Western Bridge Engineers' Seminar 2023

# Design and Construction of SR520 West Approach Bridge South


Presented by:

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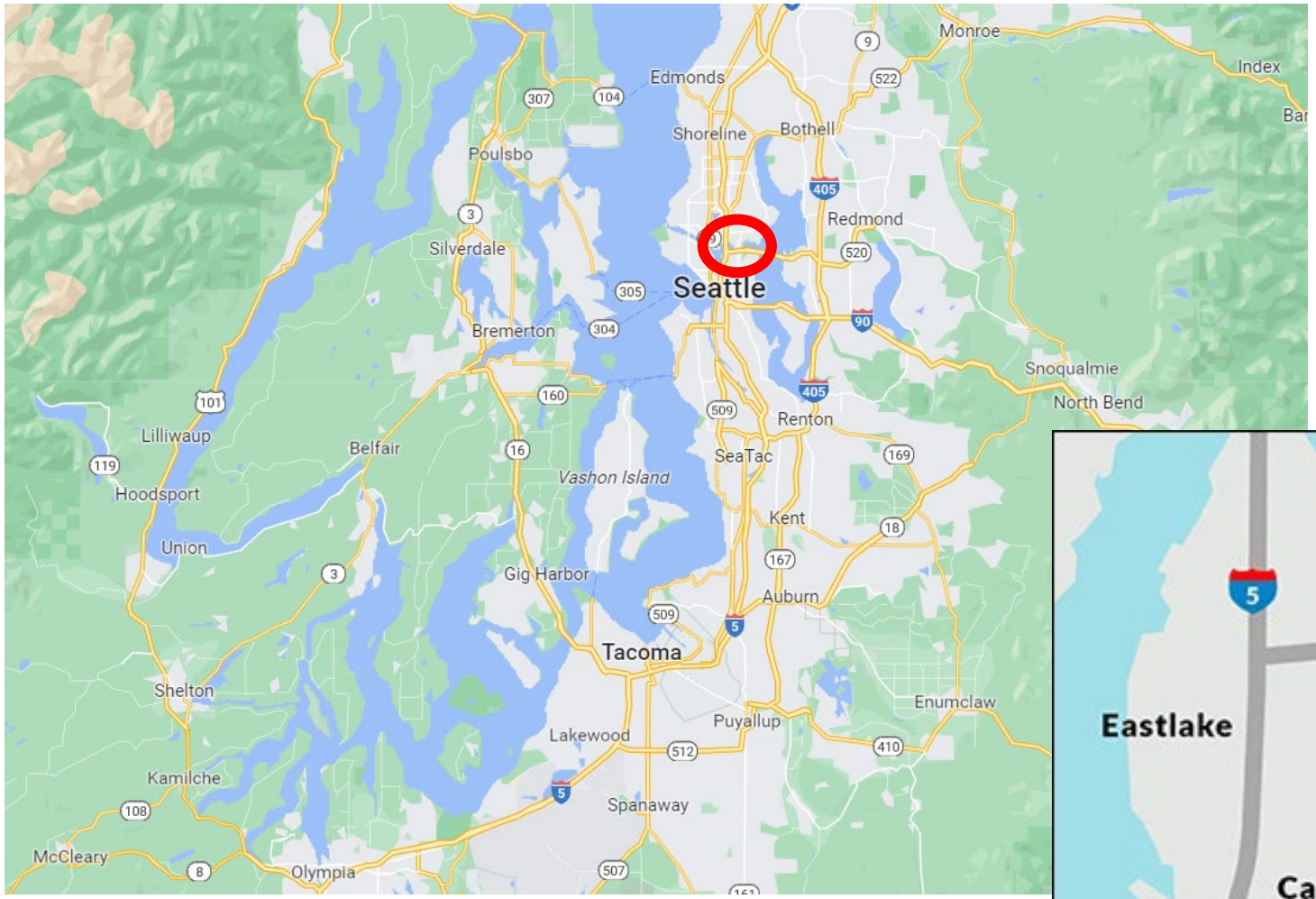
TYLin

American Bridge

WSDOT

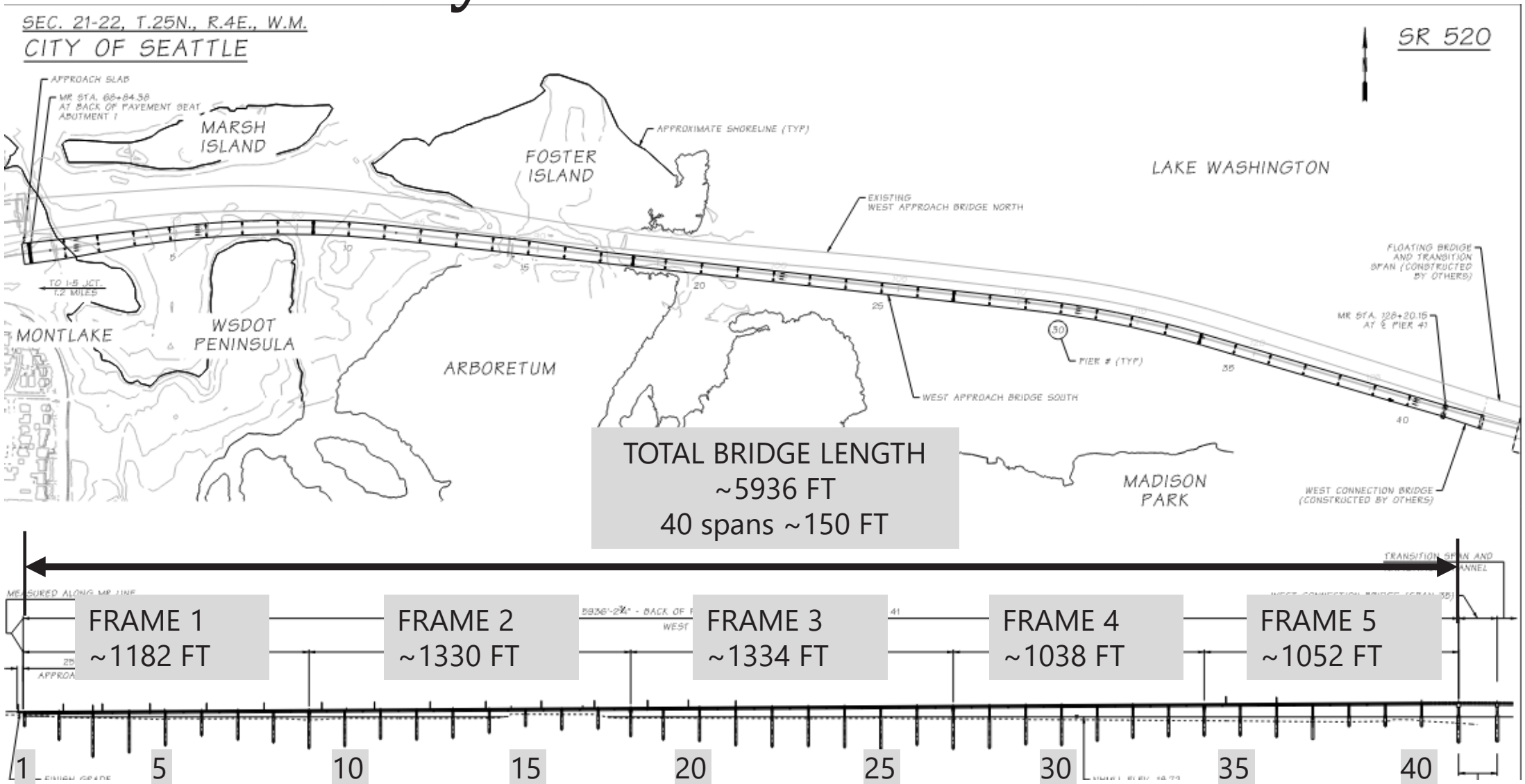
# Project Location Map



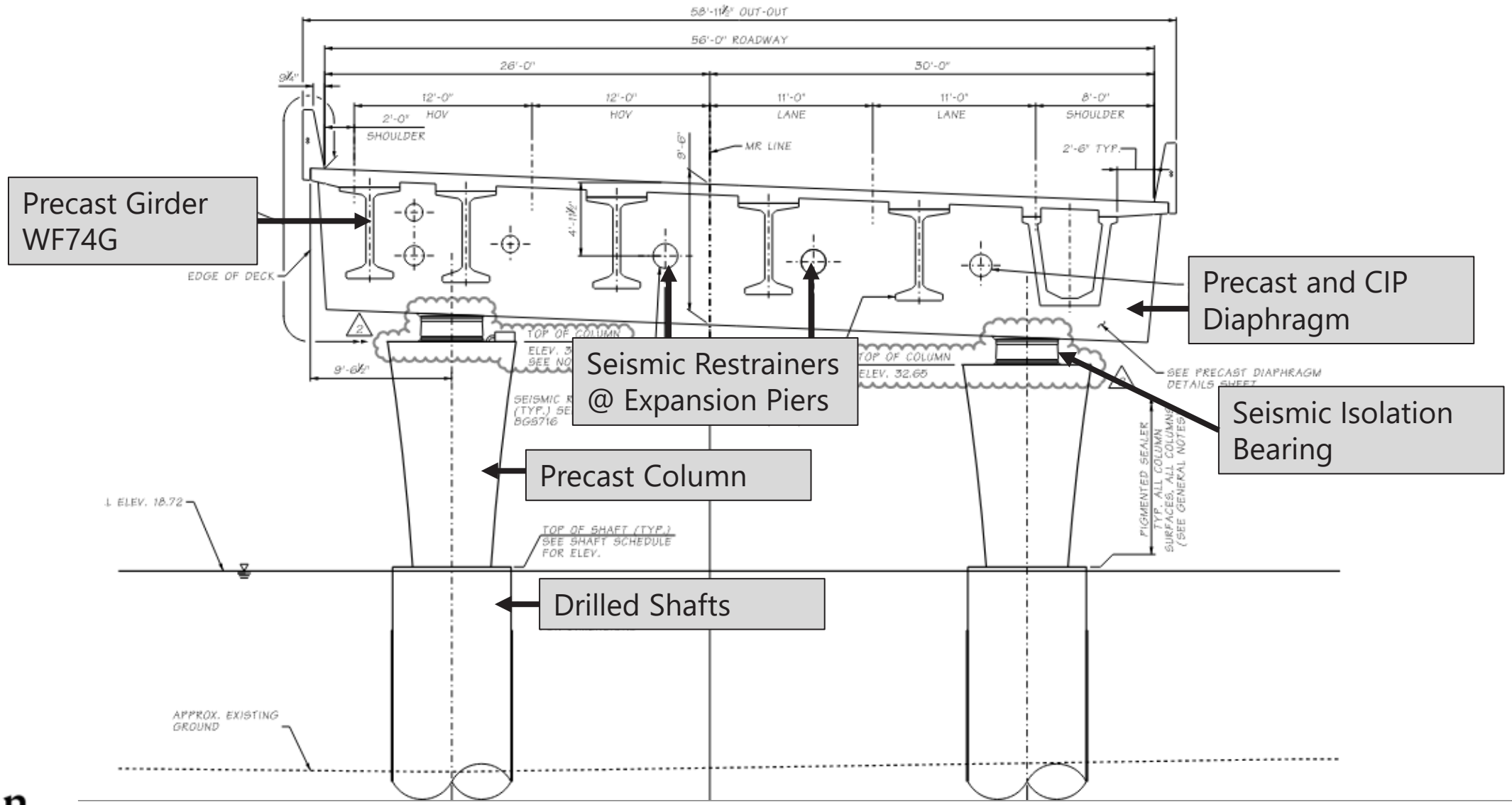

# Agenda

- DESIGN CHALLENGES
- SEISMIC DESIGN
- FUTURE COMPATIBILITY
- CONSTRUCTION STAGING
- CONSTRUCTION CHALLENGES

# Structure Layout

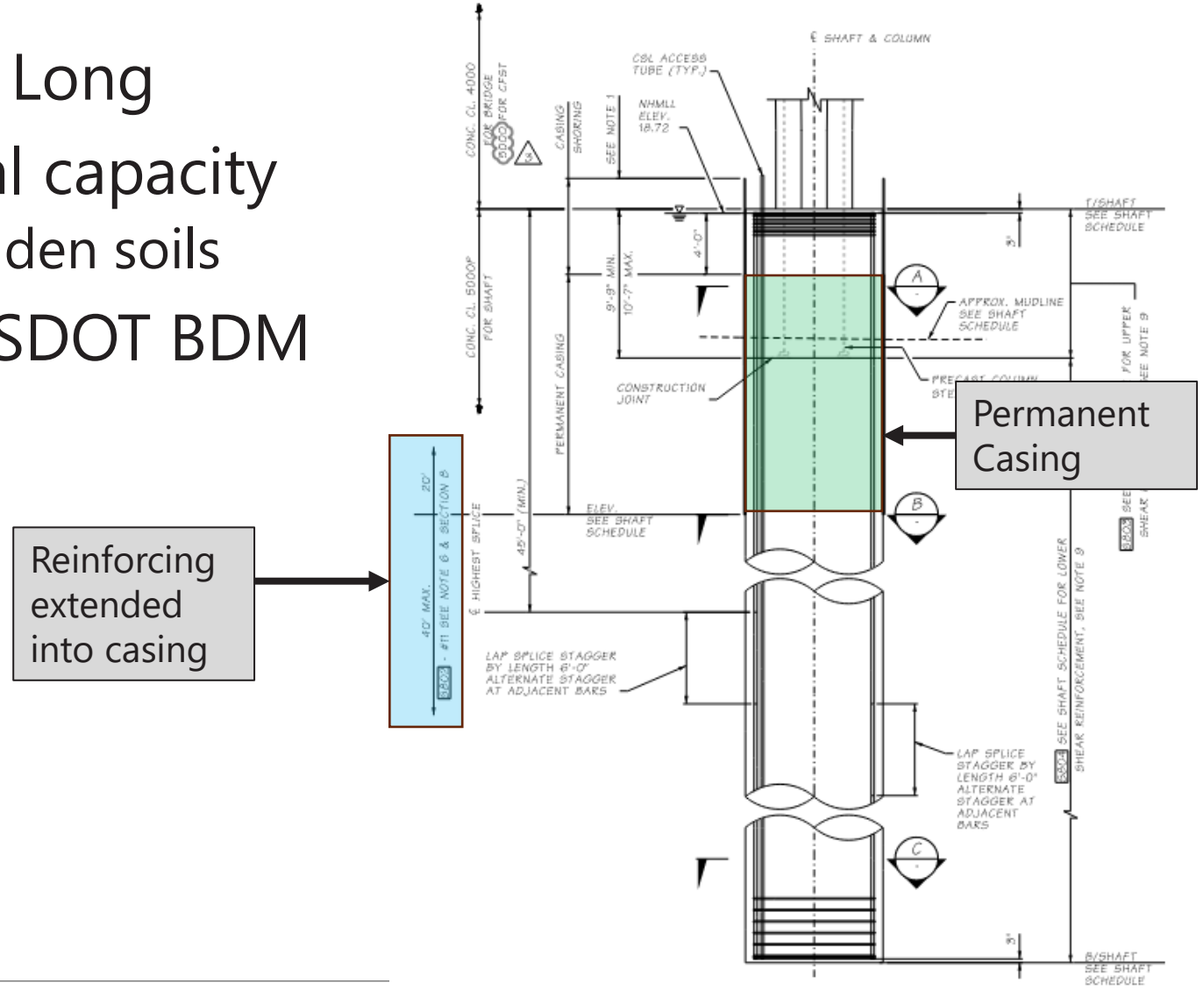


# Typical Cross-Section

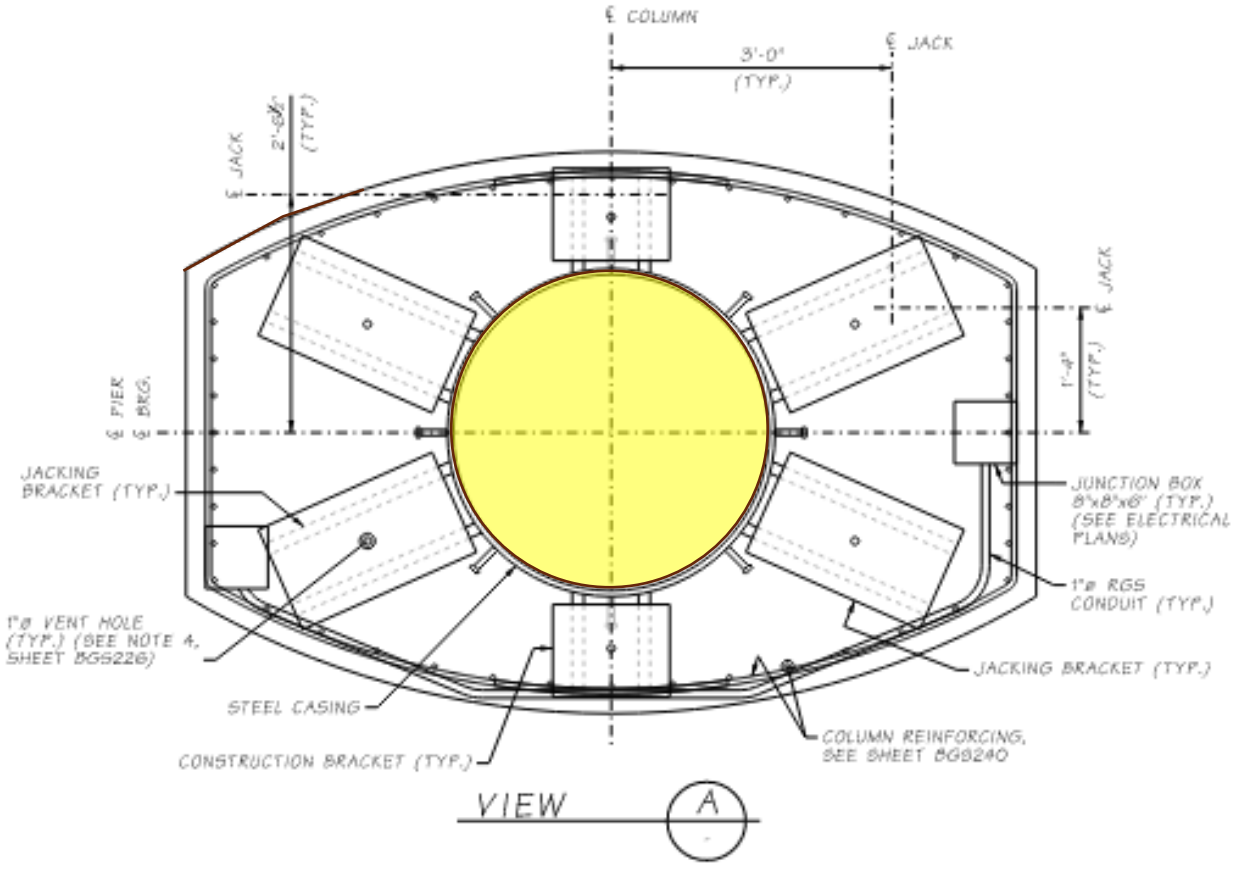


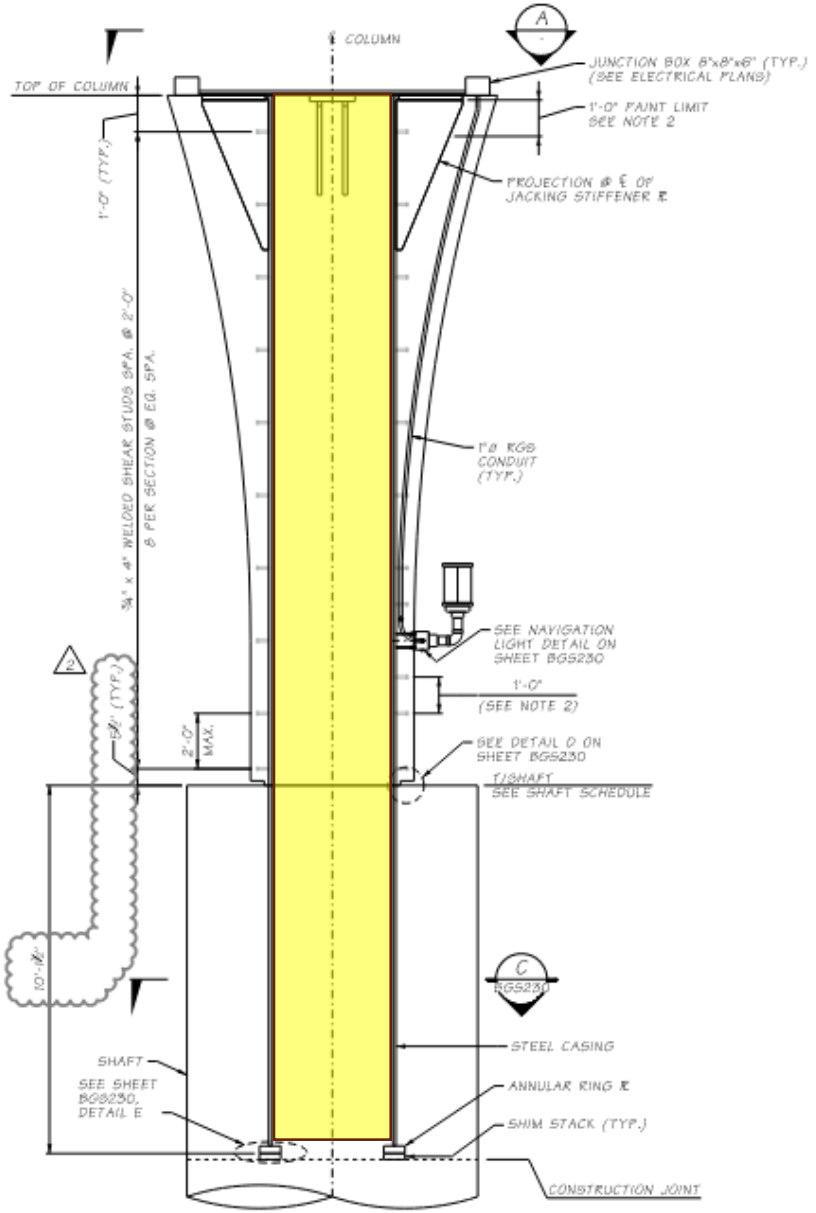
# Design Challenges – Drilled Shafts

- Shaft Lengths up to 144’ Long
- Casing used for structural capacity
  - Driven to glacially overridden soils
- Designed as CFST per WSDOT BDM



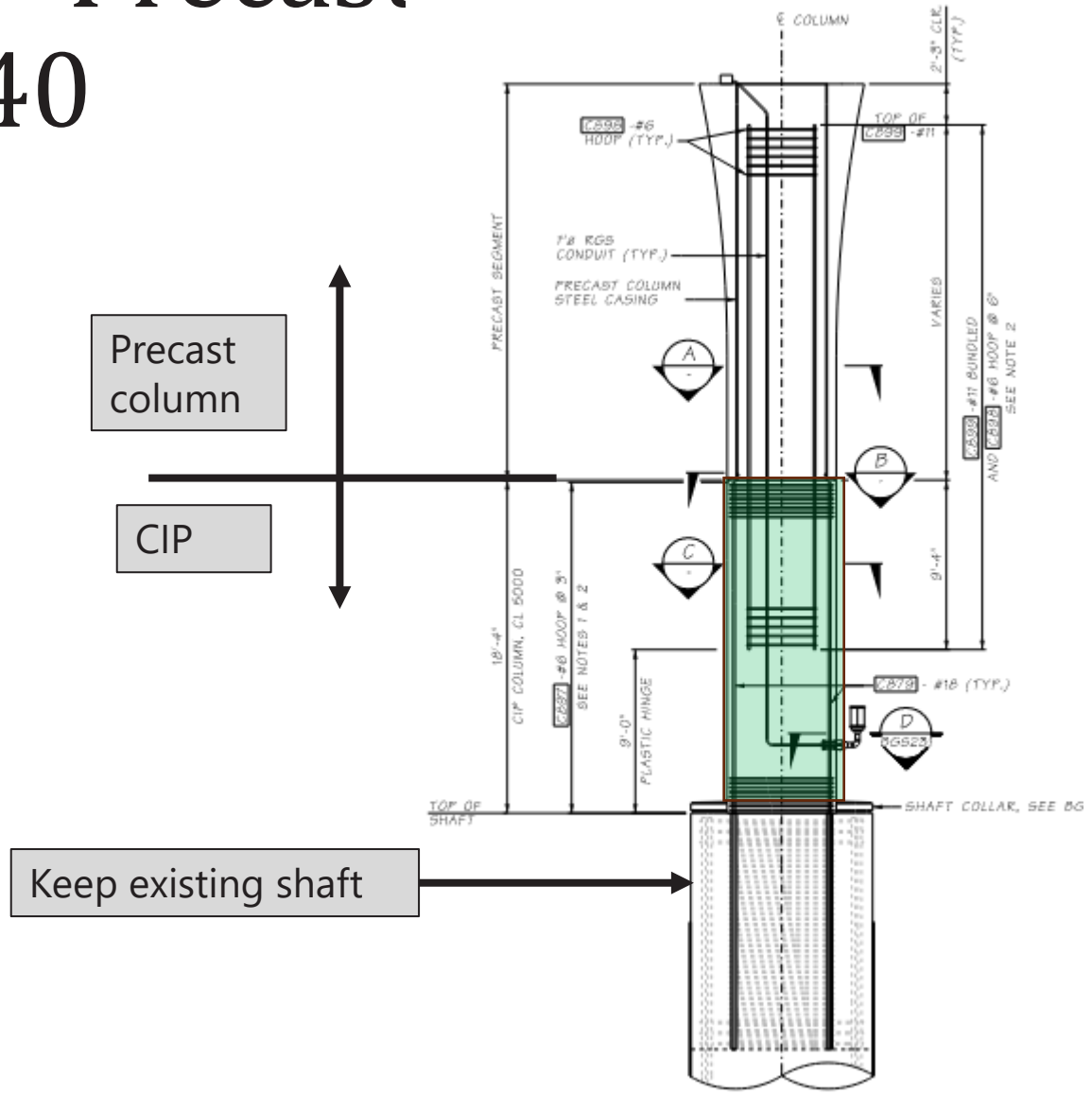
# Design Challenges – Precast Columns



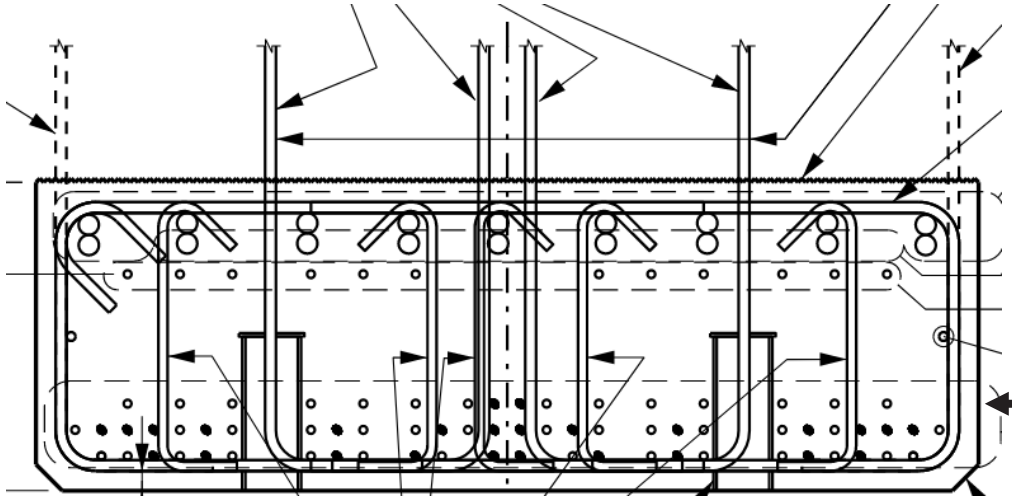

PRECAST COLUMN SECTION
CONTINUOUS COLUMN

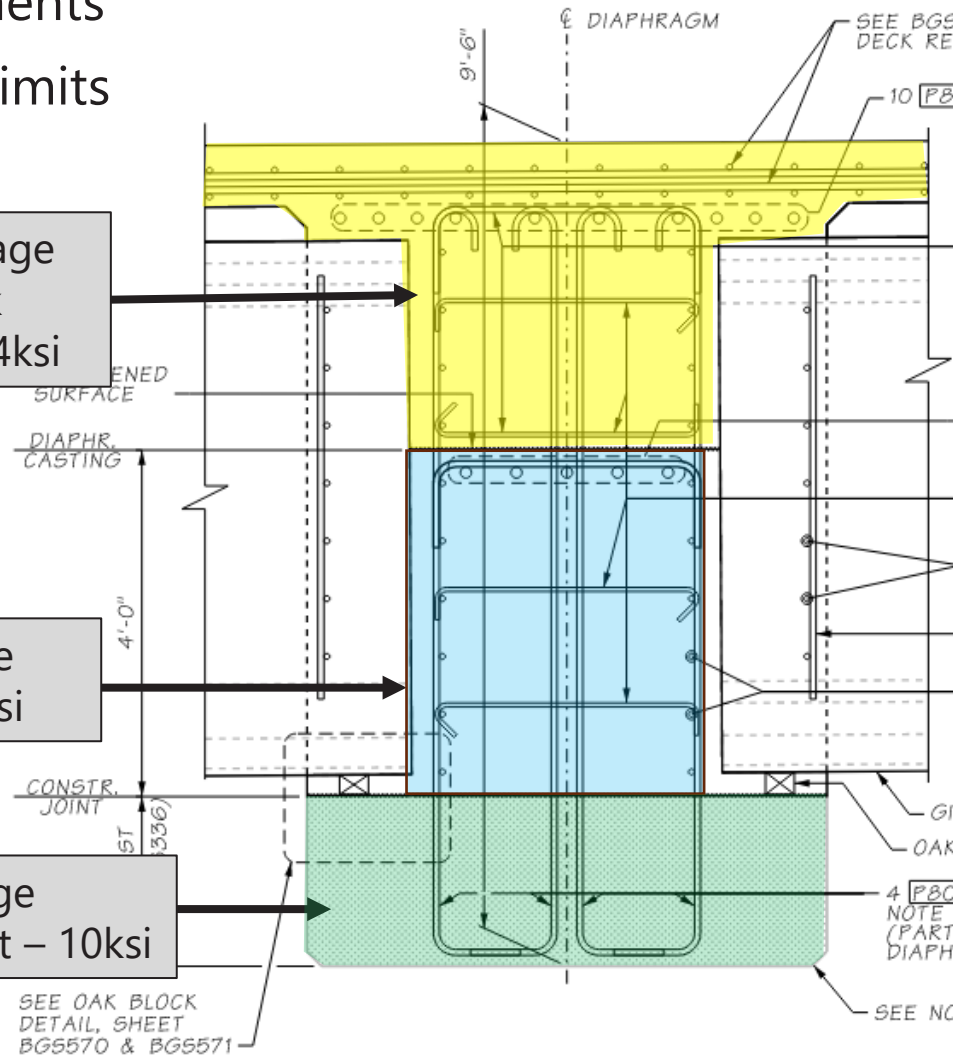
# Design Challenges – Precast Columns Piers 37-40



# Design Challenges – Precast Diaphragms

- Diaphragms limited in depth by contract requirements
- Mix of prestressing and reinforcing used to meet limits
- Checked crack width and strength in all stages
- Piers 4 and 5 has two pours for 2nd stage





# Design Challenges – Precast Diaphragms Deflections

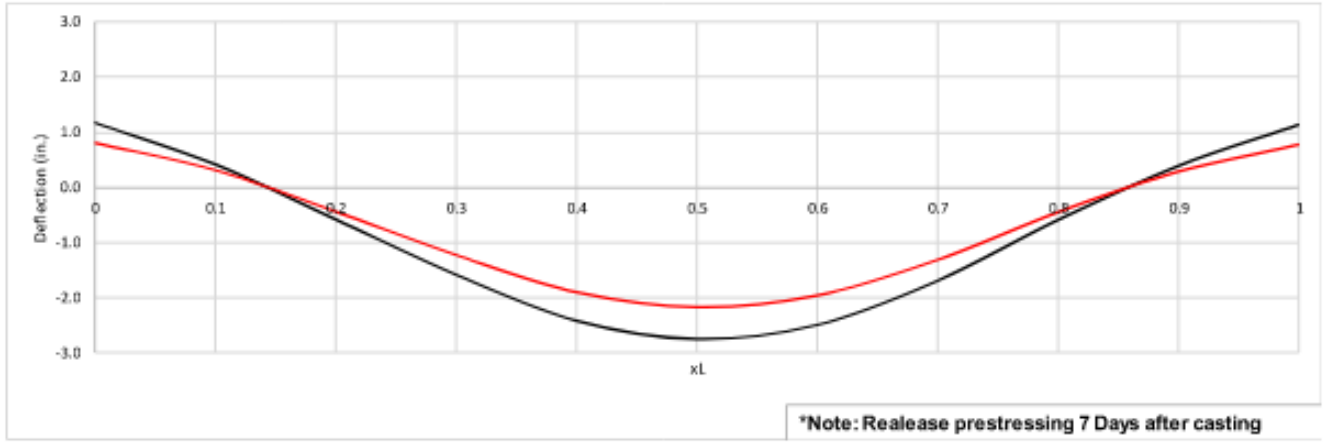



*Figure 6.58 Total deflection of Pier cap 4.*

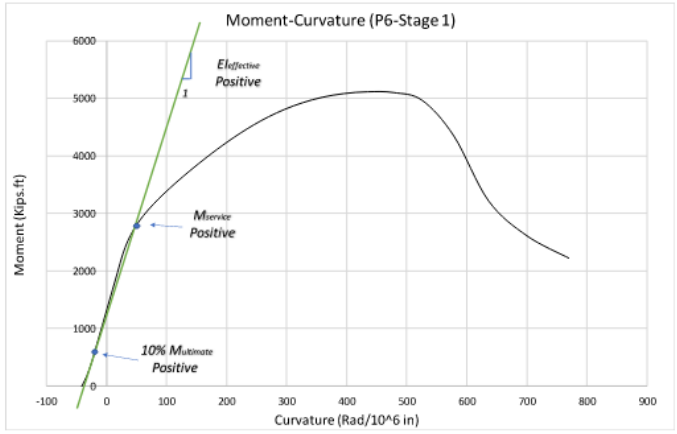



*Figure 6.59 EI effective calculation concept (Pier 6)-Stage 1- Positive Section.*

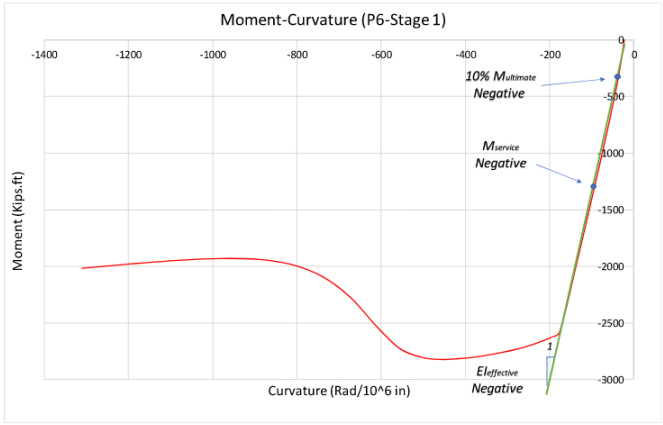



*Figure 6.60 EI effective calculation concept (Pier 6)-Stage 1- Negative Section.*

- Oak block elevations supporting precast girders adjusted to account for prestressing and dead load deflections.

# Seismic Design – Time History Analysis

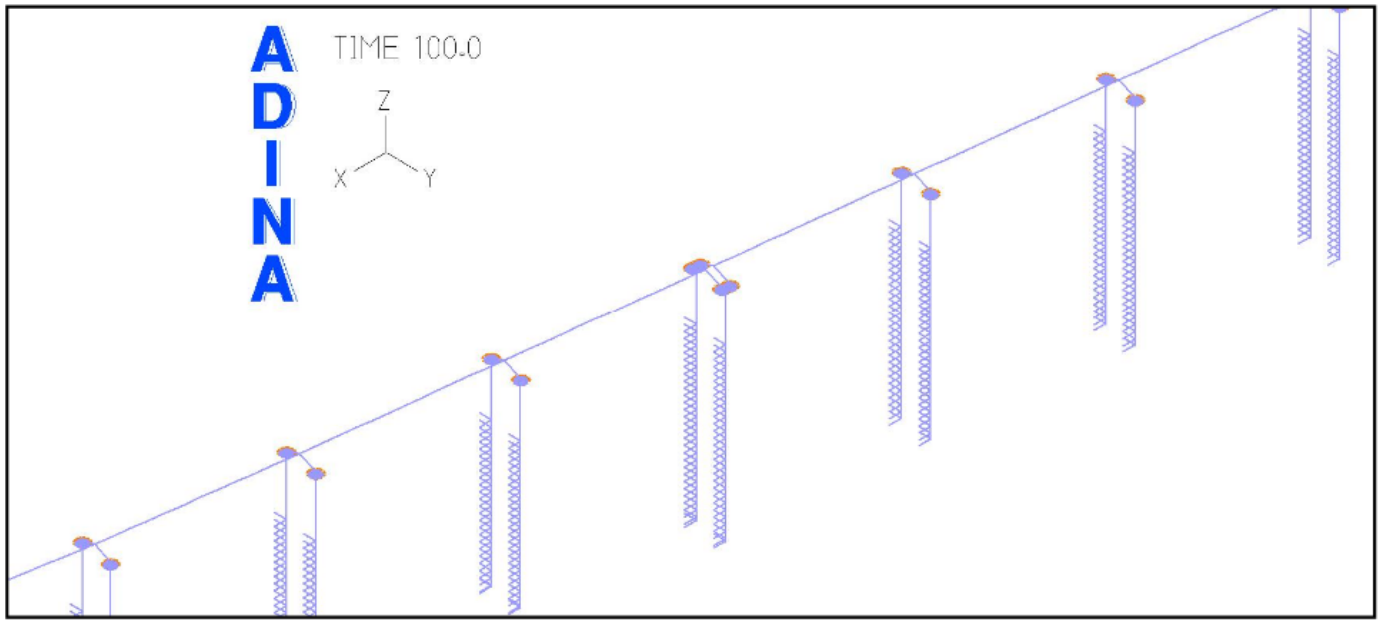



Figure 2: ADINA Typical Foundation Modeling (Shaft PY springs)

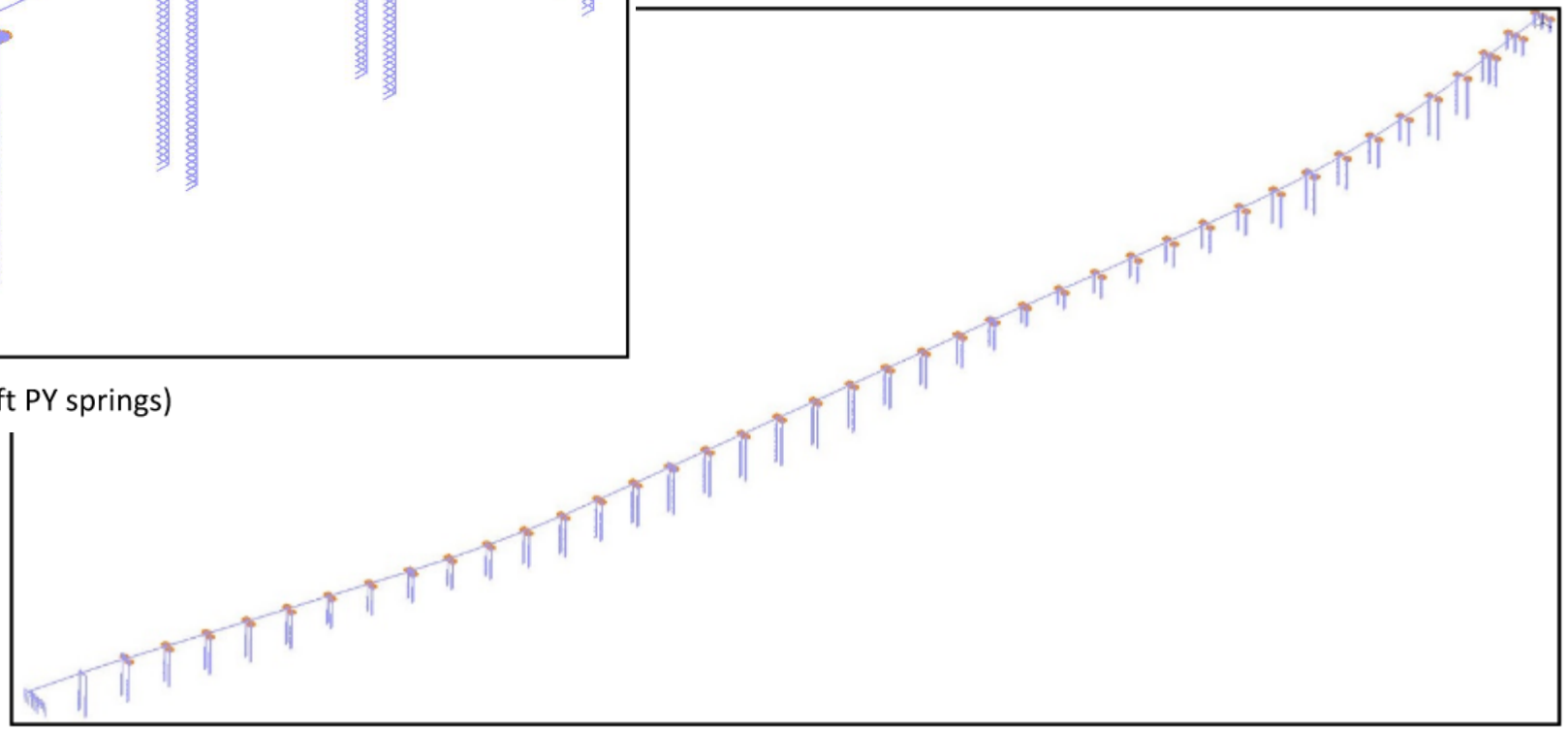
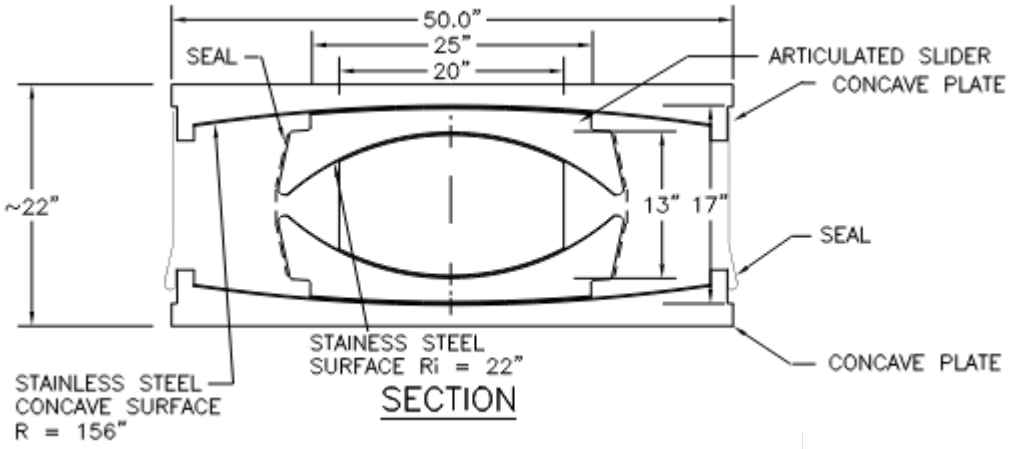
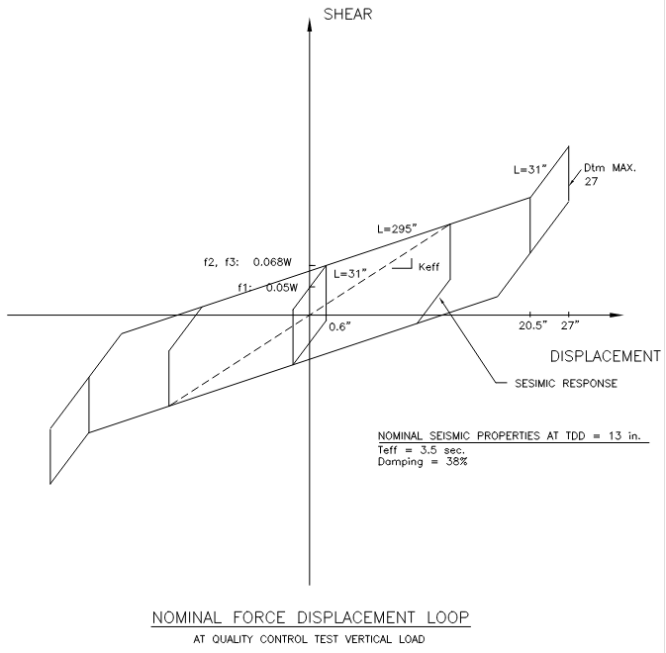


Figure 1: ADINA Global Model Abutment 1 to Floating Bridge Pontoon

# Seismic Design – Isolation Bearings



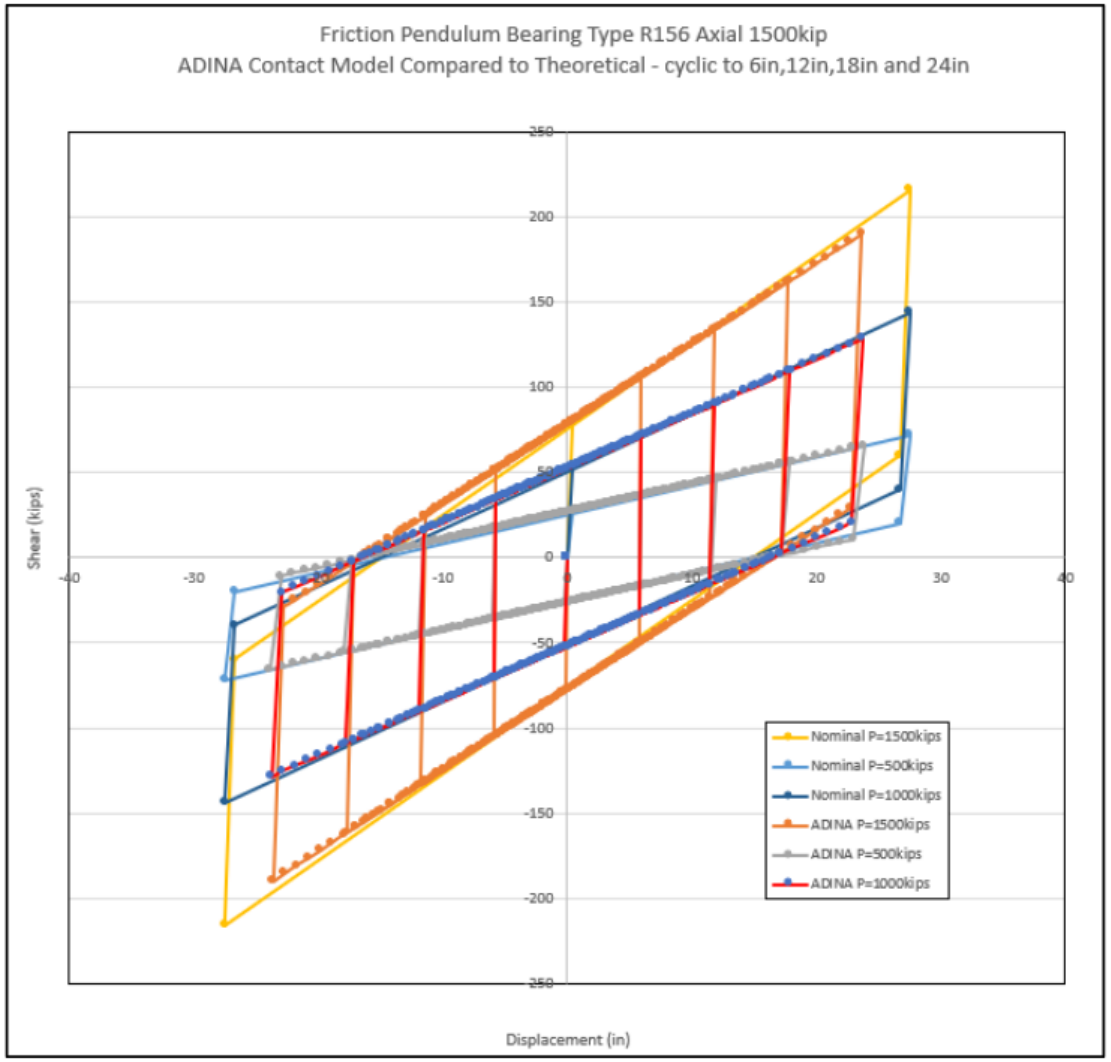




Figure 3C: ADINA Friction-Pendulum Hysteretic Response with Varying Axial Load

# Seismic Design – Time History Analysis

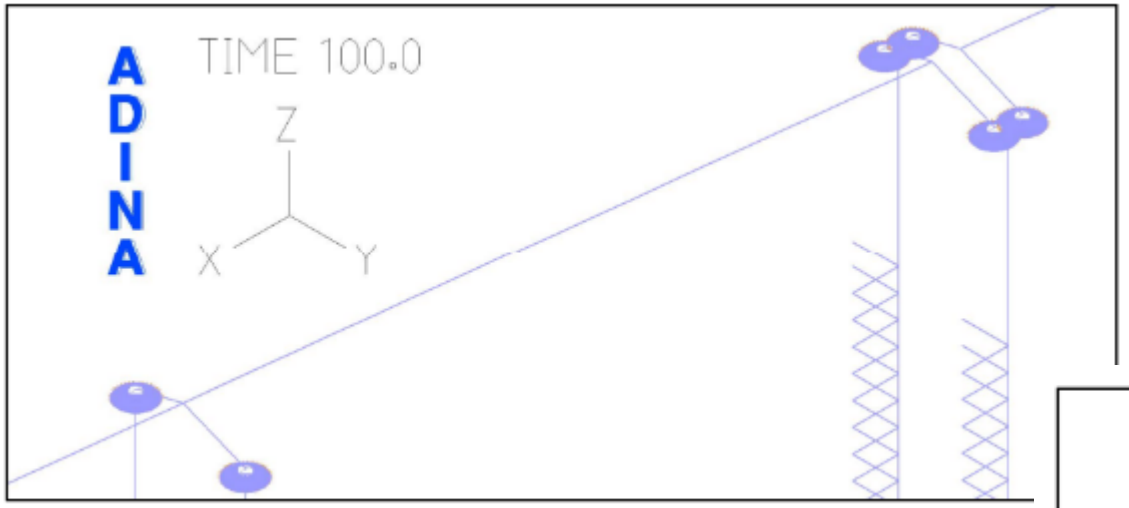



Figure 3A: ADINA Friction-Pendulum Modeling (Expansion Joint and Typical)

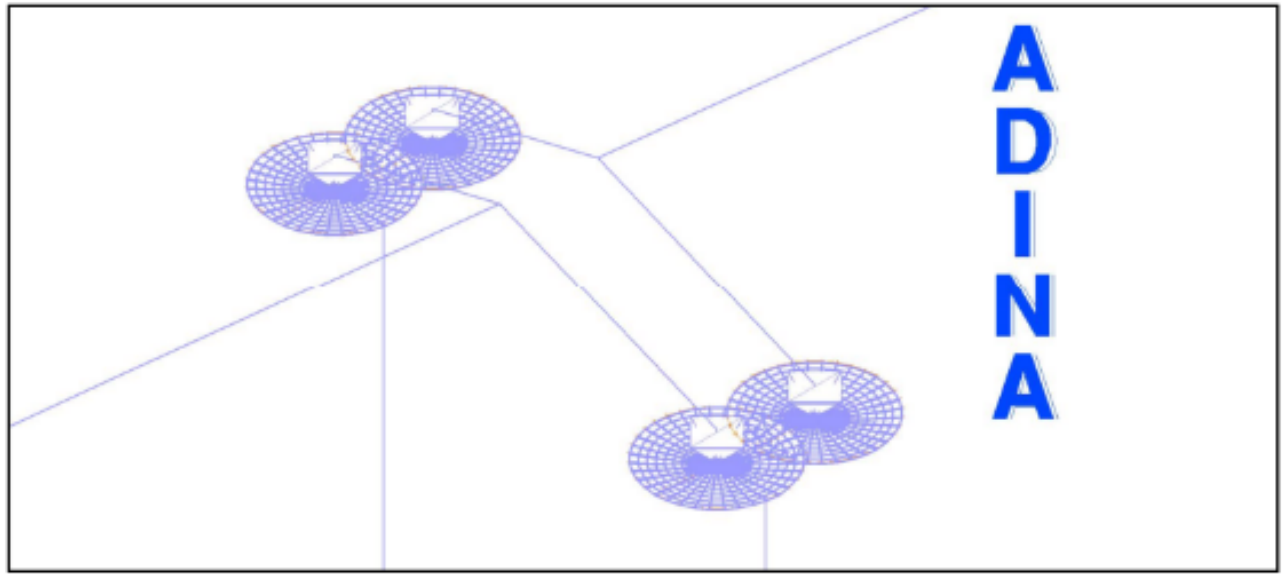



Figure 3B: ADINA Friction-Pendulum Modeling Close-Up of Contact Surface Modeling

# Seismic Design – Ground Motions

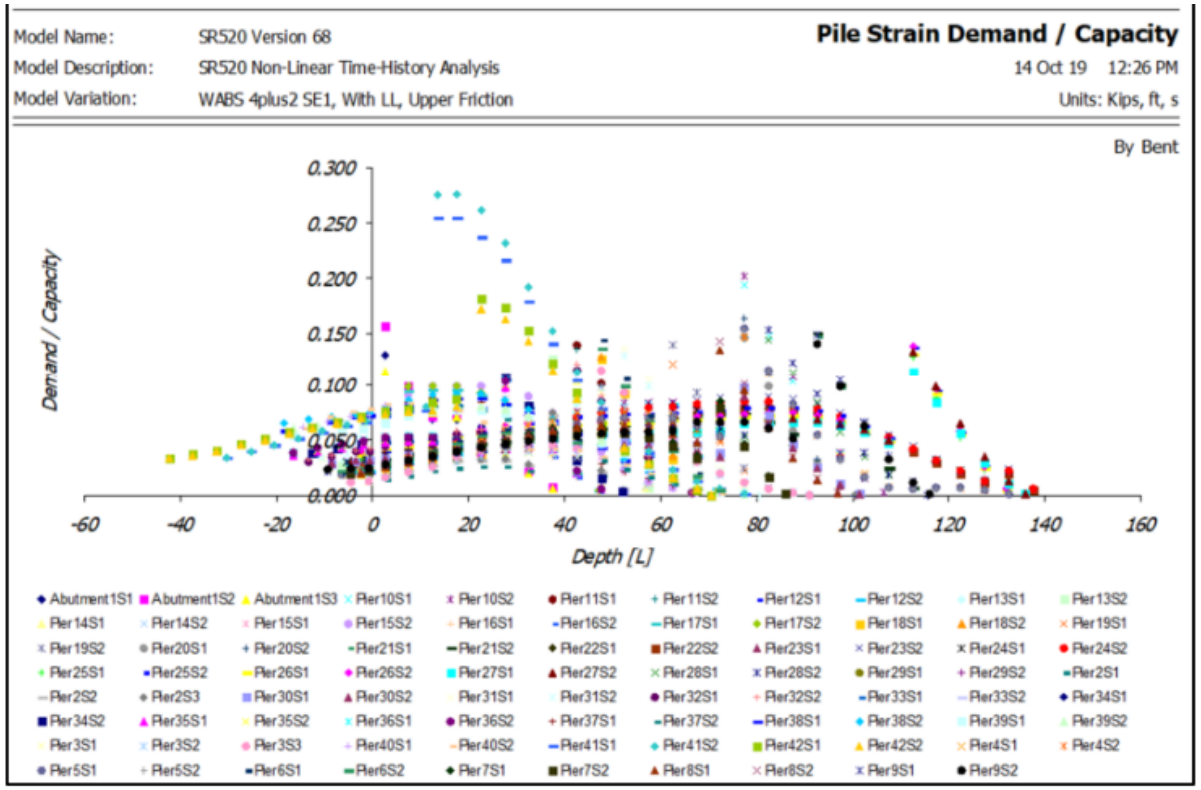



Figure 13-5: Pile Strain Demand/Capacity Ratio 5 of 18 Analysis

**SR 520 Montlake to Lake Washington I/C and Bridge Replacement**

## Control Table for WABS input motions

**General Notes:**

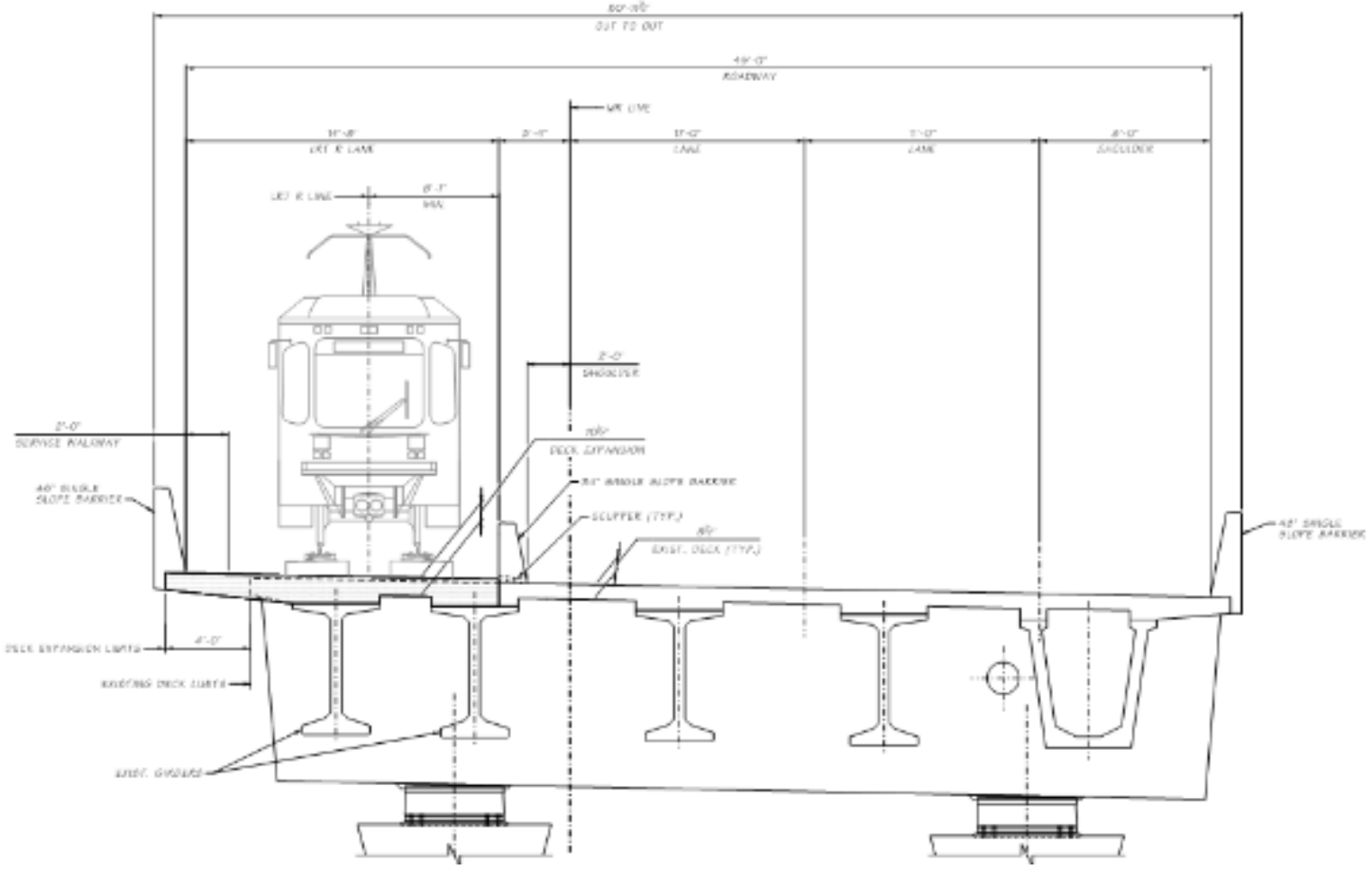
1. Motions spectrally matched to the envelope of the CMS spectra provided in Appendix G3 of the RFP
2. FN = Fault Normal; FP = Fault Parallel; CE = Crustal Earthquake, SE = Subduction, RSN = record sequence number
3. Units: Time in seconds; Displacement in feet; Acceleration in feet/second/second.
4. Refer to "Earthquake Acceleration Time Histories" memorandum prepared by Golder dated July 5th, 2019

| Source | Motion ID | Component ID | Earthquake (Station) | Time Step (sec) | Total Duration (sec) | Recommendation |
|---|---|---|---|---|---|---|
| All Crustal | CE1 | Horizontal: FN/FP Vertical: UD | Chichi, Taiwan Mw7.6 (RSN1511, TCU) | 0.005 | 89.995 | Apply FN along North-South; Apply FP along East-West |
| | CE2 | Horizontal: C1/C2 Vertical: UD | KernCounty, USA Mw7.4 (RSN15, TLS) | 0.01 | 66.39 | No significant directionality |
| Crustal Background | CE3 | Horizontal: 00/90 Vertical: UD | Loma Prieta, USA Mw6.9 (RSN762, FRE) | 0.005 | 54.245 | No significant directionality |
| | CE4 | Horizontal: EW/NS Vertical: UD | Chuetsu-oki, Japan Mw6.8 (RSN4866, Kawanishi Izumozaki) | 0.01 | 63.99 | No significant directionality |
| **Source** | **Motion ID** | **Component ID** | **Earthquake (Station)** | **Time Step (sec)** | **Total Duration (sec)** | **Recommendation** |
| Subduction Interface | SE1 | Horizontal: 90/360 Vertical: UD | Maule, Chile Mw8.8 (STL) | 0.01 | 159.99 | No significant directionality |
| | SE2 | Horizontal: EW/NS Vertical: UD | Tohoku, Japan Mw9.0 (IBR011) | 0.01 | 259.99 | No significant directionality |
| | SE3 | Horizontal: 90/360 Vertical: UD | Maule, Chile Mw8.8 (SJCH) | 0.01 | 159.99 | No significant directionality |
| | SE4 | Horizontal: EW/NS Vertical: UD | Tohoku, Japan Mw9.0 (CHB004) | 0.01 | 259.99 | No significant directionality |
| Subduction Intraslab | SE5 | Horizontal: 270/360 Vertical: UD | El Salvador Mw7.6 (MG-4359) | 0.005 | 64.495 | No significant directionality |

Figure 4: Time History Ground Motions

# Future Compatibility – 4+2 Configuration

- Design structure to accommodate possible future light rail configuration



# Future Compatibility – 6+2 Configuration

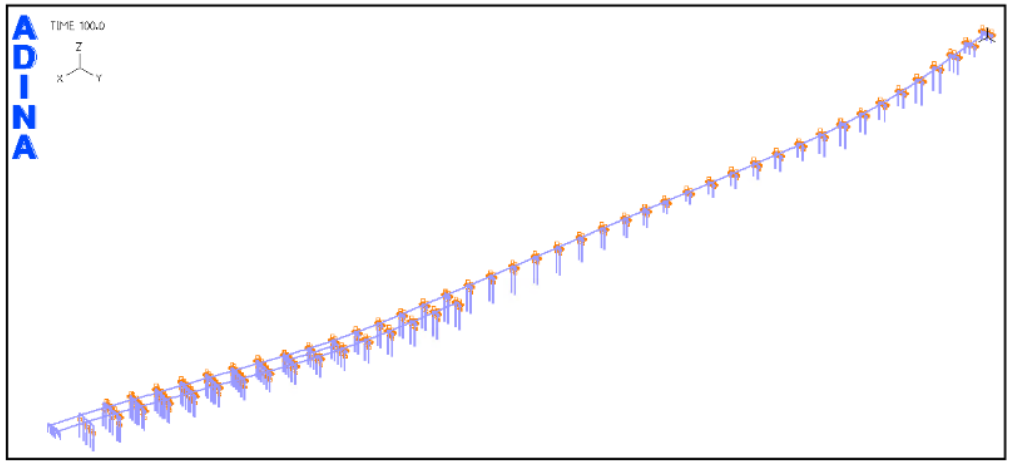
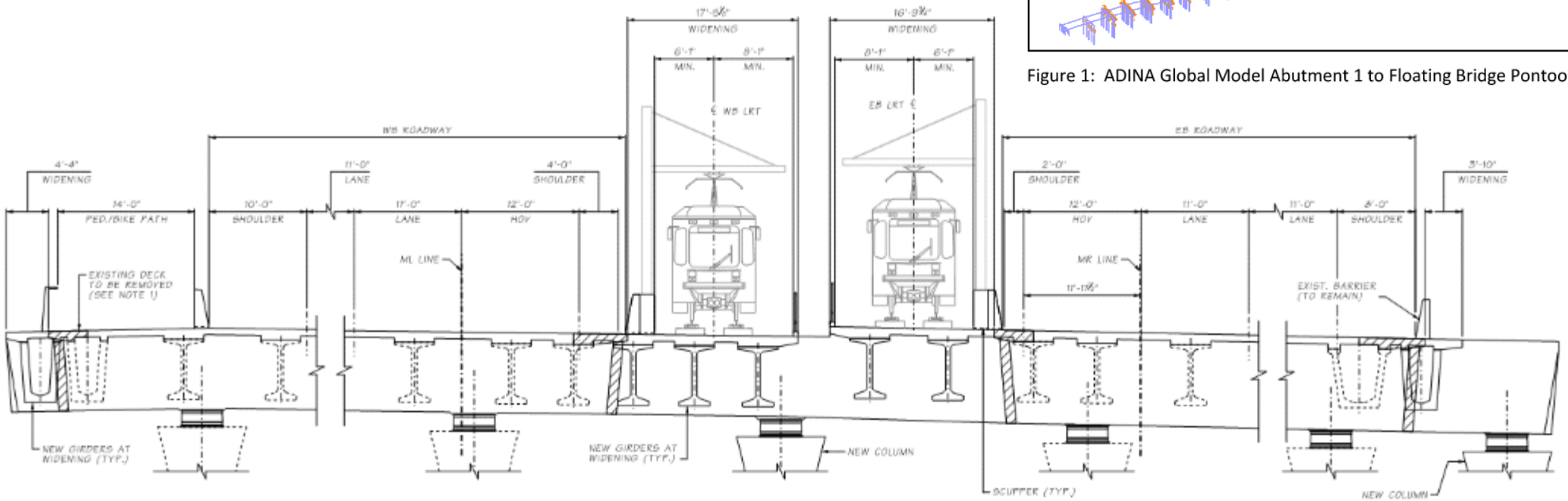
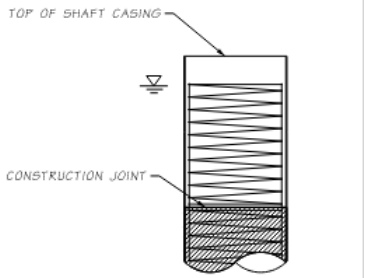



Figure 1: ADINA Global Model Abutment 1 to Floating Bridge Pontoon



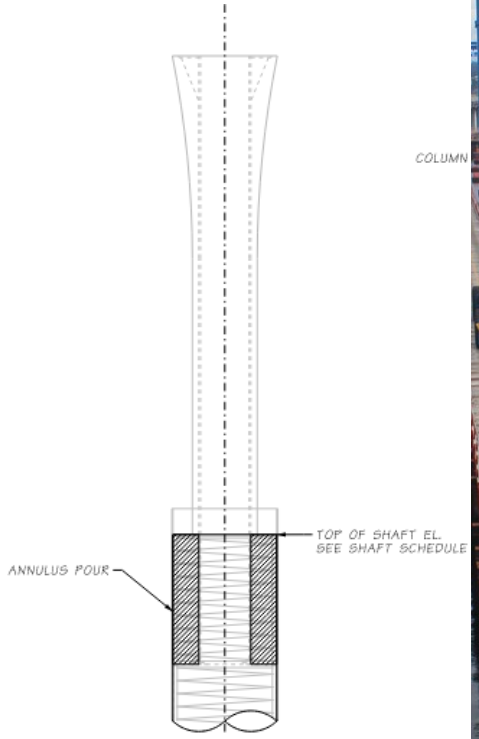
# Construction

- Precast Columns for Accelerated Construction
- May 2021 to June 2021




STAGE 1

INSTALL SHAFT REBAR, POUR CONCRETE TO CONSTRUCTION JOINT

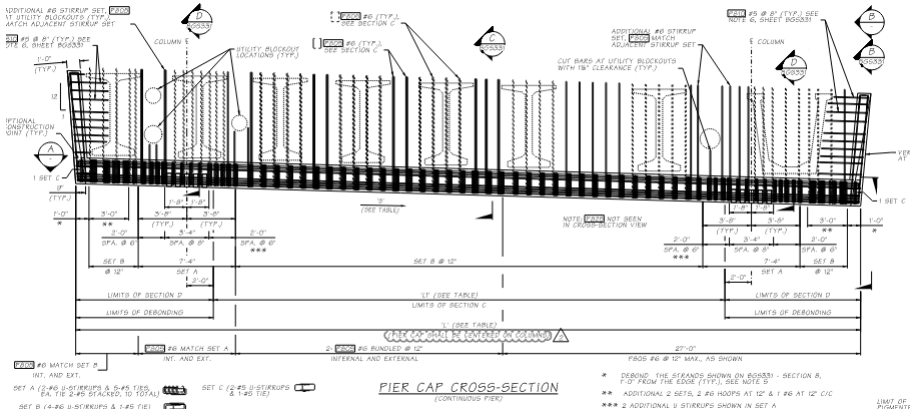



STAGE 3

POUR CONCRETE IN ANNULUS BETWEEN SHAFT CASING AND COLUMN STEEL CASING.

# Construction

## Precast Cross Beams Avoids Falsework (Oct 2021 – Nov 2021)




# Construction

– Precast Crossbeam

# Construction

- Setting the Girders (March 2022)
- Unbalanced loads on support jacks critical

# Construction

Deck Forms (March 2022)

Starting at one end

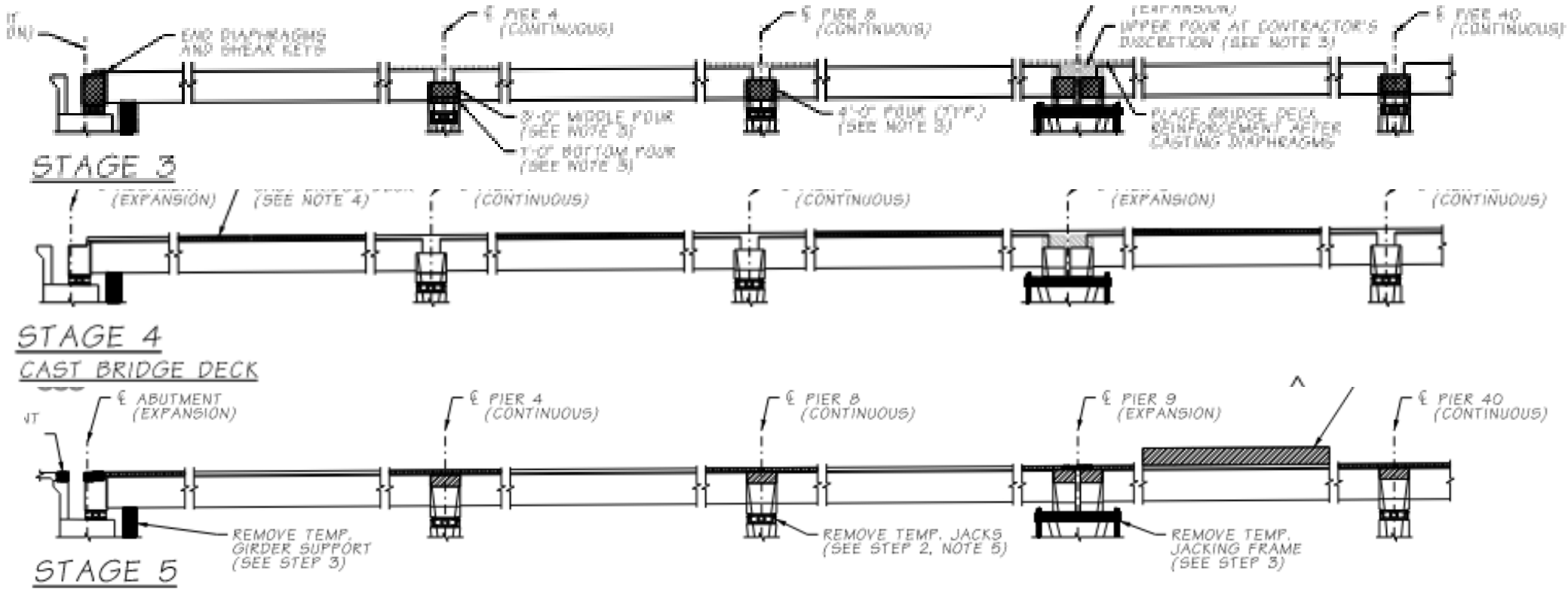
Working West to East

Assembly Line fashion

# Construction

## – Deck Sequence Critical

Detailed check of the all the critical stage was required as part of the design.



# Deck Construction

# Deck Construction

- Cast each side ready for the deck over the pier (Oct 2022)

# Questions?