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SEISMIC RETROFIT OF AN HISTORIC STEEL ARCH BRIDGE – LESSONS LEARNED

North Queen Anne Drive Bridge - Seattle, WA

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Sacramento, CA
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OUTLINE

- **Background**
  - Bridge Data
  - Pre-Retrofit Conditions
  - Overview of Retrofits
- **Construction Issues**
  - Site Access
  - Environmental
  - Temporary Shoring
  - Cross Bracing
  - Pier Strengthening

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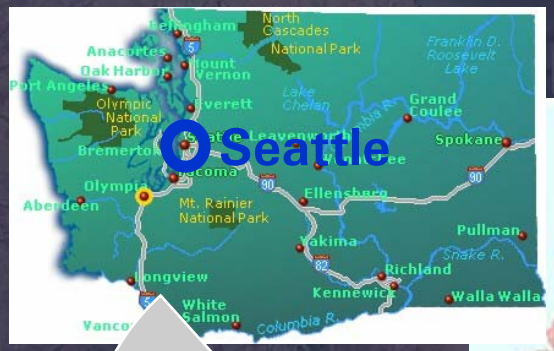
VICINITY MAP



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BRIDGE DATA

North Queen Anne Drive Bridge

- 1935 (Historic)
- 327-feet Long
- 7-Spans
- Counterforts
- Pile Supported Concrete Piers

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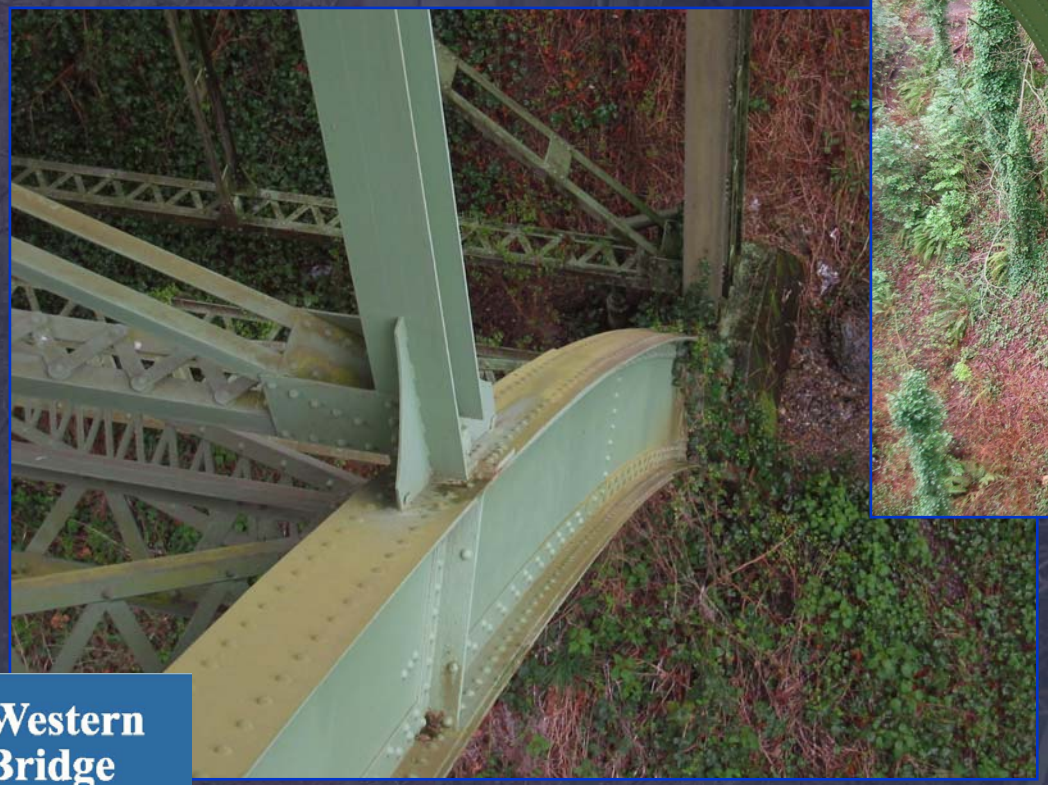
PRE-RETROFIT CONDITIONS

Main Span



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PRE-RETROFIT CONDITIONS

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Main Span Arch

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PRE-RETROFIT CONDITIONS

West Approach

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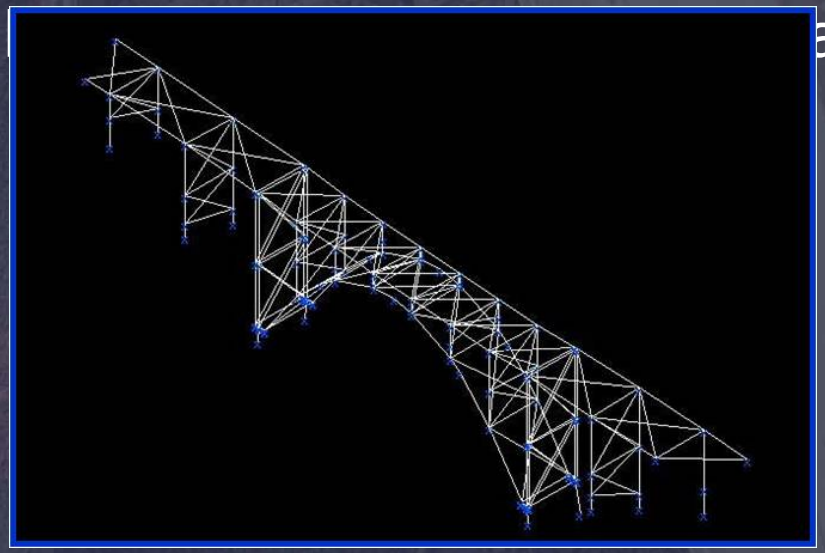
DESIGN OVERVIEW

- **Seismic Parameters**
  - a = 0.30 g
  - Design Earthquake Event = 10% PE in 50 years
  - "No Collapse" Criteria
  - GTStrudl [redacted]al Spectral Analysis



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DESIGN OVERVIEW

- **GEOTECHNICAL**
  - Empirical Liquefaction Evaluation – not susceptible
  - Slope stability
    - No evidence of deep-seated slope instabilities
    - Slope creep evident
    - Shallow slope movement potential

RETROFIT OVERVIEW

- **EXISTING ELEMENT STATUS**
  - Arches (OK)
  - Columns (OK)
  - Lateral Bracing (NG)
  - Abutment Stability (OK)
  - Stability of Arch and Approach Piers (NG)
  - Superstructure-Abutment Connection (NG)
  - Arch-Deck Connections (NG)

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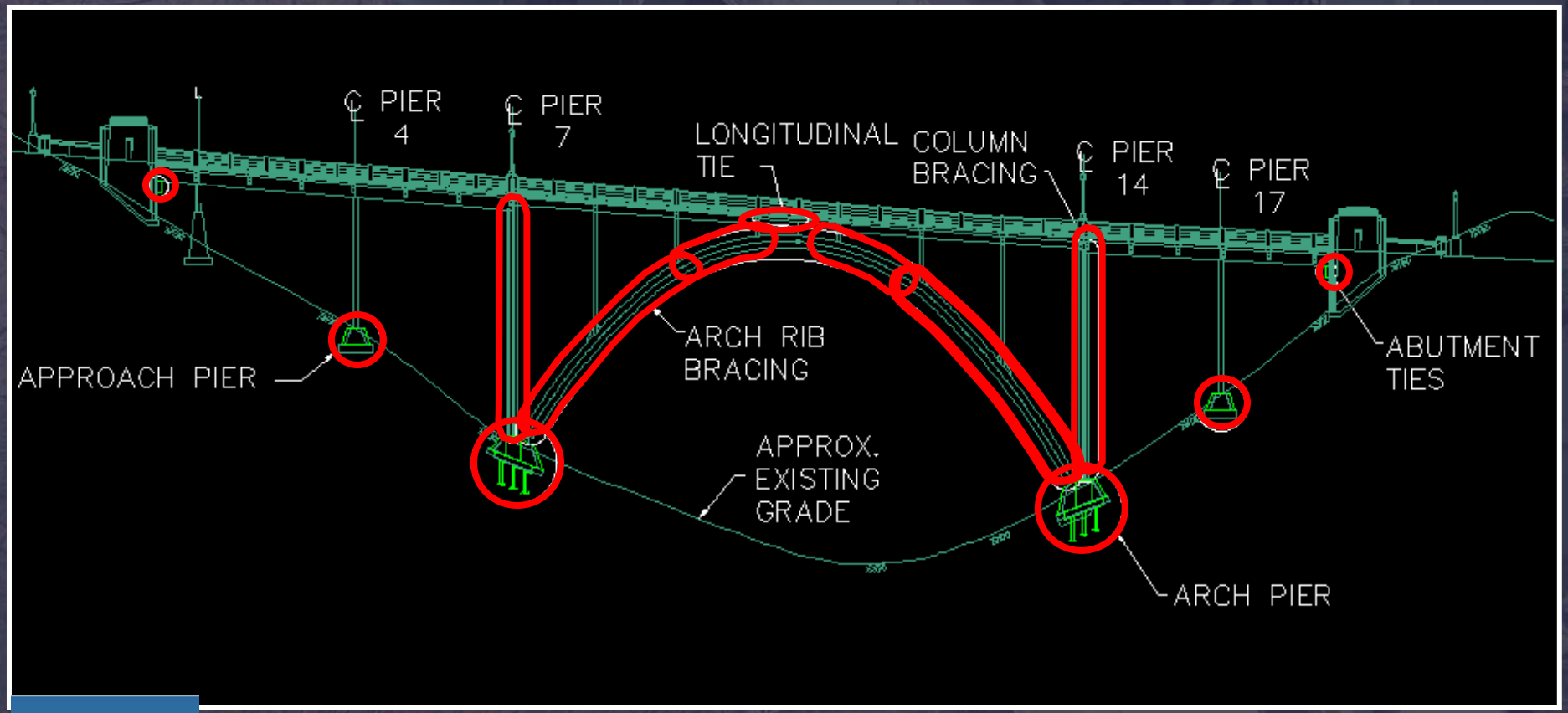
RETROFIT OVERVIEW



Recommended Retrofits

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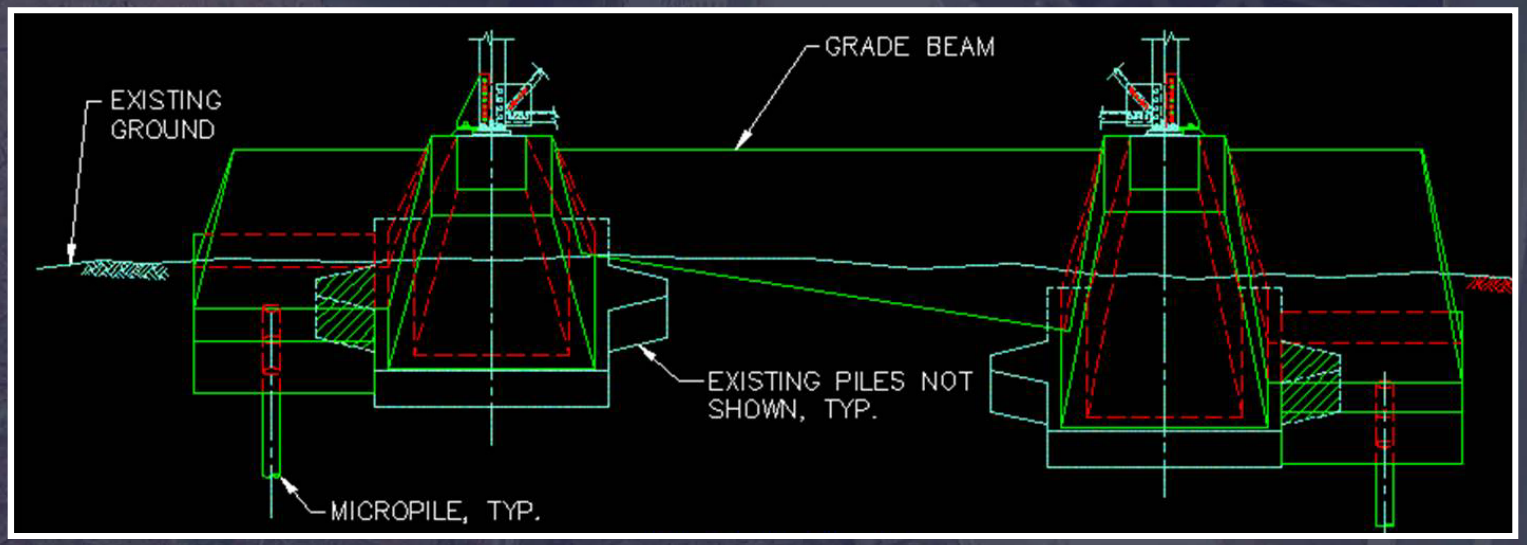
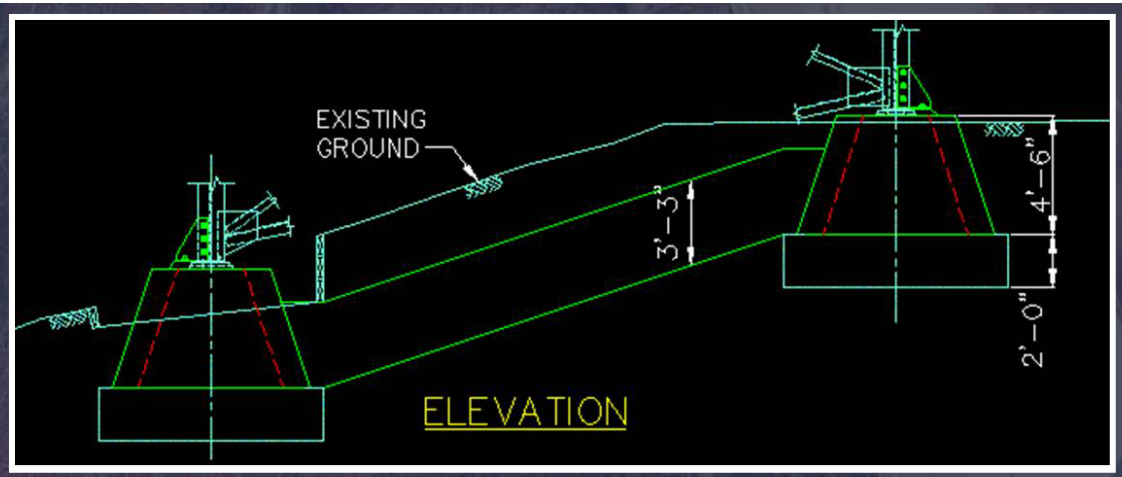
RETROFIT OVERVIEW





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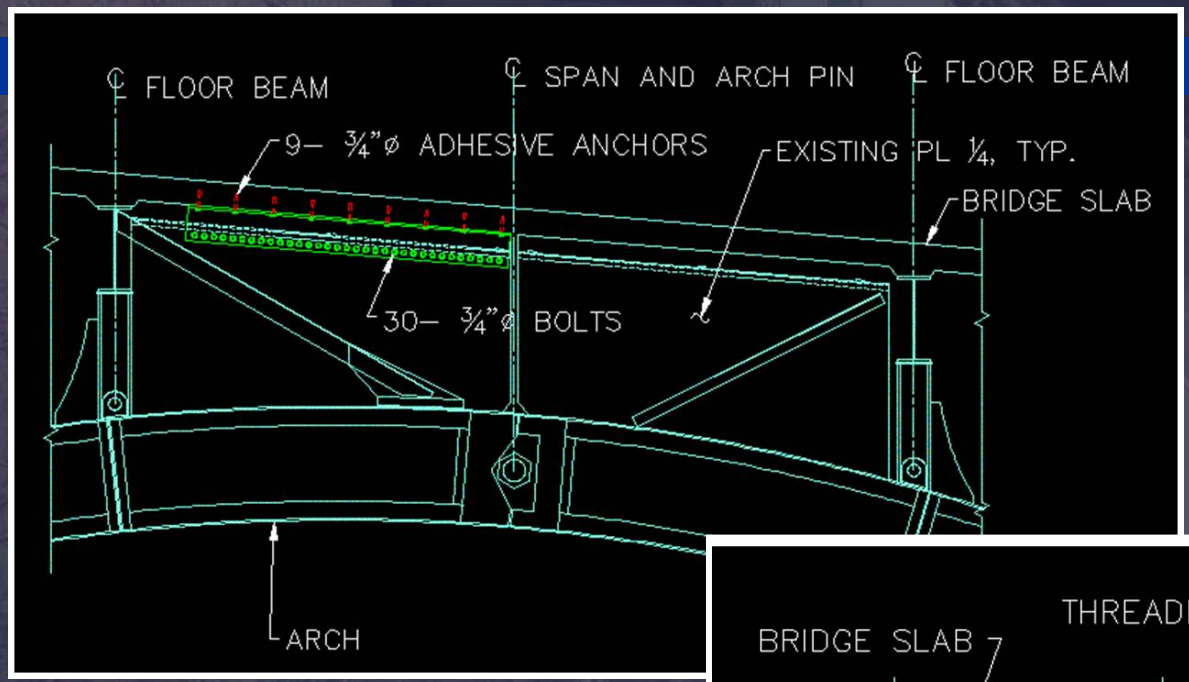
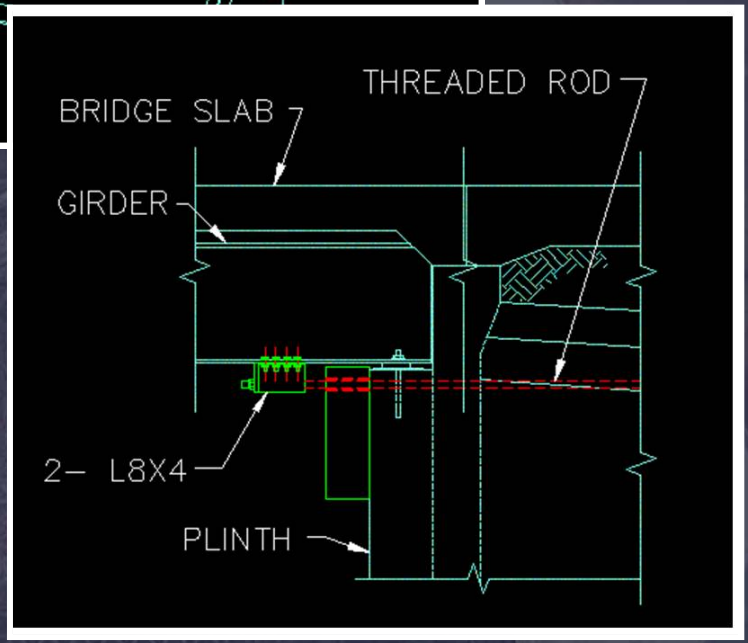
RETROFIT OVERVIEW





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SPECIAL PROVISIONS

- Field Measurements
- Monitoring of Existing Conditions
- Temporary Bracing Sequence
  - No members or rivets replaced during extreme or unusual loading conditions (sustained wind 25mph or gusts over 40 mph)
  - Rivet replacement, 25% limit
  - Member removal/replacement within one day
  - One end at a time – replacement sequencing

CONSTRUCTION ISSUES

1. Site Access
2. Environmental
3. Temporary Shoring
4. Cross Bracing
5. Pier Strengthening

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1. SITE ACCESS

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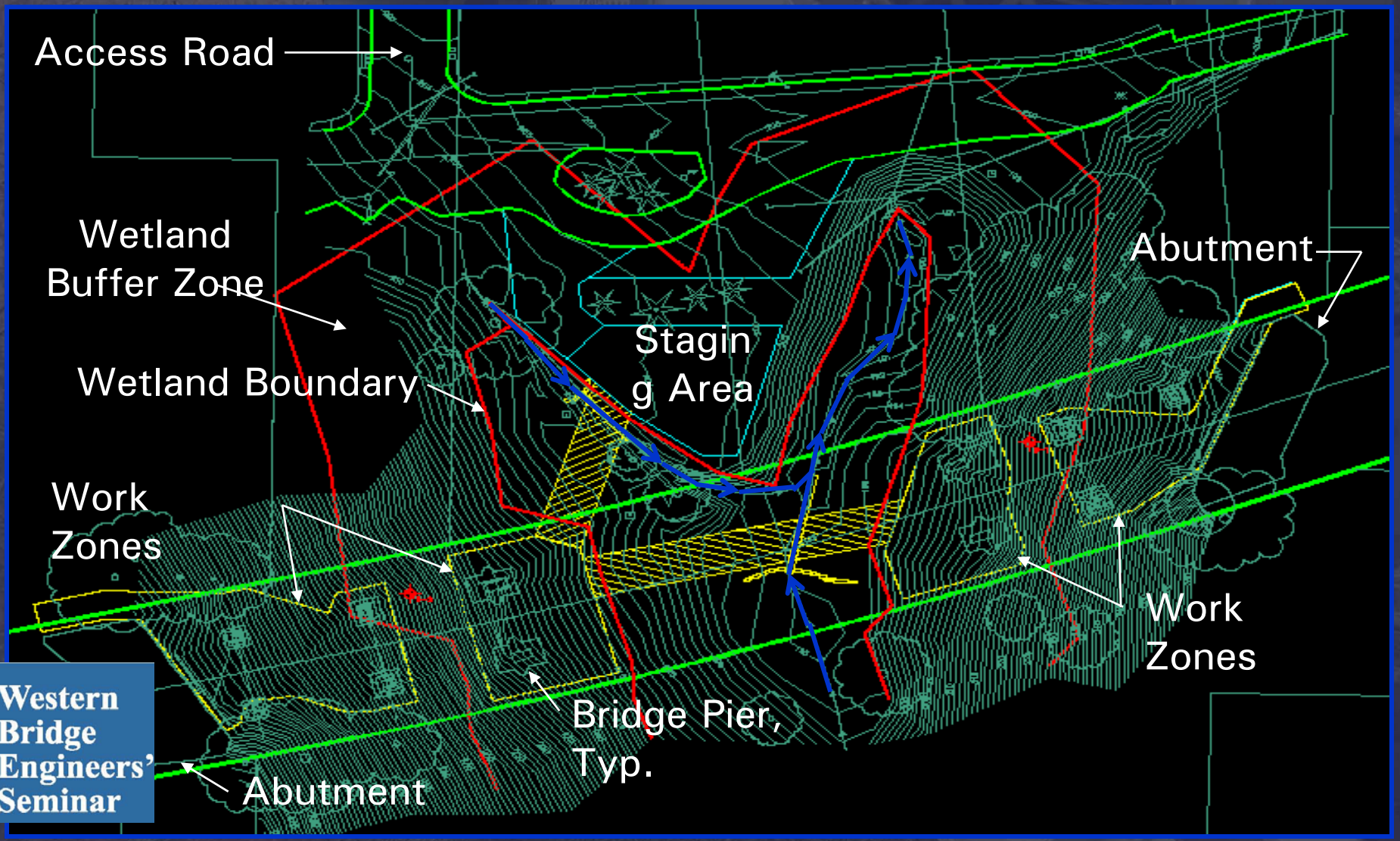
1. SITE ACCESS



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1. SITE ACCESS

Work Zones

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1. SITE ACCESS

- **Lessons Learned**
  - Engineer should walk through construction activities prior to setting access/work zones
  - Be proactive by potentially require Contractor to attend a site visit prior to bid
  - Ensure Engineers Estimate includes escalation for difficult site access conditions
  - Keep Work Zones practical with clearly defined limits
  - Provide penalties for non-adherence

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2. ENVIRONMENTAL

The Plan…

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2. ENVIRONMENTAL

Wetlands

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2. ENVIRONMENTAL

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2. ENVIRONMENTAL

Lead-Based Paint

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2. ENVIRONMENTAL

Lessons Learned

- Wetlands
  - Be vigilant in monitoring
  - Provide penalties for non-adherence
- Extent of paint removal
  - Point out if retrofits are larger than existing members
- Lead-Based Paint
  - Test soil if any possibility of lead paint
  - Add remediation to schedule

3. TEMPORARY SHORING

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3. TEMPORARY SHORING

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3. TEMPORARY SHORING

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3. TEMPORARY SHORING

- **Lessons Learned**

  - Require contractor to provide installation tolerances in submittal of contractor-designed system
  - SAFETY is everyone's responsibility

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4. CROSS BRACING

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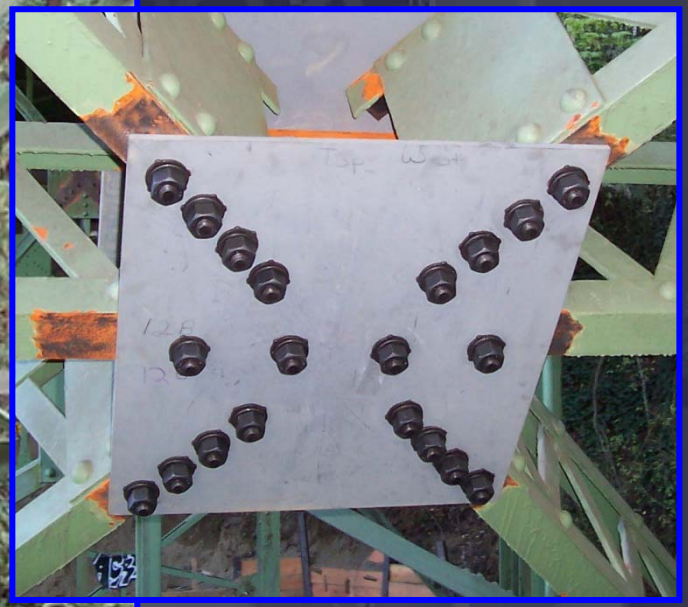
4. CROSS BRACING

Prior to Additional Paint Removal



Friction Connection

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4. CROSS BRACING

- Inadequate Bolt Edge Distances & Spacing
- Bolt Supplier Issues

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4. CROSS BRACING

- **Lessons Learned**

  - Be specific about what will be rejected
  - Specify requirements for labeling plates
  - Be clear about limits of existing paint removal

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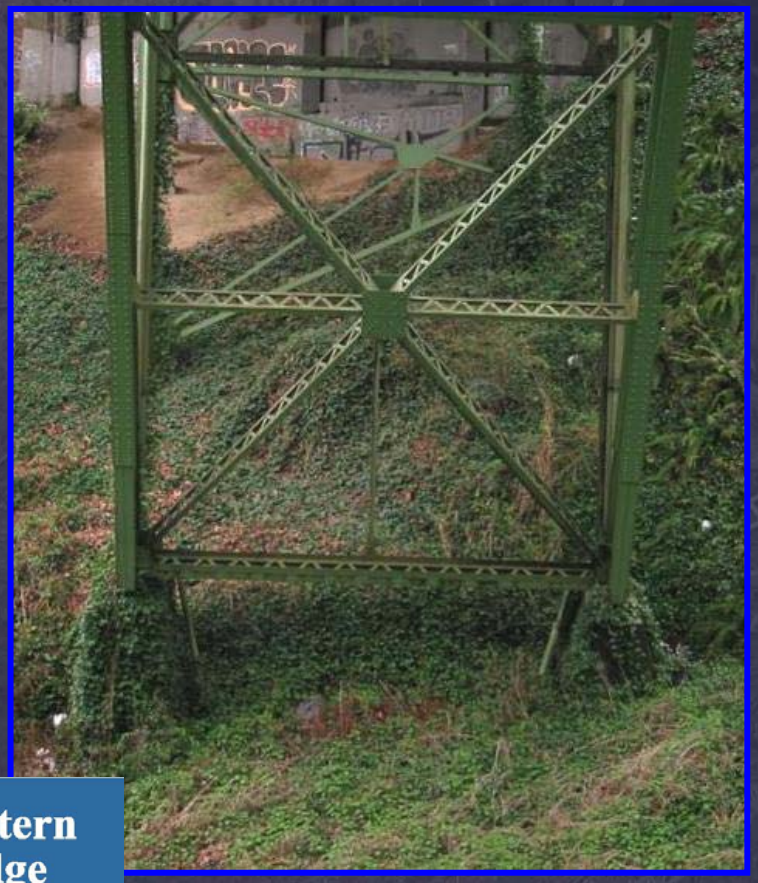
5. PIER STRENGTHENING

Before:



After:

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5. PIER STRENGTHENING

- Pier Encasement- Shotcrete

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5. PIER STRENGTHENING

- Core Drilling Drift

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5. PIER STRENGTHENING

- Column Tie-Down Shims & Broken Drill Bit

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5. PIER STRENGTHENING

- Steep slopes for approach
  pier grade beams and
  micr

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5. PIER STRENGTHENING

- Approach piers – as-built pier height incorrect

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5. PIER STRENGTHENING

Lessons Learned

- Shotcrete was great alternative
- Consider potential drift issues with core drilling
- Do not assume existing as-builts are correct
- Consider effects of sloped ground
- Ensure clarity in contract dwg dimensions


QUESTIONS?
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