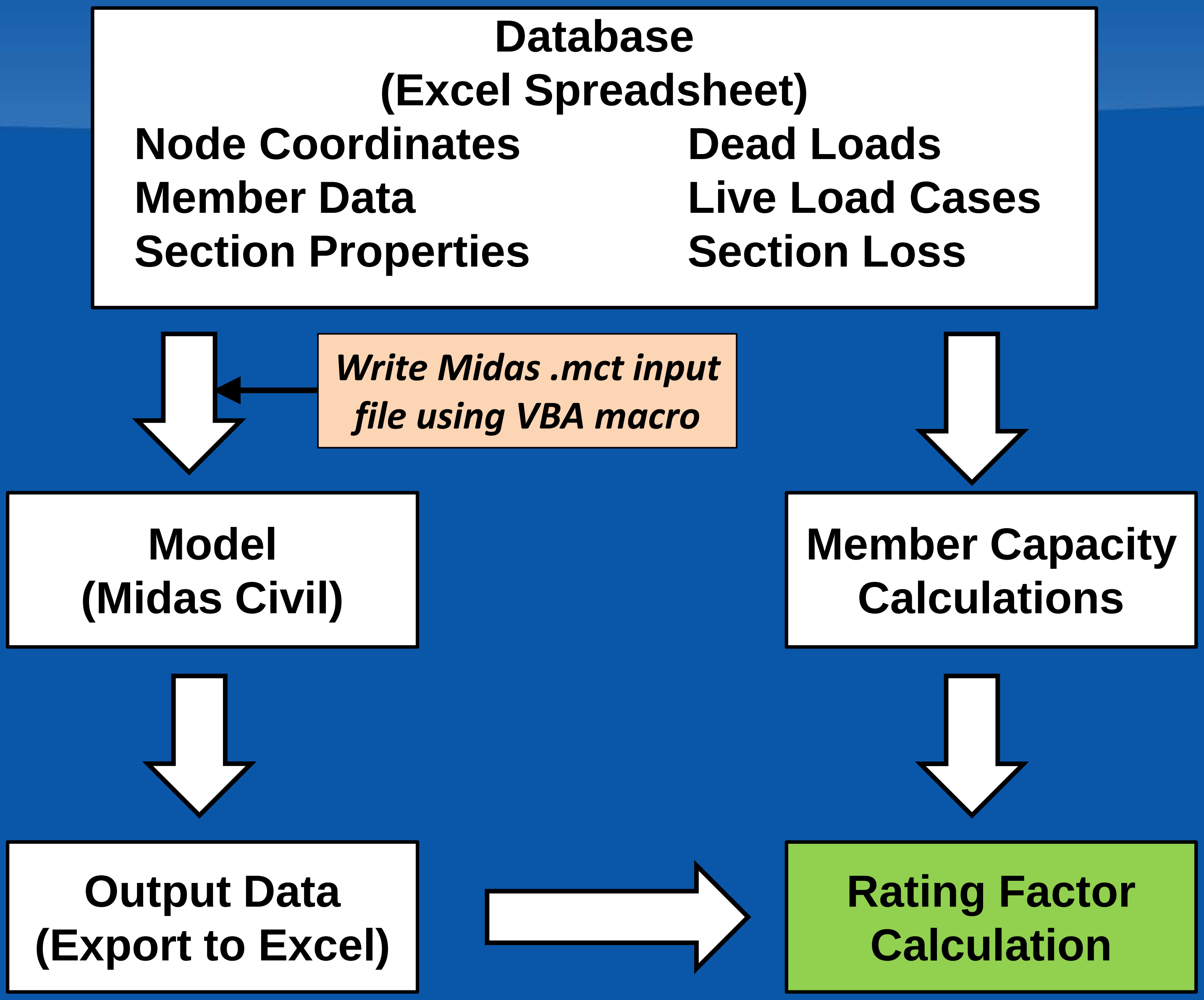



# Nonlinear Wind Analysis:

- A second version of the main model was created with wind and dead load forces only.
- Geometric nonlinear analysis was conducted for 12 wind combinations + dead load.



# Data Management:



# Data Collection:

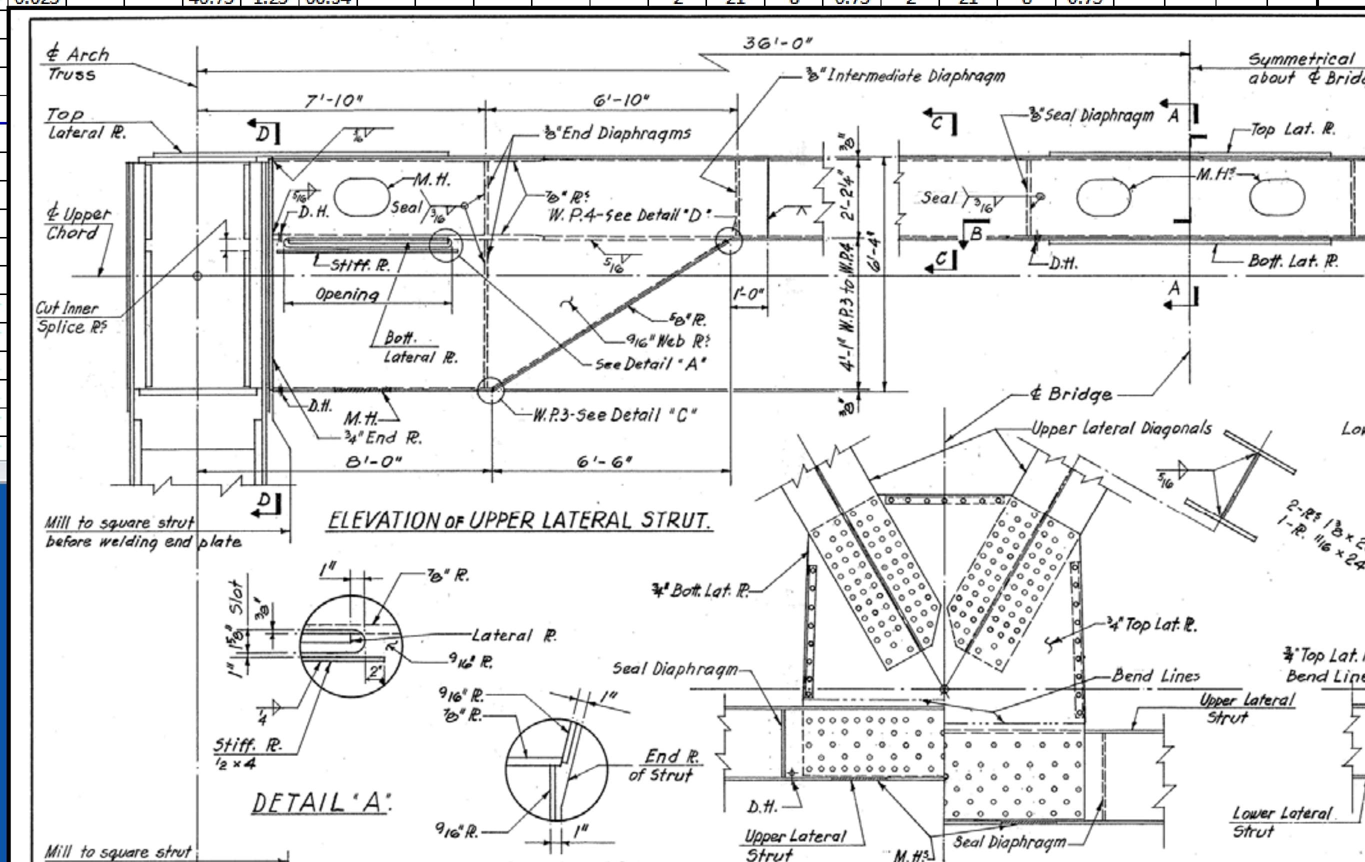
- Record member data from plans and shop drawings in Excel Database

Section Data

(Section Loss not Included)

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | AA | AB | AC | AD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Section Number | Section Type | Std. Sect. | Top Fl. | | Bot. Fl. | | Flange 3 (2 Cell, Type A) | | Web (I) L&R Web (Box) Left Web (Trap) | | | Right Web (Trap) | | Web 3 (Type A) | | | Top Fl. Long. Stiffeners | | | | Bot. Fl. Long. Stiffeners | | | | Web Long. Stiffeners (Ea. Web) | | | | Vertical Offset (in) |
| 4 | | | | $b_{tf}$ (in) | $t_{tf}$ (in) | $b_{bf}$ (in) | $t_{bf}$ (in) | $b_{f3}$ (in) | $t_{f3}$ (in) | $h_{lw}$ (in) | $t_{lw}$ (in) | c (in) | $h_{rw}$ (in) | $t_{rw}$ (in) | $h_{rw}$ (in) | $t_{rw}$ (in) | f (in) | No. | $s_{max}$ (in) | $b_{st}$ (in) | $t_{st}$ (in) | No. | $s_{max}$ (in) | $b_{st}$ (in) | $t_{st}$ (in) | No. | $s_{max}$ (in) | $b_{st}$ (in) | $t_{st}$ (in) | |
| 1398 | 101204a | Box | | 60.01 | 0.625 | 60.01 | 0.625 | | | 40.75 | 1.25 | 61.51 | | | | | | 2 | 21 | 8 | 0.75 | 2 | 21 | 8 | 0.75 | | | | | |
| 1399 | 101204b | Box | | 64.84 | 0.625 | 64.84 | 0.625 | | | 40.75 | 1.25 | 66.34 | | | | | | 2 | 21 | 8 | 0.75 | 2 | 21 | 8 | 0.75 | | | | | |
| 1400 | 101205a | Box | | 64.84 | 0.625 | 64.84 | 0.625 | | | 40.75 | 1.25 | 66.34 | | | | | | 2 | 21 | 8 | 0.75 | 2 | 21 | 8 | 0.75 | | | | | |
| 1401 | 101205b | Box | | 65.25 | 0.625 | 65.25 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1402 | 101501 | Box | | 46.5 | 0.5 | 47 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1403 | 101301a | I-Beam | | 22 | 1 | 22 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1404 | 101301b | I-Beam | | 22 | 1 | 22 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1405 | 101401a | I-Beam | | 22 | 1 | 22 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1406 | 101401b | I-Beam | | 22 | 1 | 22 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1407 | 102101a | Box | | 47.50 | 1.25 | 47.50 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1408 | 102101b | Box | | 47.5 | 0.625 | 47.5 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1409 | 102101c | Box | | 50.91 | 0.63 | 50.91 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1410 | 102102a | Box | | 50.91 | 0.63 | 50.91 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1411 | 102102b | Box | | 55.77 | 0.63 | 55.77 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1412 | 102103a | Box | | 55.77 | 0.75 | 55.77 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1413 | 102103b | Box | | 61.74 | 0.75 | 61.74 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1414 | 102104a | Box | | 61.74 | 0.75 | 61.74 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1415 | 102104b | Box | | 63.67 | 0.75 | 63.67 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1416 | 102105a | Box | | 63.67 | 0.75 | 63.67 | | | | | | | | | | | | | | | | | | | | | | | | |

Member Data | Section Data | Section Loss



# Data Collection:

- Member section loss data was collected from bridge inspection reports.
- Location and depth of loss area were recorded to allow data to be used to recalculate section properties.

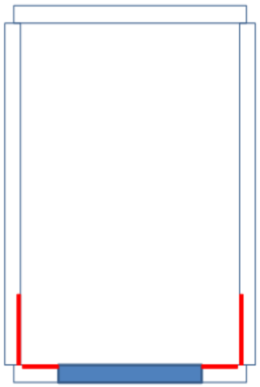
**Section Loss**

| Elem. No. | Member Name | Loc | Type | Loss Data: Sect. | Comp. | Face | At Opening? | Reference Point | Offset (in) | t (in) | b (in) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11101 | L1-L2 | Truss 1L | LC | end-I | Bot Fl | Inside | Y | Left | 0.5 | 0.0625 | 2 |
| 11101 | L1-L2 | Truss 1L | LC | end-I | Bot Fl | Inside | Y | Rt. | 0.5 | 0.0625 | 2 |
| 11103 | L3-L4 | Truss 1L | LC | end-I | Bot Fl | Inside | Y | Left | 0.5 | 0.125 | 2 |
| 11103 | L3-L4 | Truss 1L | LC | end-I | Bot Fl | Inside | Y | Rt. | 0.5 | 0.125 | 2 |
| 11103 | L3-L4 | Truss 1L | LC | end-I | L. Web | Inside | Y | Bot. | 0 | 0.0625 | 3 |
| 11103 | L3-L4 | Truss 1L | LC | end-I | R. Web | Inside | Y | Bot. | 0 | 0.0625 | 3 |
| 11105 | L5-L6 | Truss 1L | LC | Primary | L. Web | Inside | Y | Bot. | 0 | 0.0625 | 2 |
| 11105 | L5-L6 | Truss 1L | LC | Primary | R. Web | Inside | Y | Bot. | 0 | 0.0625 | 2 |
| 11104 | L4-L5 | Truss 1L | LC | end-J | Bot Fl | Outside | N | Left | 0 | 0.125 | 4 |
| 11203 | U3-U4 | Truss 1L | UC | Primary | L. Web | Inside | Y | Bot. | 0 | 0.125 | 3 |
| 11203 | U3-U4 | Truss 1L | UC | Primary | R. Web | Inside | Y | Bot. | 0 | 0.125 | 3 |
| 11203 | U3-U4 | Truss 1L | UC | Primary | Bot Fl | Inside | Y | Left | 0.5 | 0.3125 | 2 |
| 11203 | U3-U4 | Truss 1L | UC | Primary | Bot Fl | Inside | Y | Rt. | 0.5 | 0.3125 | 2 |
| 11204 | U4-U5 | Truss 1L | UC | Primary | L. Web | Inside | Y | Bot. | 0 | 0.125 | 3 |
| 11204 | U4-U5 | Truss 1L | UC | Primary | R. Web | Inside | Y | Bot. | 0 | 0.125 | 3 |
| 11204 | U4-U5 | Truss 1L | UC | Primary | Bot Fl | Inside | Y | Left | 0.5 | 0.3125 | 2 |
| 11204 | U4-U5 | Truss 1L | UC | Primary | Bot Fl | Inside | Y | Rt. | 0.5 | 0.3125 | 2 |
| 21101 | L1-L2 | Truss 1R | LC | end-I | Bot Fl | Inside | Y | Left | 0.5 | 0.0625 | 2 |
| 21101 | L1-L2 | Truss 1R | LC | end-I | Bot Fl | Inside | Y | Rt. | 0.5 | 0.0625 | 2 |
| 21105 | L5-L6 | Truss 1R | LC | Primary | Bot Fl | Inside | Y | Left | 0.5 | 0.125 | 2 |
| 21105 | L5-L6 | Truss 1R | LC | Primary | Bot Fl | Inside | Y | Rt. | 0.5 | 0.125 | 2 |
| 21105 | L5-L6 | Truss 1R | LC | Primary | L. Web | Inside | Y | Bot. | 0 | 0.125 | 2 |
| 21105 | L5-L6 | Truss 1R | LC | Primary | R. Web | Inside | Y | Bot. | 0 | 0.125 | 2 |
| 21201 | U1-U2 | Truss 1R | UC | Primary | Bot Fl | Inside | Y | Left | 0.5 | 0.0625 | 2 |
| 21201 | U1-U2 | Truss 1R | UC | Primary | Bot Fl | Inside | Y | Rt. | 0.5 | 0.0625 | 2 |
| 21206 | U6-U7 | Truss 1R | UC | Primary | Bot Fl | Inside | Y | Left | 0.5 | 0.125 | 2 |
| 21206 | U6-U7 | Truss 1R | UC | Primary | Bot Fl | Inside | Y | Rt. | 0.5 | 0.125 | 2 |

**Member Section Loss Datasheet**

| | |
|---|---|
| Member Number: | 12101 |
| Section: | end-I |
| At Opening?: | Y |

| | | |
|---|---|---|
| Data Row: | 706 | |
| Member Name: | L1-L2 | |
| Location: | Truss 2L | |
| Type: | LC | |
| Tapered Section?: | N | |
| Section No.: | 12101b | |
| Data Row: | 905 | |
| Section Type: | Box | |
| $b_{tf}$ = | 13.00 | in |
| $t_{tf}$ = | 1.00 | in |
| $b_{bf}$ = | 13.00 | in |
| $t_{bf}$ = | 1.00 | in |
| $h_{w}$ = | 19.38 | in |
| $t_{w}$ = | 0.88 | in |
| c = | 14.00 | in |



Opening Widths

| | | |
|---|---|---|
| Top Flange: | - | in |
| Bottom Flange: | 8.00 | in |
| Web: | - | in |

Add Loss Record:

| | |
|---|---|
| Component = | |
| Face = | |
| At Opening? | |
| Reference Point = | |
| Offset = | |
| t = | |
| b = | |

Recorded Section Loss

| Data Row | Comp. | Face | At Opening? | Reference Point | Offset (in) | t (in) | b (in) |
|---|---|---|---|---|---|---|---|
| 177 | Bot Fl | Inside | Y | Left | 0.50 | 0.19 | 2.00 |
| 178 | Bot Fl | Inside | Y | Rt. | 0.50 | 0.19 | 2.00 |
| 179 | L. Web | Inside | Y | Bot. | 0.00 | 0.19 | 4.00 |
| 180 | R. Web | Inside | Y | Bot. | 0.00 | 0.19 | 4.00 |
| | | | | | | | |

# Member Capacity:

- Capacity computations are conducted using an excel spreadsheets that imports member data and loss data from the database.
- Detailed calculations can be printed for any rated member as needed.

**Steel Member Load Rating - I-Beam and Box Sections - Flexural and Axial Strength**
**AASHTO Standard Specifications, 17th Edition, 2002, Load Factor Rating**

| | | | | | |
|---|---|---|---|---|---|
| Project ID: | 53246 | Live Load: | HS20 (Design) | Location: | Truss 3L |
| Bridge: | New River Gorge | Element: | 13117 i-End | Mem | |
| | | Rating Type: | Axial Only | At Openi | |

Date: 2/12/2015

Input

*Section Dimensions:*

| | | |
|---|---|---|
| Type: | Box | in |
| $t_f$ (TF) = | 0.38 | in |
| $b_f$ (TF) = | 13.00 | in |
| $t_f$ (BF) = | 0.38 | in |
| $b_f$ (BF) = | 13.00 | in |
| $t_W$ = | 0.625 | in |
| $h_w$ = | 20.00 | in |
| o/o web = | 14.00 | in |

*Compression Member Data:*

| | | | |
|---|---|---|---|
| $L_x$ = | 23.92 | ft | Unbraced Len., Torsion |
| $L_y$ = | 23.92 | ft | Unbraced Len., Y-Axis |
| $L_z$ = | 23.92 | ft | Unbraced Len., Z-Axis |
| $k_x$ = | 1.000 | | Eff. Len. Factor, Torsion |
| $k_y$ = | 0.750 | | Eff. Len. Factor, Y-Axis |
| $k_z$ = | 0.750 | | Eff. Len. Factor, Z-Axis |

Gen / Mom / Allo / End / Tab. / Impo / Equ / Incl

*Bending Member Data:*

| | | | |
|---|---|---|---|
| $s_{ts}$ = | U | in | Trans. Stiff. (U=Unstiff.) |
| $L_b$(tf) = | 23.92 | | Unbraced Length, LTB |
| $L_b$(bf) = | 23.92 | | Unbraced Length, LTB |
| $C_b$(+) = | 1.00 | | Moment Continuity Factor, $M_y$(+) |
| $C_b$(-) = | 1.00 | | Moment Continuity Factor, $M_y$(-) |

*Material Properties:*

| | | |
|---|---|---|
| $F_{yf}$ (TF) = | 50 | ksi |
| E = | 29000 | ksi |
| G = | 11154 | ksi |

*Top Fl. Stiffeners:*

| | | |
|---|---|---|
| No. = | | |
| $s_{max}$ = | | in |
| $b_{st}$ = | | in |
| $t_{st}$ = | | in |

*Bot. Fl. Stiffeners:*

| | | |
|---|---|---|
| No. = | | |
| $s_{max}$ = | | in |
| $b_{st}$ = | | in |
| $t_{st}$ = | | in |

*Web Stiffeners:*

| | | |
|---|---|---|
| No. = | | (per web) |
| $s_{max}$ = | | in |
| $b_{st}$ = | | in |
| $t_{st}$ = | | in |

Section Loss

Op

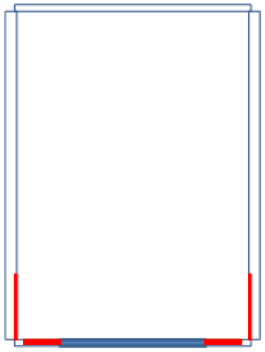
| Data Row | Comp. | Face | At Open? | Ref. Point | Offset (in) | t (in) | b (in) |
|---|---|---|---|---|---|---|---|
| 636 | Bot Fl | Inside | Y | Left | 0.50 | 0.25 | 2.00 |
| 637 | Bot Fl | Inside | Y | Rt. | 0.50 | 0.25 | 2.00 |
| 638 | L. Web | Inside | Y | Bot. | 0.00 | 0.125 | 4.00 |
| 639 | R. Web | Inside | Y | Bot. | 0.00 | 0.125 | 4.00 |

**Steel Member Load Rating - I-Beam and Box Sections - Flexural and Axial Strength**
**AASHTO Standard Specifications, 17th Edition, 2002, Load Factor Design**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Project ID: | 53246 | Live Load: | HS20 (Design) | Location: | Truss 3L | Date: | 2/12/2015 |
| Bridge: | New River Gorge | Element: | 13117 i-End | Member: | L17-L18 | | |
| | | Rating Type: | Axial Only | At Opening?: | Y | | Page 2 of 7 |

Section Properties

| | Calculated Properties | Adjust. for Loss | Final | |
|---|---|---|---|---|
| A | 31.75 | -2.00 | 29.75 | $in^2$ |
| $y_b$ | 11.36 | 0.66 | 12.01 | in |
| $y_t$ | 9.39 | -0.66 | 8.74 | in |
| $I_y$ | 1505 | -218 | 1286 | $in^4$ |
| $I_z$ | 1240 | -67 | 1173 | $in^4$ |
| J | 2228 | - | 2228 | $in^4$ |
| $D/t_w$ | 32.00 | - | 32.00 | |
| $r_y$ | 6.88 | -0.31 | 6.58 | in |
| $r_z$ | 6.25 | 0.03 | 6.28 | in |
| $z_p$ | 11.58 | 0.80 | 12.38 | in |
| $y_p$ | 0.01 | - | 0.01 | in |
| $Z_y$ | 192 | -21 | 171 | $in^3$ |
| $Z_z$ | 193 | -11 | 181 | $in^3$ |
| $h_b$ | 10.38 | - | 10.38 | in (shear cent.) |
| $y_o$ | 1.20 | - | 1.20 | in |
| $C_w$ | - | - | - | $in^6$ |
| $(b_f/t_f)_{tf}$ | 34.67 | - | 34.67 | |
| $(b_f/t_f)_{bf}$ | 34.67 | - | 34.67 | |

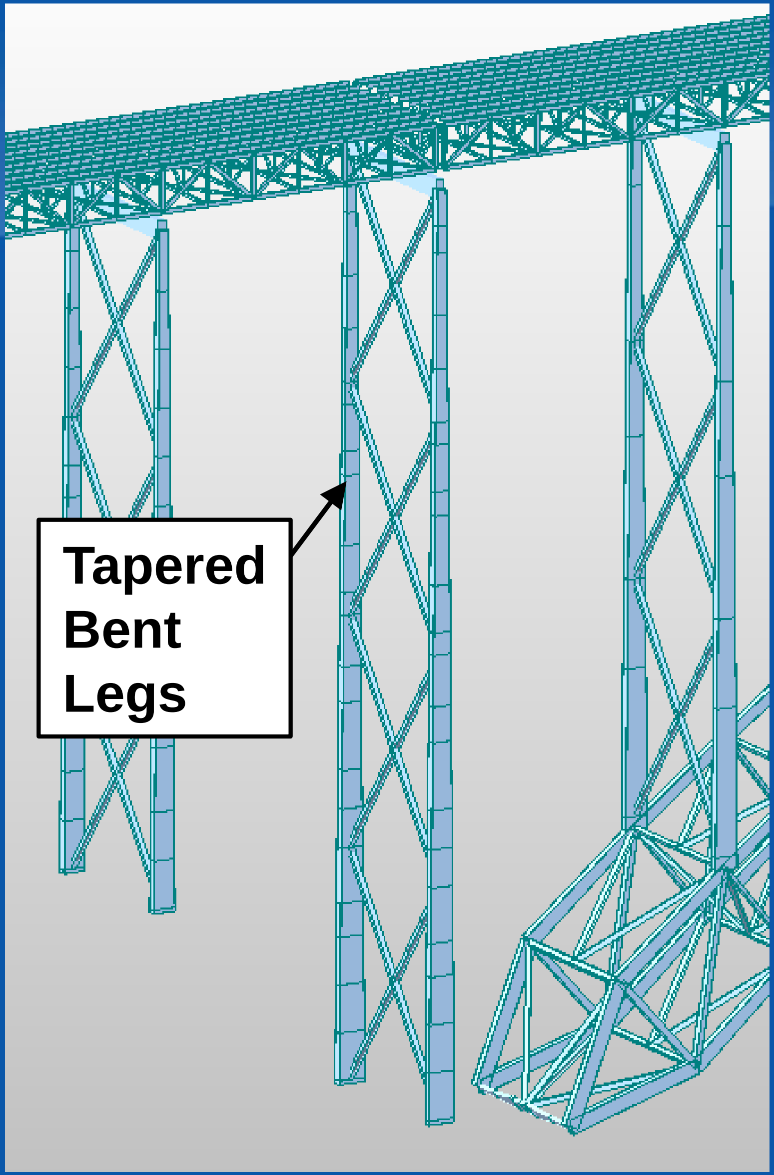


Section Sketch: ON

Overload, 10.57

# Member Capacity - Buckling Analysis Model:

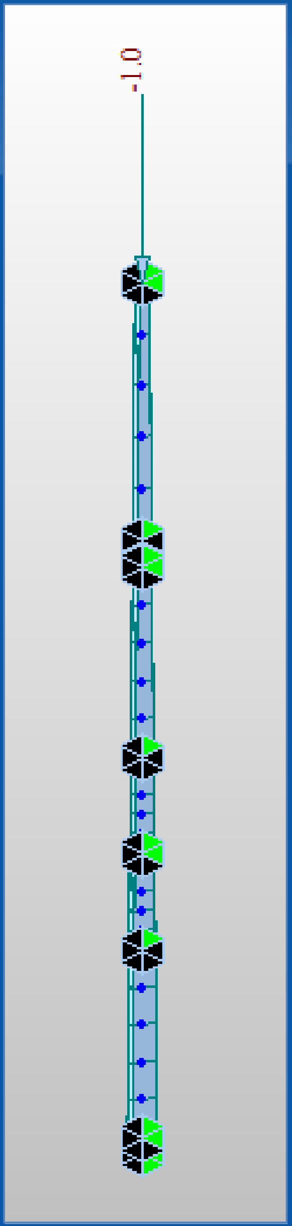
- The legs of the bents have a tapered cross section
- Calculation of elastic flexural buckling strength for tapered columns is complex
- The linear buckling analysis feature in Midas Civil was used to determine the buckling strength

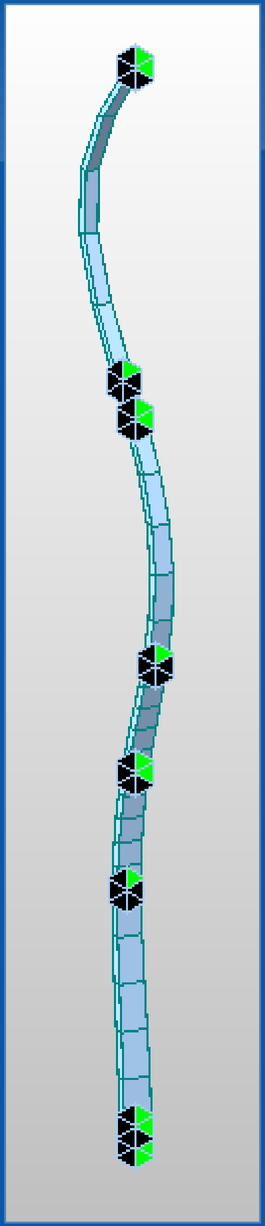


# Buckling Analysis Model:

- A separate model was created for each bent column
- Lateral supports were added at bracing locations
- A unit load was placed at the top of the column
- Eigenvalues are equal to the column buckling load
- X-Axis and Y-Axis buckling were isolated

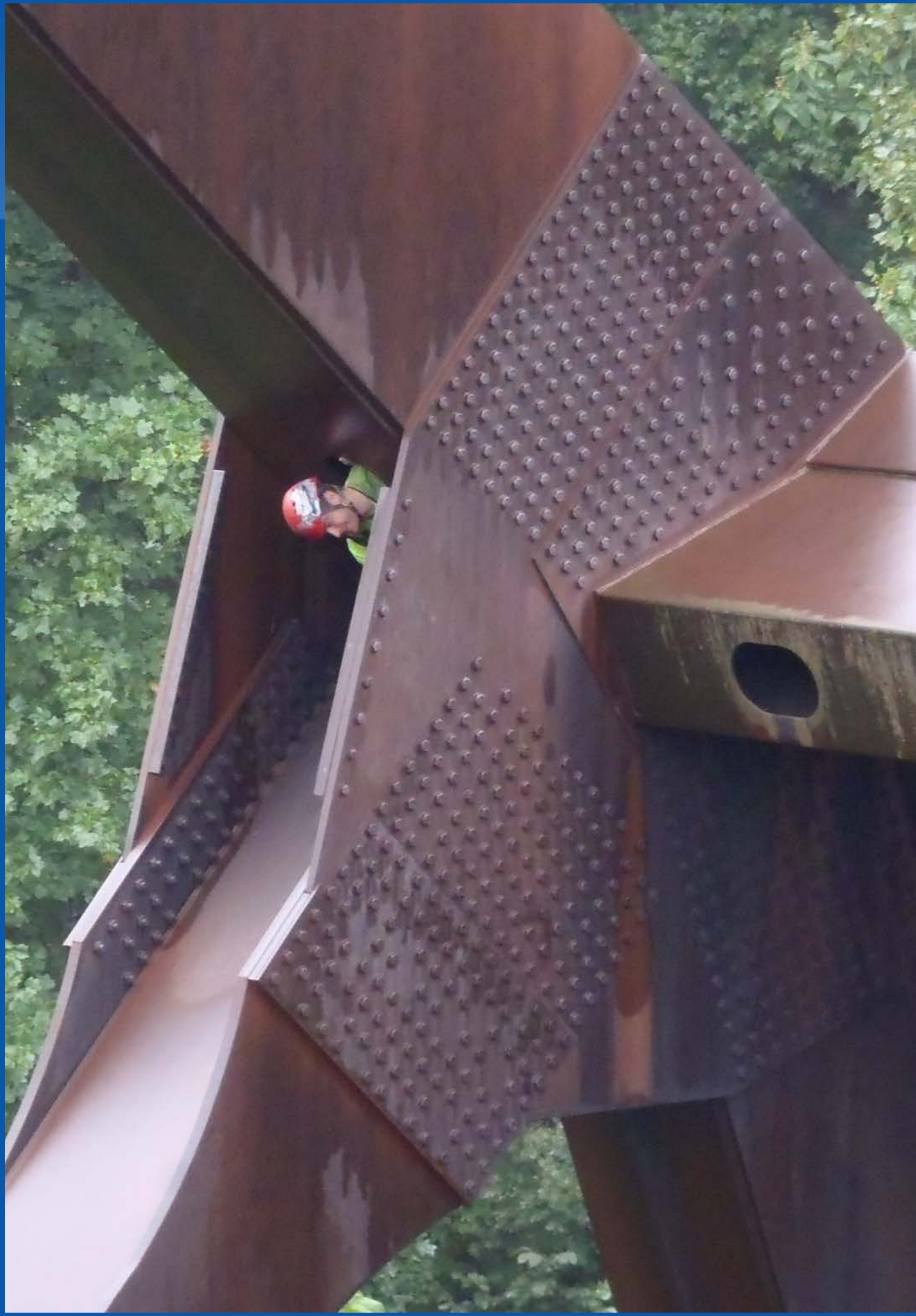
| | Node | Mode | UX | UY |
|---|---|---|---|---|
| | BUCK | | | |
| | | Mode | Eigenvalue | Tolerance |
| | | 1 | 11059.355611 | 9.9039e-007 |
| | | 2 | 21898.292992 | 3.9749e-005 |
| | | 3 | 35101.554177 | 1.3323e-004 |
| | | 4 | 45774.476305 | 8.4520e-005 |
| | BU | | | |



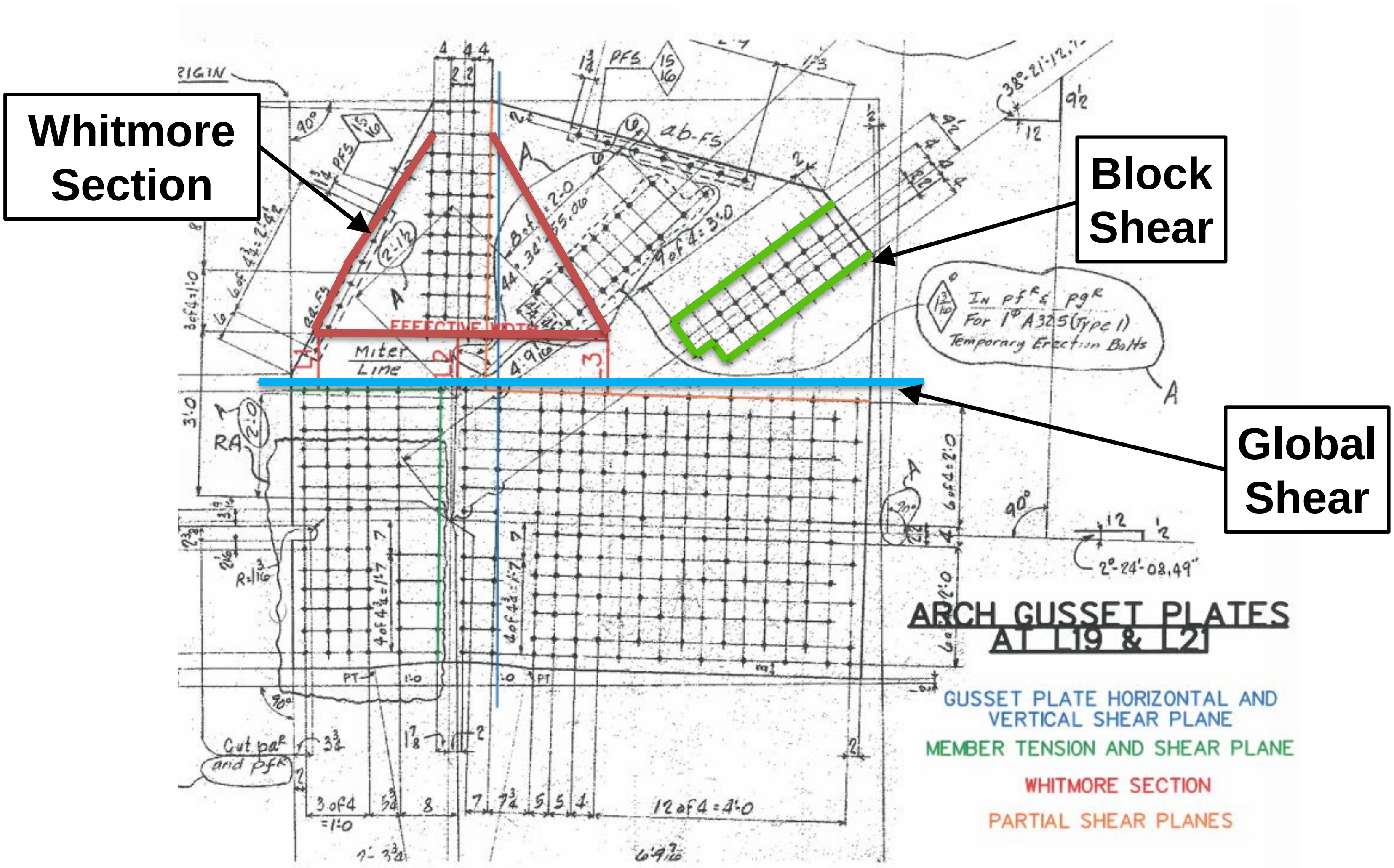
# Gusset Plate Rating:

- A total of 871 gusset plates were rated.
- Many of the connections are very large and very complex.
- A standardized data collection and rating system was used for efficiency and consistency.



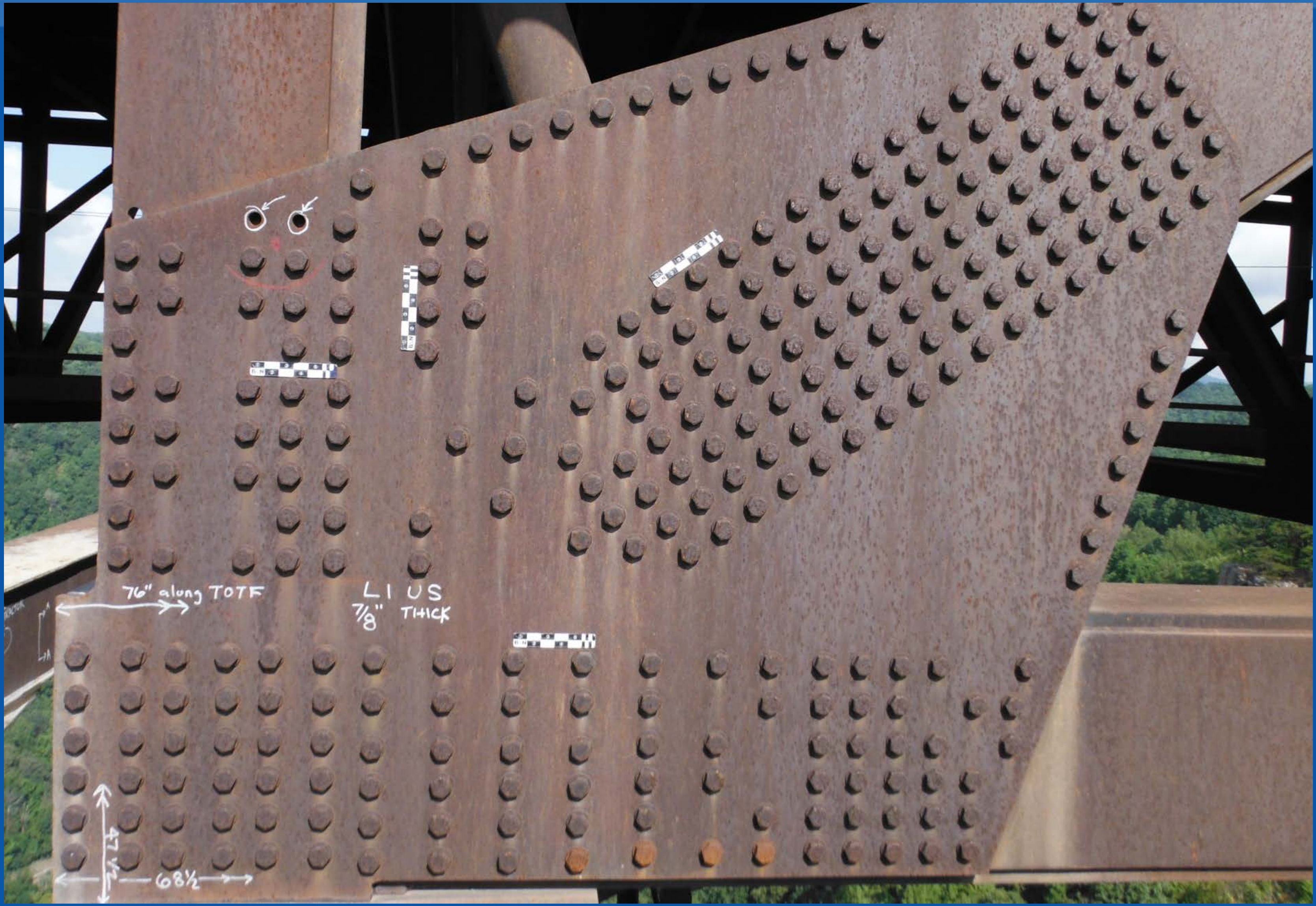
# Gusset Plate Geometry Data Collection:

- Shop drawings were imported into cadd and scaled.
- Critical dimensions (Whitmore section, block shear, global shear planes) were added and measured within the drawing.



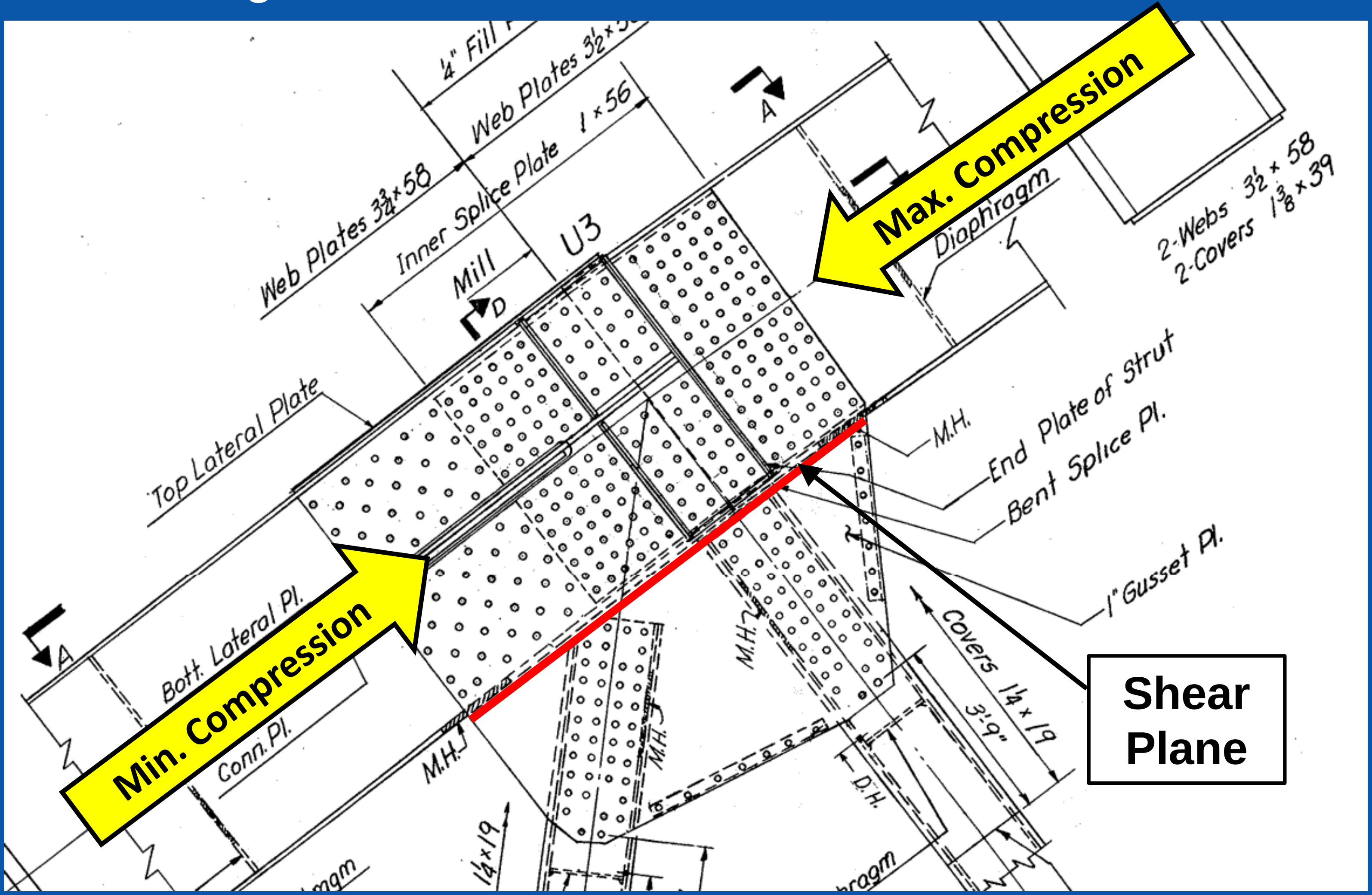
# Gusset Plate Rating:

**Field data collection was used where plan data was incomplete.**



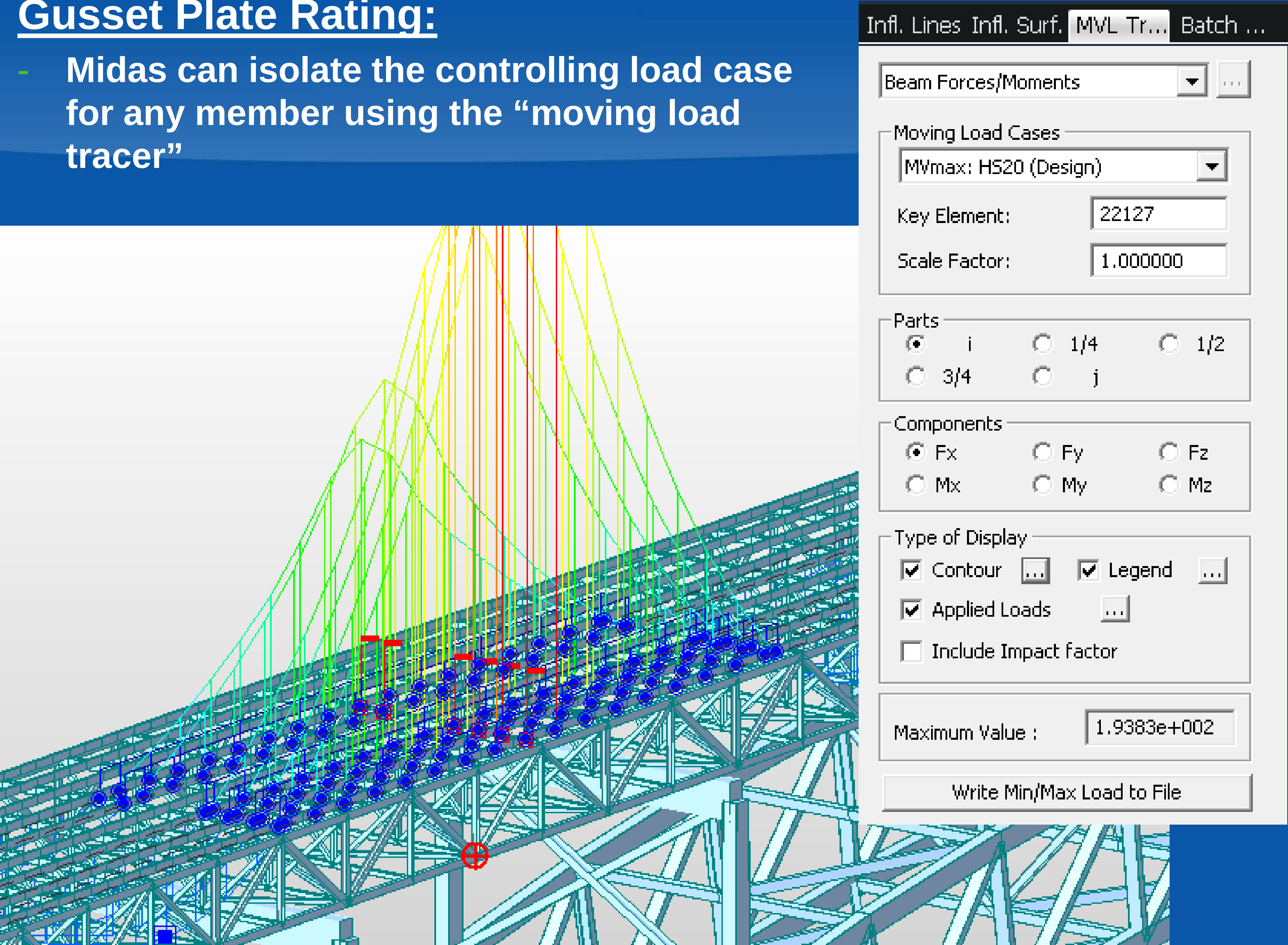
# Gusset Plate Rating:

- Using envelope forces to rate gusset plates can produce overly conservative ratings.
- Concurrent live load and wind load forces are needed to produce an accurate rating.



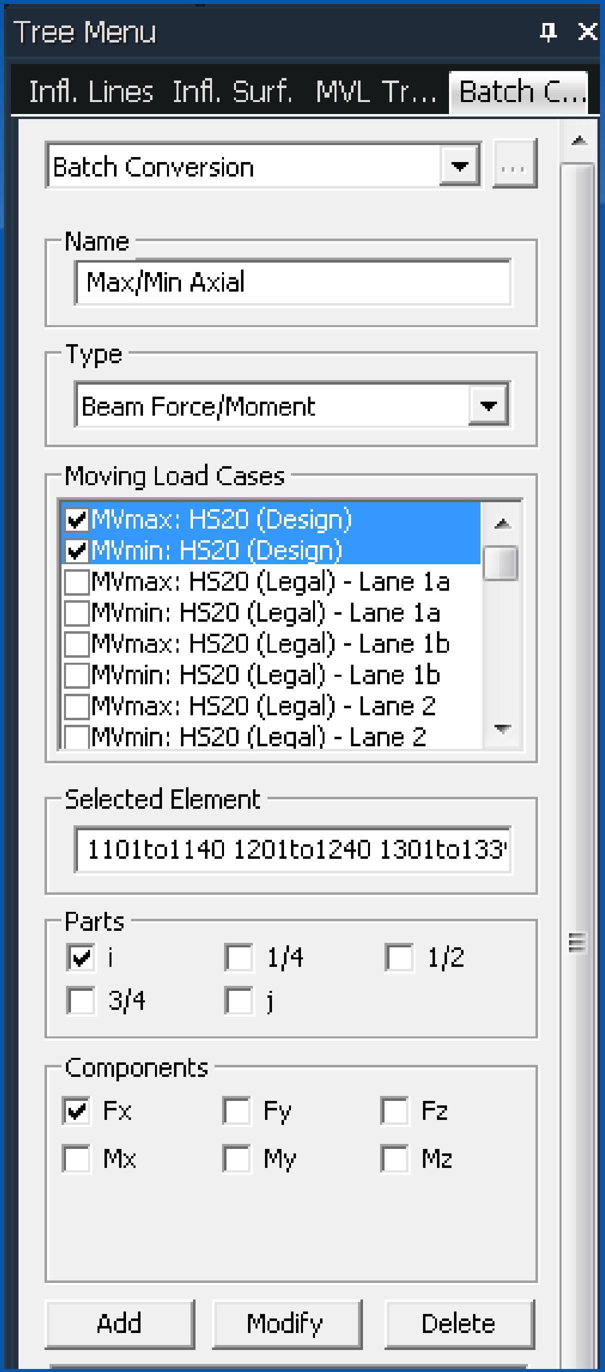
# Gusset Plate Rating:

- Midas can isolate the controlling load case for any member using the “moving load tracer”



# Gusset Plate Rating:

- Midas can do a batch run of controlling live load cases for the members of interest.
- The results are written to a .mct file that can be run using the MCT command shell.
- Running the .mct file writes each controlling live load case as a static load case in the file.
- Force results for critical load case are exported to a database used for the gusset rating computations.



# Gusset Plate Rating:

- Rating calculations are carried out using a spreadsheet that checks up to 12 live load and 12 wind load combinations.
- Minimum and maximum axial load is checked for each member, along with concurrent loads for all connecting members.

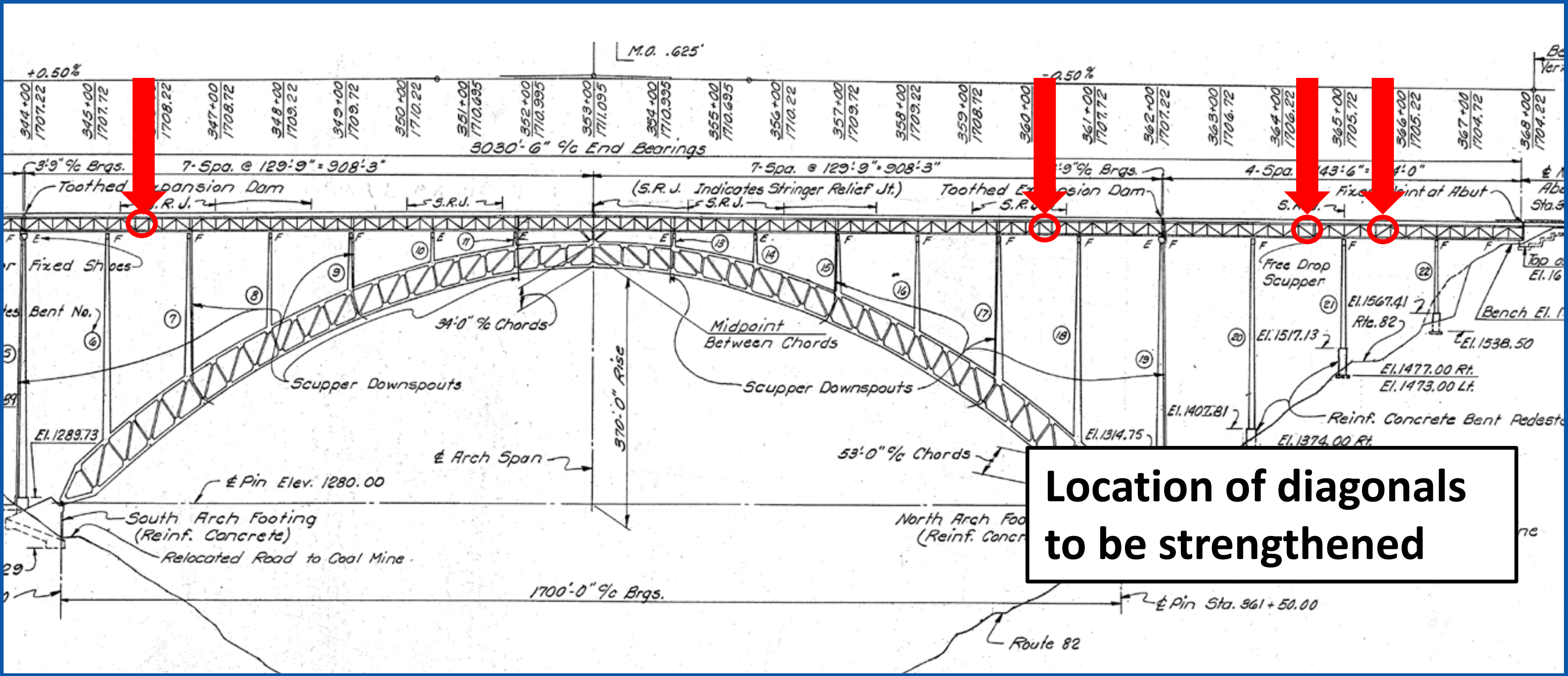
**Member Service Forces: (+Tension, - Compression)**

Note: Forces are per member. Divide by 2 for Gusset Check (2 Gussets per member).

| | Member: | L18-L19 | L19-L20 | U19-L19 | L19-U20 | | | Pin $F_x$ | Pin $F_y$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | % Load to Gusset Connections | 50.0% | 50.0% | 100.0% | 100.0% | | | - | - | (Adjust. for Contin./Mill-to-bear) |
| Dead Load | DL | -5345.70 | -4842.40 | 252.66 | -635.92 | | | 5.27 | -82.00 | kips |
| Wind Load Cases | $W_1$ | 406.94 | 413.07 | 33.03 | -23.83 | | | 12.57 | -0.79 | kips |
| | $W_2$ | 378.56 | 160.30 | -136.93 | 244.51 | | | 24.73 | 1.85 | kips |
| | $W_3$ | -107.20 | 123.68 | 170.08 | -277.22 | | | -11.56 | -2.91 | kips |
| | $W_4$ | -570.45 | -568.30 | -29.66 | 10.28 | | | -9.99 | -0.95 | kips |
| | $W_5$ | -63.99 | -276.90 | -184.53 | 296.23 | | | -21.16 | -2.65 | kips |
| | $W_6$ | -482.58 | -260.63 | 163.42 | -297.01 | | | 13.04 | 1.07 | kips |
| | $W_7$ | 425.99 | 431.76 | 33.87 | -24.33 | | | 13.30 | -0.50 | kips |
| | $W_8$ | 397.79 | 179.27 | -135.47 | 243.24 | | | 25.98 | 2.03 | kips |
| | $W_9$ | -87.18 | 142.38 | 170.10 | -276.70 | | | -10.68 | -2.39 | kips |
| | $W_{10}$ | -358.08 | -373.22 | -39.95 | 33.22 | | | -11.14 | 3.98 | kips |
| | $W_{11}$ | 146.85 | -82.27 | -194.18 | 318.31 | | | -22.70 | 2.09 | kips |
| | $W_{12}$ | -270.04 | -65.76 | 152.35 | -273.18 | | | 11.56 | 6.22 | kips |
| Wind on Live | Max WL | 0.00 | 0.00 | 0.00 | 0.00 | | | 0.00 | 0.00 | kips |
| | Min WL | 0.00 | 0.00 | 0.00 | 0.00 | | | 0.00 | 0.00 | kips |
| Temperature Load | T+ | 521.30 | 524.10 | 24.23 | 3.84 | | | -5.87 | -4.95 | kips |
| | T- | -521.30 | -524.10 | -24.23 | -3.84 | | | 5.87 | 4.95 | kips |
| Live Load + Impact Cases | $LL_1$ | 434.05 | 438.36 | 22.65 | -7.27 | | | 1.24 | 0.09 | kips |
| | $LL_2$ | -730.05 | -656.82 | 26.59 | -92.18 | | | -0.03 | 0.01 | kips |
| | $LL_3$ | 395.50 | 482.72 | 84.21 | -108.89 | | | -1.30 | -0.10 | kips |
| | $LL_4$ | -680.70 | -694.11 | -43.07 | 23.76 | | | -5.07 | -0.37 | kips |
| | $LL_5$ | -271.13 | 41.16 | 240.89 | -407.17 | | | 9.70 | 0.72 | kips |
| | $LL_6$ | -44.00 | -283.44 | -196.67 | 314.58 | | | -9.21 | -0.68 | kips |
| | $LL_7$ | -31.34 | -270.15 | -195.61 | 313.73 | | | -9.19 | -0.68 | kips |
| | $LL_8$ | -284.60 | 27.99 | 240.60 | -407.62 | | | 9.76 | 0.72 | kips |
| | $LL_9$ | 0.00 | 0.00 | 0.00 | 0.00 | | | 0.00 | 0.00 | kips |
| | $LL_{10}$ | 0.00 | 0.00 | 0.00 | 0.00 | | | 0.00 | 0.00 | kips |
| | $LL_{11}$ | 0.00 | 0.00 | 0.00 | 0.00 | | | 0.00 | 0.00 | kips |
| | $LL_{12}$ | 0.00 | 0.00 | 0.00 | 0.00 | | | 0.00 | 0.00 | kips |

## Rating Results:

- Results for the existing condition of the bridge show 8 deck truss diagonals need strengthened.
- All rated members have HS20 operating ratings > 1.0
- All gusset plates and connections have HS20 inventory and operating ratings > 1.0



# Bridge Rehabilitation:

**Rehabilitation plans are currently in development.**

***Items addressed (partial list):***

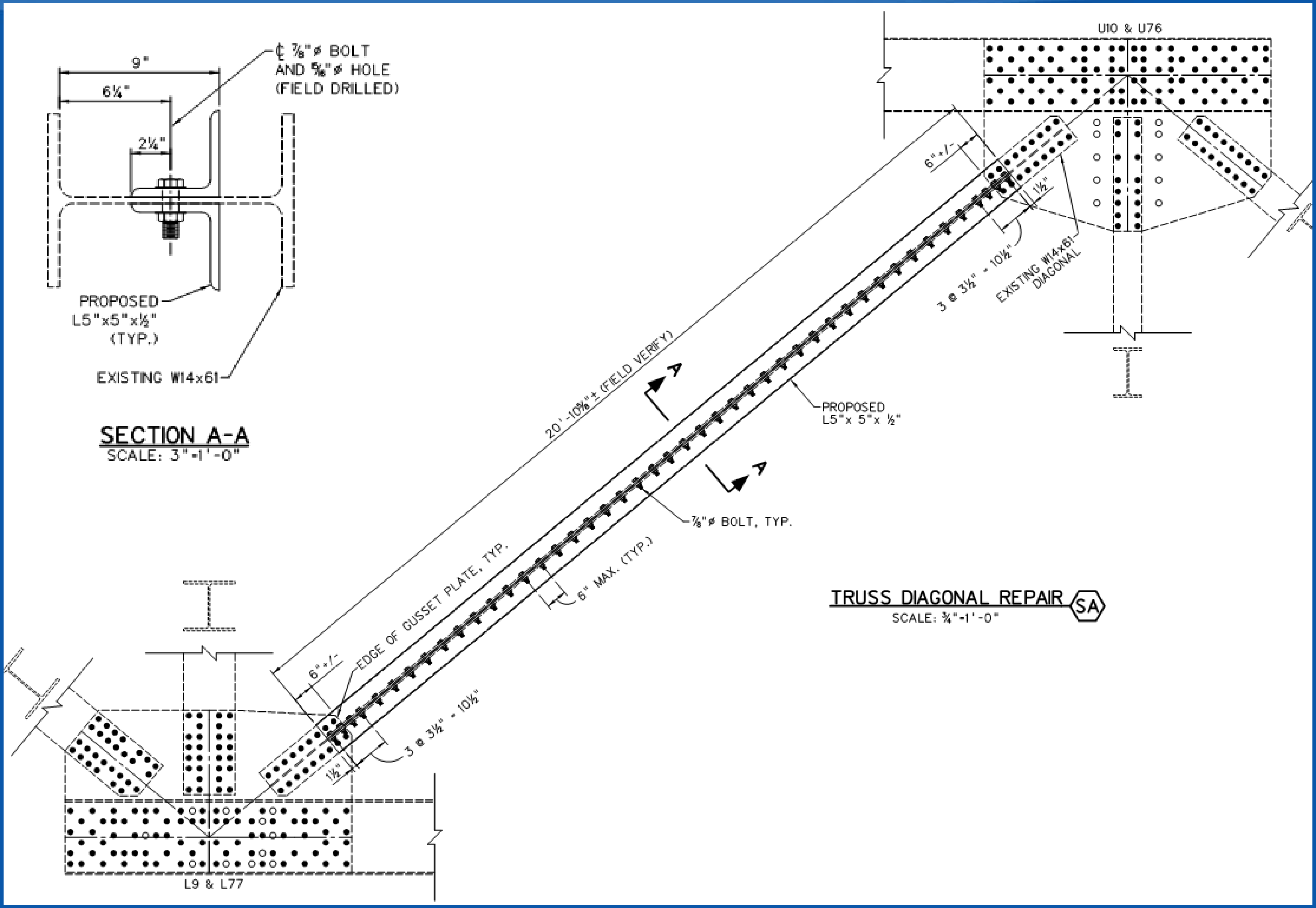
- **Repair welds in catwalk access ladders**
- **Clean and paint selected areas of the bents, arch, and deck truss**
- **Replace missing & deteriorated bolts**
- **Add drip bars near openings with water infiltration**
- **Replace stringer relief joints**
- **Patch and coat barriers**

→ **Strengthen deck truss diagonals**

→ **Retrofit and reset bearings at Bents 19 and 5**

# Member Strengthening:

- Weak axis bending strength will be increased by addition of bolted angles.



## Bearing Repositioning:

- The roller bearings at bents 5 and 19 have excessive tilt.
- Upper and lower bearing plates are misaligned at base temperature positions.
- Roller has slipped so that it would not be plumb if the upper and lower plate were aligned.
- Retainer plates should prevent slippage, but they are not functioning properly.

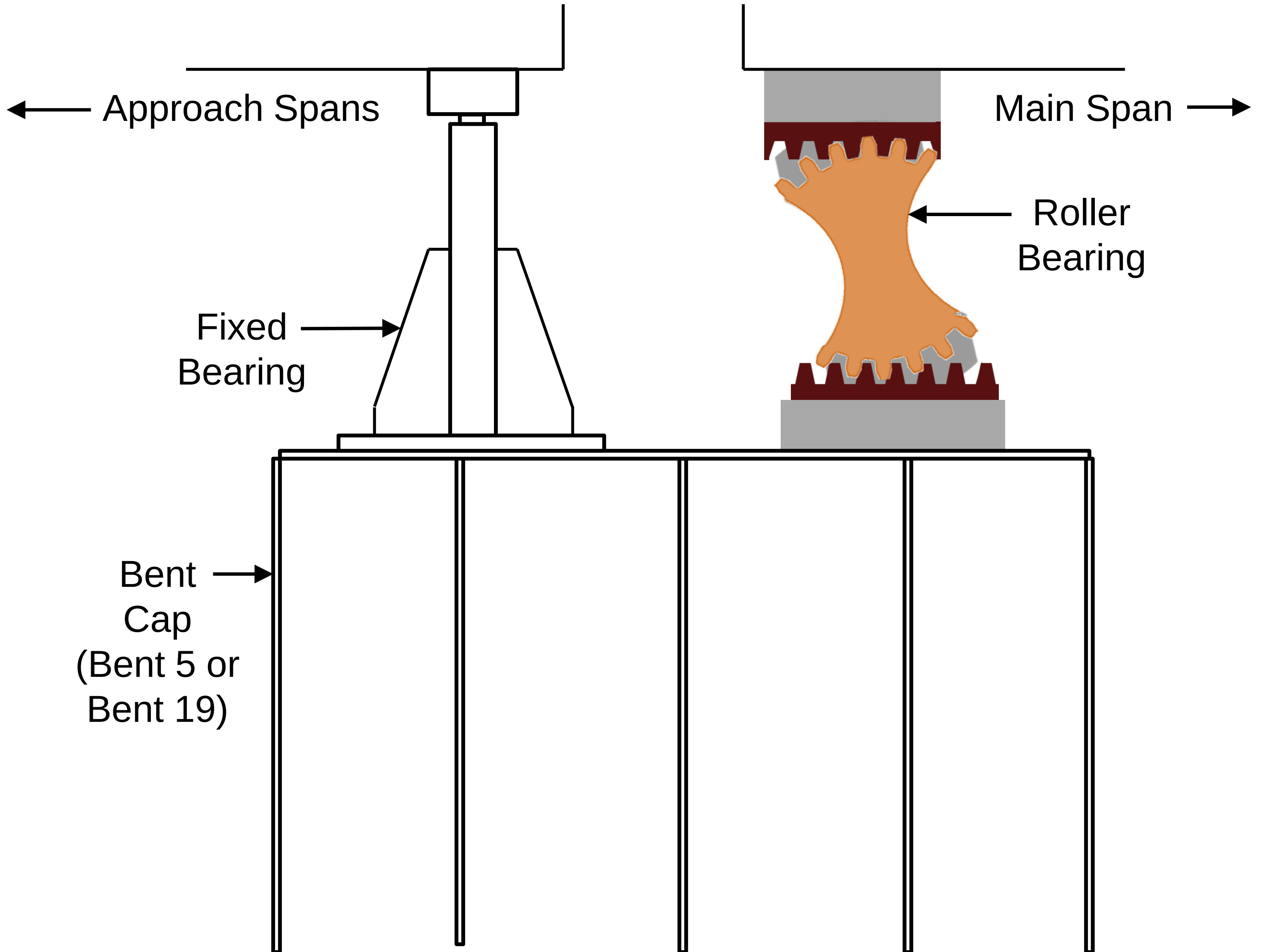
## Bearing Repositioning:

- Geared retainer plates are intended to keep bearing from slipping relative to the baseplate and sole plate.
- Retainer plates are connected to the roller only at the center of the roller.
- This connection allows the plates to rotate relative to the roller, making the retainer plates ineffective.

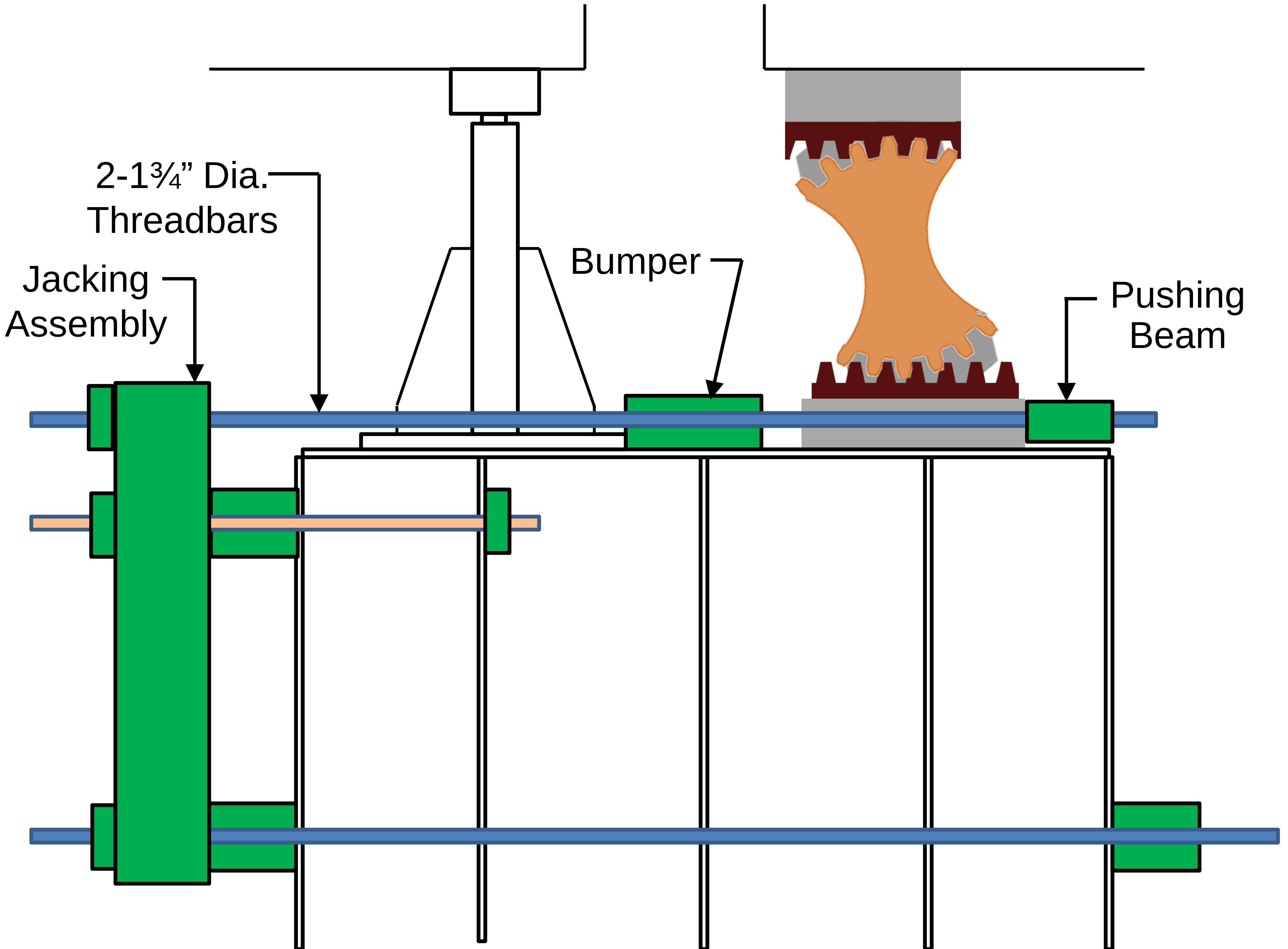
## Bearing Repositioning:

- Vertical jacking would be very difficult due to height of the bent and the steel pier cap.
- The bearings will be repositioned without removing the structure dead load by horizontally jacking the baseplate and roller.

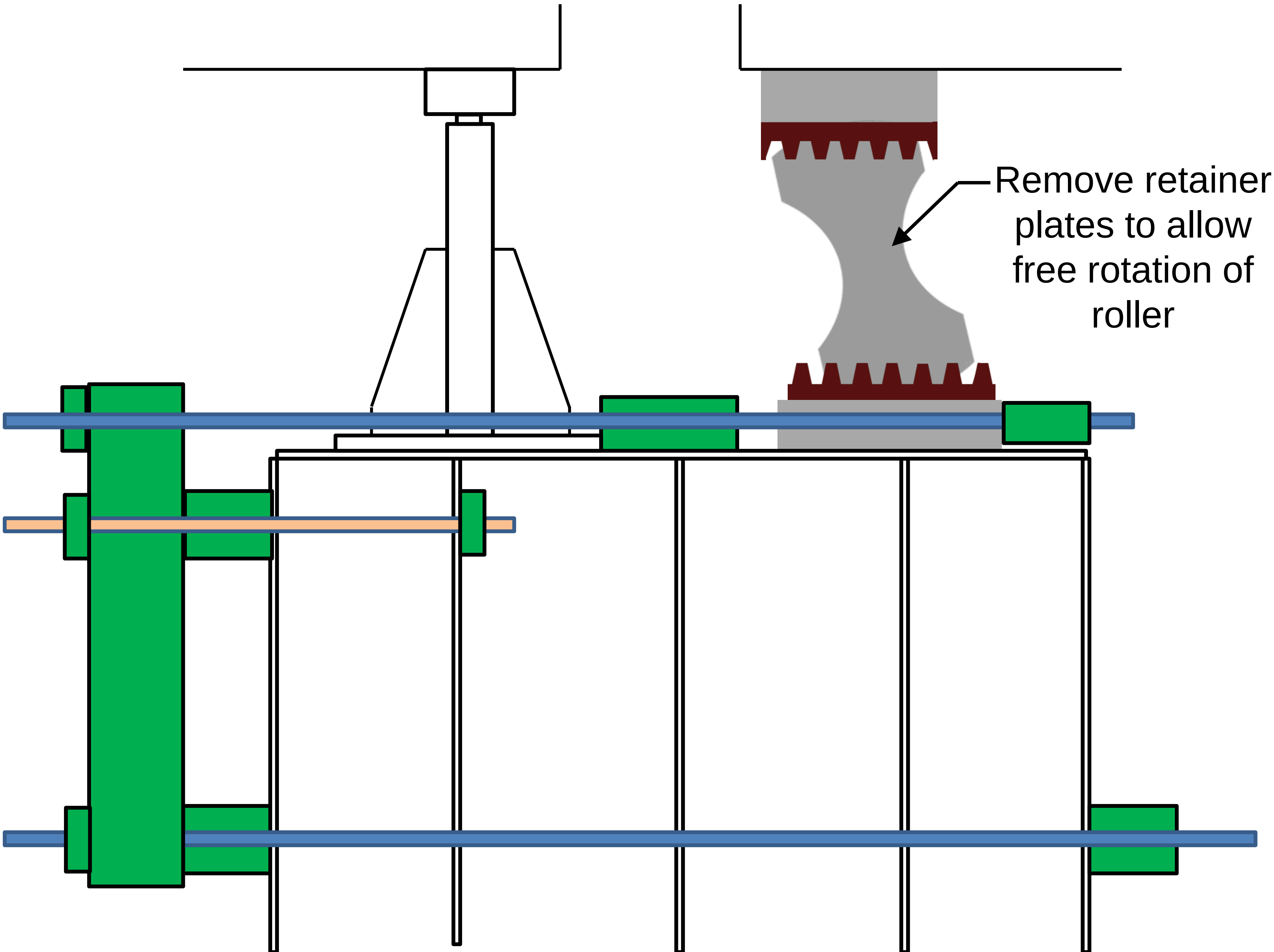
Schematic layout of Bent 5 / Bent 19 bearings:



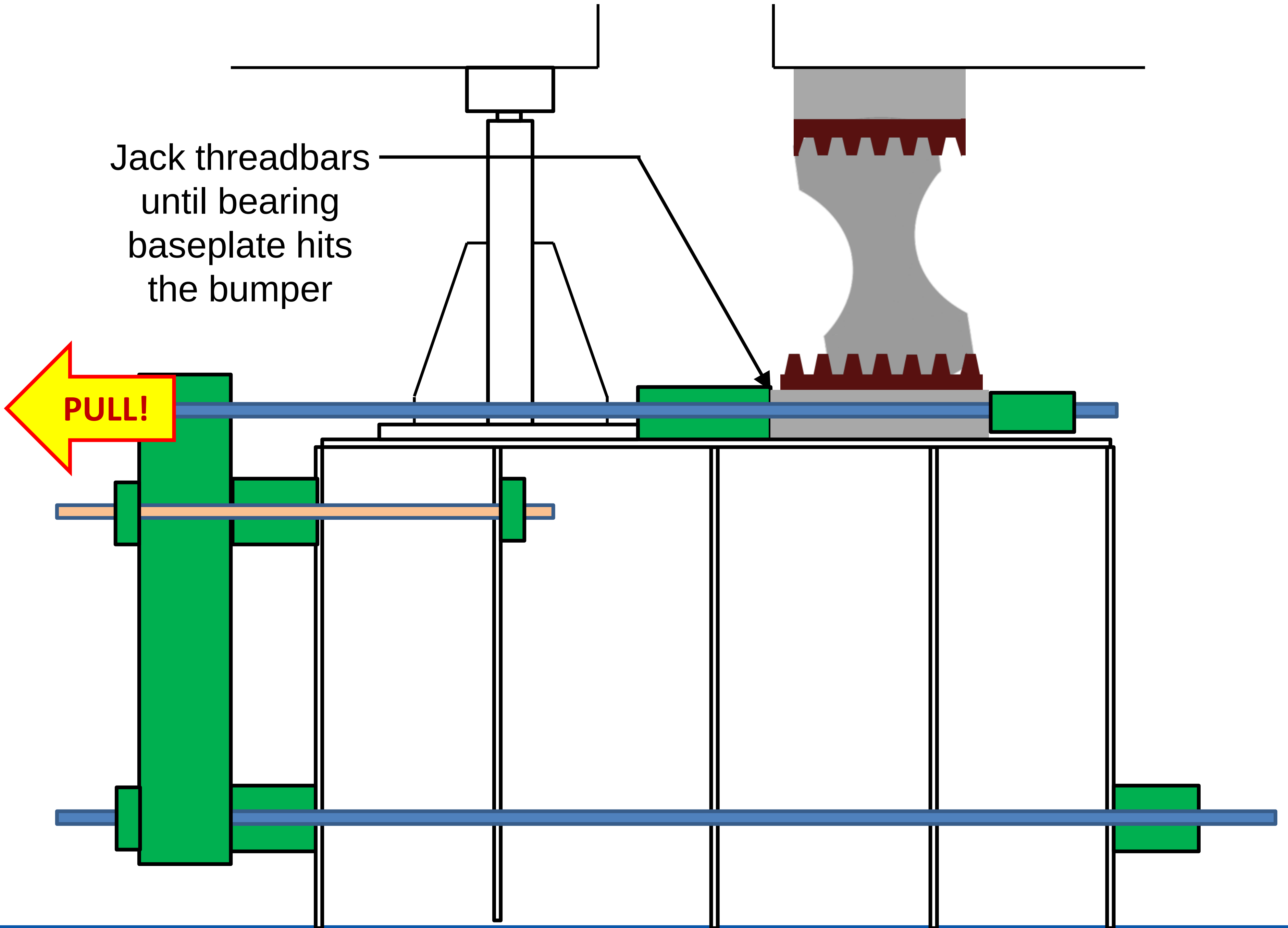
# Step 1: Install Jacking Assembly & Threadbars



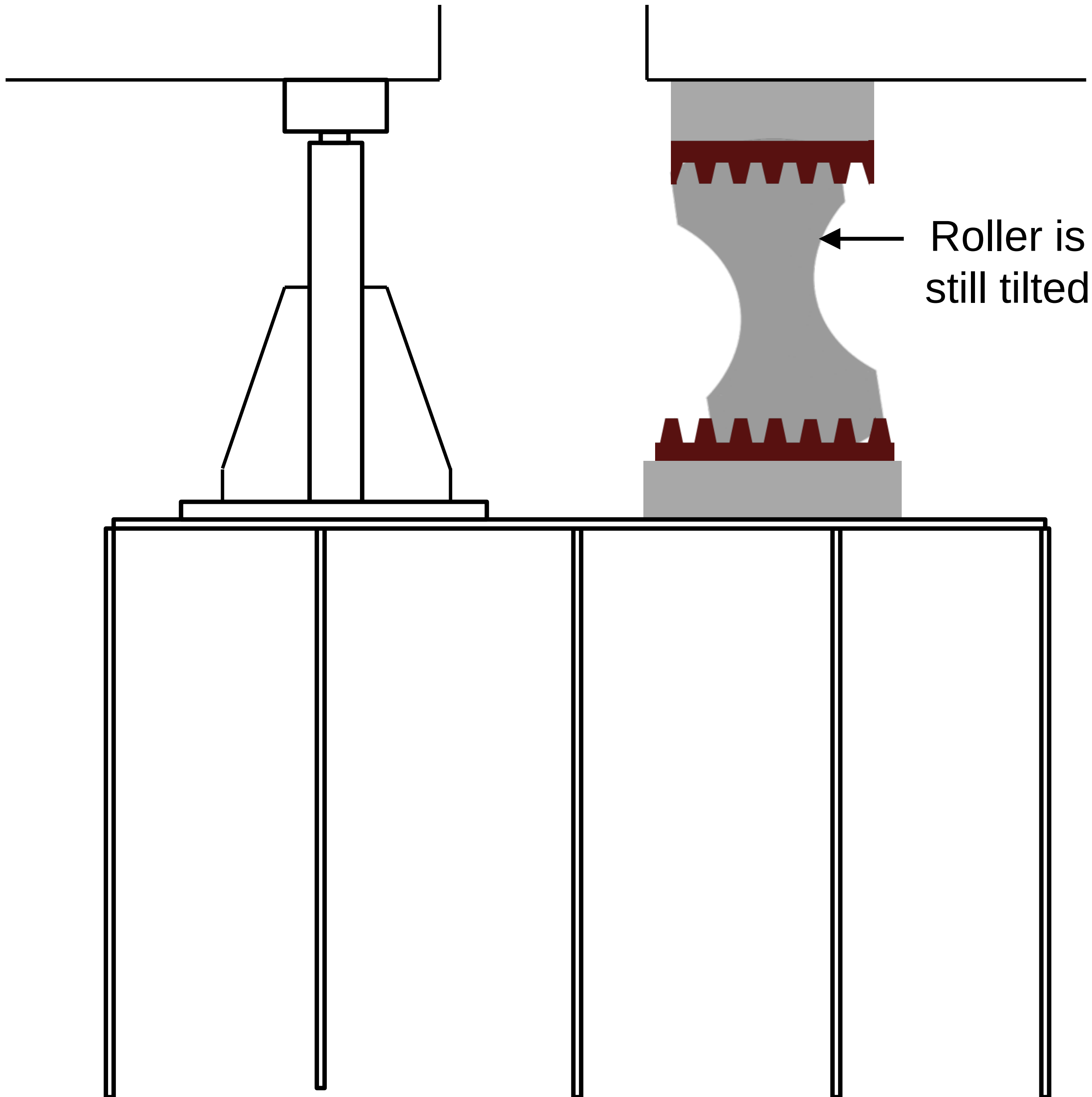
Step 2: Temporarily remove retainer plates from roller bearing



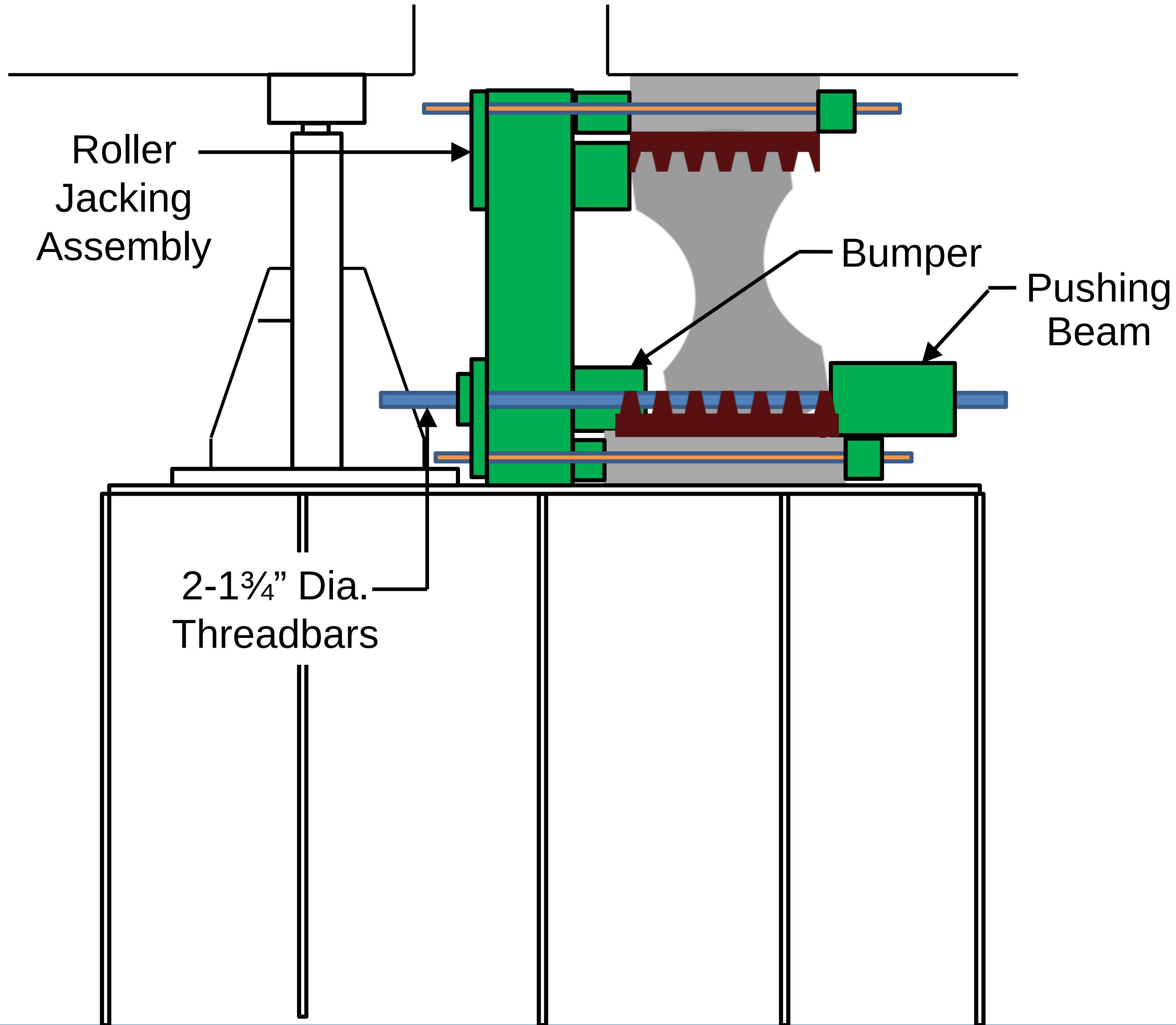
# Step 3: Jack threadbars, pull bearing base plate to final position



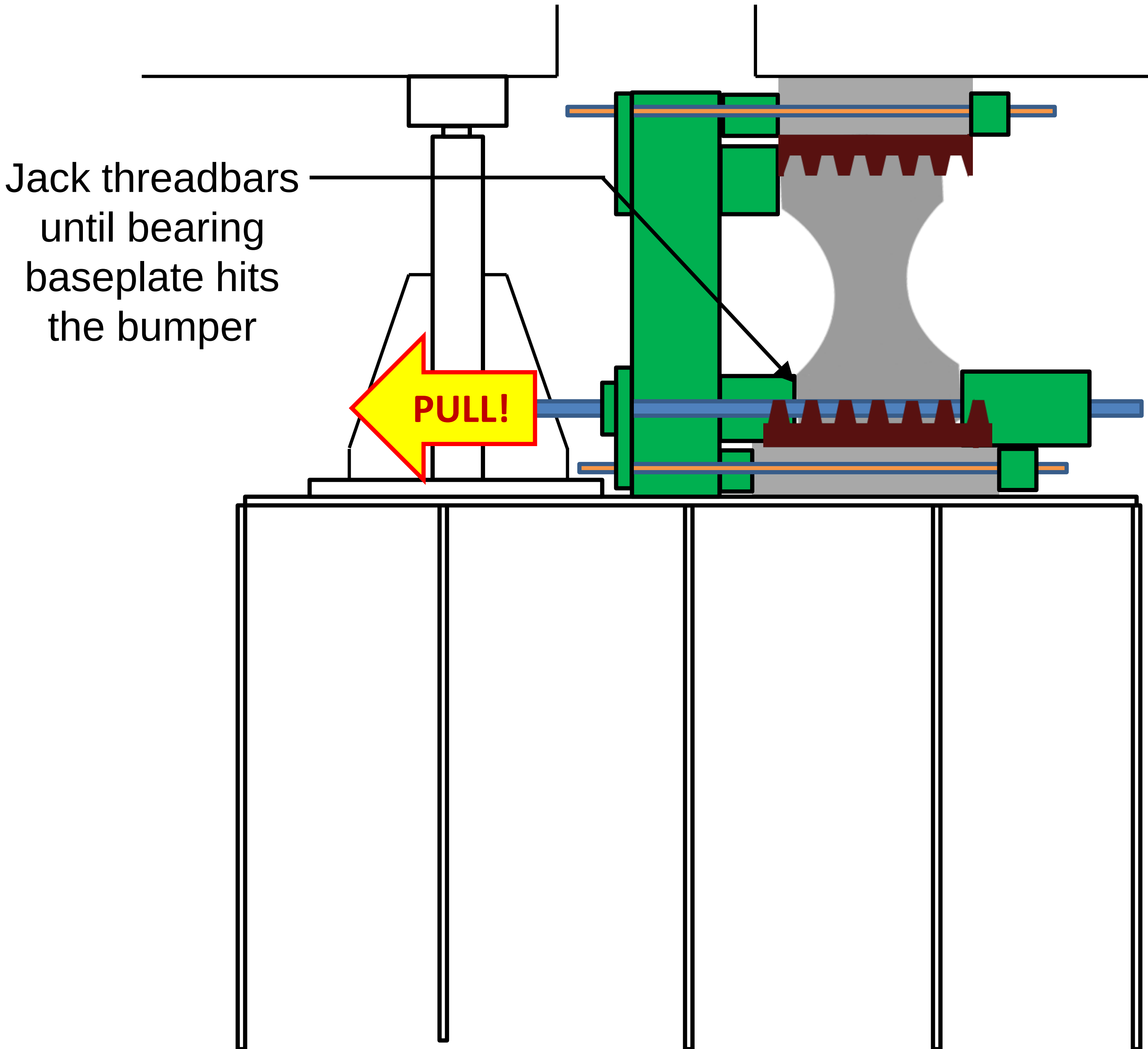
Step 4:  Remove jacking assembly



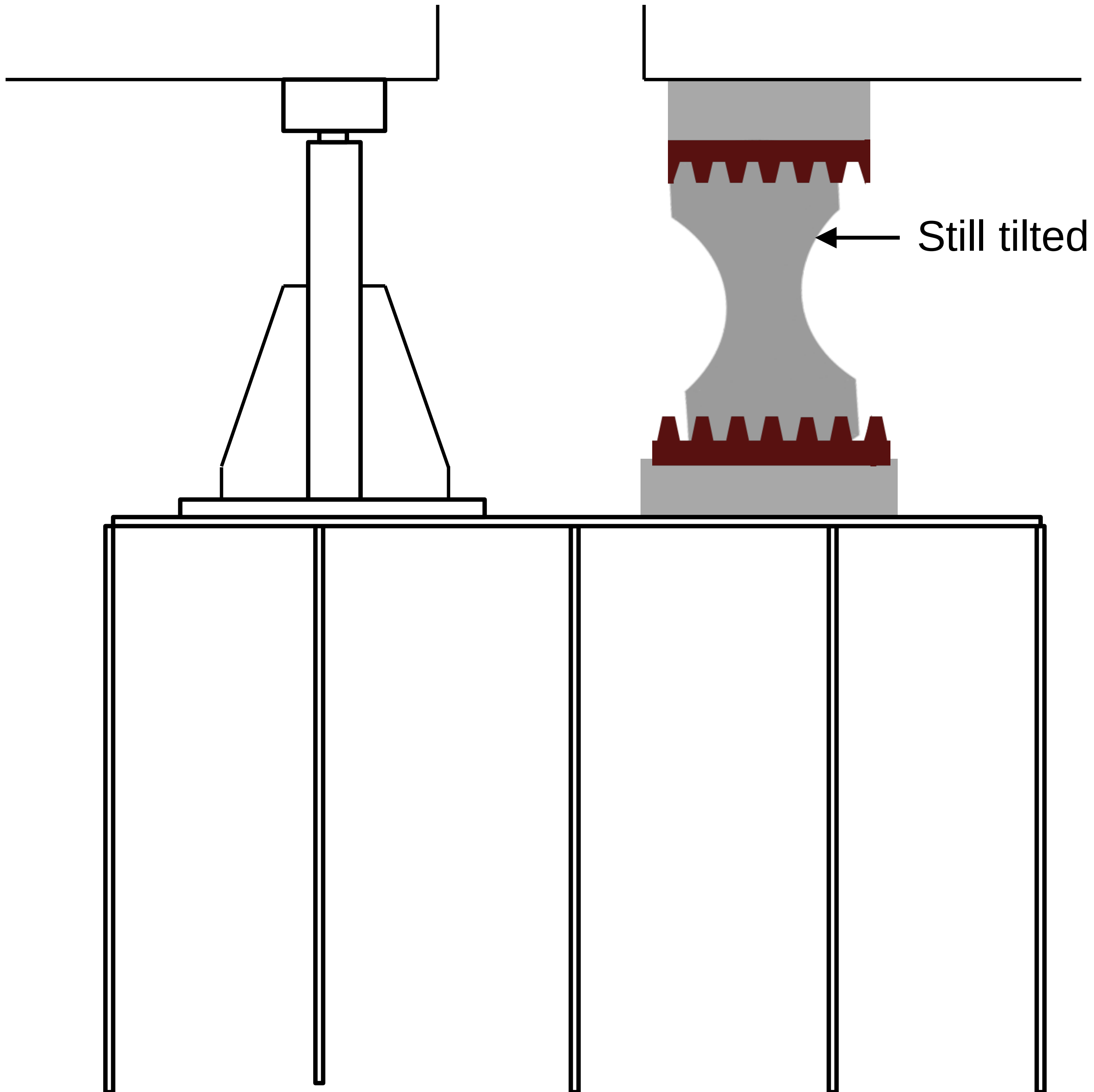
Step 5:  Install roller jacking assembly and threadbars



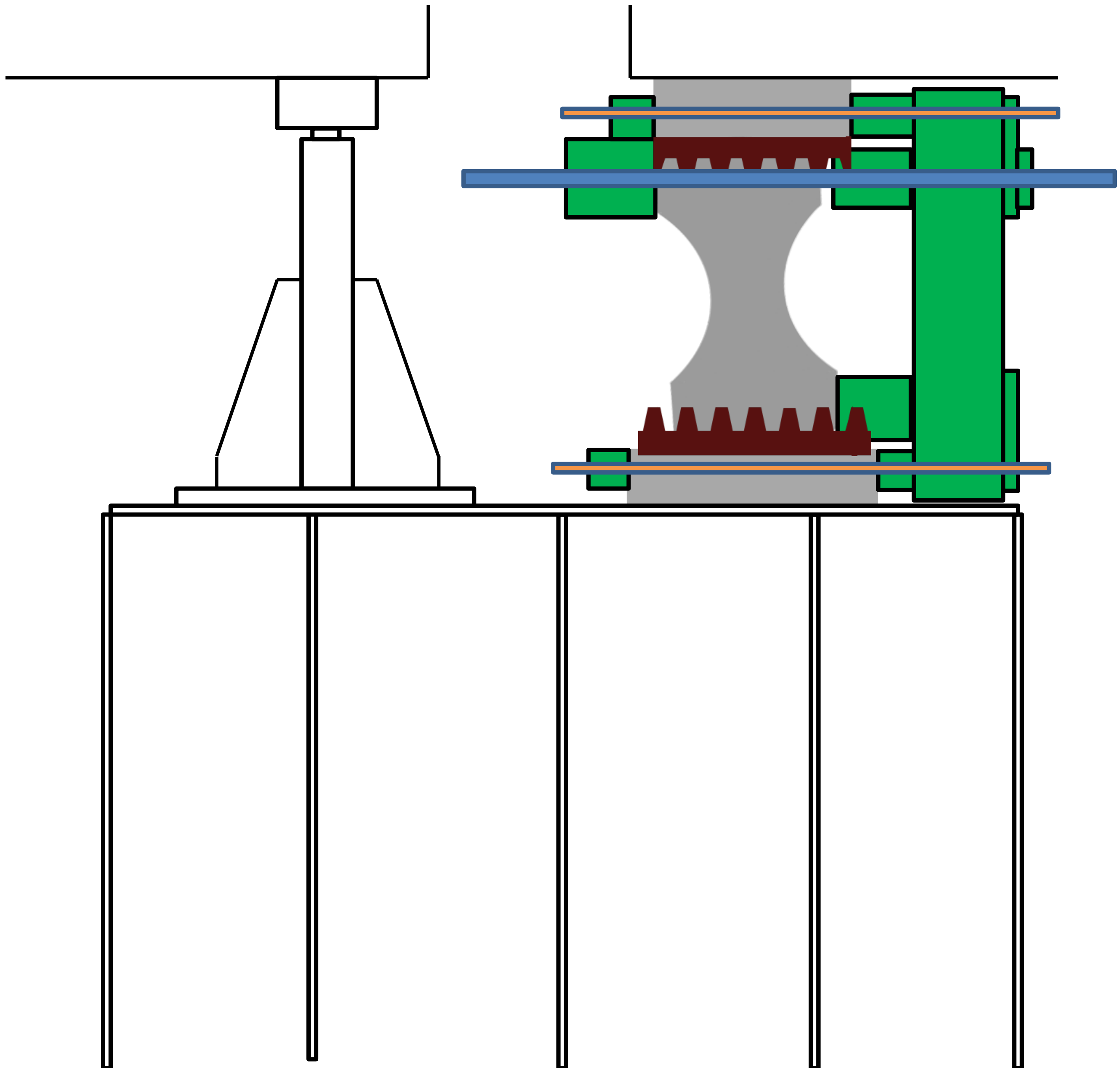
# Step 6: Jack threadbars and pull roller base to final position



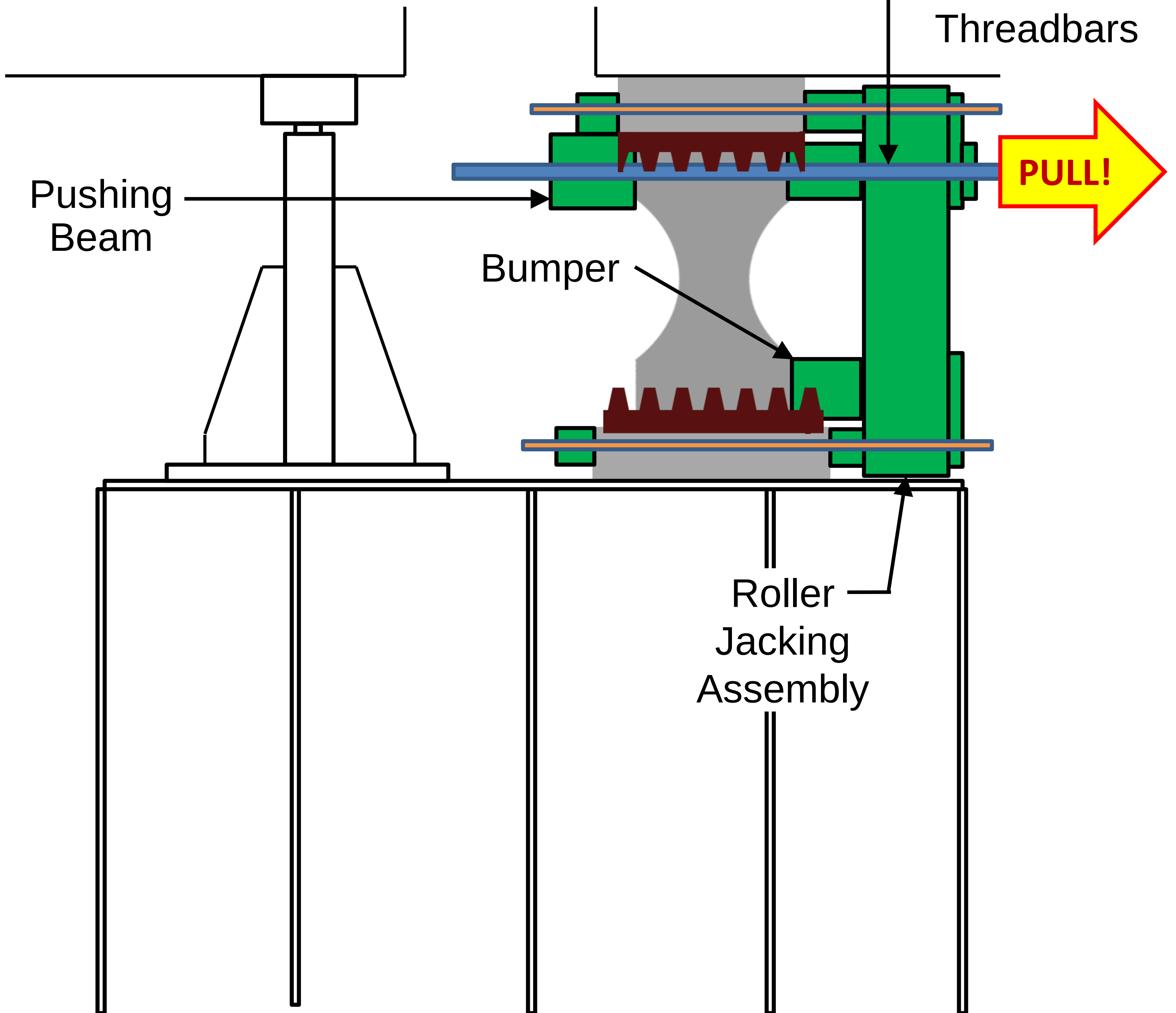
# Step 7:  Remove roller jacking assembly



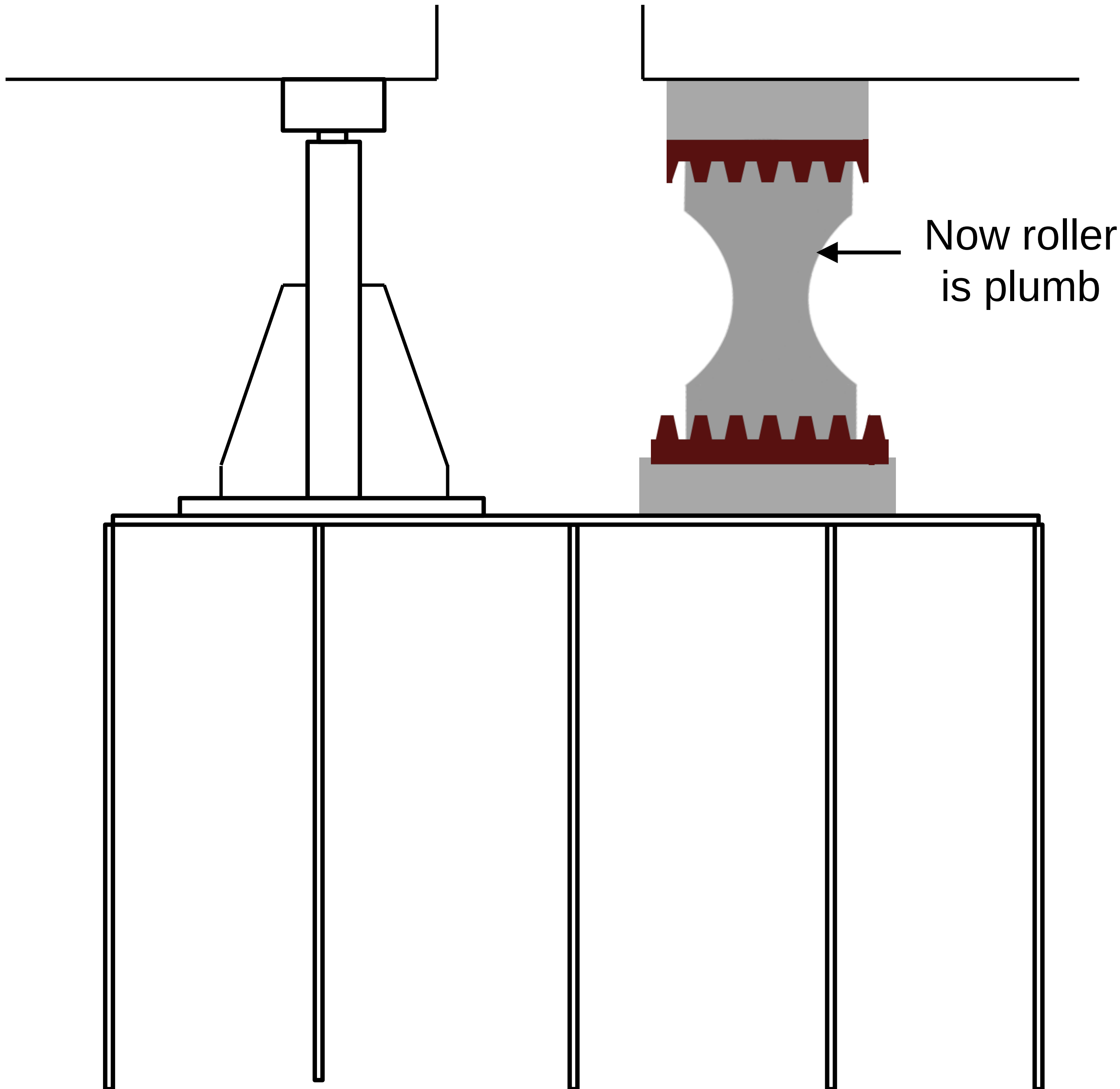
# Step 8: Re-install roller jacking assembly



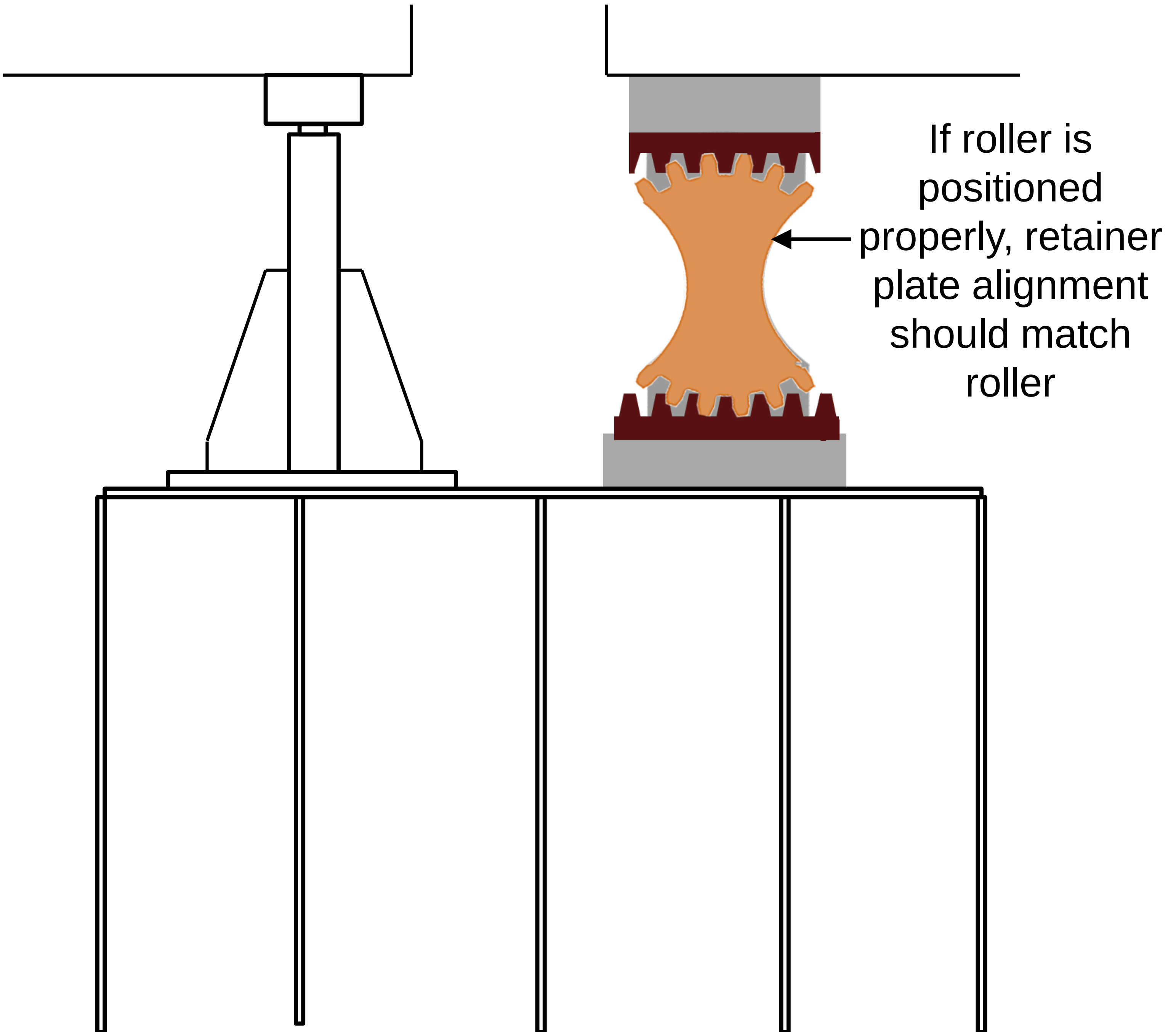
Step 9: Jack threadbars, pull top of rocker to final position



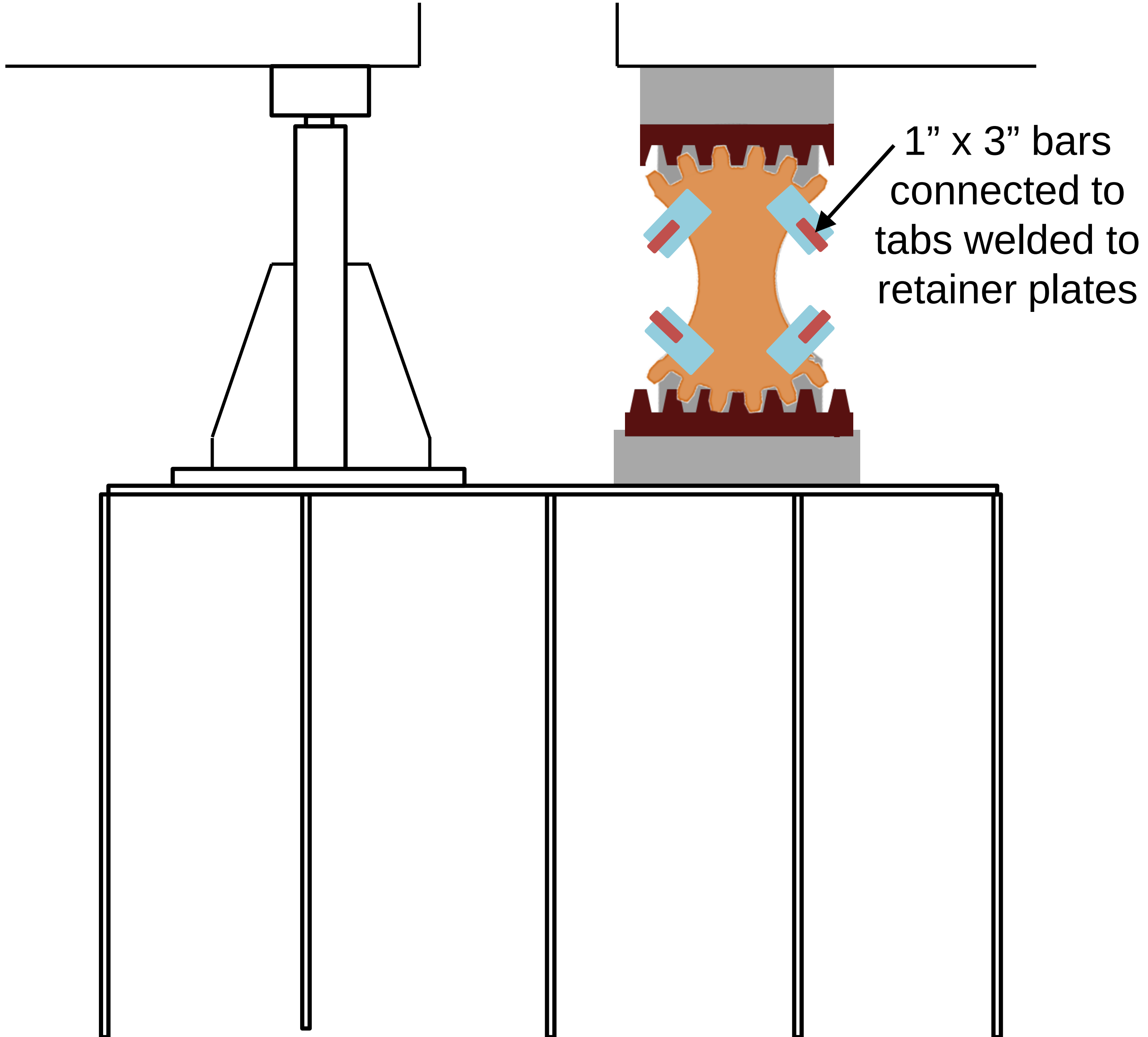
Step 10:  Remove roller jacking assembly



# Step 11:  Reinstall retainer plates



Step 12: Install retaining bars to lock retainer plates and roller together



## Acknowledgements:

**West Virginia Department of Transportation**

**MIDAS Software**

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