DESIGN of the 4th AVE S OFF-RAMP
Eastbound South Spokane Street Viaduct
Seattle, WA

by
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Western Bridge Engineers' Seminar

Sacramento, CA
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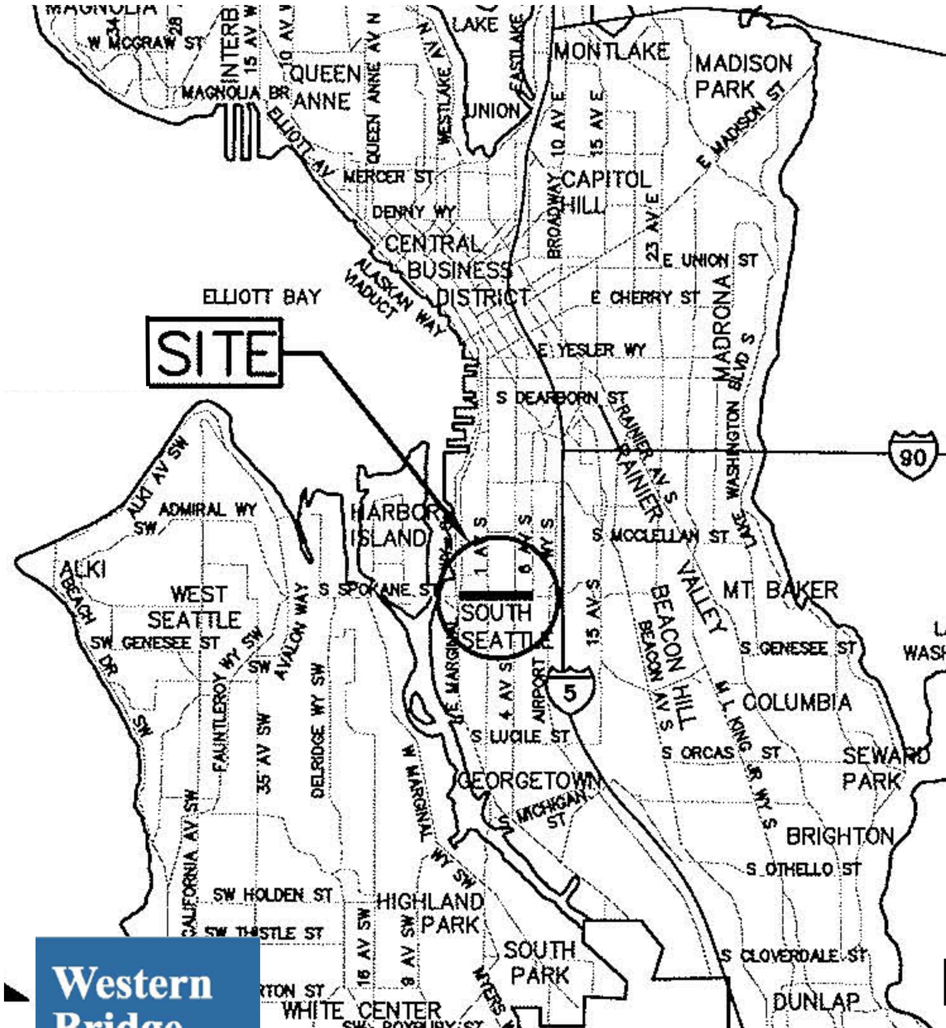
OUTLINE

- Project Overview
- Selection of Preferred Alternative
- Seismic Analysis for Connectivity
- Special Box Girder Design Considerations (see handout)

PROJECT OVERVIEW



Owner

Seattle Department of Transportation (SDOT)

Structural, Roadway, Traffic, Storm Drainage, Electrical, Landscaping, Irrigation

Jacobs Engineering Inc.

SEW

HDR

Survey

Lin & Associates

Fire Protection

PACE Engineers

Geotechnical

Shannon & Wilson

PROJECT OVERVIEW

- Project Status
  - Existing SSSV Built in 1941; EB Egress only at 1st Avenue South
  - Planned Widening (1994)
  - Partial Seismic Retrofit (1999)
  - Technical Feasibility Study (2006-PB)
  - TS&L Report (2007-JE)
  - Final Design Complete (2008)

PROJECT OVERVIEW

- Benefits of 4th Ave Off-Ramp
  - Improve access to CBD from West Seattle
  - Facilitate transit access to E-3 Busway
  - Create grade-separation bypass over railroad
  - Alternative route into CBD during Alaskan Way Viaduct closure/construction
  - Provide access to surface roadway to alleviate I-5 ramp congestion

PROJECT OVERVIEW

- Complete Redevelopment of EB Lower Roadway:
  - Roadway Re-Grading: pavement, curbs, sidewalk; SCL parking lot
  - Traffic: new signalized intersection, signal interconnect, signal loops, pedestrian movements, signs
  - Storm Drainage: upgrades and utility relocations
  - Illumination: bridge structure and parking lot

PROJECT OVERVIEW

Selection of Preferred Alternative

- Selection Process
  - Determine Constraints & Assumptions
  - Develop Selection Criteria
  - Method 1 – Weighted Criteria
  - Method 2 – Unweighted Criteria
  - Prepare Alternatives Selection Matrix
  - Hold Alternative Selection Workshop

Selection of Preferred Alternative

- Constraints & Assumptions
  - No Piers in EB Lower Roadway
  - No Column in 4th Avenue South
  - Ramp to be Seismically Isolated from Viaduct
  - Maintain 20-foot Overheight Vehicle Corridor
  - No Lane Closures on Viaduct for Installation of Substructure
  - 15-foot Minimum Clearing in SCL Parking Lot
  - Staging in SCL Parking Lot

Selection of Preferred Alternative

- Selection Criteria
  - Non-Varying Elements between Alternatives
    - Site Prep & Removals
    - Illumination
    - Storm Drainage
    - Signalization
    - Paving
    - Impacts to Seattle Fire Dept or Metro Bus during Construction
    - Signing
    - Fire Protection
    - Utility Impacts – Qwest / MCI
    - Generalized Staging of Work

Selection of Preferred Alternative

- Selection Criteria
  - Applicable Criteria (for Selection Matrix)
    - Construction Cost (Year of Cost)
    - Life Cycle Costs (Total)
    - Performance Risk
    - Environmental Impacts
    - Ease of Construction (falsework, staging)
    - Aesthetics
    - Engineering Cost
    - Traffic Impacts
    - Utility Impacts during Construction (SPU / OPL)
    - Permanent SCL Parking Lot Impacts

Selection of Preferred Alternative

- Selection Criteria
  - Non-Applicable Criteria
    - Community Impacts
    - Geological/Geotechnical Variation
    - Environmental Impacts (Wildlife, Wetlands, Air Quality, Noise)
    - Cultural-Archeological-Historic Preservation Concerns
    - Hazardous Materials Cleanup
    - Parking Lot Disruption During Construction
    - Soil Remediation
    - Weather Sensitivity of Structure
    - Maintenance
    - In-Service Bridge Inspection Frequency and Ease
    - Minimizing Number of Bridge Spans

Selection of Preferred Alternative

- Method 1 – Weighted Criteria

CRITERIA WEIGHTING						
		Maintenance	Geometrics	Aesthetics	Geotech	
CRITERIA		**B**	**C**	**D**	**E**	**WT**
Capital Cost	**A**	3A	2C	4A	2E	**7**
Maintenance	**B**	-	3C	3B	3E	**3**
Geometrics	**C**	-	-	3C	2C	**10**
Aesthetics	**D**	-	-	-	3E	**0**
Geotechnical	**E**	-	-	-	-	**8**
	4	Major Preference				
	3	Medium Preference				
	2	Minor Preference				
	1	No Preference				

Selection of Preferred Alternative

- Method 1 – Selection Matrix

WEIGHTED MATRIX					
CRITERIA	**WT**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**
Capital Cost	**7**	3	4	3	2
Maintenance	**3**	2	5	2	3
Geometrics	**10**	3	3	2	4
Geotechnical	**8**	5	5	5	3
TOTAL WT		**97**	**113**	**87**	**87**
RANKING		**2**	**1**	**3**	**3**

Selection of Preferred Alternative

- Method 2 – Selection Matrix

UNWEIGHTED MATRIX					
CRITERIA	**WT**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**
Capital Cost	**1**	3	4	3	2
Maintenance	**1**	2	5	2	3
Geometrics	**1**	3	3	2	4
Geotechnical	**1**	5	5	5	5
TOTAL WT		**13**	**17**	**12**	**14**
RANKING		**3**	**1**	**4**	**2**

Selection of Preferred Alternative

- Alternatives
  - Transition Structure
    - T1 2-span T-Beams; 5-span W50G Girders; (81-foot spans); drilled shaft foundations
    - T2 2-span T-Beams (81-feet); 3-span W74G (120-foot spans); drilled shaft foundations
    - T3 Same as T1 with partial micropile foundations
    - T4 Same as T2 with partial micropile foundations
    - **T5 9 Spans T-Beams (40-foot spans); drilled shafts**

Selection of Preferred Alternative

- Alternatives
  - Ramp Structure
    - R1 3-span steel girder or box
    - R2 1-span steel girder or box; either 4-spans W50G or 2-spans concrete box
    - R3 2-span steel girder or box with extended SEW
    - R4 6-span W50G with pier in roadway
    - R5 11-span W50G with spliced WF74PTG over roadway
    - B1 2-span T-Beams; 4-span P/T Box; 3-span P/T Box; 2-span P/T Box
    - **B2 5-span P/T Box**

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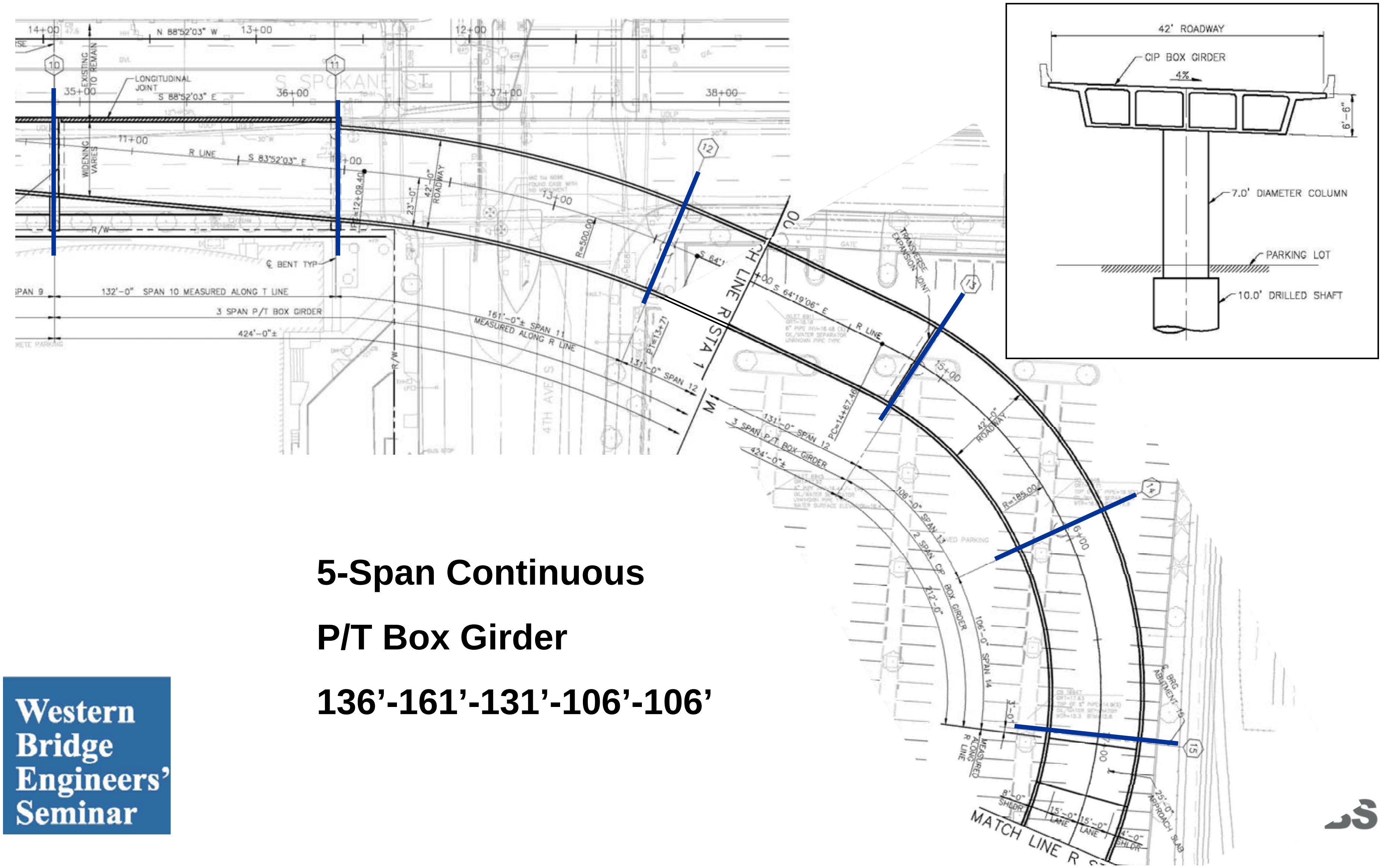
Selection of Preferred Alternative



5-Span Continuous

P/T Box Girder

136'-161'-131'-106'-106'

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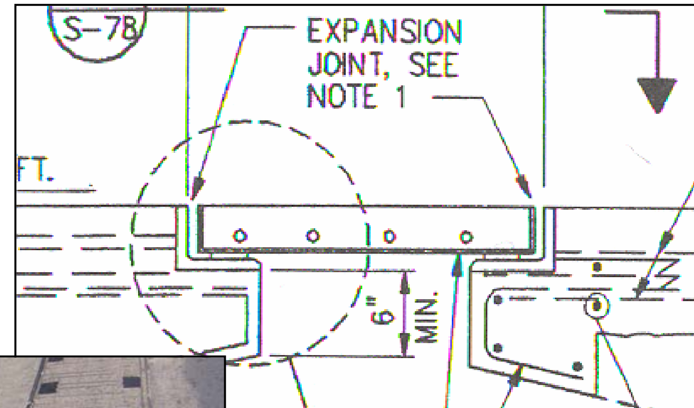
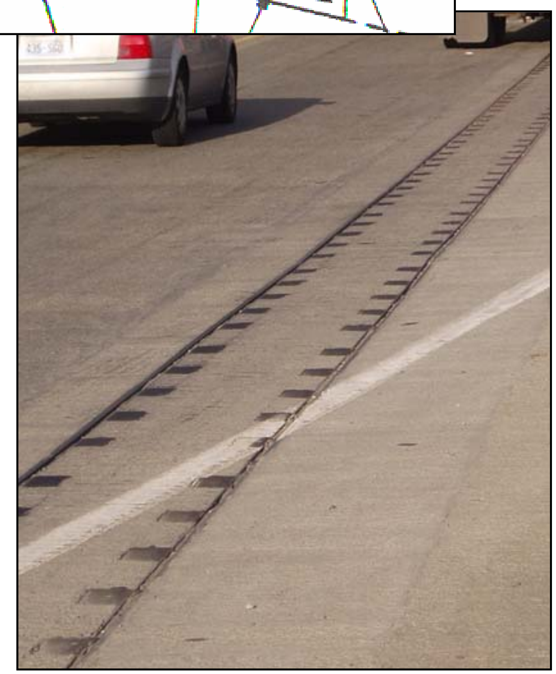
Seismic Analysis / Connectivity

- Seismic Separation
  - Steel-Filled Grate
  - Successful Previous Use
  - No Maintenance Issues
  - Lateral Load Transfer





- Concrete Closure Pour

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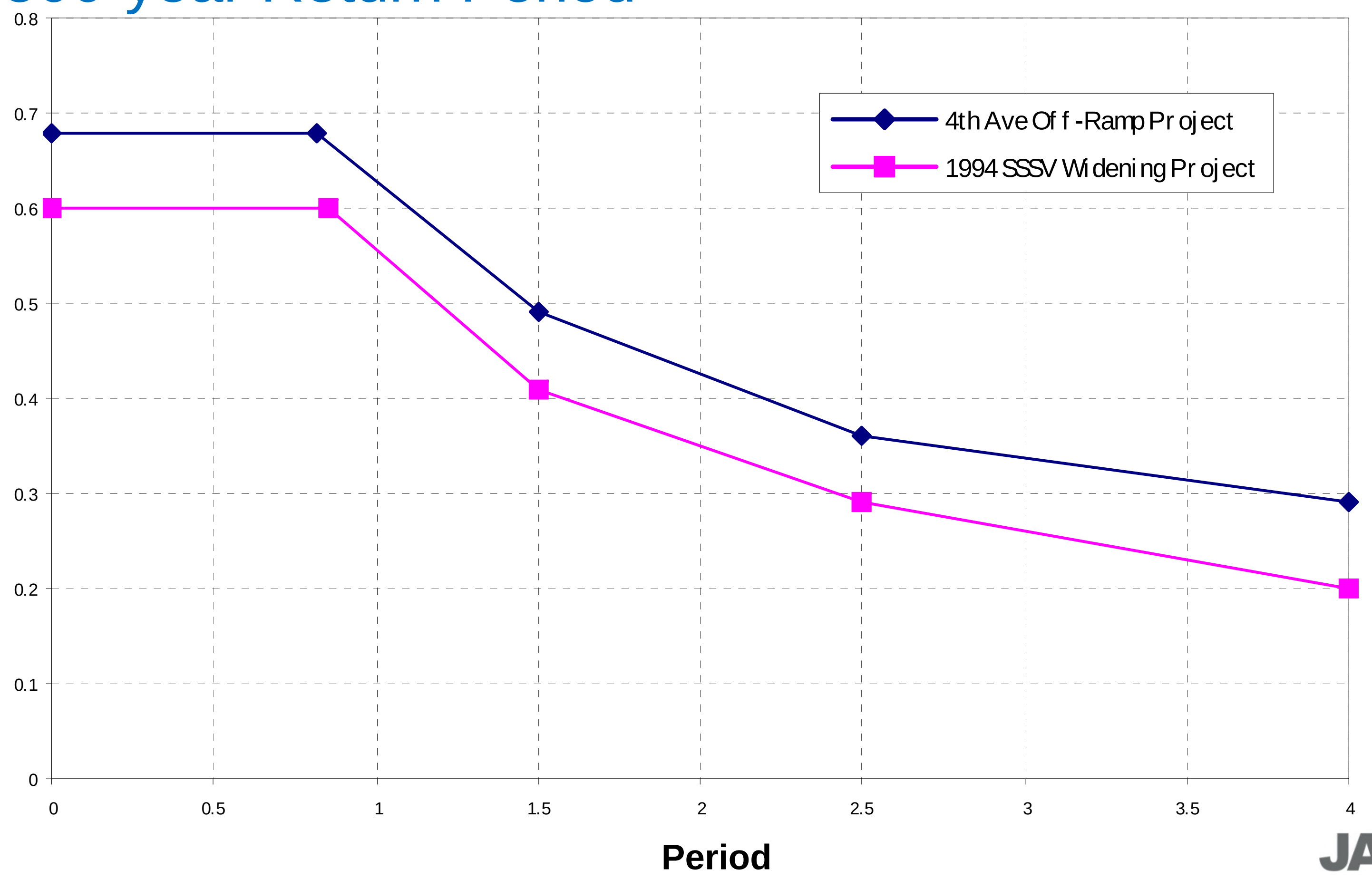
Seismic Analysis / Connectivity

- Seismic Response Spectrum
  - 500-year Return Period



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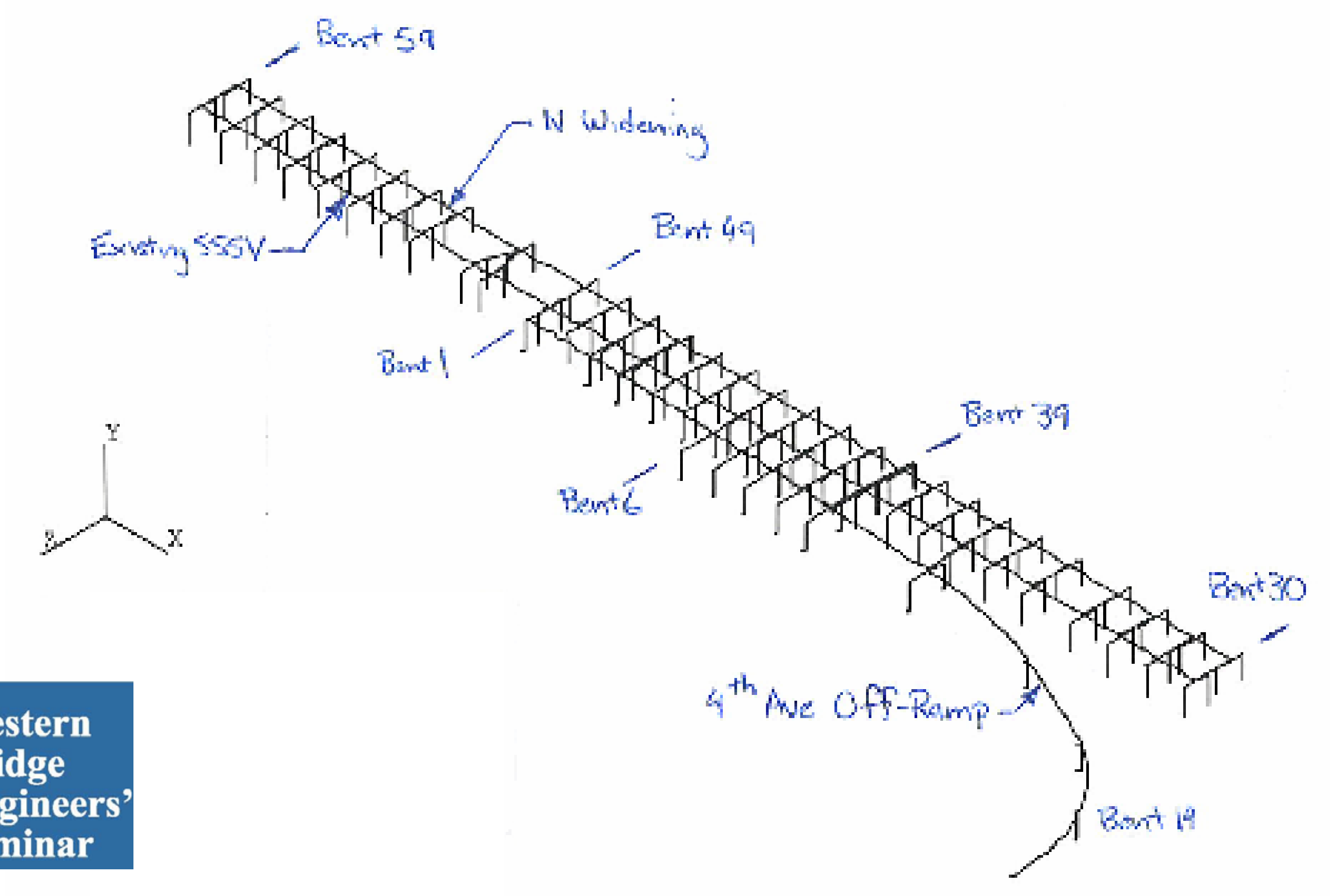
Seismic Analysis / Connectivity

- Seismic Models
  - Model 1 - Existing SSSV
    - Three Frames
    - Properties from As-Built Plans
    - Includes Retrofits Required for Widening
  - Model 2 - Existing SSSV with Widening
  - Model 3 - Existing SSSV with Ramp
  - Model 4 - Widened SSSV with Ramp
  - Model 5 - Ramp Alone

Seismic Analysis / Connectivity

- Model 4 – Widened SSSV with Ramp



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Seismic Analysis / Connectivity

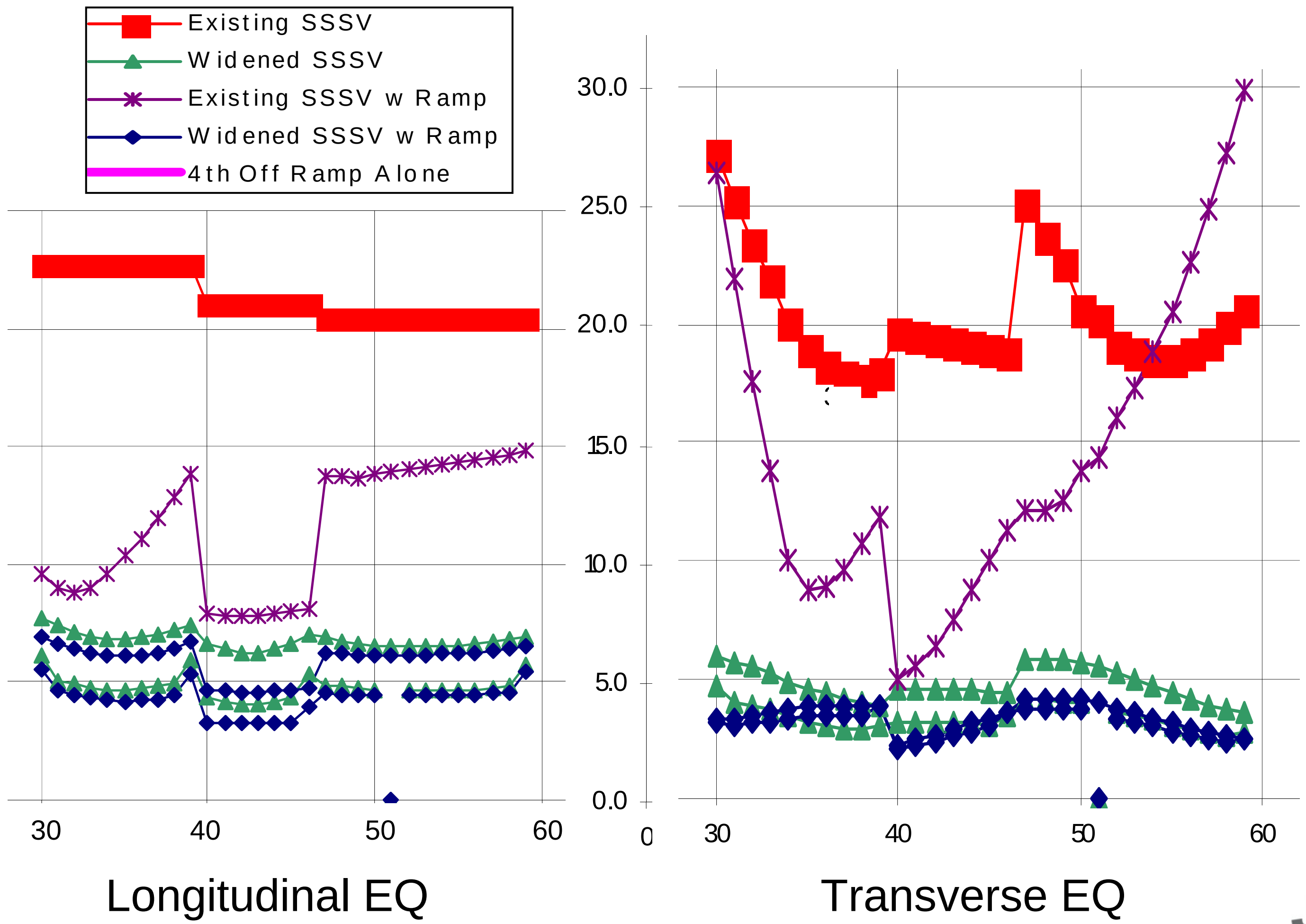
- Analysis Methodology
  - Linear-Elastic Multi-Modal RSA
  - Seismic Design Forces Not Calculated
    - Similar Analysis Procedures
    - Significantly Different Design Codes
  - Column Displacement Demands Used for Comparative Analysis of Relative Displacements
  - Compression Model w/ Stiffened Joints Lock Frames
  - Tension Model with Reduced Joint Stiffness Allows Independent Transverse and Longitudinal Movement Across Joints

Seismic Analysis / Connectivity

- Analysis Parameters
  - Columns: $I_{cr} = 0.5\ I_g$
  - Cap Beams / Girders: $I_{uncracked}$
  - Foundations
    - Ramp/Widening Drilled Shafts: rotational and translational springs @ base of columns
    - Existing Timber Pile Foundations: assumed pinned (Springs would lengthen period and reduce column displacements)
    - Non-liquefied soil properties maximized foundation stiffness

Seismic Analysis / Connectivity

- Tension Model Results



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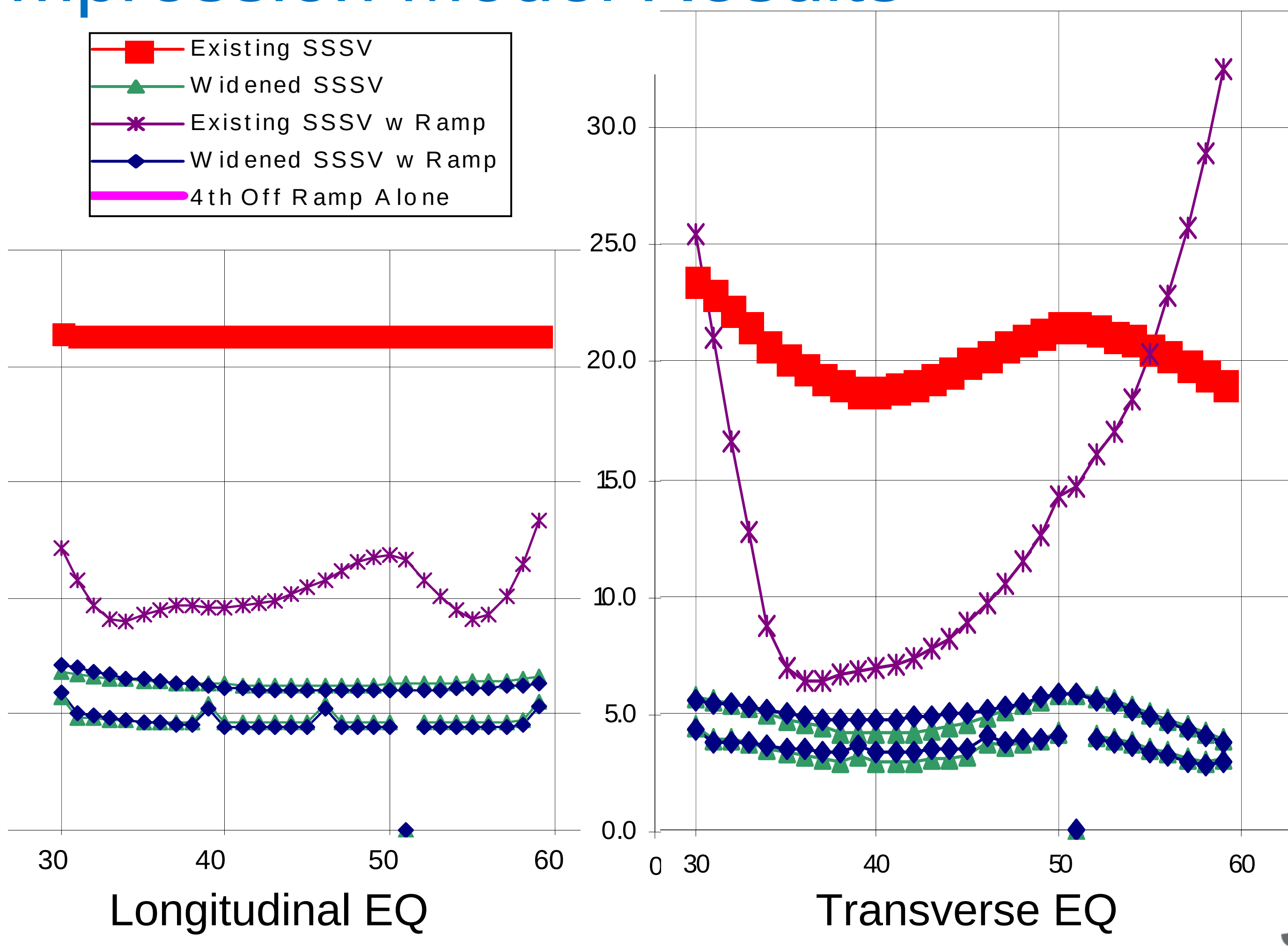
Seismic Analysis / Connectivity

- Compression Model Results



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Seismic Analysis / Connectivity

- Comparative Displacements Summary

Model 1- Existing SSSV	Demands much higher than with Widening (Model 2) installed retrofits do not protect columns
Model 2- Widened SSSV	Displacement demands lower than existing structure (Model 1)
Model 3- Existing w/ Ramp (Pre-Widening)	Significant reduction in demand on most existing columns; increased demand on 4 bents for transverse EQ temporarily until widened
Model 4- Widened SSSV w/ Ramp	Displacement demands not appreciably different than w/ Model 2
Model 5- Ramp Alone	Displacement higher than when connected (Model 4); leads to conservative design forces

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Seismic Analysis / Connectivity

- Conclusion
  - Ramp Structure does not have long-term negative impacts to SSSV structure
  - Design Completed 2008 (with closure pour)
  - Low Bid $17.23M
  - Completion Planned for Fall 2010

Schematics – Lower Roadway

Schematics – North View

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QUESTIONS?