Western Bridge Engineers' Seminar 2023

Pedestrian Land Bridge – Blending Nature and City

Presented by:

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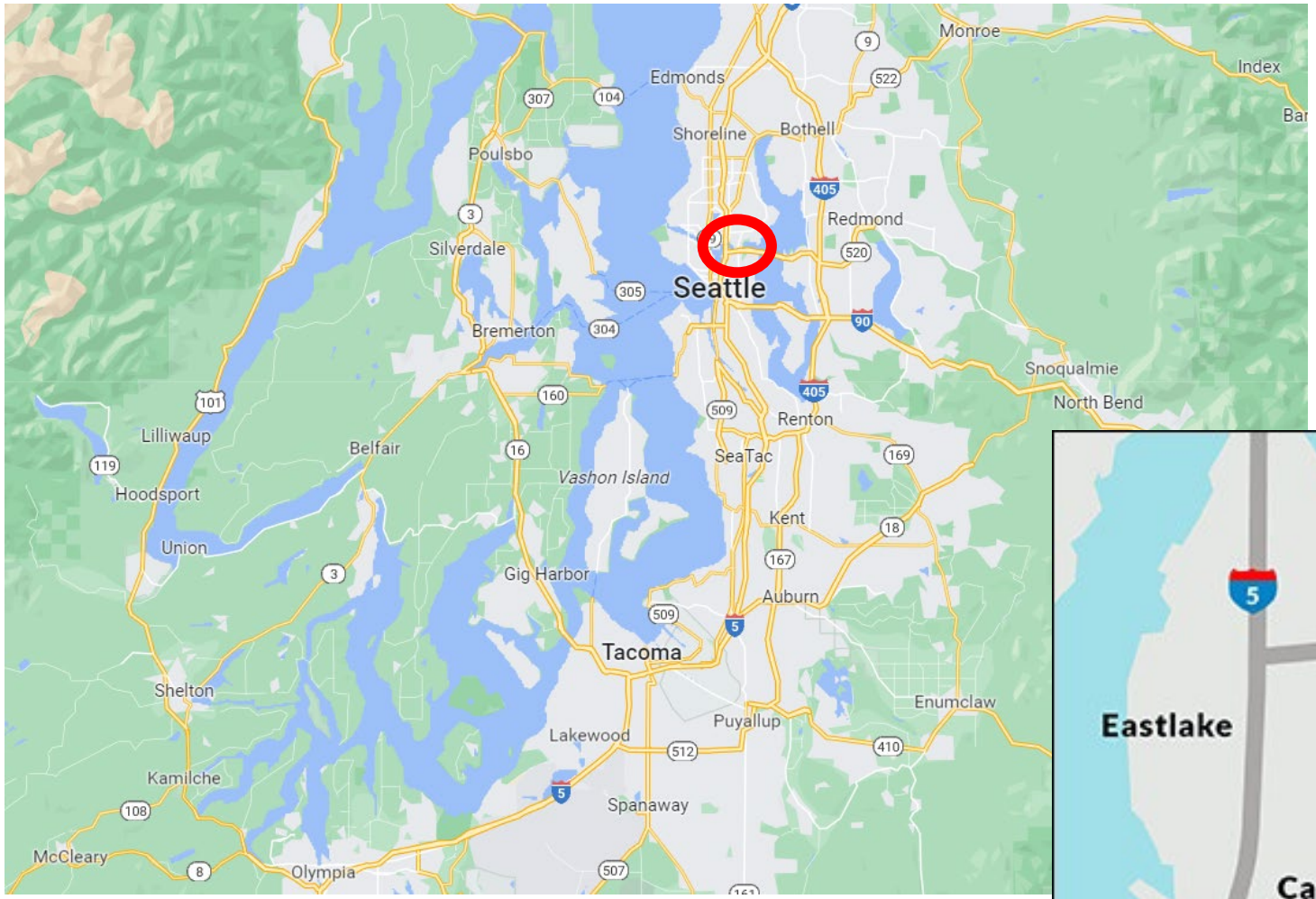
Senior Bridge Engineer - TYLin

TYLin

GRAHAM

WSDOT

Project Location Map



PLB Location Map

- 5395 ft West Approach Bridge South (WABS)
- 3 Acre Lid
- 318 ft Pedestrian Land Bridge (PLB)

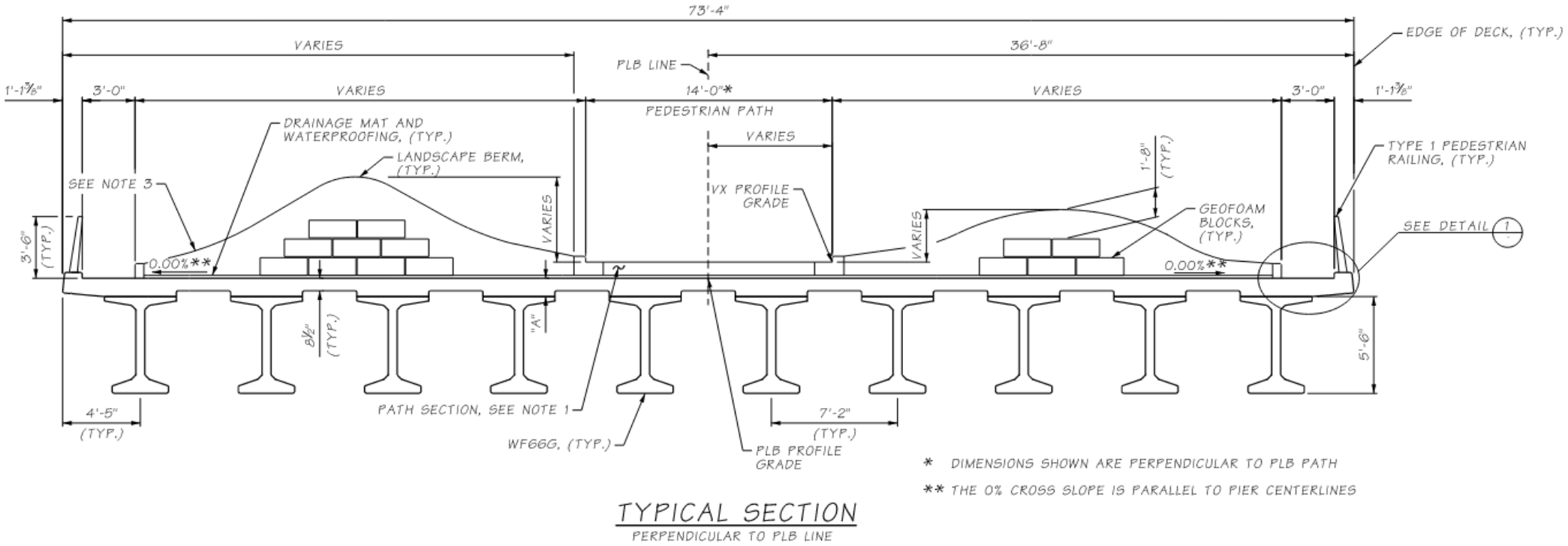
Agenda

- DESIGN CRITERIA
- PROJECT COMPONENTS
- BRIDGE LAYOUT ITERATIONS
- ARCHITECTURAL COMPONENTS
- DESIGN CHALLENGES
- CONSTRUCTION CHALLENGES & PHOTOS

Design Criteria

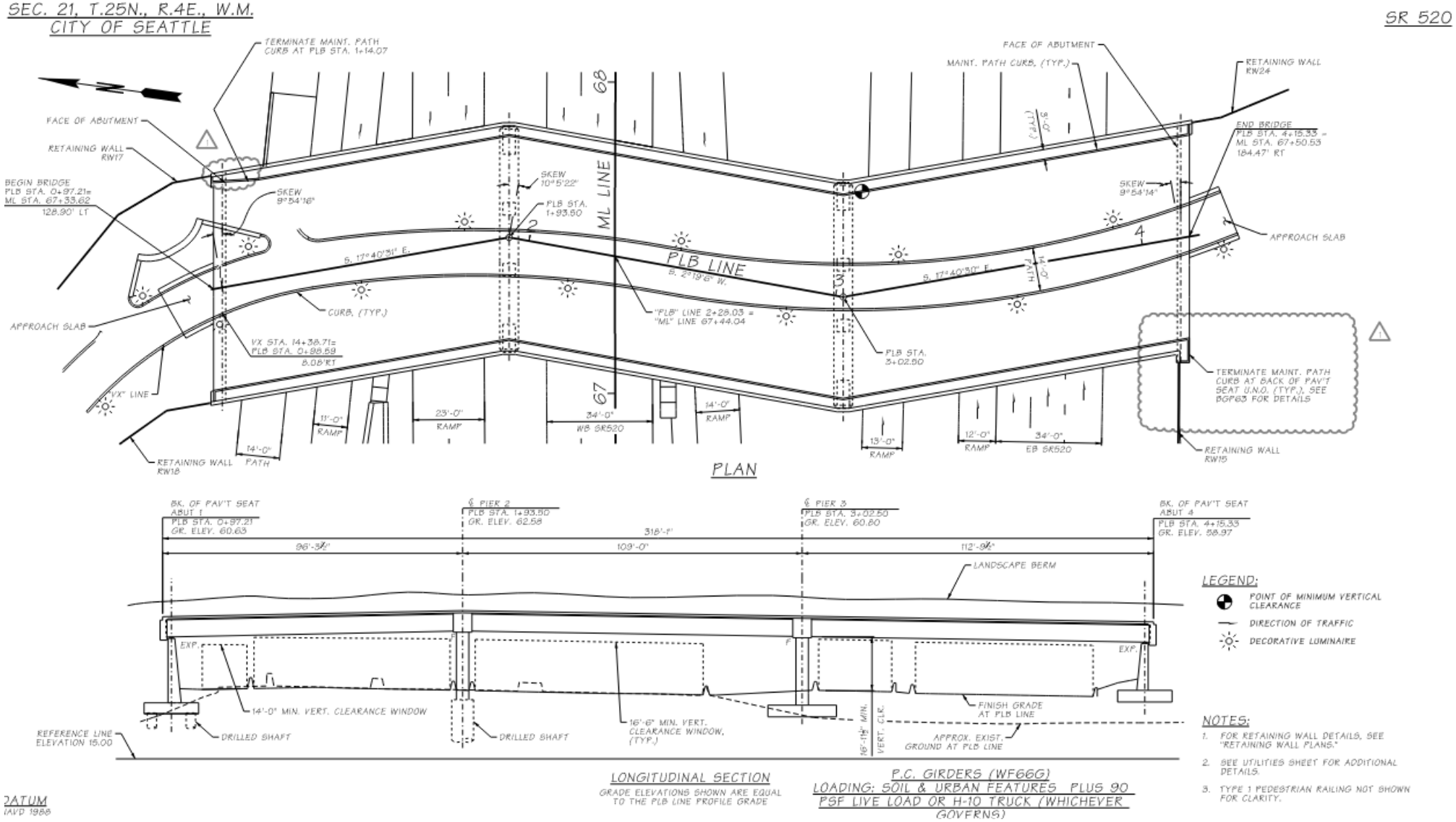
- Seismic Design Criteria For Lid Bridges
- WSDOT Bridge Design Manual (LRFD)
- AASHTO LRFD Seismic Guide 2nd Edition
- AASHTO LRFD 8th Edition
- AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges (AASHTO Ped)

Typical Section



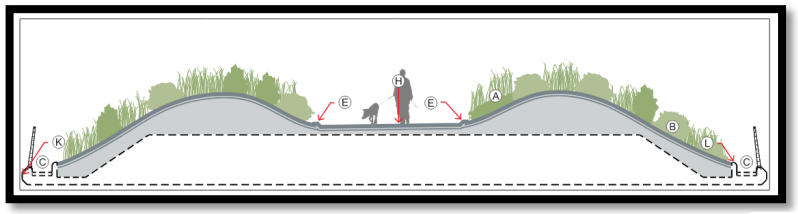
TYPICAL SECTION
PERPENDICULAR TO PLB LINE

Plan & Elevation

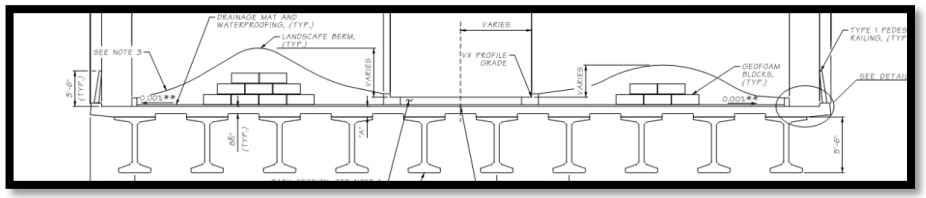


Bridge Layout Iteration

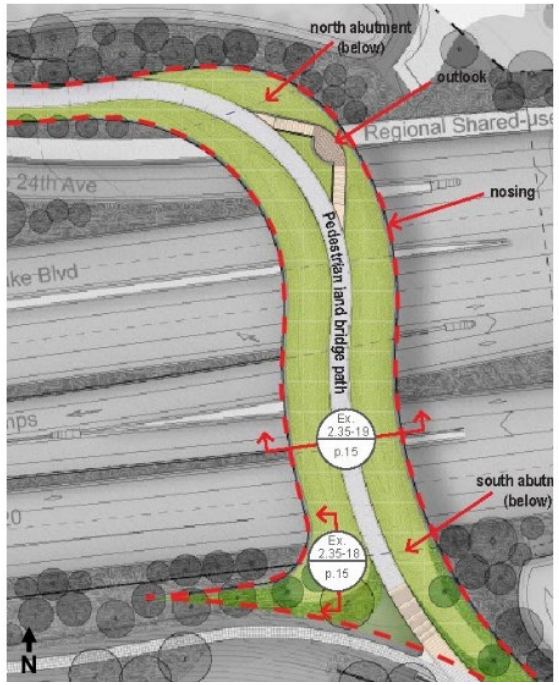
2018 RFP Section



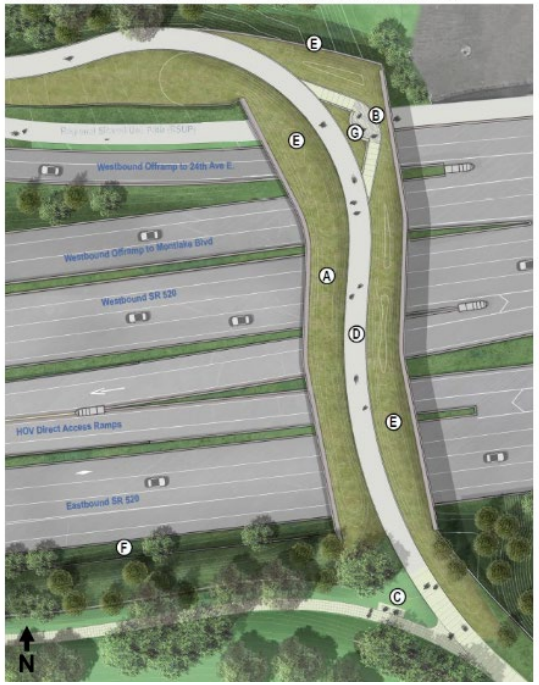
Final Section



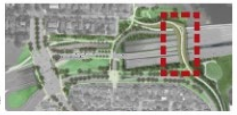
2018 WSDOT RFP Plan



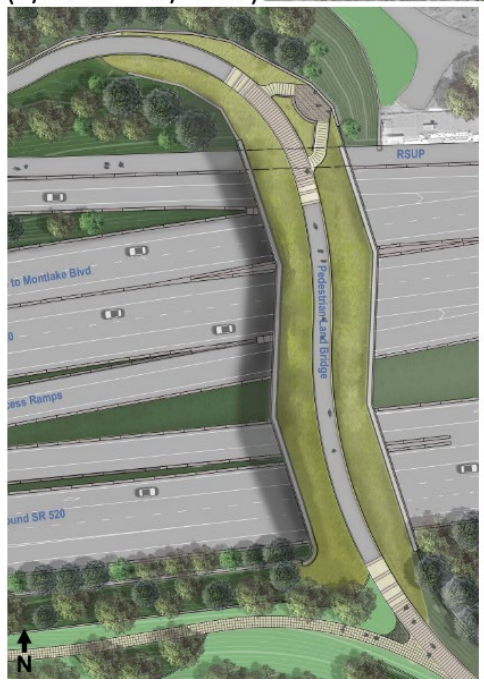
Response to RFP Plan (11/2018)



Key Plan

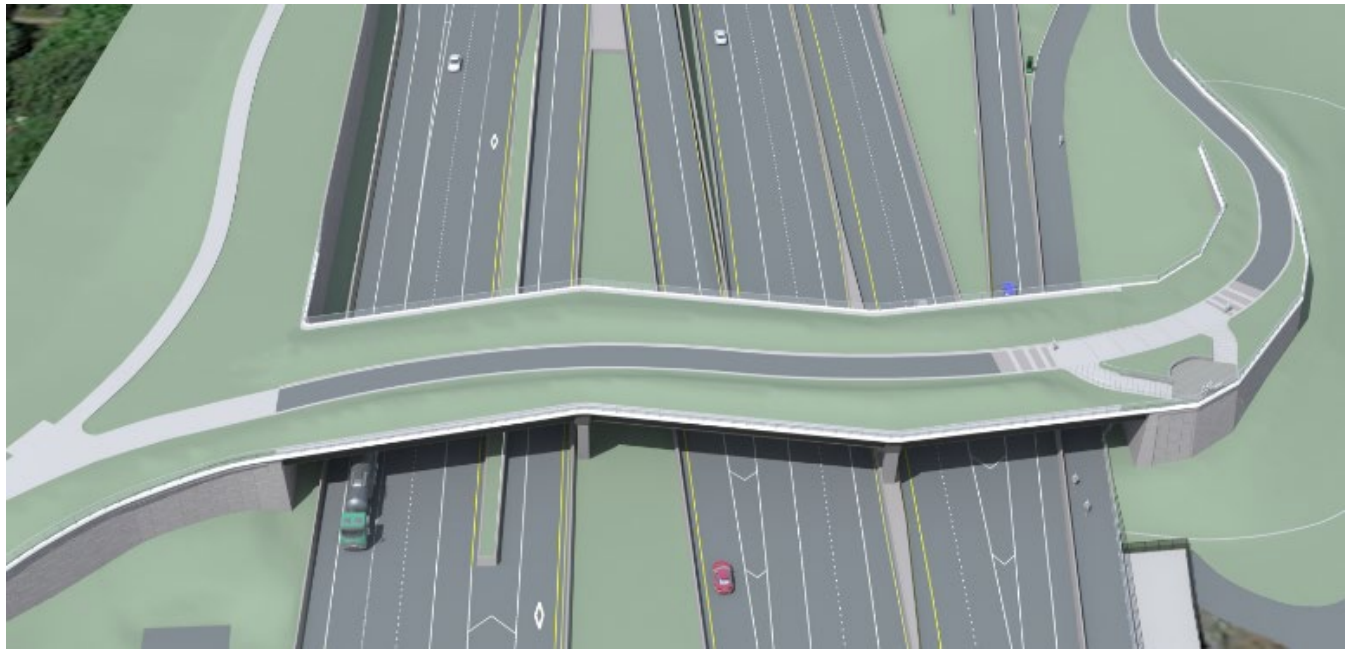


Current Plan
(7/2019 - 10/2019)



Architectural Features

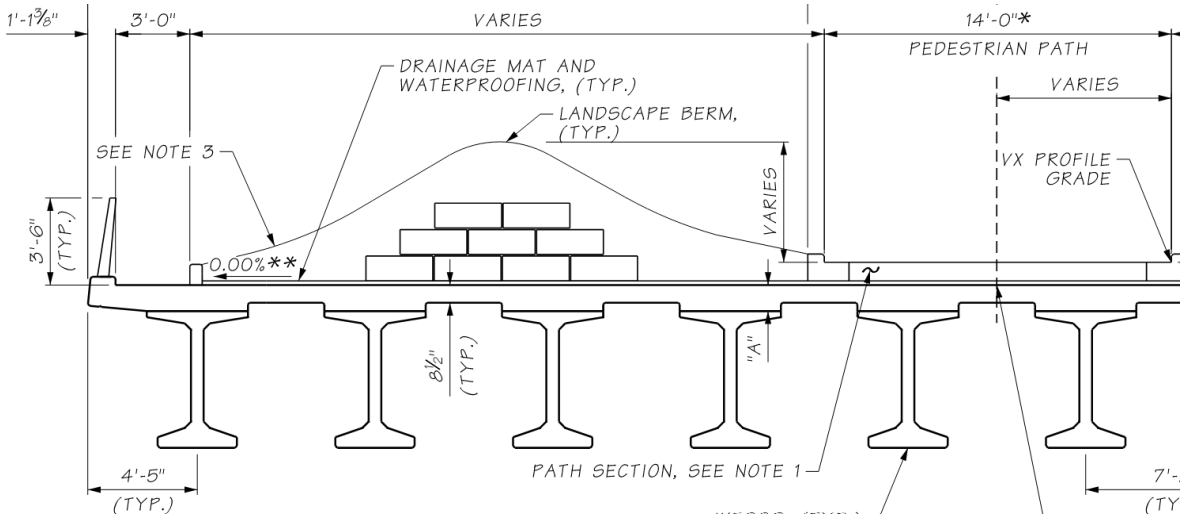
- Design team worked closely with Seattle Design Commission (SDC) to ensure the “nature meets city” was achieved
- PLB is intended to be a gateway to the city



Architectural Features

Landscape Berms

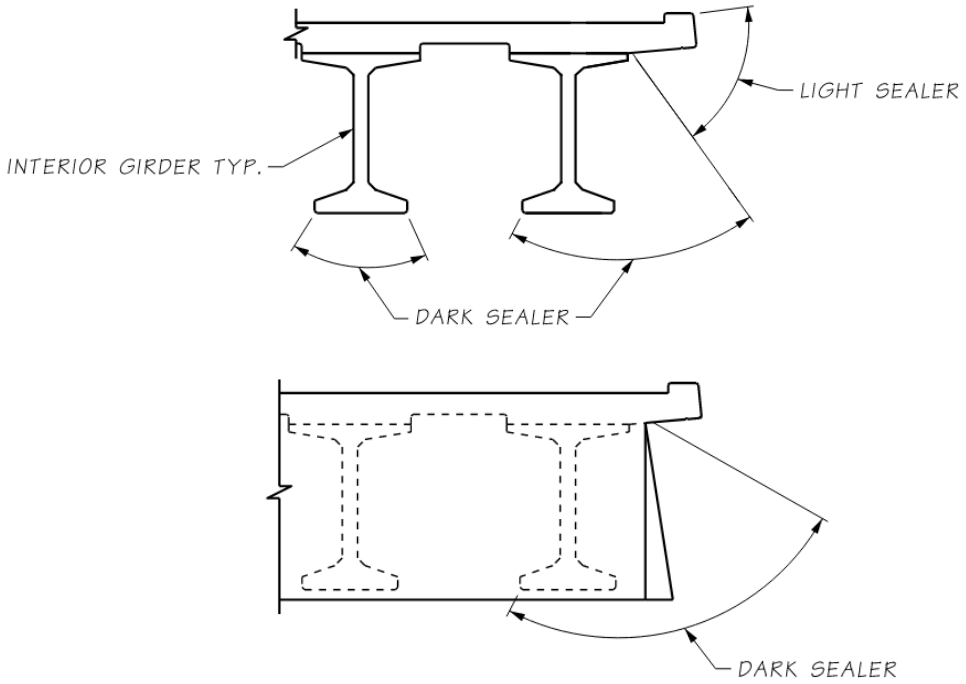
- Vary in height from 3.5ft to 5ft
- DW 240psf loading achieved with Geofoam blocks
- Drainage mat and waterproof membrane
- 0% cross slope
- No deck penetrations through membrane



Architectural Features

Floating Deck

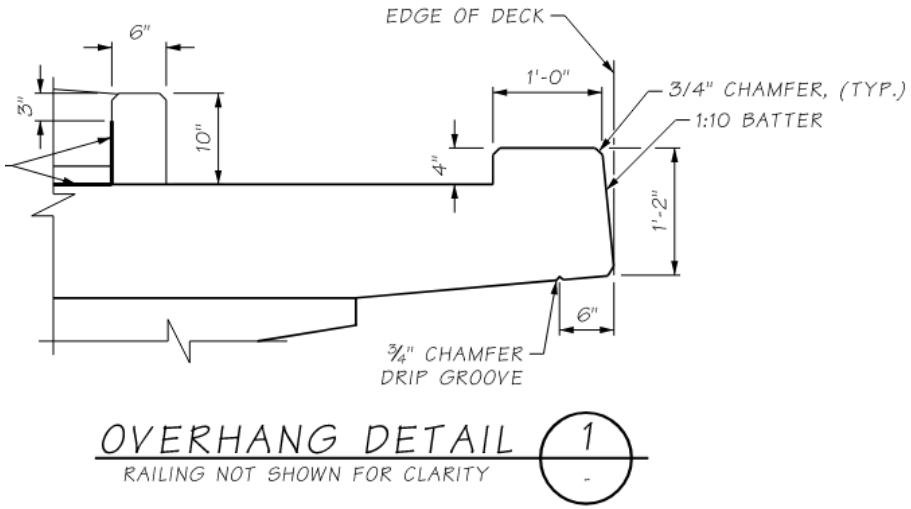
– Sealers are used to reinforce the appearance of a floating deck/berms



Architectural Features

Nosing and Walls

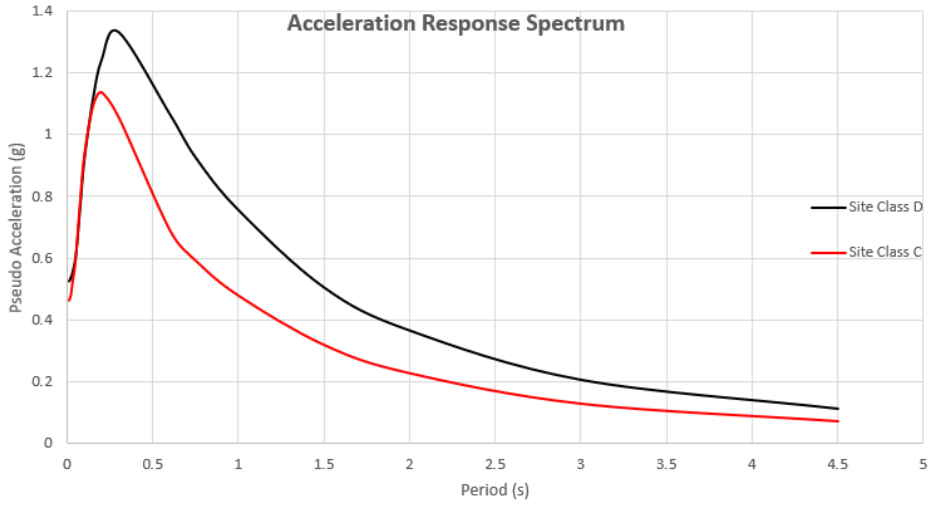
- Edge of deck nosing is continuous off bridge into adjacent walls
- All walls battered at 10V:1H with architectural pattern
- Exterior columns flared to match pier cap
- Integral pier caps



Design Challenges

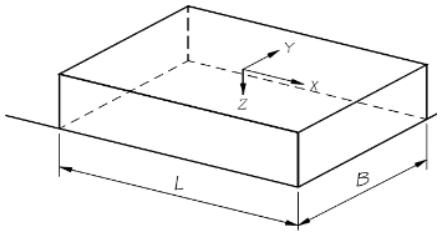
Varying Soil Conditions - Mixed Foundations

- Abutment 1 (3’ Dia. Shafts)
- Pier 2 (7’ Dia. Shafts)
- Pier 3 & Abutment 4 (Spread Footings)
- Soil improvement at Abutment 4 and Piers (5ft)
  - Controlled density fill (CDF) reduced seismic demands

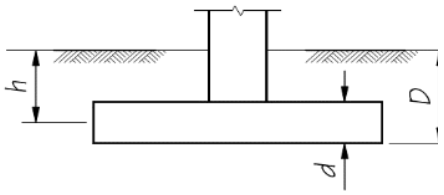


Design Challenges

- Balance stiffness requirements (Shafts vs Spread FTG)
- Derived p-y springs for shafts in LPile
- BDM provides stiffness derivation for spread footing



Orient axes such that $L > B$.
If $L = B$ use x-axis equations for both x-axis and y-axis.
Figure 7.2.7-1



Degree of Freedom	K_{sur}
Translation along x-axis	$\frac{GB}{2-\nu}\left[3.4\left(\frac{L}{B}\right)^{0.65}+1.2\right]$
Translation along y-axis	$\frac{GB}{2-\nu}\left[3.4\left(\frac{L}{B}\right)^{0.65}+0.4\frac{L}{B}+0.8\right]$
Translation along z-axis	$\frac{GB}{1-\nu}\left[1.55\left(\frac{L}{B}\right)^{0.75}+0.8\right]$
Rocking about x-axis	$\frac{GB^3}{1-\nu}\left[0.4\left(\frac{L}{B}\right)+0.1\right]$
Rocking about y-axis	$\frac{GB^3}{1-\nu}\left[0.47\left(\frac{L}{B}\right)^{2.4}+0.034\right]$
Torsion about z-axis	$GB^3\left[0.53\left(\frac{L}{B}\right)^{2.45}+0.51\right]$

Stiffness of Foundation at Surface
Table 7.2.7-1

Degree of Freedom	β
Translation along x-axis	$\left(1+0.21\sqrt{\frac{D}{B}}\right)\left[1+1.6\left(\frac{hd(B+L)}{BL^2}\right)^{0.4}\right]$
Translation along y-axis	$\left(1+0.21\sqrt{\frac{D}{L}}\right)\left[1+1.6\left(\frac{hd(B+L)}{LB^2}\right)^{0.4}\right]$
Translation along z-axis	$\left[1+\frac{1}{21}\frac{D}{B}\left(2+2.6\frac{B}{L}\right)\right]\cdot\left[1+0.32\left(\frac{d(B+L)}{BL}\right)^{\frac{2}{3}}\right]$
Rocking about x-axis	$1+2.5\frac{d}{B}\left[1+\frac{2d}{B}\left(\frac{d}{D}\right)^{-0.2}\sqrt{\frac{B}{L}}\right]$
Rocking about y-axis	$1+1.4\left(\frac{d}{L}\right)^{0.6}\left[1.5+3.7\left(\frac{d}{L}\right)^{1.9}\left(\frac{d}{D}\right)^{-0.6}\right]$
Torsion about z-axis	$1+2.6\left(1+\frac{B}{L}\right)\left(\frac{d}{B}\right)^{0.9}$

Correction Factor for Embedment
Table 7.2.7-2

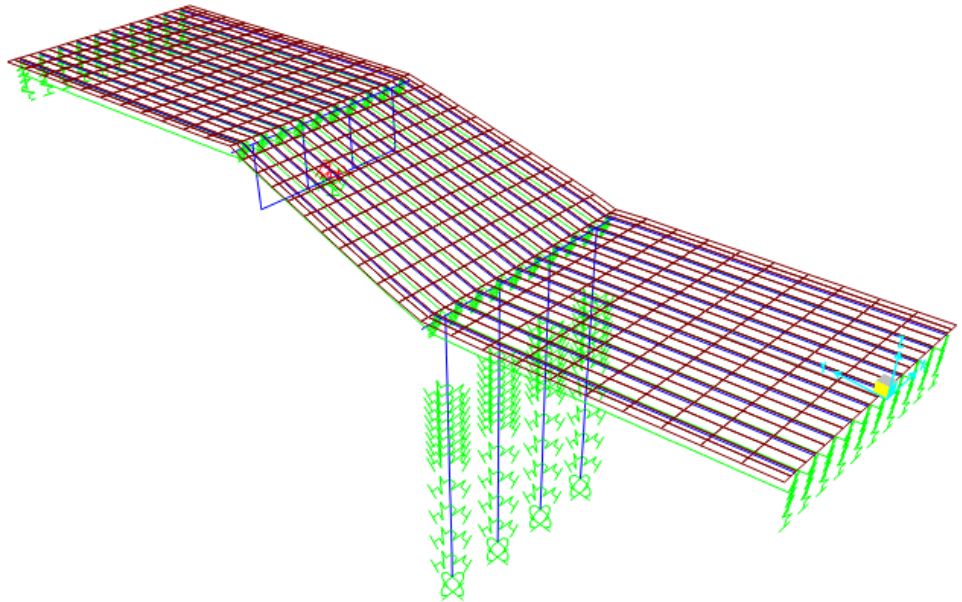
Design Challenges

- Balance stiffness requirements
- Hand Calcs

k_i^e	649	kip/in	smaller effective stiffness
k_j^e	857	kip/in	Larger effective stiffness
ratio	0.76		>= 0.75 Adjacent bents within a frame or adjacent col
Check?	OK		

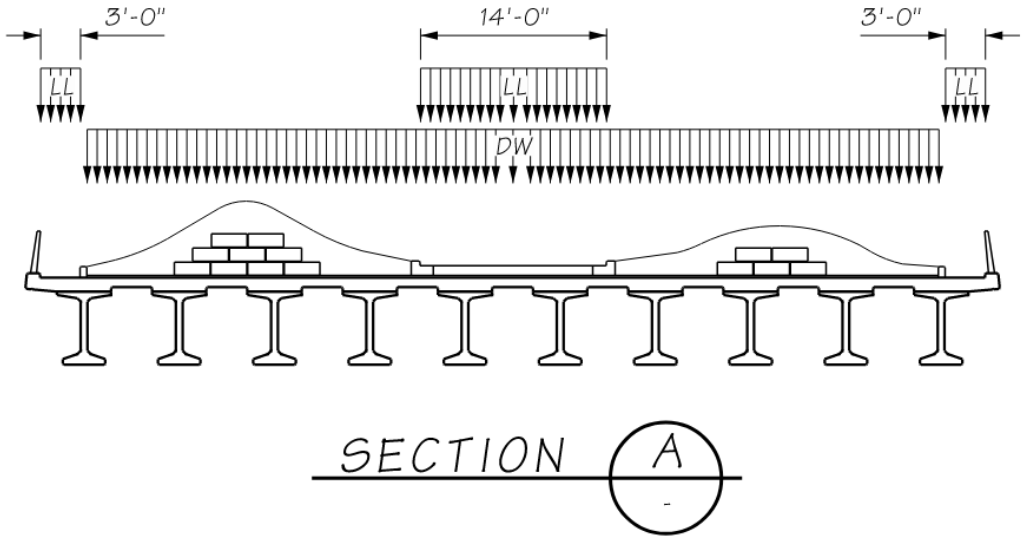
- From Model

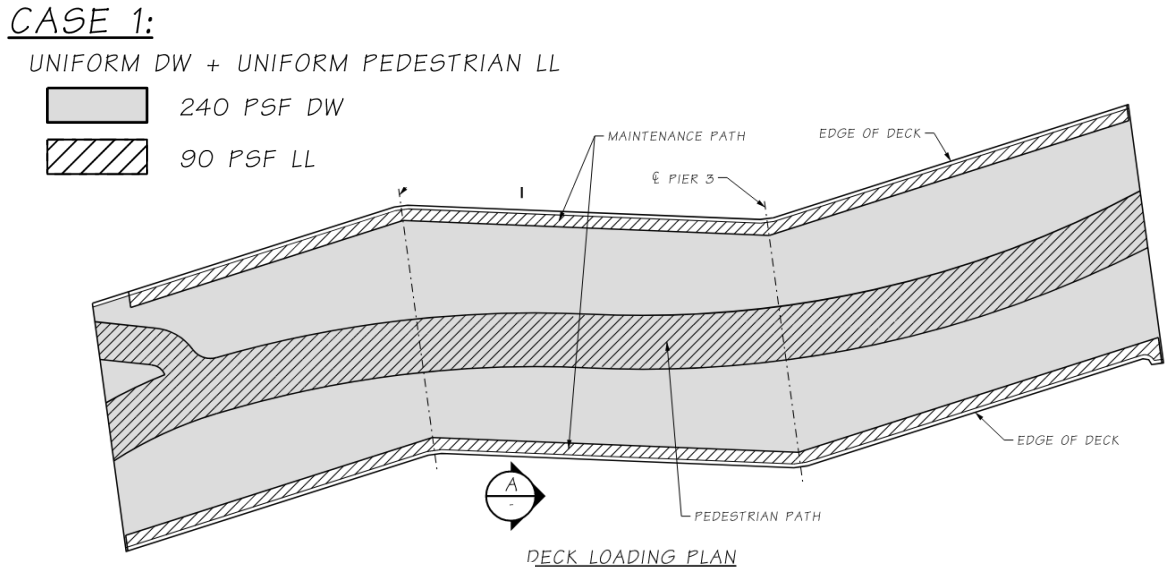
k_i^e	703	kip/in	smaller effective stiffness
k_j^e	795	kip/in	Larger effective stiffness
ratio	0.88		>= 0.75 Adjacent bents within a frame or adjacent col
Check?	OK		

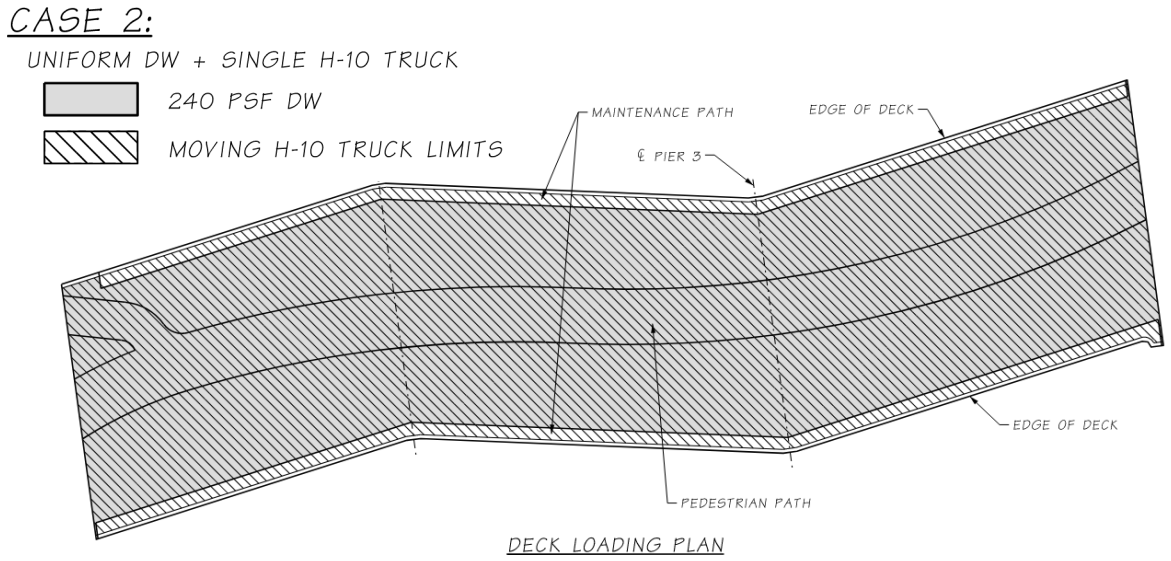


Design Challenges

- Deck Loading Criteria
- Snow Loads







Design Challenges

- Seismic Design Criteria For Lid Bridges Load combination

$$1.0\ DC + 1.0\ DW + 0.5\ LL \pm 1.0\ EQH \pm 1.0\ EQV$$

- EQH = Seismic overstrength forces (Mo,Vo)
- EQV = Site-specific vertical response spectrum 0.47(DC+DW)
- EQV had 30% increase to the longitudinal pushover case

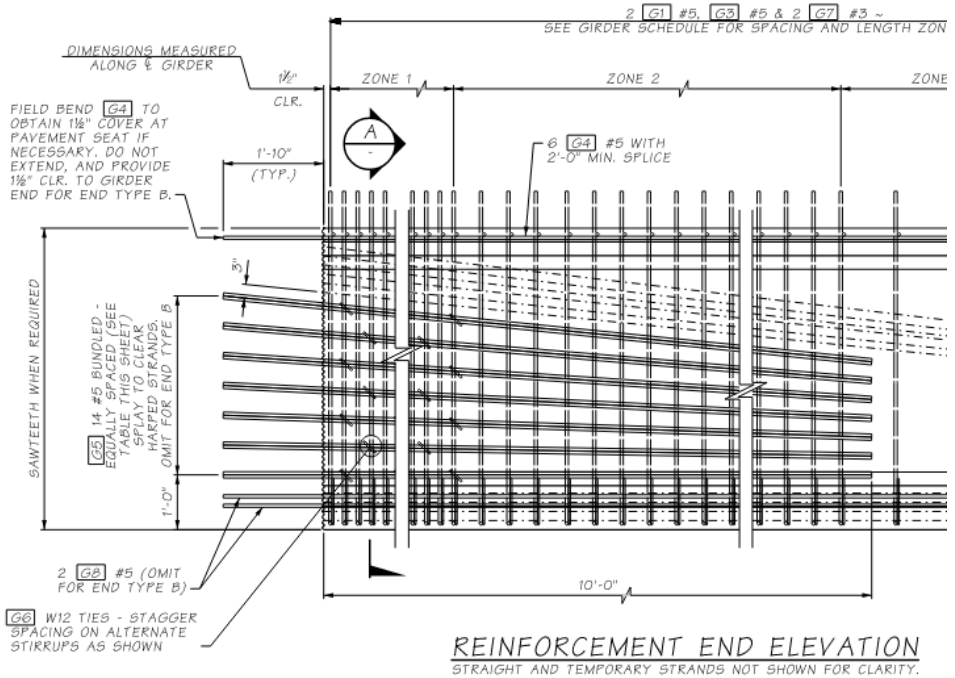
Design Challenges

- Integral girders
  - Interface shear capacity governed
  - Lid load combination governed shear design
  - Additional bars needed with roughened construction joint
    - Provided twice the STD Plan extensions
  - Interface Shear Capacity

$$\phi_v \cdot V_n = 575 \cdot \text{kip}$$

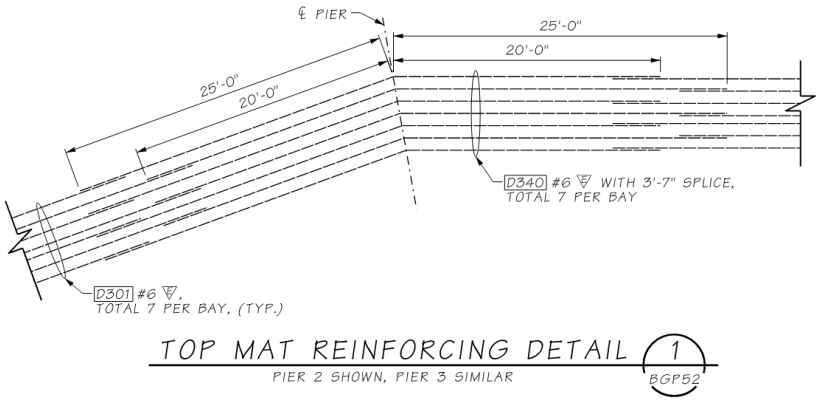
  - Girder Shear Capacity

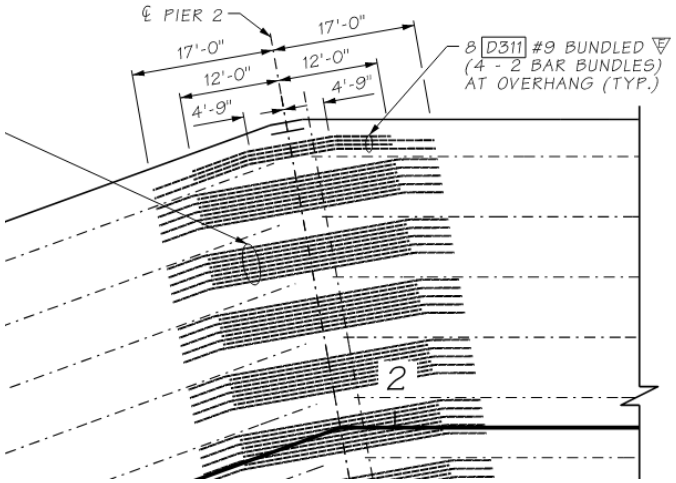
$$\phi V_n = 735 \text{ kip}$$

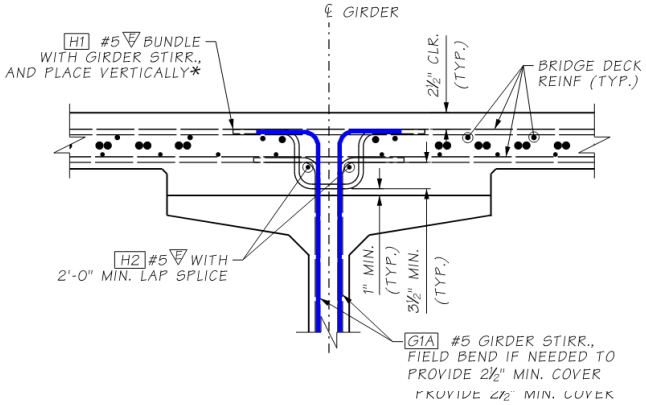


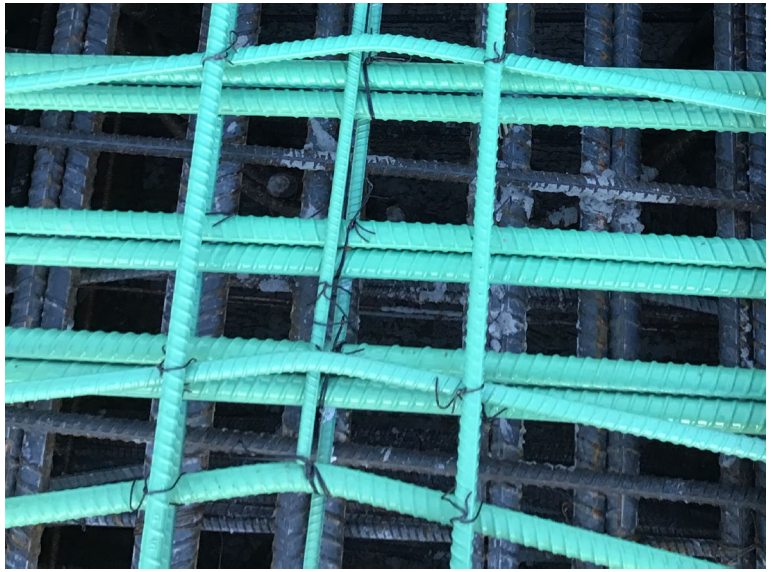
Design Challenges

- Deck rebar
  - Top mat continuous, bent at pier
  - Additional #9 bars custom bends to avoid hat bars (stirrups)





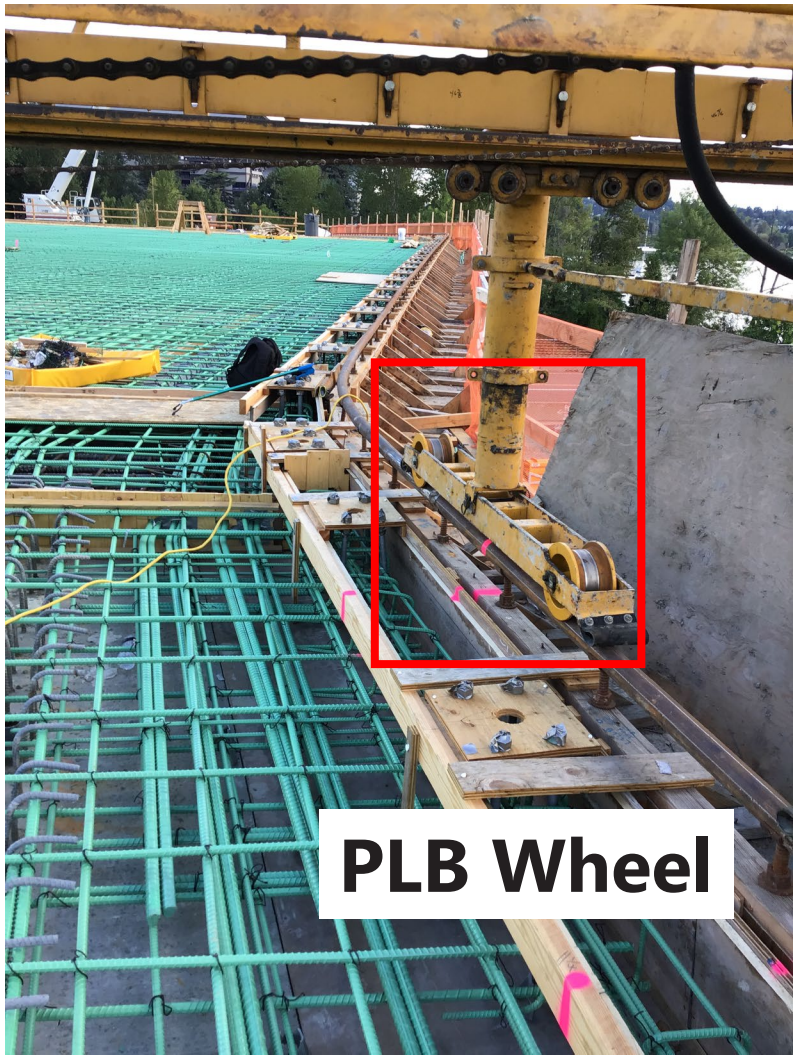




Construction Challenges

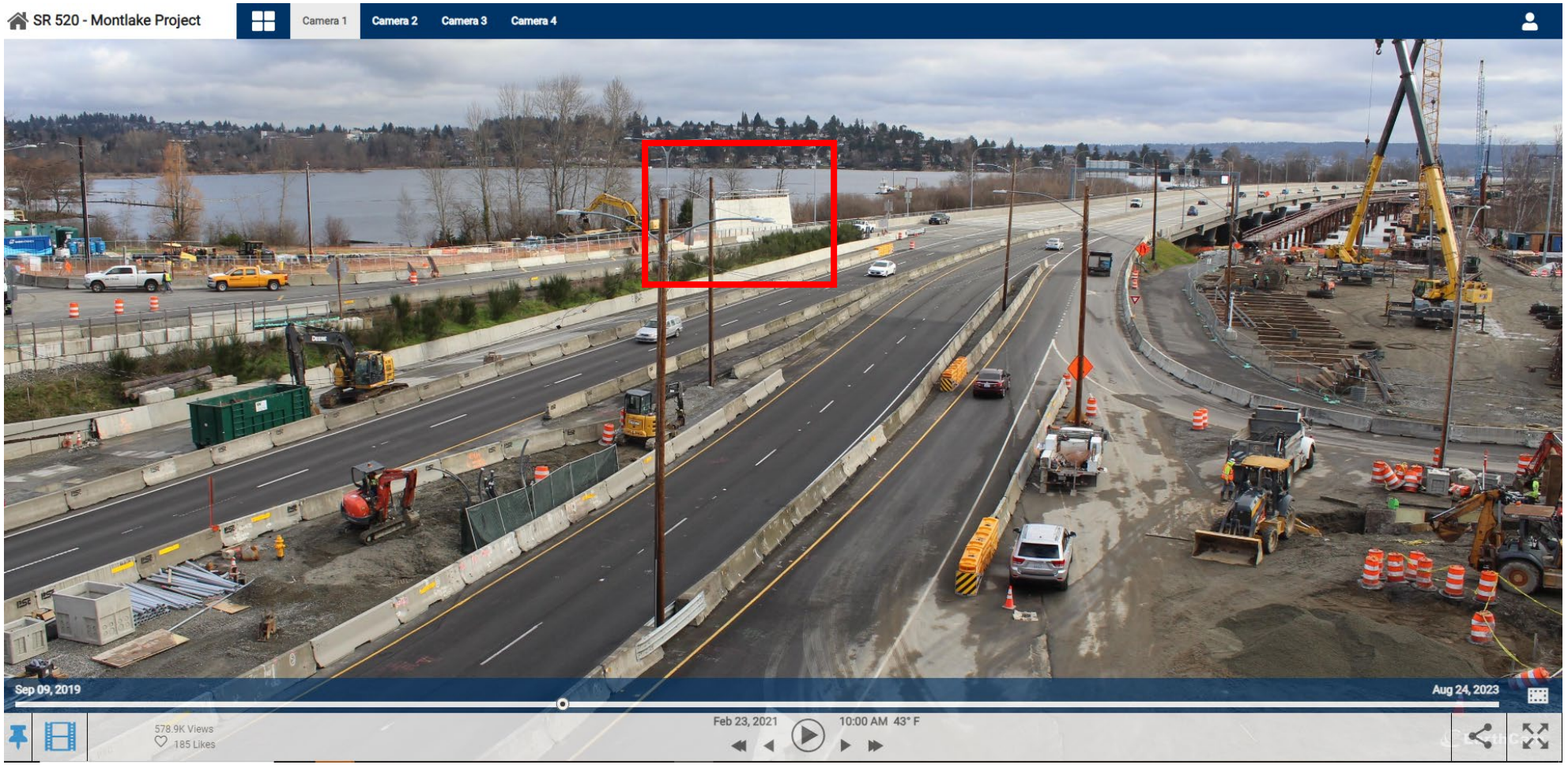
Bid-Well

- Curved runners at kinks avoids a crane lift
- Wider/flat wheels with lip used
  - Allows lateral movement around kink



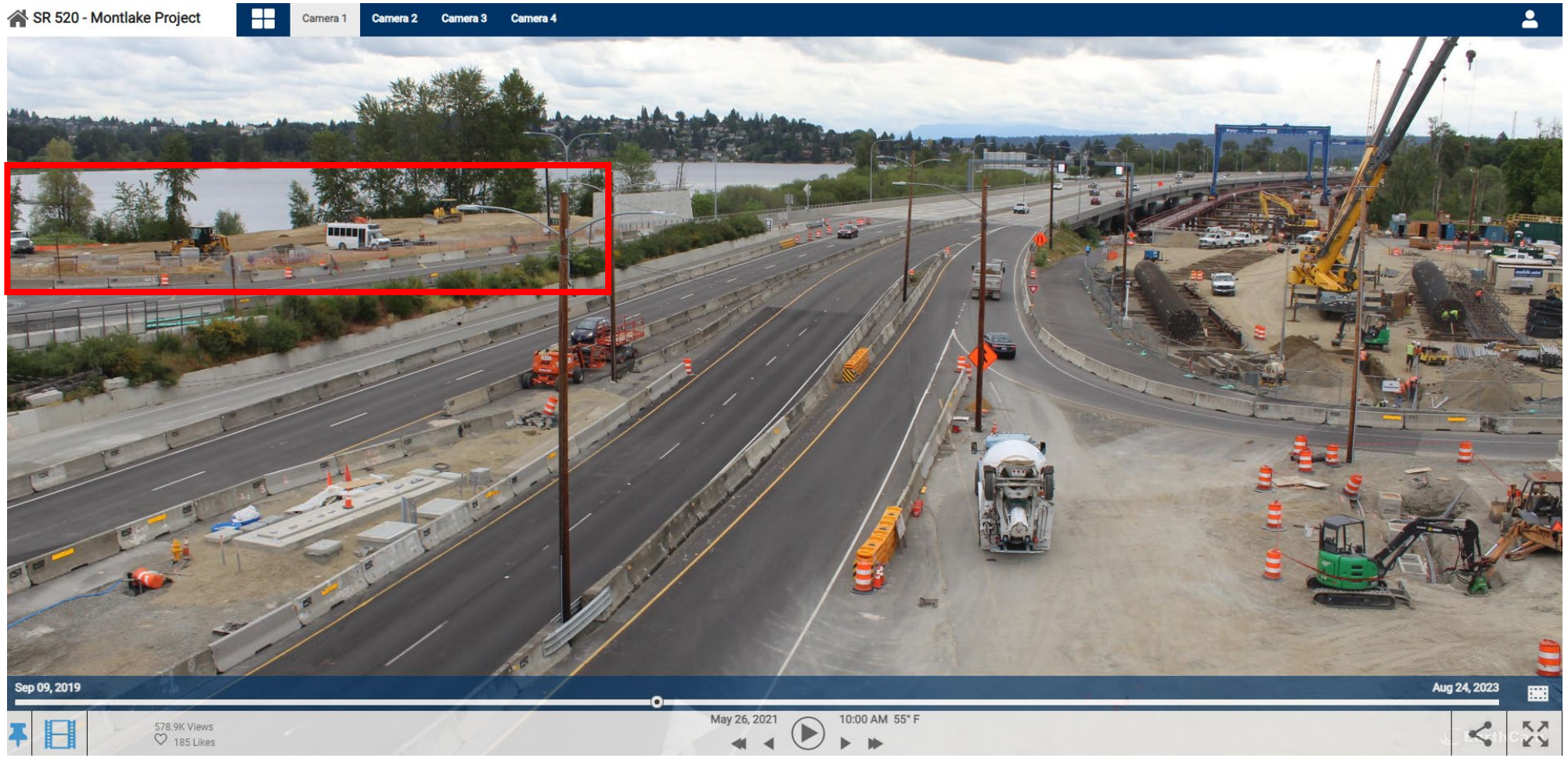
Construction Photos

– Abutment 1



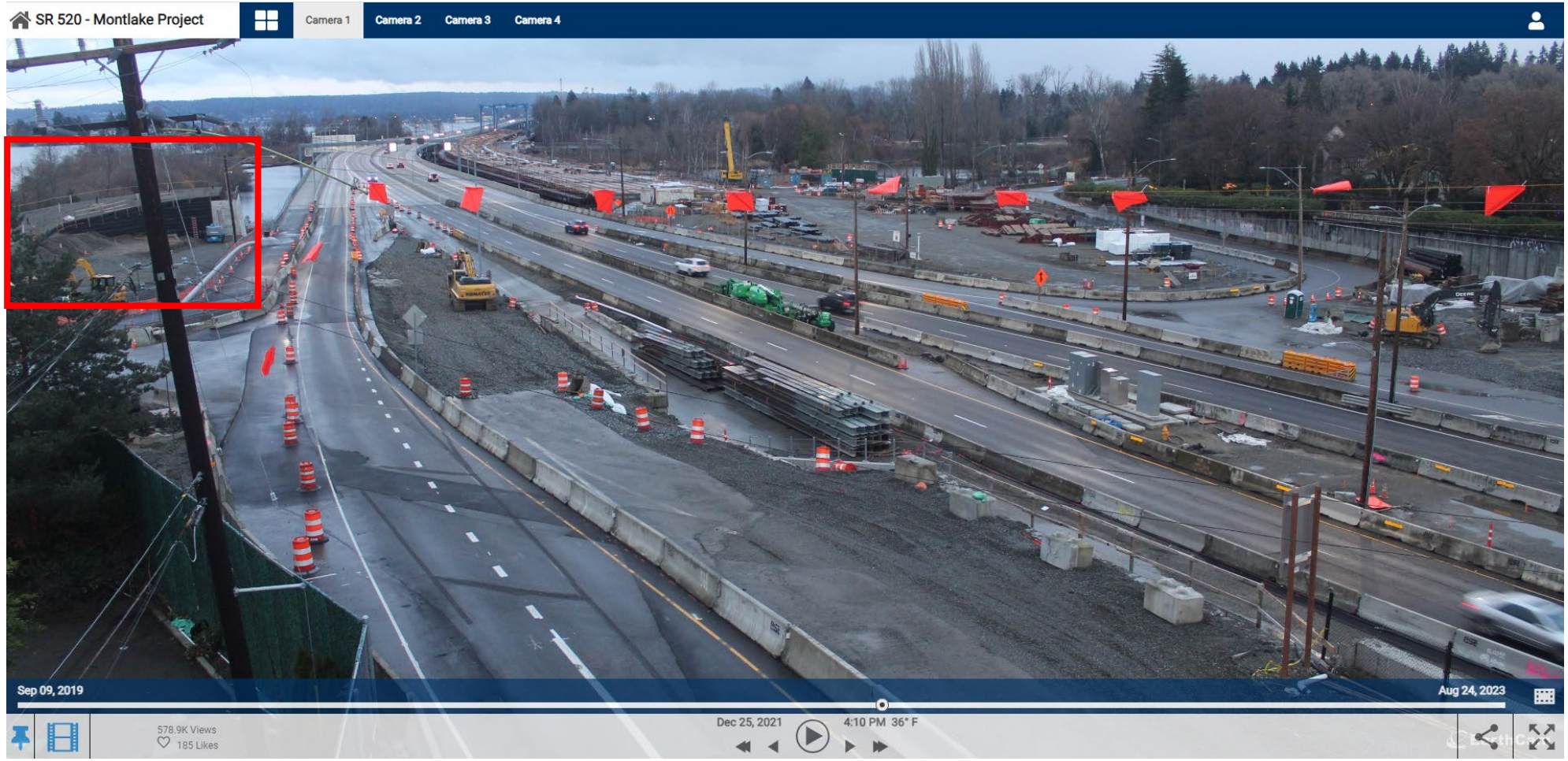
Construction Photos

– Embankment Near Abutment 1



Construction Photos

– Embankment Near Abutment 1



Construction Photos

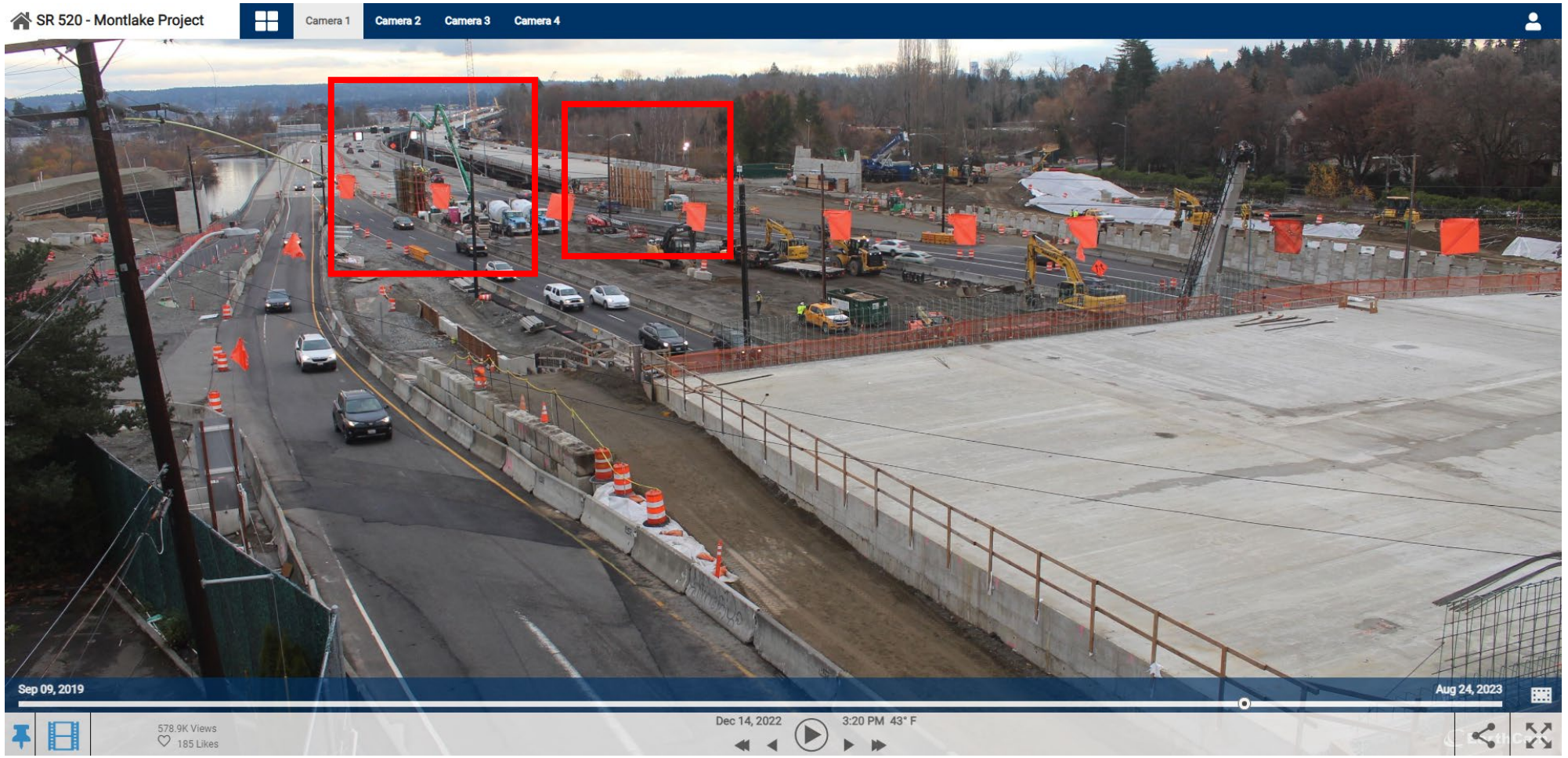
– Pier 3

Construction Photos

– Abutment 4

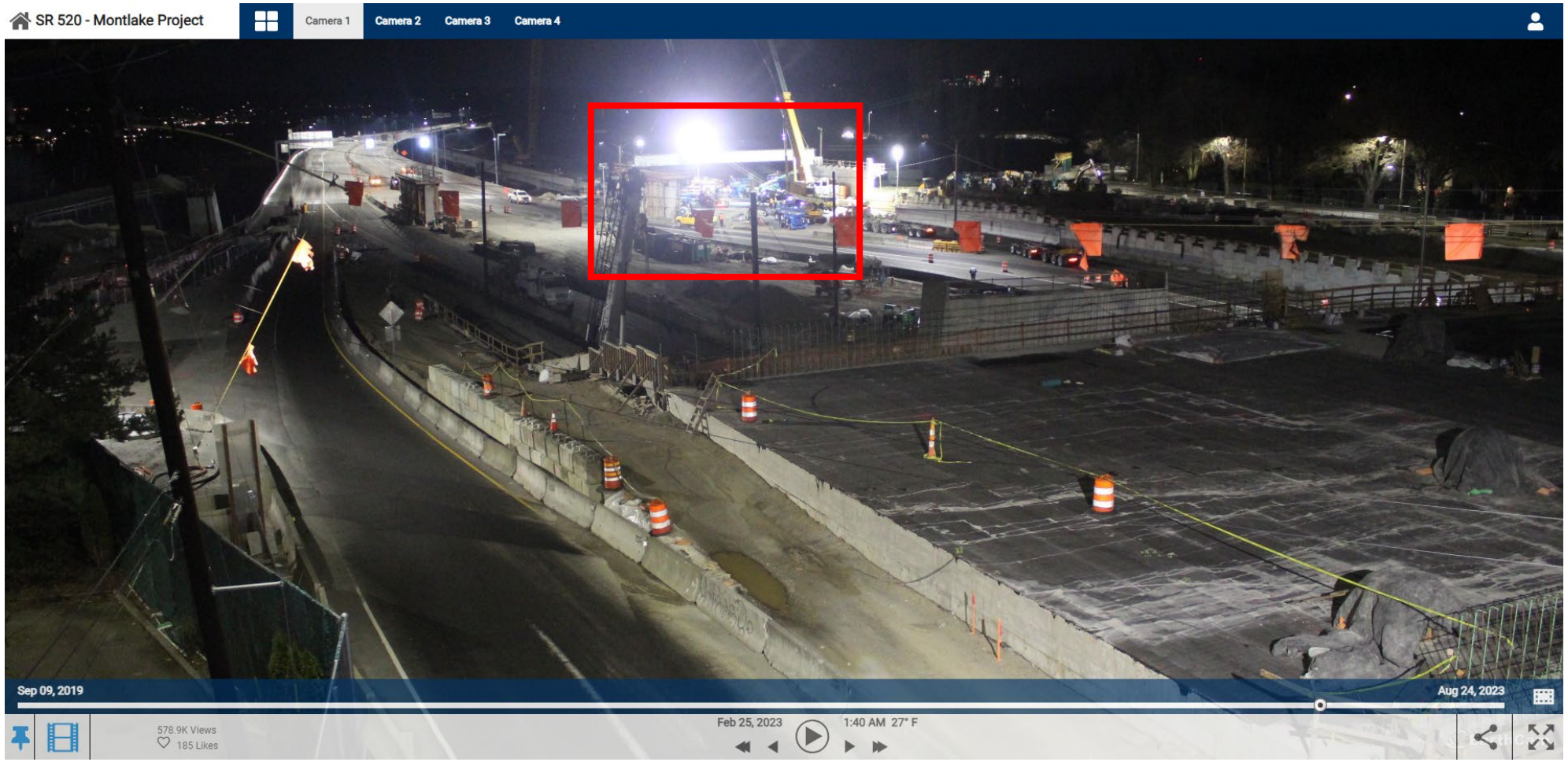
Construction Photos

– Pier 2



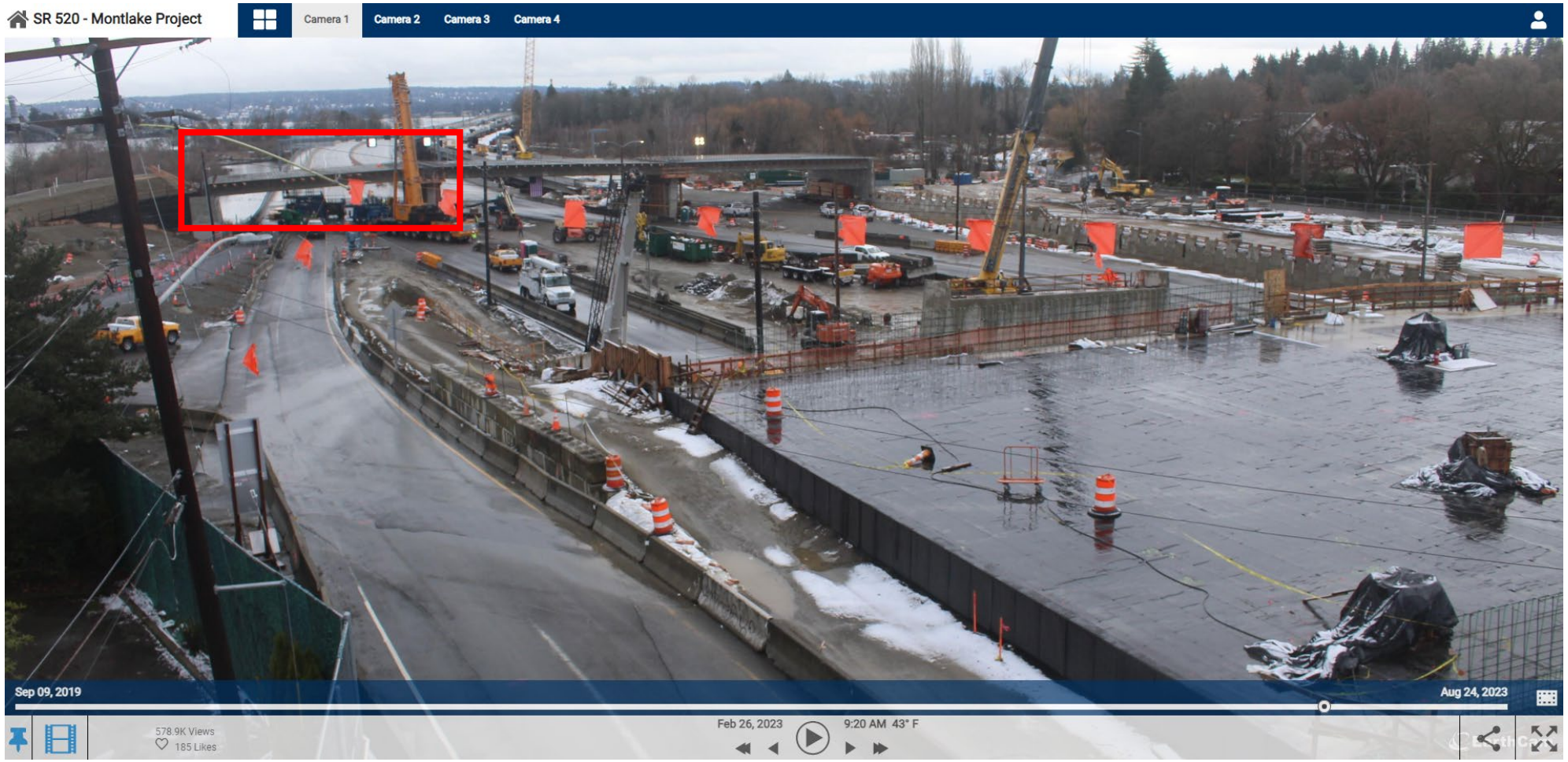
Construction Photos

– 1st Girder place in span 3



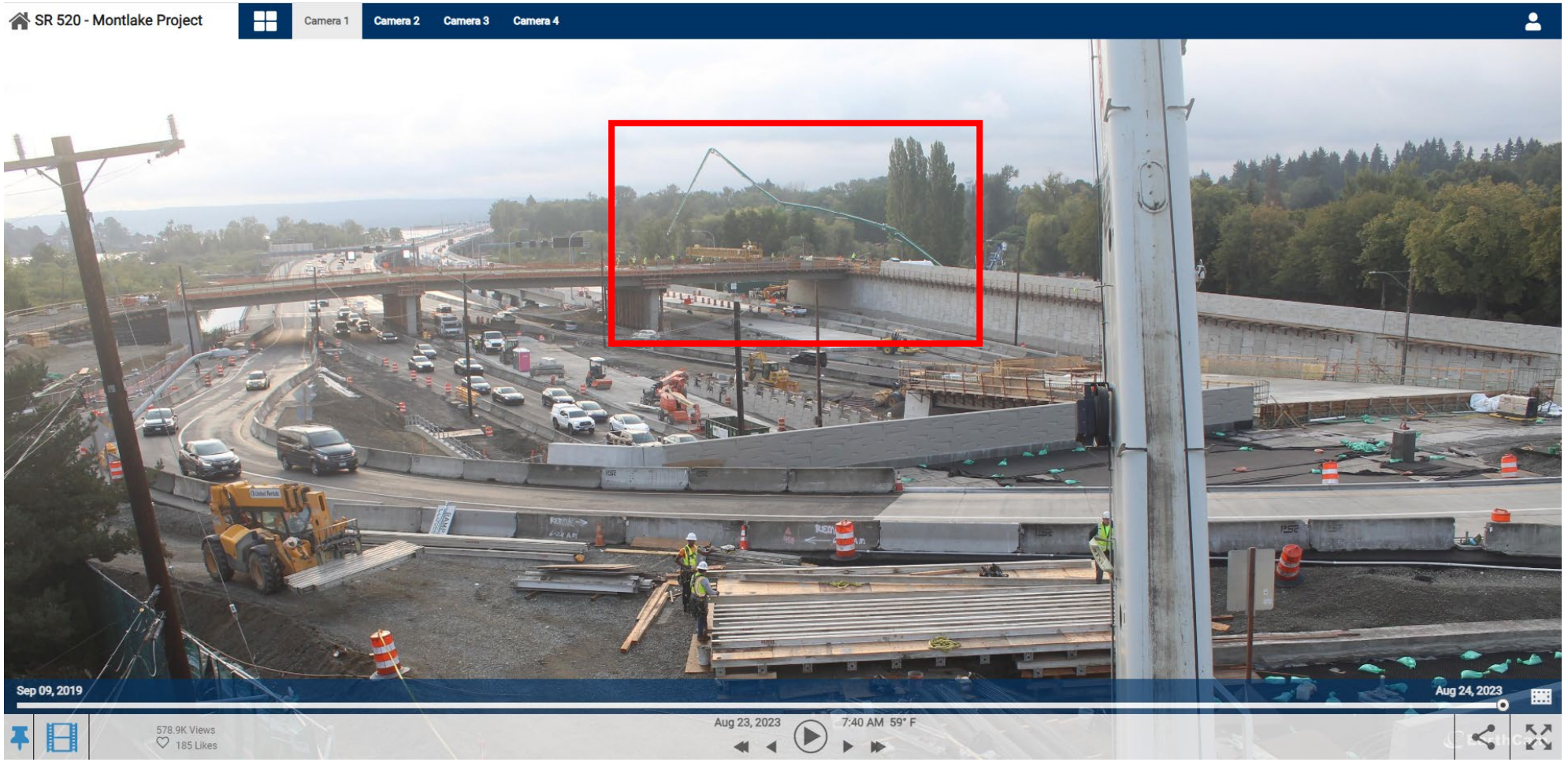
Construction Photos

– Last girder place in span 1



Construction Photos

– Span 3 deck pour



Timeline Summary

- Fall 2018 WSDOT awards DB team $455 million contract
- Summer 2019 construction begins
- April 2020 – RFC plans for PLB completed
- Early 2024 anticipated construction completion date

Questions?