Healdsburg Avenue Bridge – Reviving a Piece of History

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Cornerstone Structural Engineering Group

Western Bridge Engineers' Seminar

September 6-8, 2017

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Healdsburg Avenue Bridge – Reviving a Piece of History

Project Location

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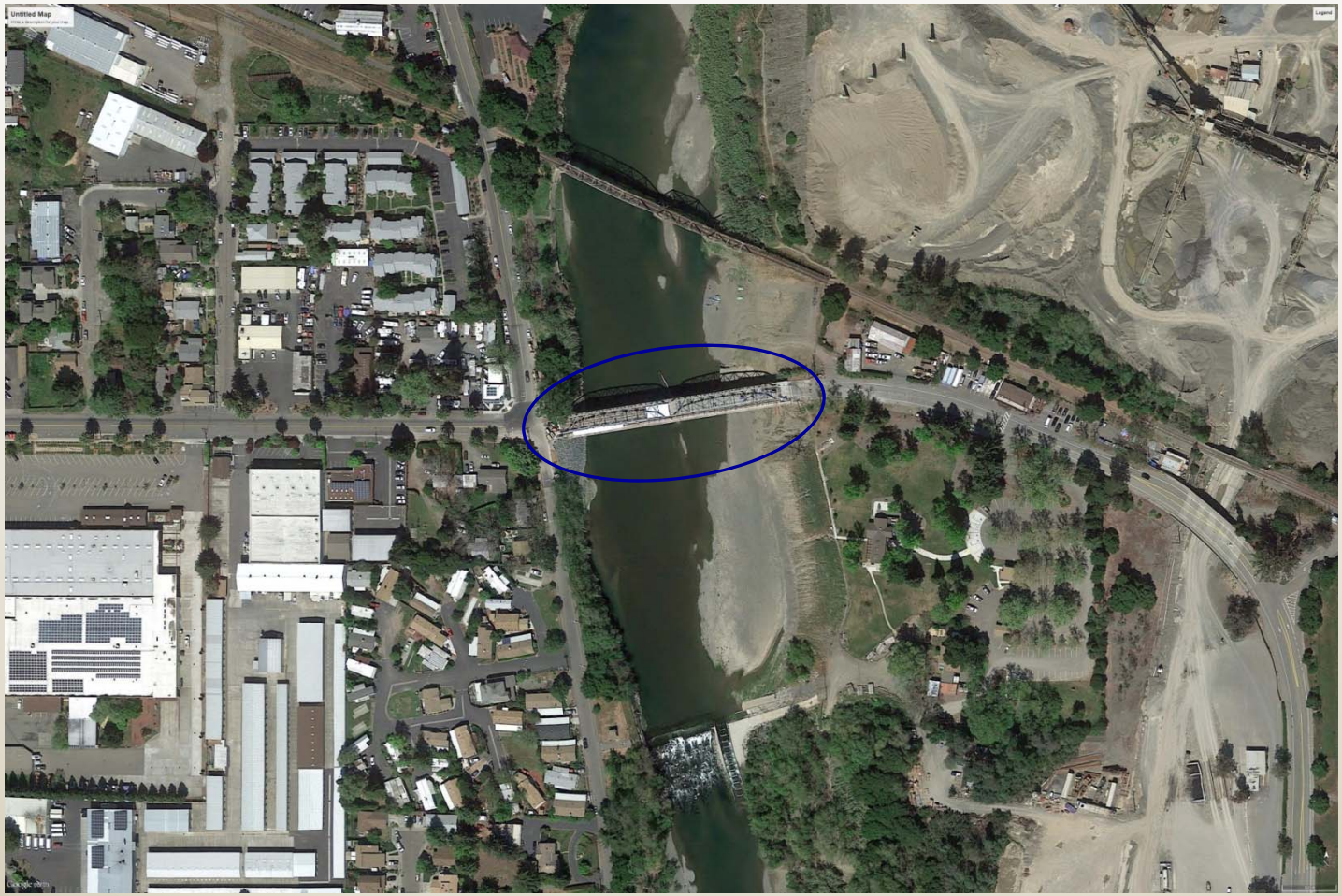
Project Location



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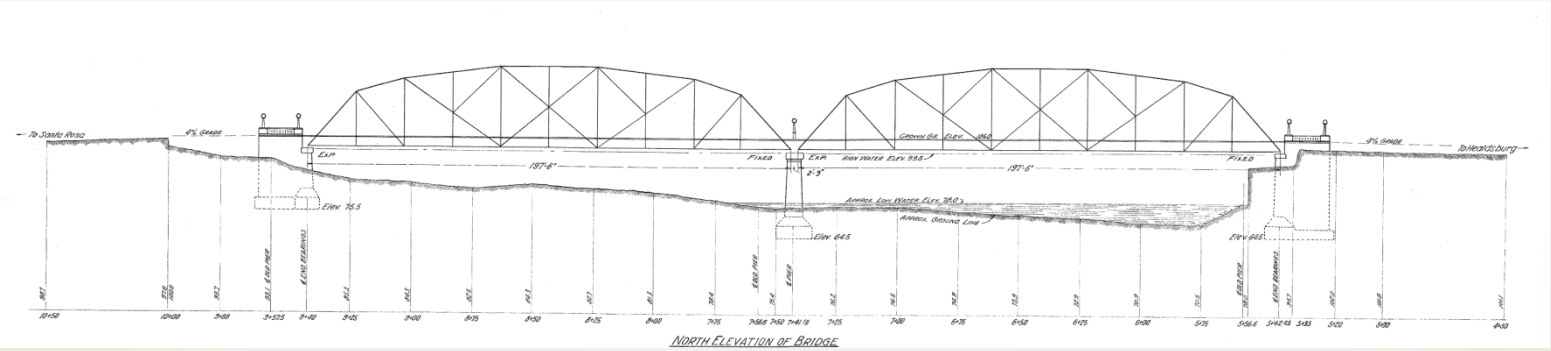
Existing Bridge



- Location: City of Healdsburg, Sonoma County
- Construction Date: 1921
- Carried US 101/Redwood Highway until 1960s
- On National Register of Historic Places
- One of only Two Pennsylvania Pratt Through Truss Bridges in California
- Slated for Seismic Retrofit since mid '90s After Loma Prieta
- Retrofit postponed until late 2000's when our design team brought onto project

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Design and Construction Team

Owner

Design and Construction Administration Team

omni · means
ENGINEERS · PLANNERS

PARIKH
Practicing in the Geosciences

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ICF
INTERNATIONAL

GRANITE

Construction Contractor

- Preliminary Design Began: January 2010
- Environmental Documents Completed: December 2012
- Final Design: January 2013 - April 2014
- Contract Award: June 2014
- Construction: August 2014 – January 2016
  - Continuously Open to Pedestrian/Bicycle Traffic
  - October 15th,2015 Open to Vehicular Traffic

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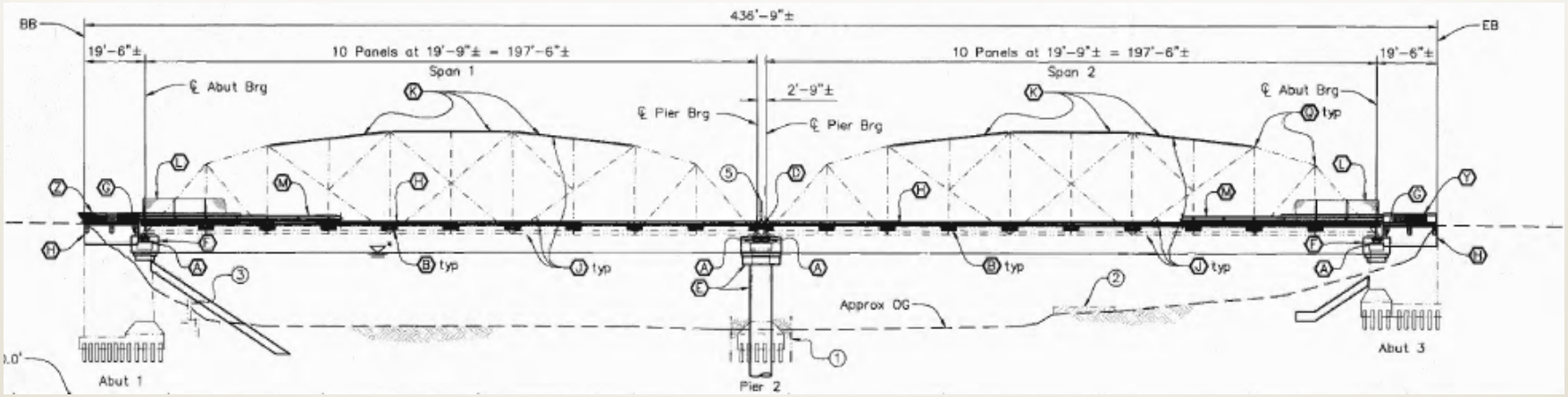

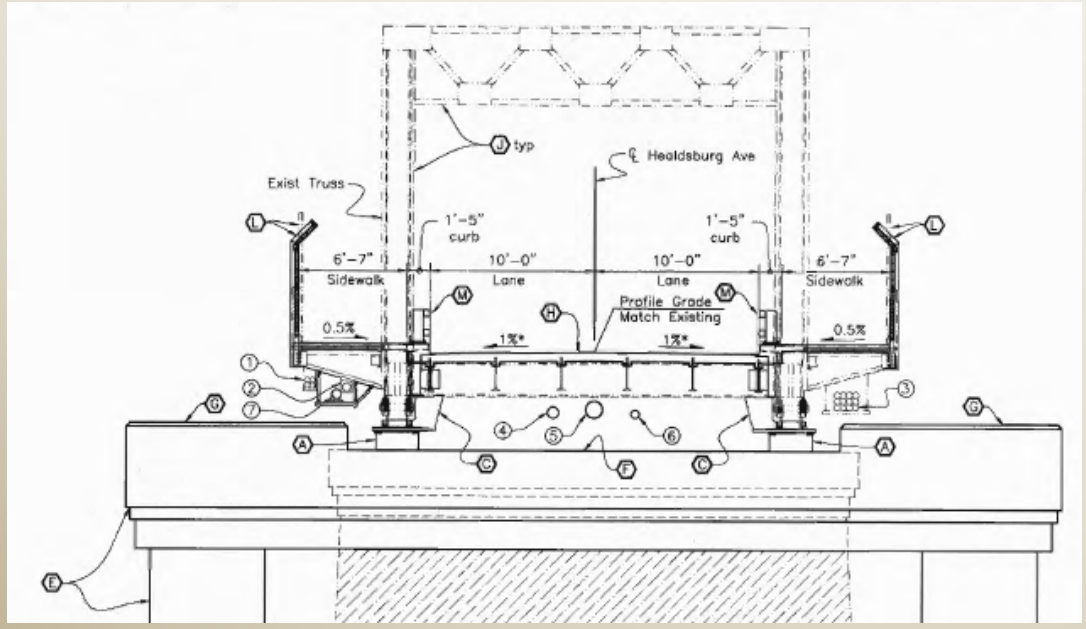

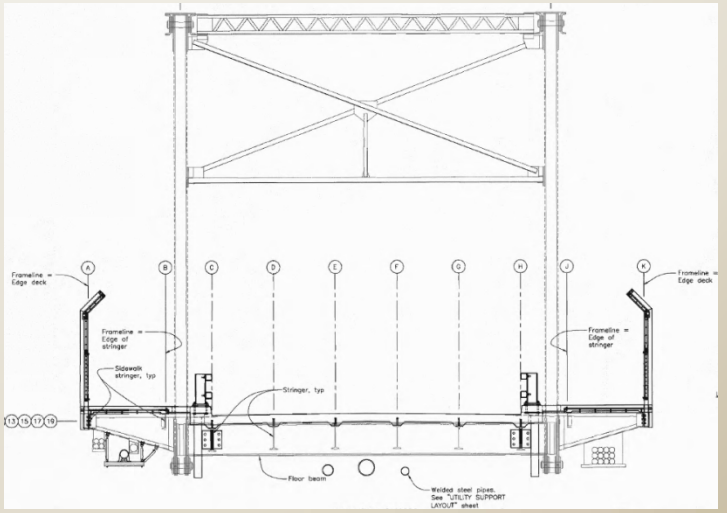

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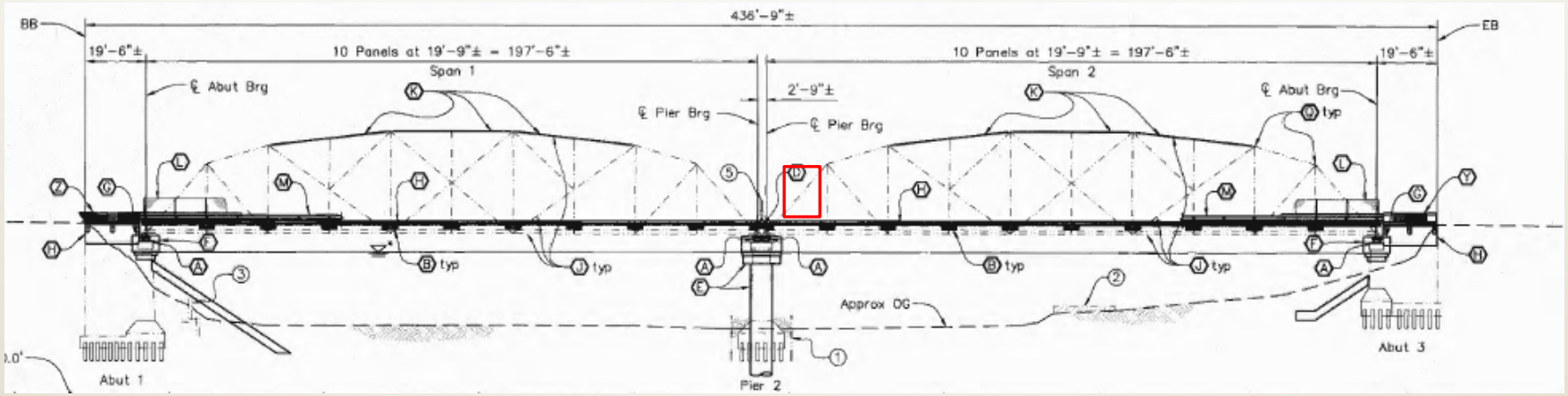
Existing Conditions



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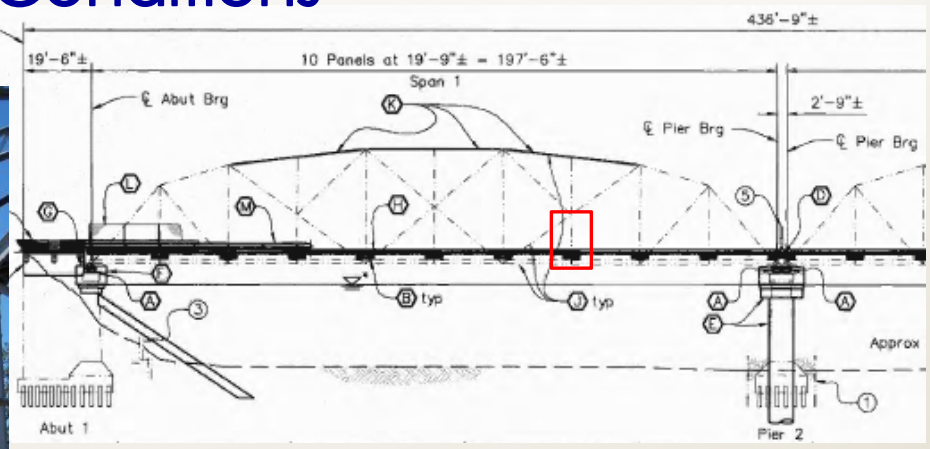

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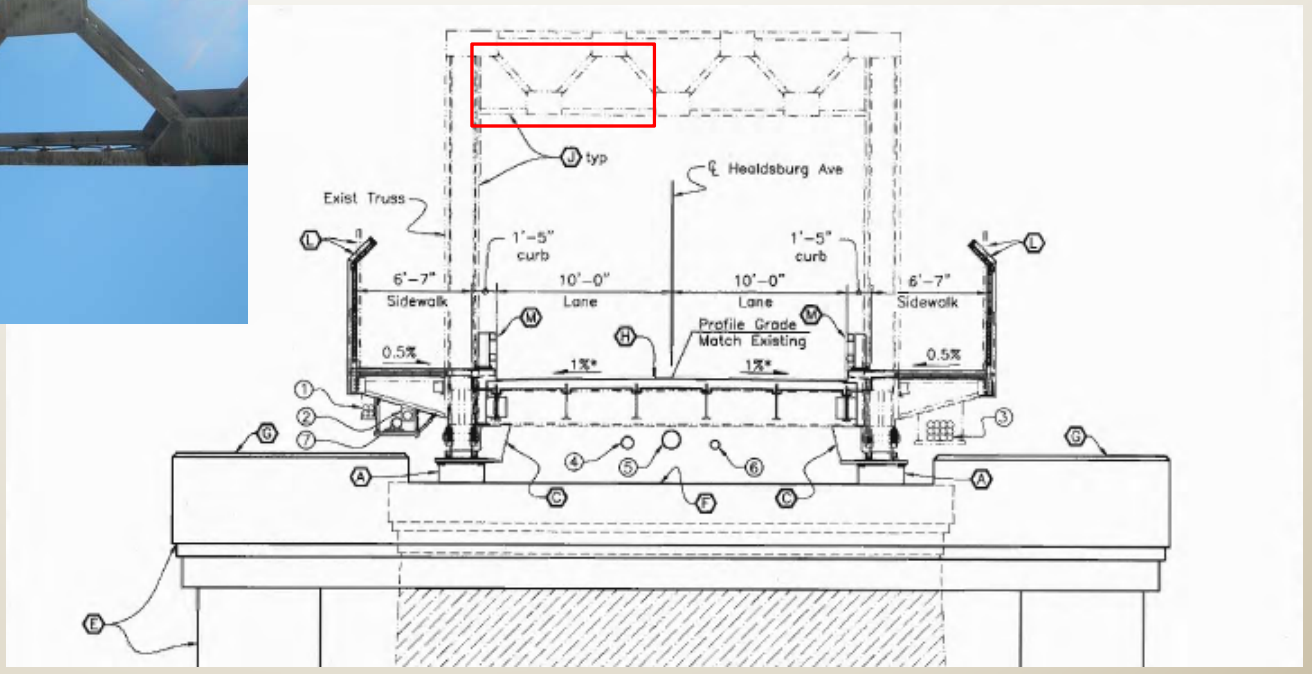
Existing Conditions



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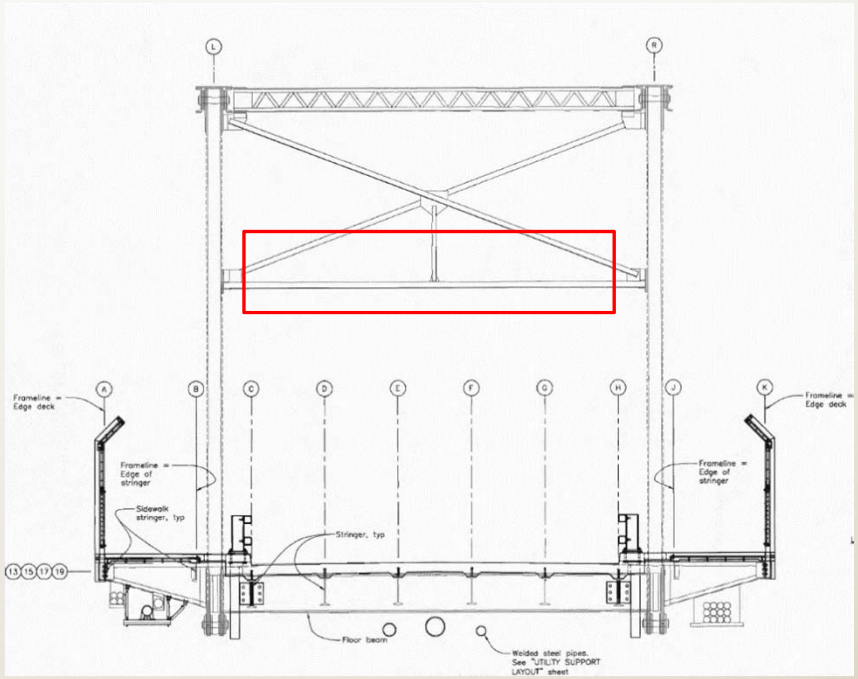
Existing Conditions



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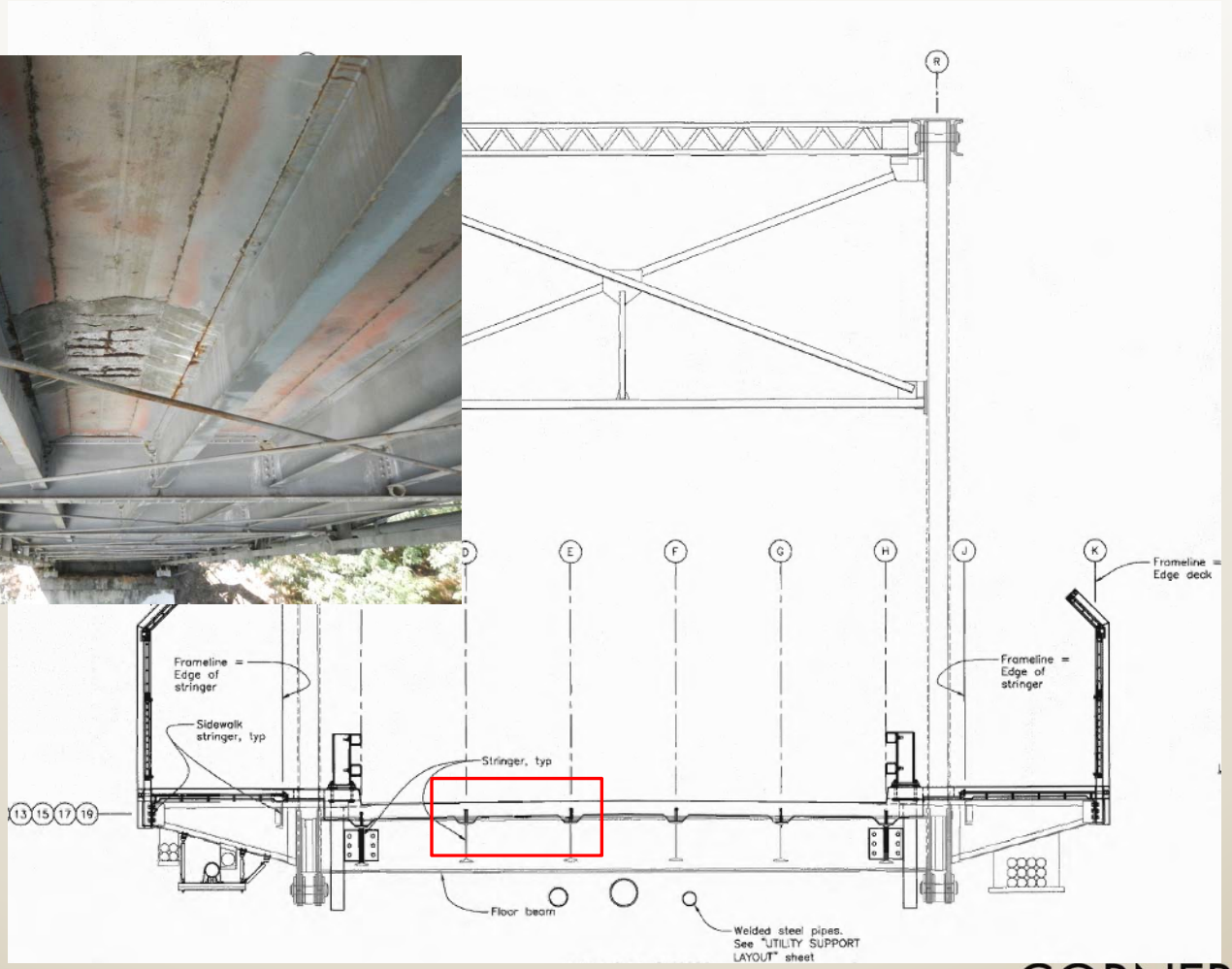

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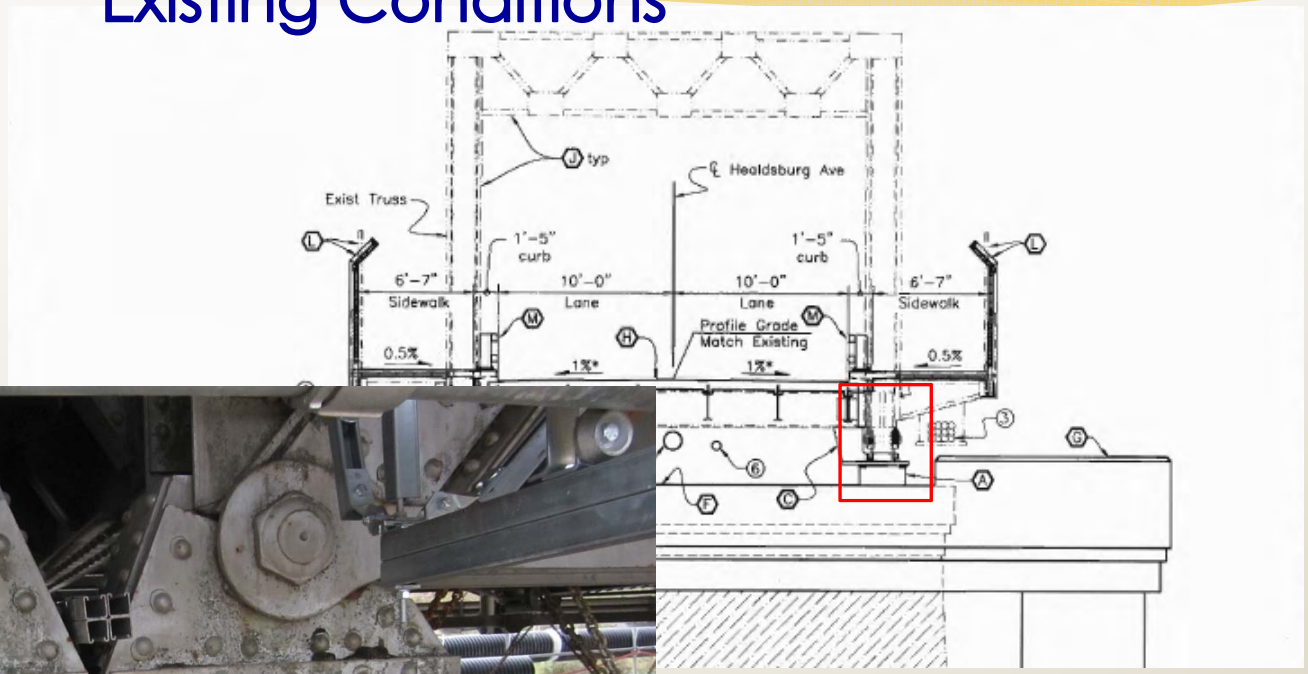

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Seismic Retrofit Strategy

	MECHANISM/FUSE	ACCLERATION REQUIRED TO CREATE FUSE (% GRAVITY)	COMMENTS
Transverse	Bearing Plate at End Floor Beam Out-of-Plane Bending	0.15g	Governing transverse fuse. End diaphragm strengthening required for earthquake forces greater than 0.15g.
	Truss Bearing Plates Out-of-Plane Bending	0.85g	
	Shoe Bearing Plates Out-of-Plane Bending	0.70g	
	Shoe Bearing Plate to Angle Shear in Rivets	0.22g	
	Angle Connection to Base Plate - Fixed End Bending in Angle	7.36g	
	Angle Connection to Base Plate - Roller End Bending in Angle	0.20g	Connection of interior angles to base plate questionable. If rivetted connection assumed, fuse increases to 0.40g
	Shearing of Anchor Bolts	1.0g	
Longitudinal	Slipping of Bearing Plates Against Truss Pin	0.30g	Stabilizer plates hold pin in place. Combined longitudinal fuse = slipping of bearing plates + failure of stabilizer plate = 0.66g
	Pin Stabilizer Plate Shear in Plate	1.22g	
	Pin Stabilizer Plate Shear in Rivets	0.36g	Stabilizer plates hold pin in place. Combined longitudinal fuse = slipping of bearing plates + failure of stabilizer plate = 0.66g
	Shearing of Anchor Bolts	0.90g	

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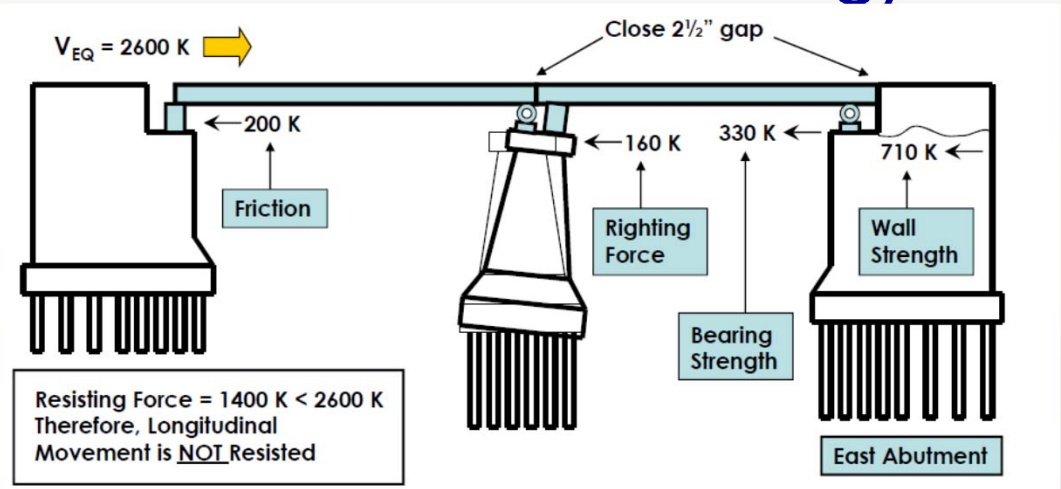
Seismic Retrofit Strategy



DEMAND	LONGITUDINAL PUSH TOWARDS EAST ABUTMENT			COMMENTS
Peak Inertial Force (k)	2600			Abut walls FAIL. Long. movement is unrestrained.
RESISTANCE				
Friction force at West Abut (k)	-	200		
Righting force at Pier (k)	-	160		
Bearing Strength at East Abut (k)	-	330		
Remaining Force	1910			
ELEMENT	**DEMAND (k)**	**SHEAR CAPACITY**	**D/C**	
Abut walls	1910	710	**2.7**	
DEMAND	**LONGITUDINAL PUSH TOWARDS WEST ABUTMENT**			Abut walls FAIL. Long. movement is unrestrained.
Peak Inertial Force (k)	2600			
RESISTANCE				
Friction force at Pier (k)	-	200		
Bearing Strength at East Abut (k)	-	330		
Remaining Force	2070			
ELEMENT	**DEMAND (k)**	**SHEAR CAPACITY**	**D/C**	
Abut walls	2070	710	**2.9**	

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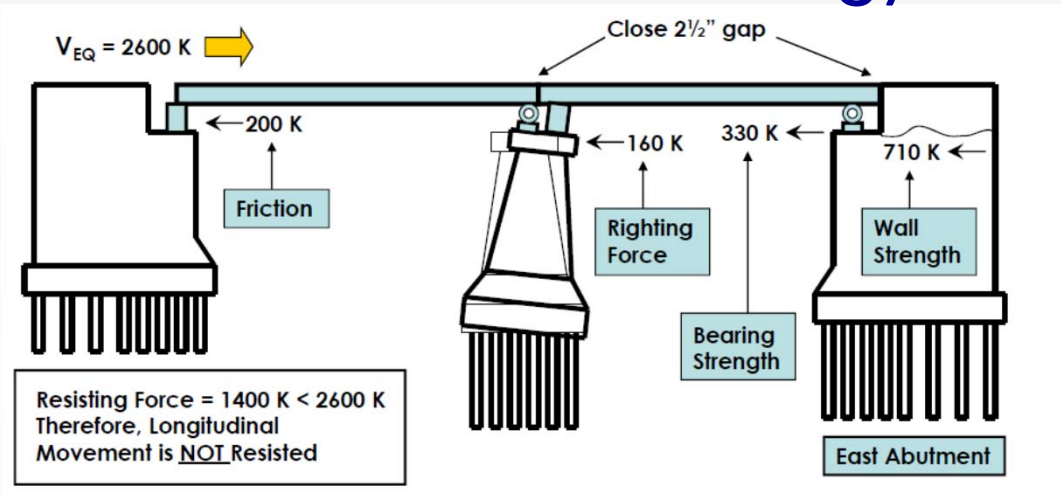
Seismic Retrofit Strategy



MODE	TRANSVERSE RESPONSE DEMAND	CAPACITY	D/C	COMMENTS
Pile Shear (k)	17	10	**1.70**	Piles FAIL in shear.
Moment (k-ft)	45,120	17,675	**2.55**	Pier UPLIFTS.
Pile Compression (tons)	160	40	**4.00**	Piles FAIL in compression.
MODE	**LONGITUDINAL RESPONSE DEMAND**	**CAPACITY**	**D/C**	**COMMENTS**
Pile Shear (k)	3	10	**0.30**	Piles OK in shear.
Moment (k-ft)	41,960	5,600	**7.49**	Pier UPLIFTS.
Pile Compression (tons)	96	40	**2.40**	Piles FAIL in compression.

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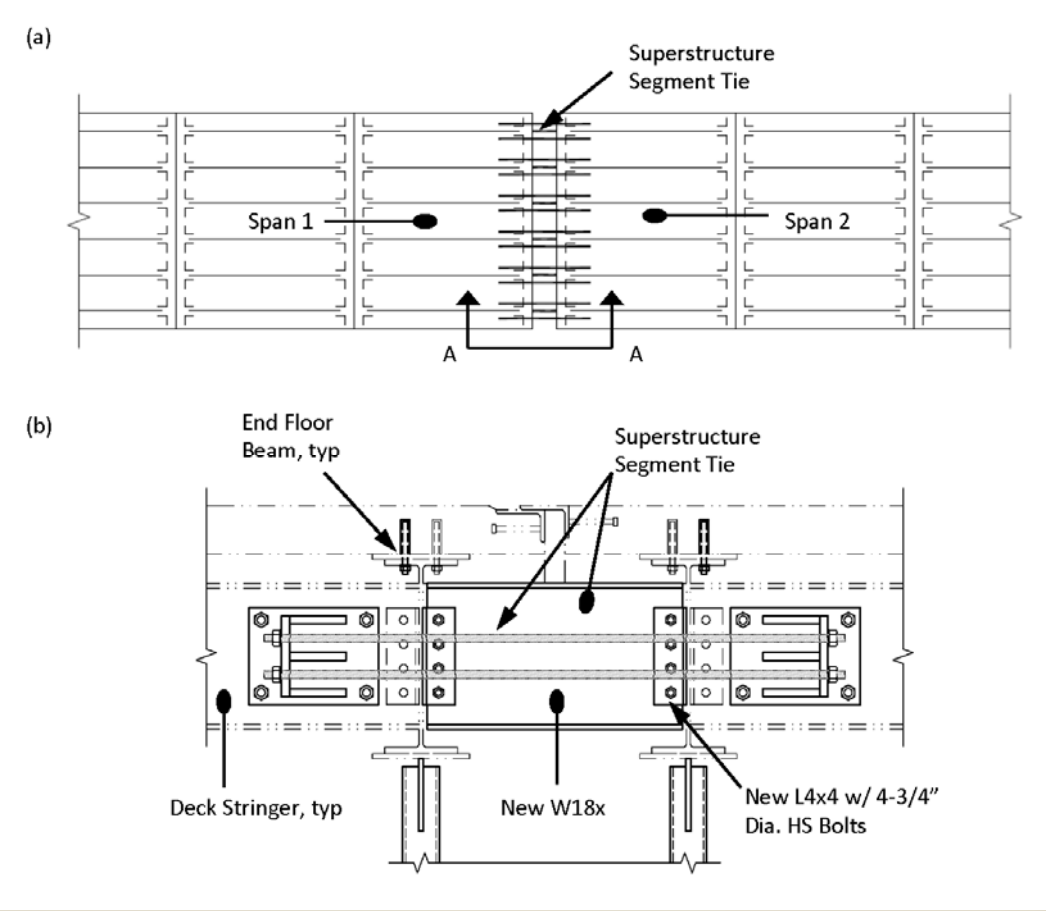
Seismic Retrofit Strategy



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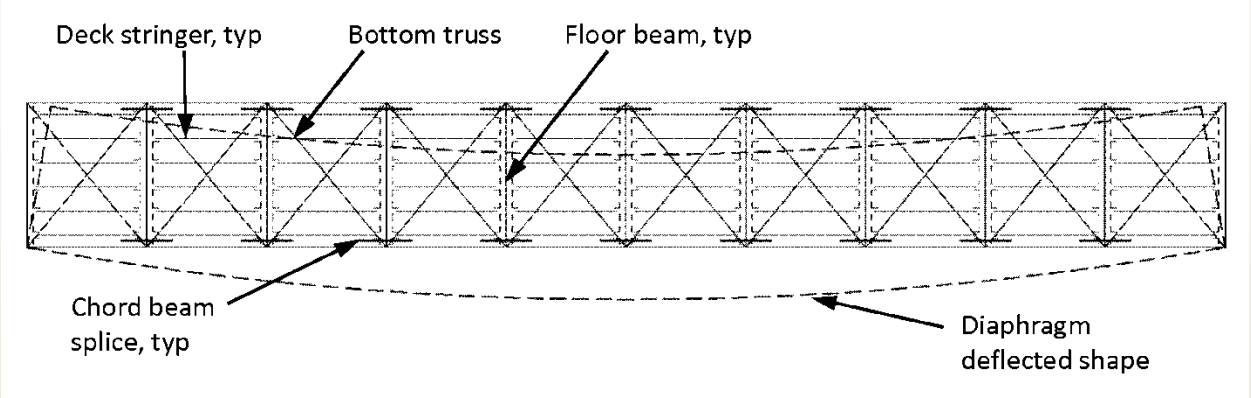
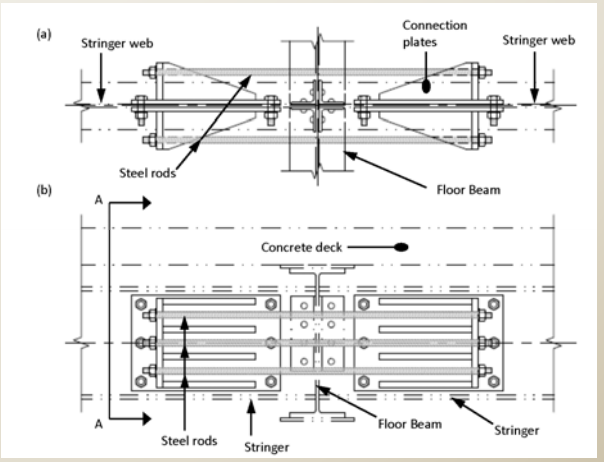
Seismic Retrofit Strategy



MODE	TRANSVERSE RESPONSE				
	DEMAND	CAPACITY		D/C	COMMENTS
Shear (k)	440	Deck	470	0.94	Deck OK in shear.
		Shear Connectors	0	**NG**	No mechanism for shear transfer between deck & end floor beams.
Tension (k)	1040	Stringer	490	**2.12**	Stringer YEILDS, resulting in loss of support for deck.
		Stringer-to-floor beam Connection	130	**8.00**	Connection FAILS, resulting in loss of stringer.



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FHWA Conditions of Funding Approval

* Strengthen Truss to Carry HS-20 Loading
* Provide New Vehicle Barrier Rail to Protect Trusses From Vehicular Impact
* Raise Sway Frames by one Lacing Bar
* Provide Maintenance Plan and Local Funding Source for Future Maintenance
* Include 25% contingency through Final Design for Dealing with Uncertainties Encountered During Construction

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City Driven Design Features

* Provide 3 New Wet Utilities and 1 Electrical Utility Capable of Operating After a Seismic Event
* Replace Chain Link Fence with New Pedestrian Barrier
* Restore Lighting at Pier (And Abutments)

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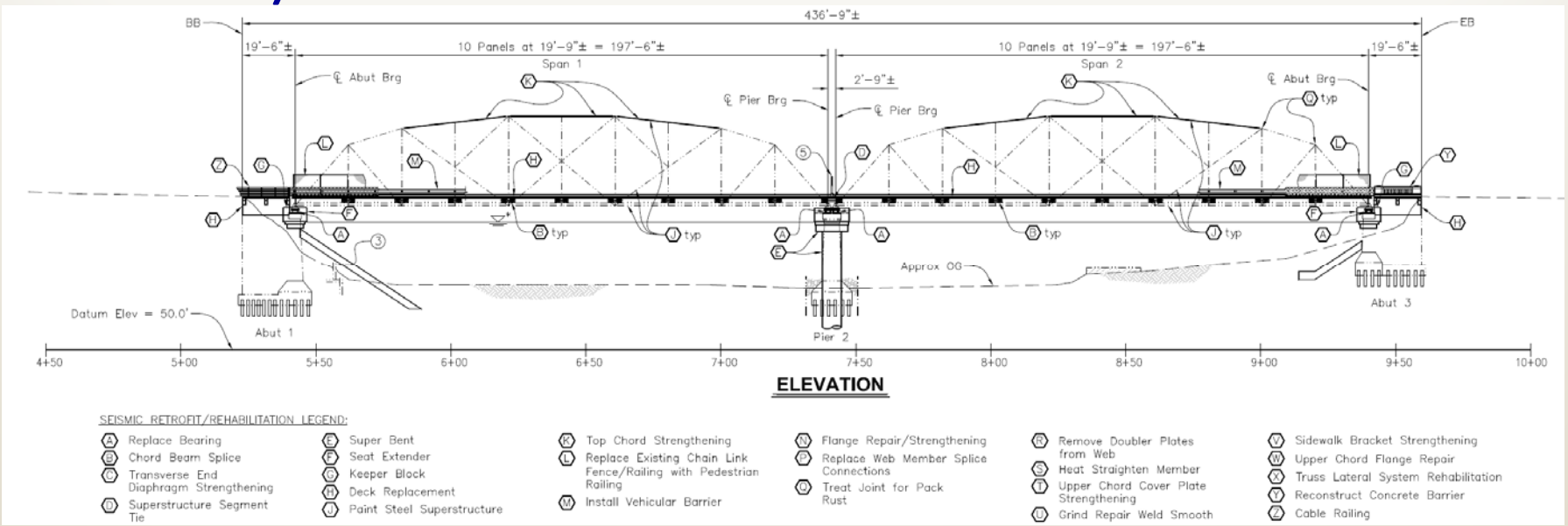
Summary of Rehabilitation and Seismic Retrofit Goals



Rehabilitation

- Strengthen Top Chord Members To Carry HS-20 Loading
- Repair Members Damaged From Vehicular Impact
- Replace Lead Based Paint System
- Replace Bridge Deck
- Replace Seized Bearings
- Provide New Vehicle Barrier Rail to Protect Trusses From Vehicular Impact
- Replace Lattice Rail and Fencing with New Railing
- Preserve Historic Fabric of Bridge

Seismic Retrofit

- Replace Seismically Vulnerable Pier with new "Super Bent"
- Reconstruct Abutments to Increase Passive Resistance
- Install Lead-Rubber Isolation Bearings
- Add Shear Key "Keeper Blocks" to control seismic displacements
- Provide Chord Beam Ties to Allow Deck to act as a Diaphragm
- Provide Headed Studs on Floor Beams to Provide Positive Shear Transfer to Deck Diaphragm

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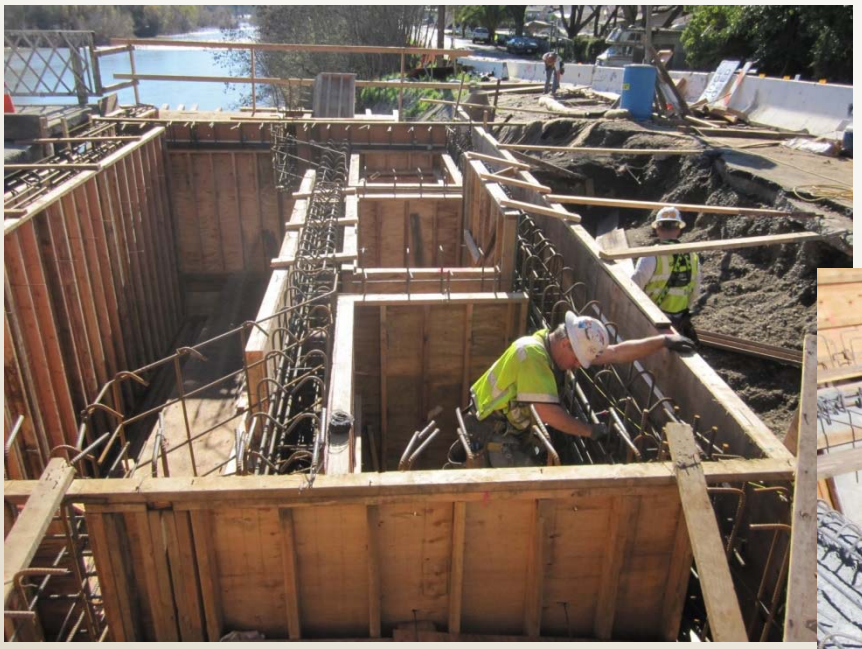
Abutment Reconstruction



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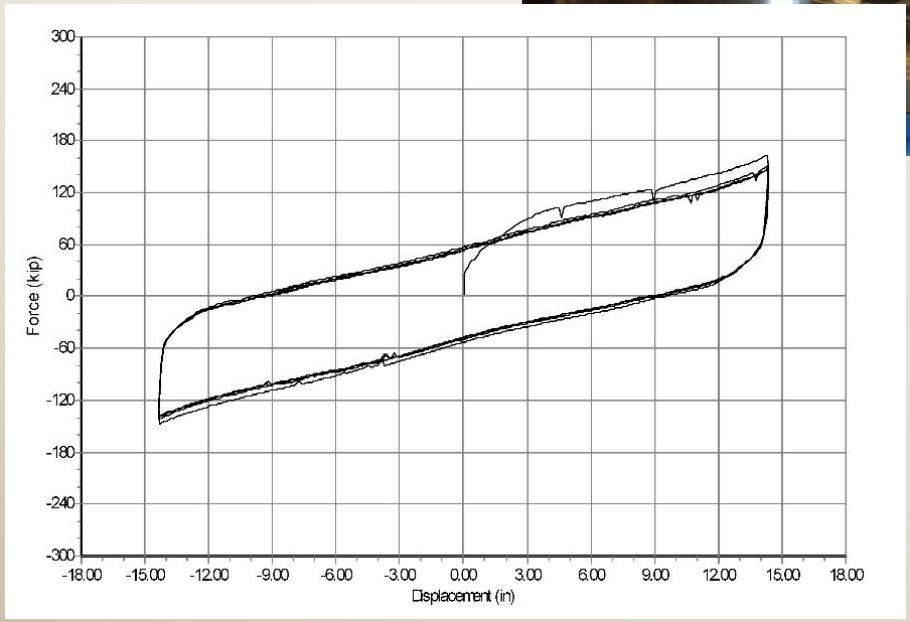
Lead Rubber Isolation Bearings



Limited Seismic Force to ~63% of Seismic Mass

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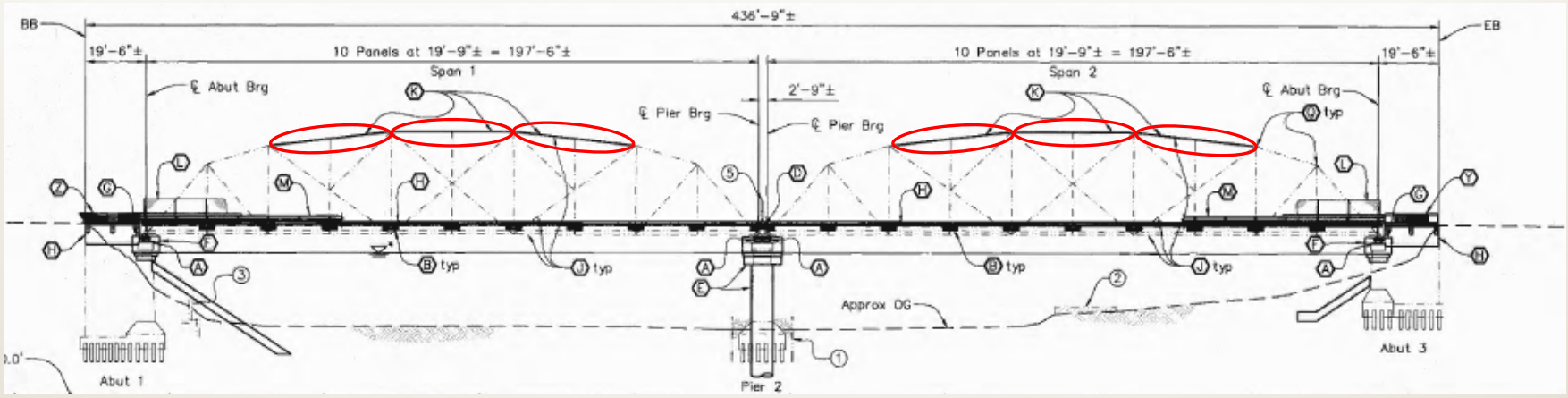
Strengthen Top Chord Members



Always Check Truss Pin Eccentricity

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Lead Paint Abatement and Recoat

Work Complicated by Conveyance of Pedestrians Through Work Zone

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Lead Paint Abatement and Recoat

Freshly Cleaned Steel Awaiting Primer Coat

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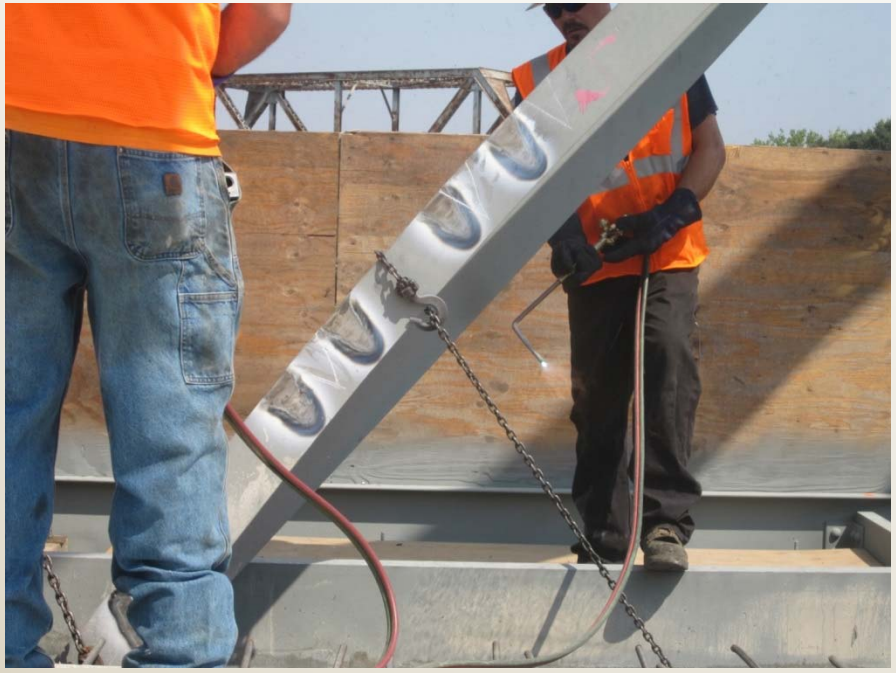
Heat Straightening



Before Heat Straightening

After Heat Straightening

- Highly Effective
- Completed in Only a Few Days
- Web Members Tuned to Balance Load

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Bridge Deck Replacement

Staged Deck Removal

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Bridge Deck Replacement

Fiber Reinforcement Used in Concrete to Control Cracking of Lightweight Concrete Deck

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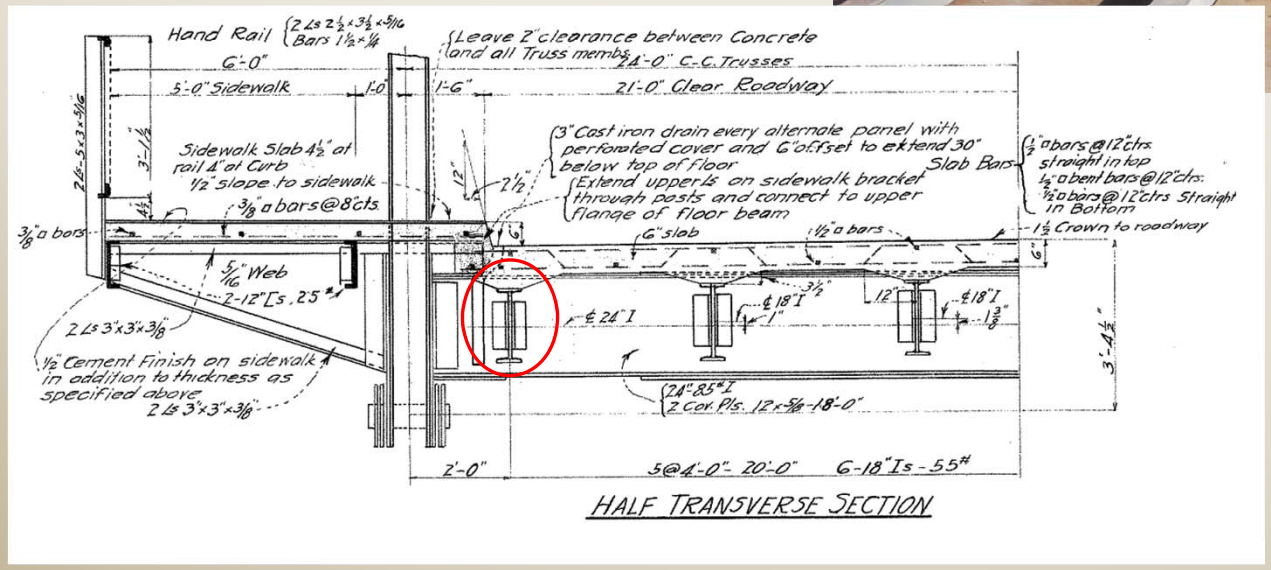
Restoring Members with Advanced Section Loss

- Severe Pack Rust on Exterior Stringers
- Interior Stringers Minor Surface Rust
- Maintaining Deck Drainage is Not a Minor Concern For Steel Bridges



HALF TRANSVERSE SECTION

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Stringer Replacement/Strengthening

Before Cleaning Stringer

After Cleaning Stringer

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Stringer Replacement/Strengthening

Granite Sourced Historically Accurate
S18x Shapes for Replacement

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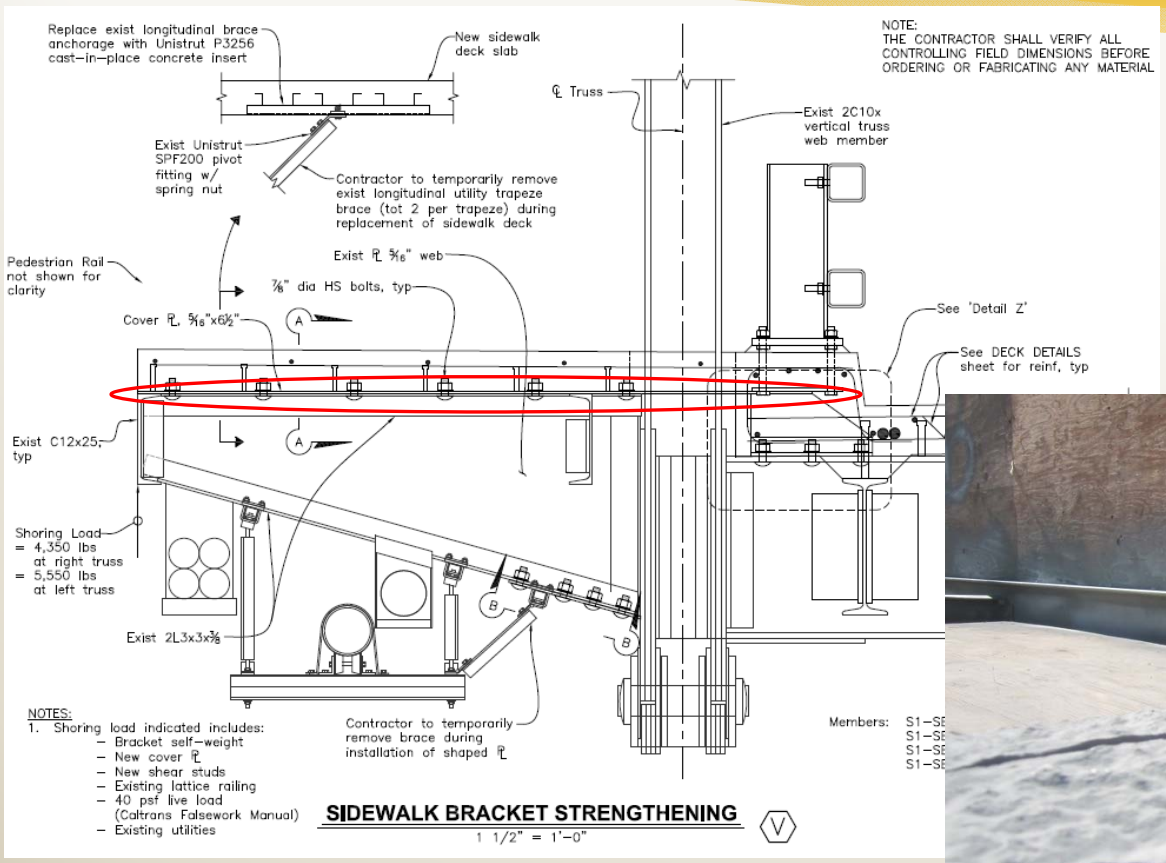

- Primary Sidewalk Support Member Almost Entirely Gone
- Double Angles Replaced

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Super Bent Construction

Pile Driven In Close Proximity to Existing Bridge to Limit Span of Bent

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Super Bent Construction

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Super Bent Construction

Pipe Dowels for Shear Transfer To New Cap Beam

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Super Bent Construction

Self Supporting Cap Prior to Infill Wall Construction

Completed Super Bent

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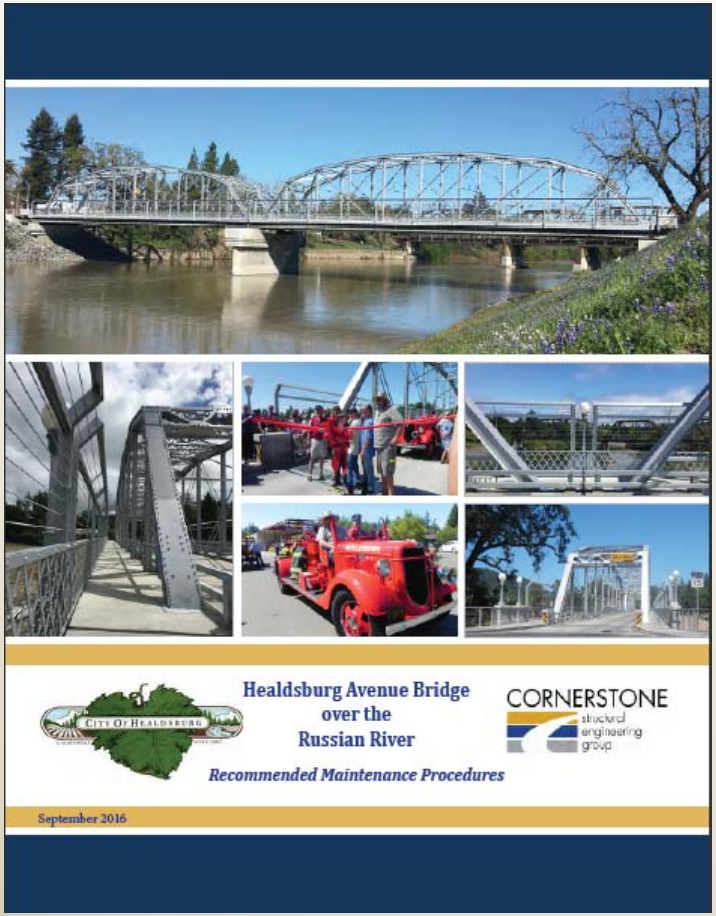
Long Term Preservation



		Approximate Maintenance Interval (Years)					
		1	2	5	10	20	60
1	Maintenance Inspection	•					
2	Visual Inspection of Eye Bars	•					
3	Graffiti Removal	•					
4	Flush Out Deck Drains	•					
5	Remove Debris from Truss Joints and Pedestrian Barrier Rail	•					
6	Repair/Replace Bird Deterrent Spikes	•					
7	Remove Debris from Pedestrian Barrier Rail Drainage Elements	•					
8	Inspect and Clean Lead Rubber Bearings	•					
9	Inspect and Clean Pier and Abutment Seats	•					
10	Clean Joints and Joint Seals	•					
11	Ultrasonic Testing of Pin Connectors		•				
12	Underwater Inspection			•			
13	Methacrylate Deck Seal Overlay			•			
14	Repair/Replace Barrier Railing Damaged By Vehicular Impact			•			
15	Paint Lead Rubber Bearing Cover Plates			•			
16	Scour/Slope Protection				•		
17	Repair Spalls and Cracks in Substructure				•		
18	Repair Damaged Portal Frame & Sway Bars				•		
19	Bridge Paint Inspection and Spot Painting Repair				•		
20	Replacement of Fractured Eye Bars					•	
21	Bridge Painting Recoat					•	
22	Repair/Replace Joint or Joint Seal					•	
23	Bridge Paint System Replacement						•
24	Clean and Treat Pack Rust						•

City Committed to Long Term Maintenance and Established Dedicated Local Funding Source

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New Pedestrian and Vehicular Railing

Completed Vehicle Barrier and Restored
Lattice Railing/Cable Railing Hybrid
Pedestrian Barrier

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Bridge Reopened to Traffic

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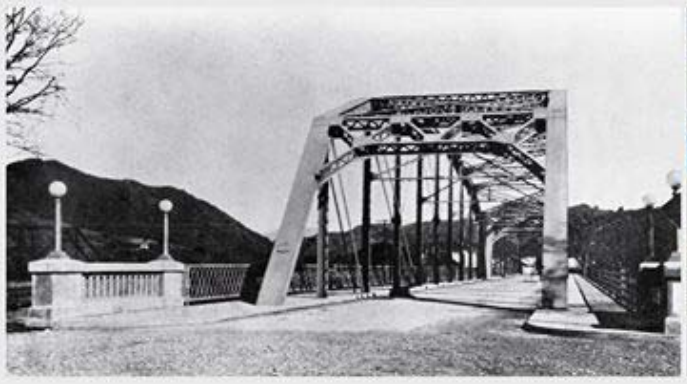
Questions?



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