3-D Pushover Analysis & Innovative Seismic Strengthening of:

North Going Street Bridge

KPFF Consulting Engineers
Stuart Finney, P.E.
September 2011

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North Going Street Bridge, Portland, OR

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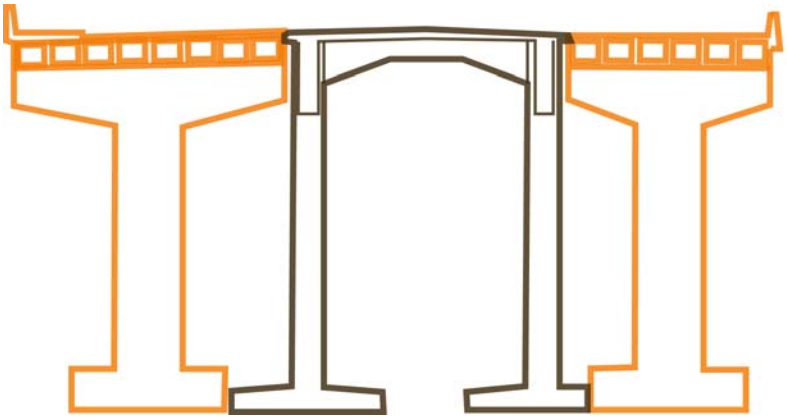
- Middle section constructed in 1930
- Outer sections constructed in 1973



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Existing Bridge

Problem:

Critical transportation link vulnerable to moderate earthquake

Solution:

Provide seismic retrofit making best use of available funds.

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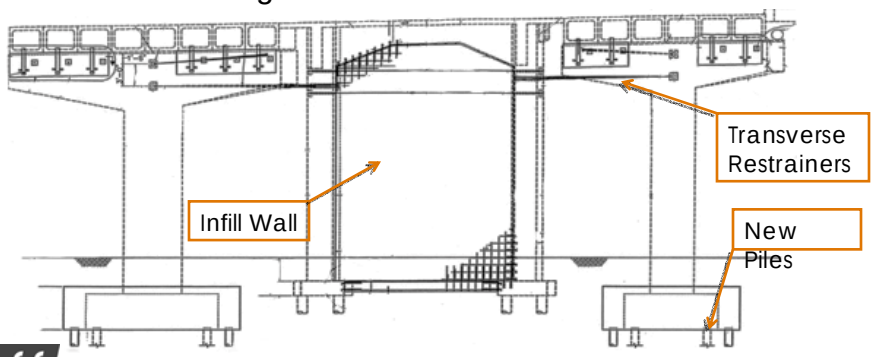
1996 Original Retrofit Strategy

- Required railroad track realignment
- Force based design
- Work below bridge around railroad tracks



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View Beneath Bridge

- Impact to railroad
- Limited construction staging area

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2006 KPFF Preliminary Design

- Work only on top of bridge
- Add new 4” concrete deck overlay
- Add drilled shafts at bridge ends
- Insufficient funding

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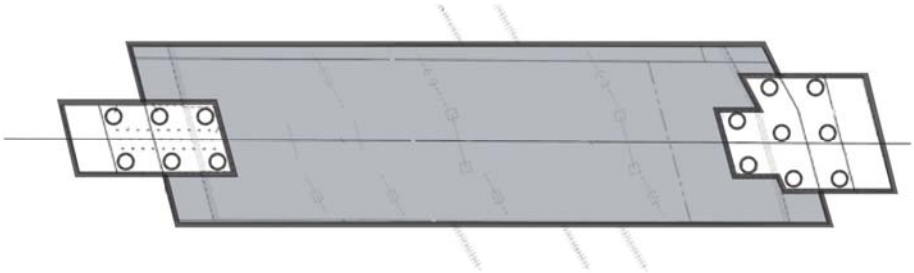
2006 KPFF Preliminary Design

- Concrete deck overlay
- Drilled shafts limit deflection



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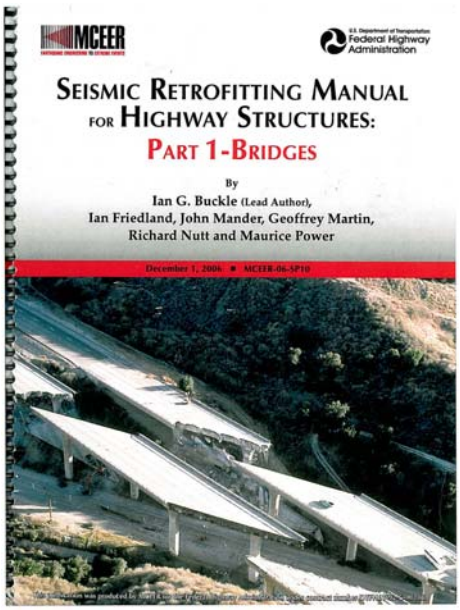
2008 Final Design

- City of Portland – Owner
- ODOT, FHWA – Oversight
- OBEC – Project Manager, Roadway Design
- KPFF – Bridge Design
- Kittelson – Traffic
- GRI – Geotechnical

Seismic Retrofitting Manual

- Published December 2006
- MCEER/FHWA



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Displacement Based Design Pushover Analysis

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What is a “Pushover Analysis”?

- Displacement Demand
- Displacement Capacity

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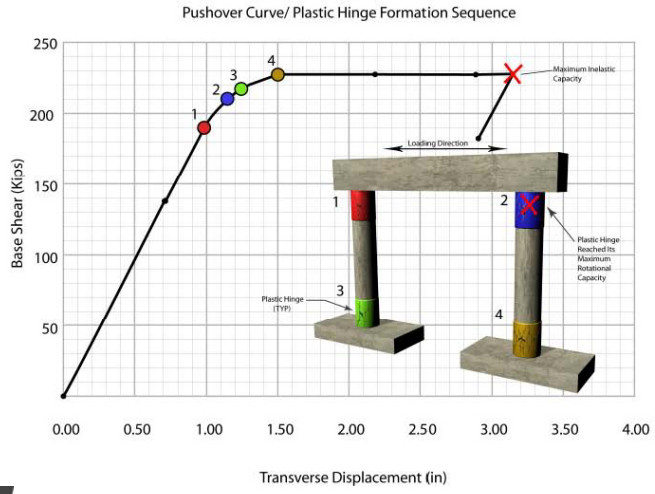
Pushover Curve
Plastic Hinge Formation



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Performance Levels

- 100 yr Return Period ⇒ Operational, remain elastic
- 500 yr Return Period ⇒ Life safety
- 1000 yr Return Period ⇒ Life safety (possible soil liquefaction)

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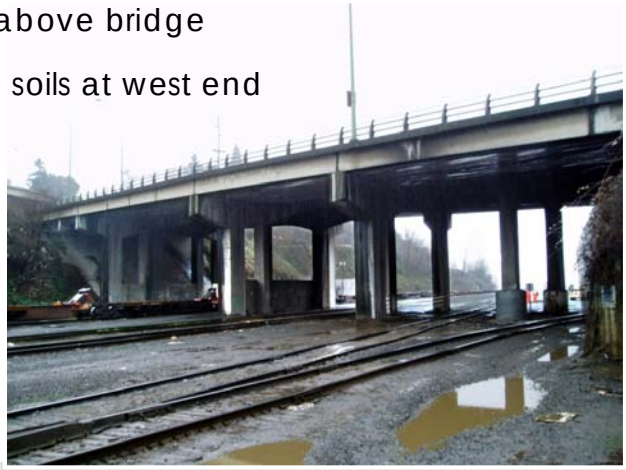
Design Constraints

- Limit displacement
- Work only above bridge
- Liquefiable soils at west end



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Reduce Seismic Displacement by:

- Linking three portions of bridge together with new overlay
- Installing drilled shafts at bridge ends

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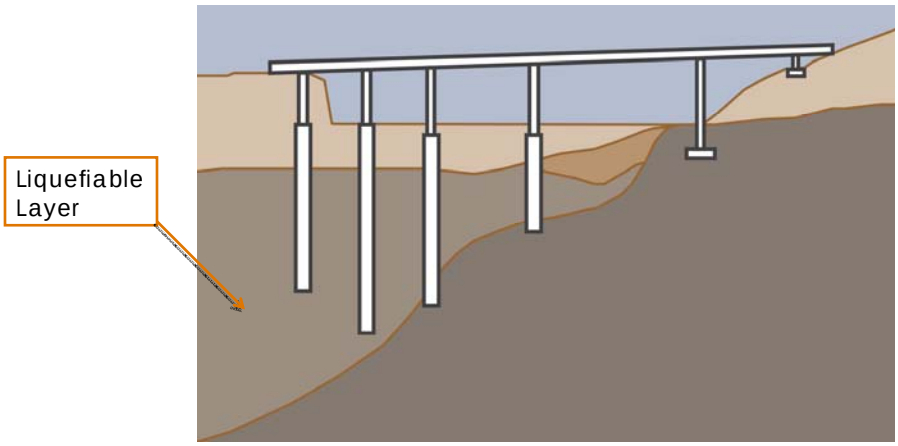
Mitigate Effects of Liquefaction by Adding Steel Piles



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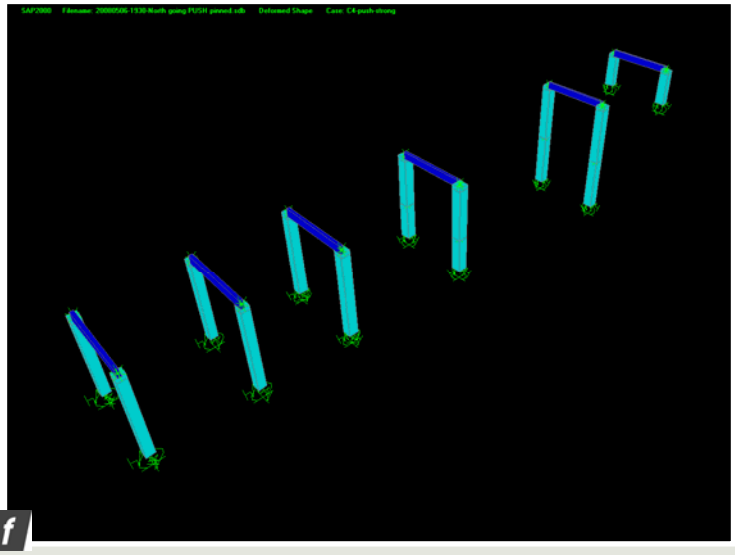
SAP Model – 1930 Section



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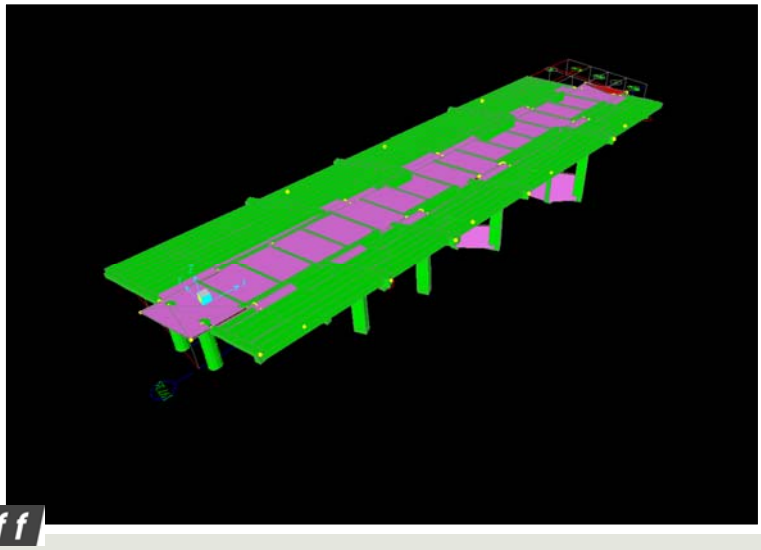
SAP Model



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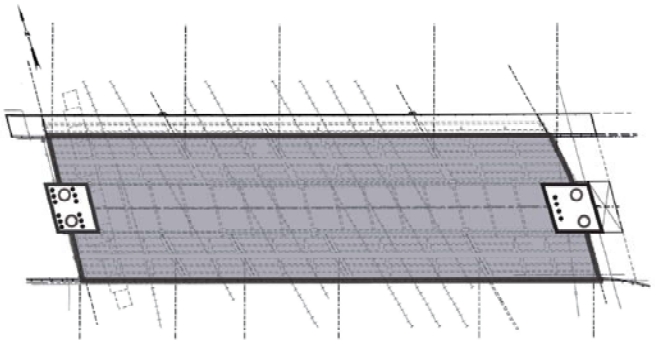
Plan

- New concrete deck overlay
- New drilled shafts each end
- New driven steel piles



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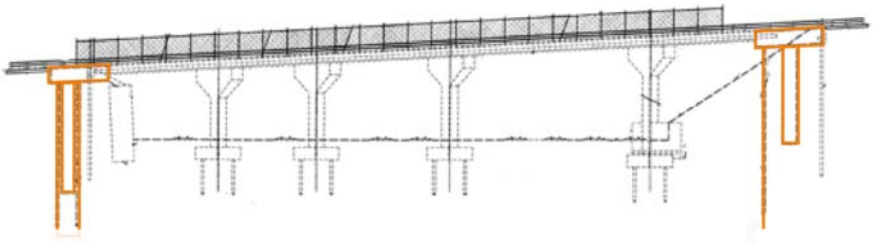
Elevation



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Gravity Load Rating

- Retrofit must not reduce load rating
- Retrofit should increase load rating, if possible
- New overlay transfers live loads from widened to original portion

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Gravity Load Rating

- SAP model modified to model live load effects
- Shear rating factor less than 1.0
- Add shear anchors to 1930 section during retrofit
- Overlay improves load rating of existing deck slab

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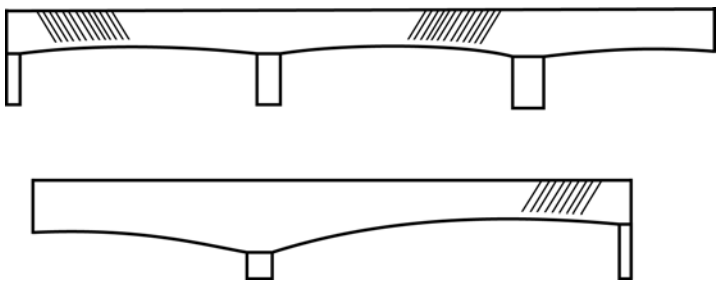
Internal Shear Anchors

- Shear anchors installed prior to deck pour
- 1930 section of bridge



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Pedestrian & Bicycle Access

- Pedestrian access to Swan Island
- Busy adjacent traffic

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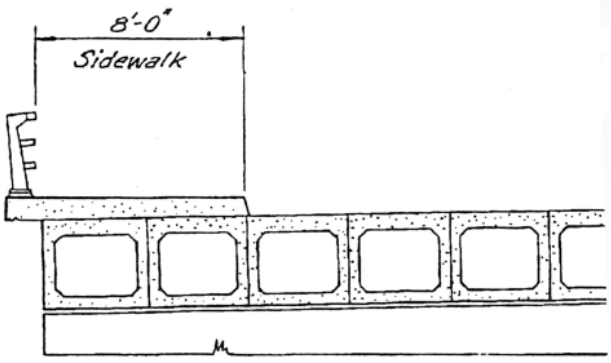
Pedestrian & Bicycle Access

- No protection for pedestrians
- Main pedestrian access to Swan Island



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Pedestrian & Bicycle Access

- Pedestrian access to Swan Island
- No protection from adjacent traffic

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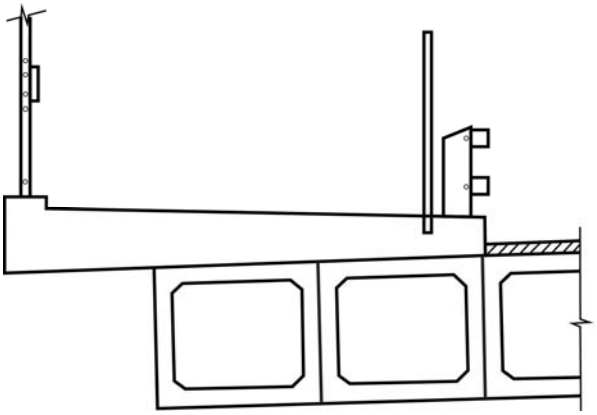
Widen Sidewalk & Maintain Roadway Width



New Sidewalk Detail

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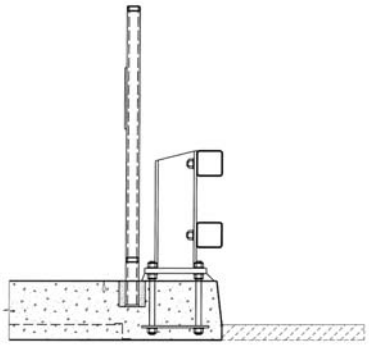
New Rail to Protect Pedestrians



2-TUBE CURB MOUNT RAIL
AND PEDESTRIAN RAIL AT SIDEWALK
Scale: 1"= 1'-0"

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Mobility

Need to maintain a minimum of two traffic lanes in each direction

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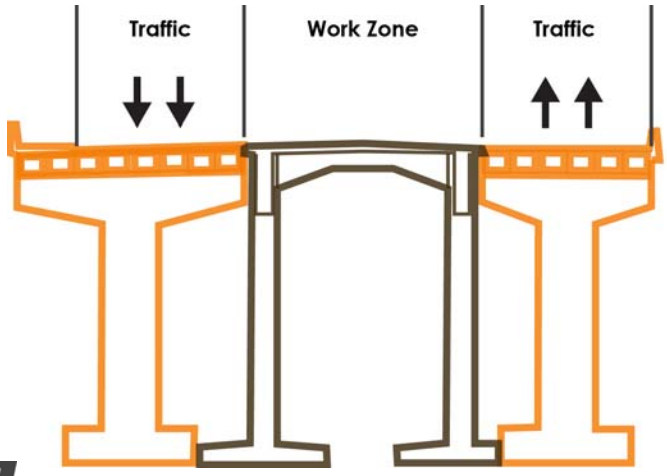
Construction Stage 1



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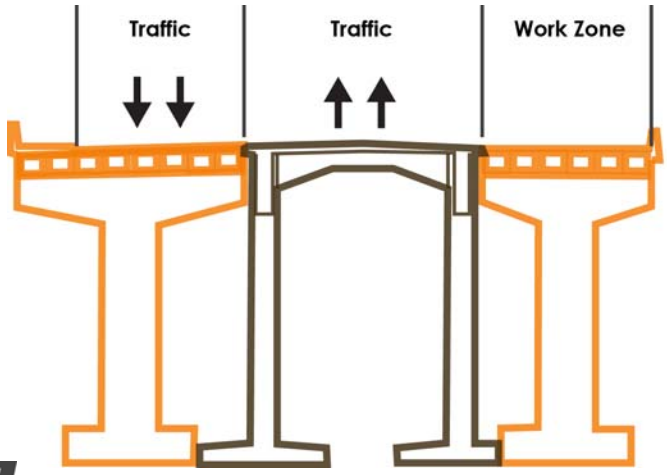
Construction Stage 2



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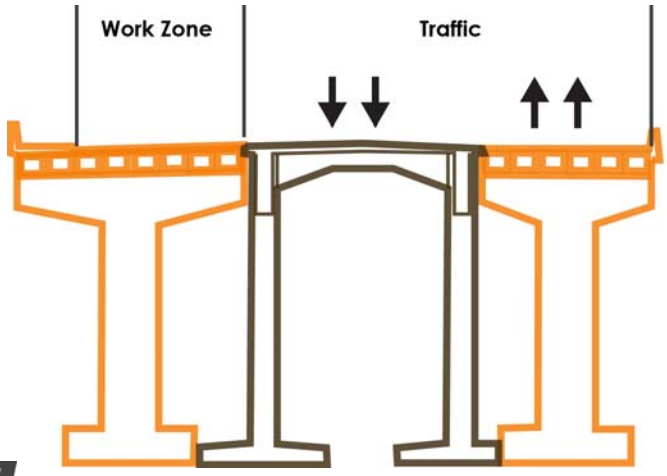
Construction Stage 3



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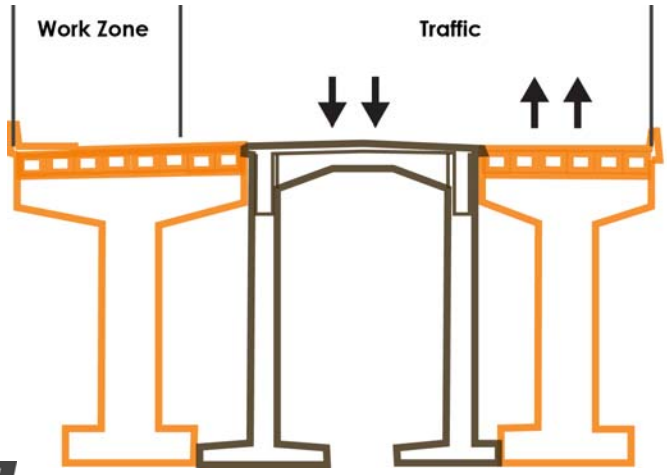
Construction Stage 3B



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Conclusion
Displacement Based Design

- Eliminated work below bridge
- Reduced cost of seismic retrofit
- Enabled remaining funds to be used to improve pedestrian access

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Construction Complete
October 2010

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Questions?

KPFF Consulting Engineers
111 SW 5th Avenue, Portland, OR 97204
(503) 227.3251
www.kpff.com