Bridge Seismic Isolation

Some Western Canada Experience

Steve Zhu, Ph.D., P.Eng., P.E.

Buckland & Taylor Ltd.

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a COWI company

Design Standards

- 1991 AASHTO Guide Specifications
- CAN/CSA-S6-06 CHBDC (Similar to 1991 AASHTO Guide Specifications)
- 1999 AASHTO Guide Specifications (Including 2000 Interim Revisions)

Design Earthquakes

- 475 Year Design Earthquake
- 975 Year Design Earthquake
- 2475 Year Design Earthquake

Analysis Methods

- Multi-Mode Response Spectral Analysis - Reduced Effective Stiffness and Increased Equivalent Viscous Damping
- Nonlinear Time History Analysis – Hysteretic Behaviour of Isolation System

Testing

1999 AASHTO Guide Specifications

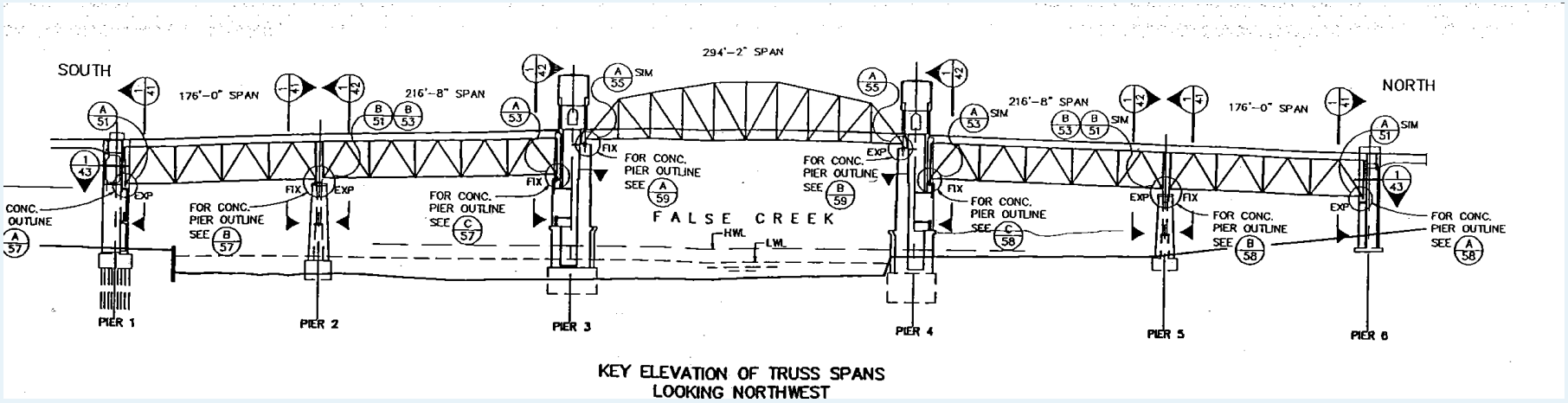
- System Characterization Tests
- Prototype Tests
- Quality Control Tests

Design

- Substructures to Remain Essentially Elastic ($R \leq 1.5$)
- Ductile Detailing for Potential Plastic Hinge Regions
- Adequate Seat Length
- Fuse Expansion Joints under 2475 Year Design Earthquake

Burrard Bridge, Vancouver, BC

Burrard Bridge, Vancouver, BC



KEY ELEVATION OF TRUSS SPANS
LOOKING NORTHWEST

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Burrard Bridge, Vancouver, BC

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Burrard Bridge, Vancouver, BC

Granville Bridge, Vancouver, BC

South Approach to Granville Bridge, Vancouver, BC

South Approach to Granville Bridge, Vancouver, BC

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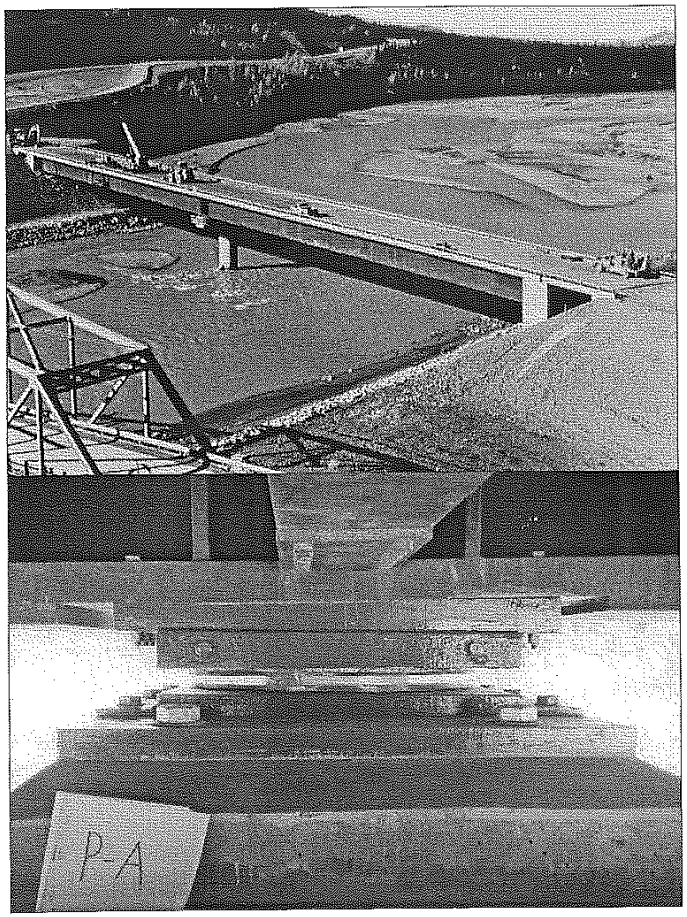
South Approach to Granville Bridge, Vancouver, BC

White Water Bridge, Yukon



Owner: Government of the Yukon, Canada
Engineer: Buckland & Taylor, Vancouver
Contractor: Peter Kiewit & Sons

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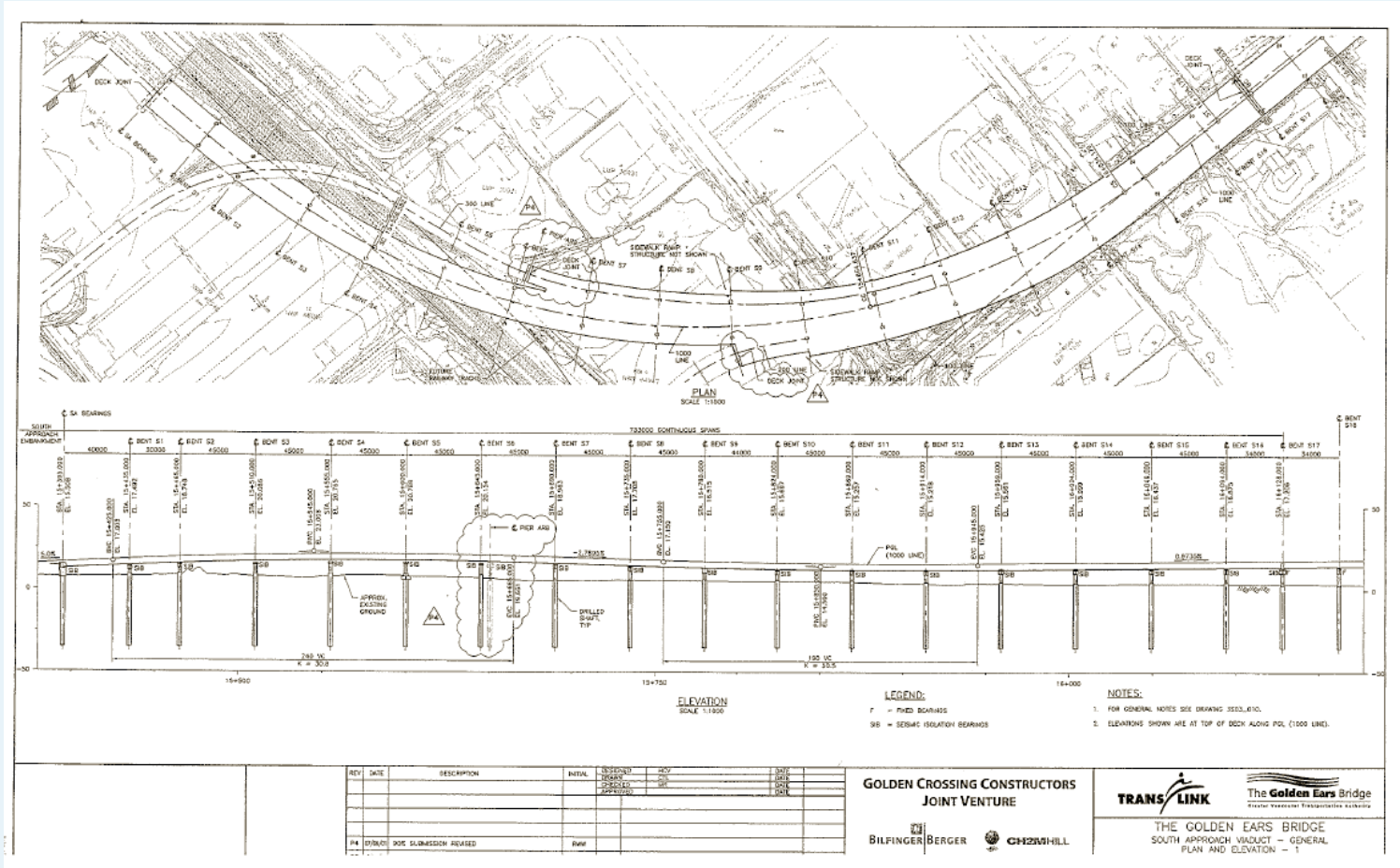
Golden Ears Bridge – Main Spans

Golden Ears Bridge – South Approach

Golden Ears Bridge – South Approach



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Testing of Seismic Isolation Bearings

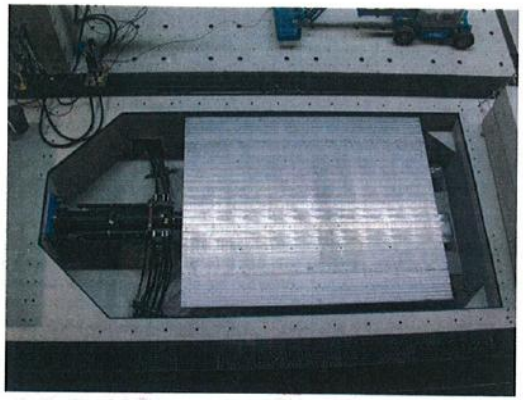

Figure 1. The TREES Lab Shaking Table

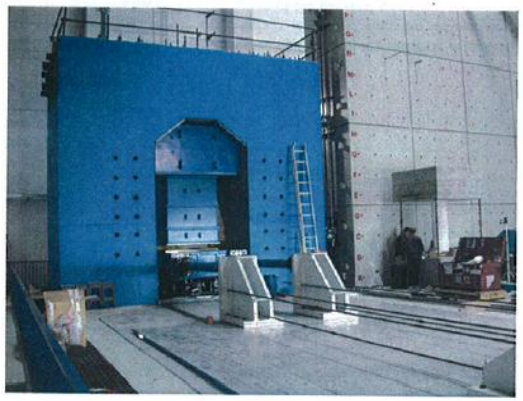

Figure 2. The TREES Lab Bearing Tester

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Testing of Seismic Isolation Bearings

6.2 ALGAPEND APS 9100/1200-5 #2

Figure 11. ALGAPEND APS 9100/1200-5 # 2 prior testing

Figure 12. ALGAPEND APS 9100/1200-5 # 2 prior testing

Figure 13. ALGAPEND APS 9100/1200-5 # 2 testing

Figure 14. ALGAPEND APS 9100/1200-5 # 2 testing

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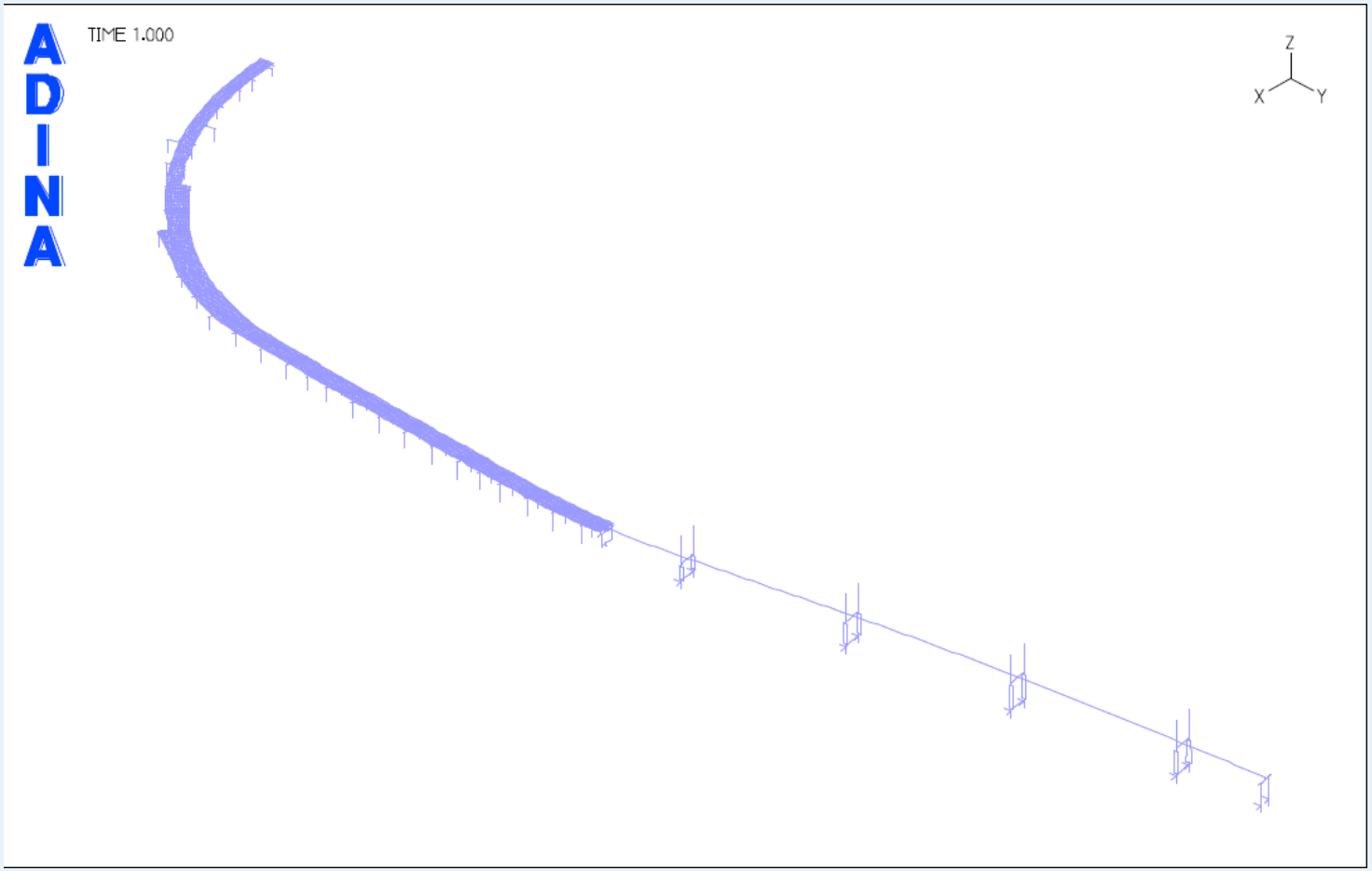
3D Computer Model



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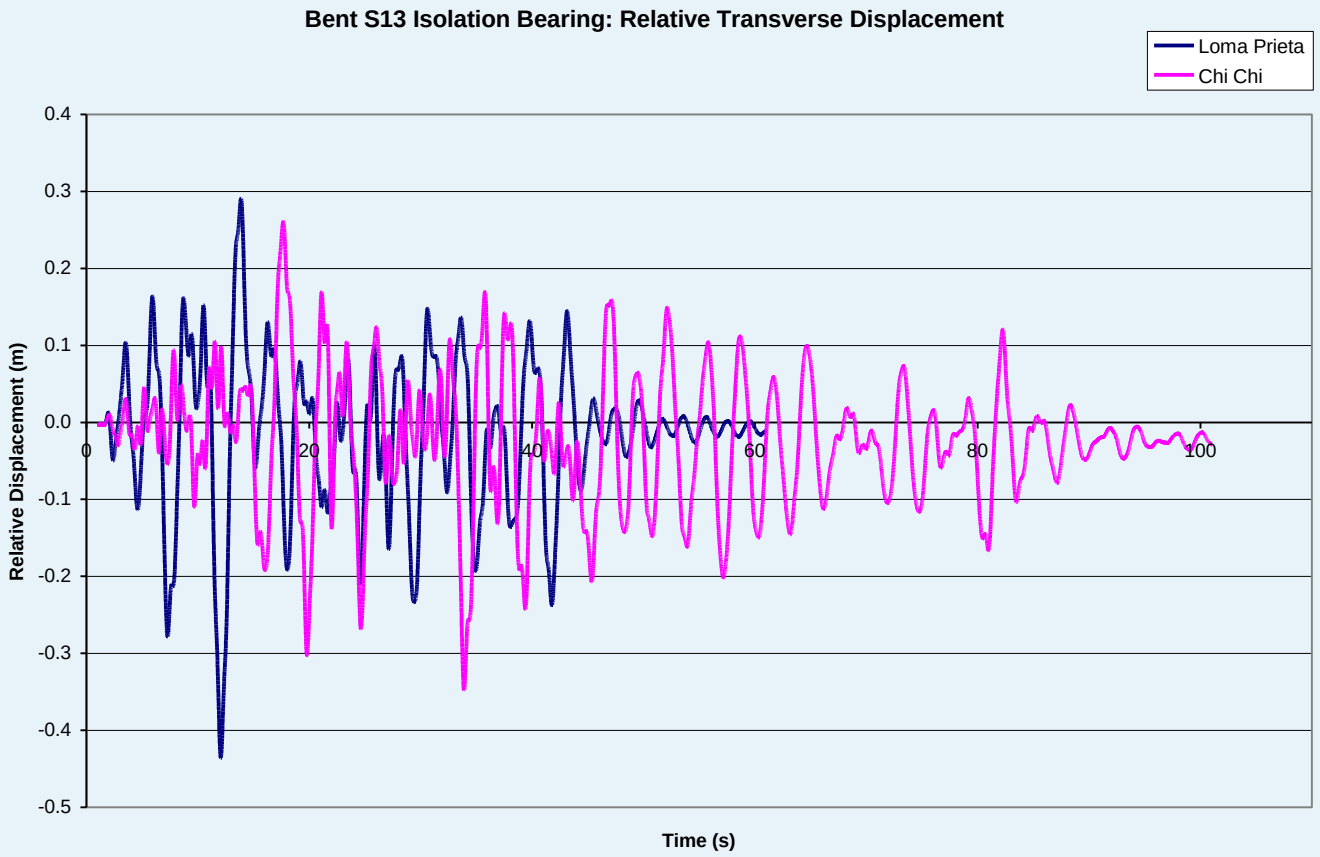
Nonlinear Time History Analysis



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Design Displacement Combinations

- 475 Year Design Earthquake

  C/S + 0.5 T + EQ

- 2475 Year Design Earthquake

  C/S + EQ

Where

C/S = Creep and Shrinkage Effects

T = Thermal Effects

EQ = Seismic Effects

Issues

- How to Combine with Thermal Displacements
- Cold Weather Effects
- Appropriate Levels of Lateral Restoring Force
- Vertical Load Stability
- Reliability over Time
- Maintenance
- How to Address Various Effects Systematically to Provide Levels of Protection Appropriate for Structure Importance and Design Earthquake Considered.