I-405 / SR 167 Direct Connector

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Overview

- Background information
- Talbot Bridges
- East 5 Noise Wall relocation
- Flyover Bridge
  - -Geofoam Approach
  - -Stiffness Balancing
  - -Pipe-Pin Connection

https://www.wsdot.wa.gov/Projects/I405/SR167ICDirectConnector/

The Problem: Traffic Congestion

- This picture was taken on Thursday, August 31, at 8:12 AM
- 12 miles from this location to Bellevue
- Takes about 15 minutes without traffic

https://www.wsdot.wa.gov/Projects/I405/SR167ICDirectConnector/

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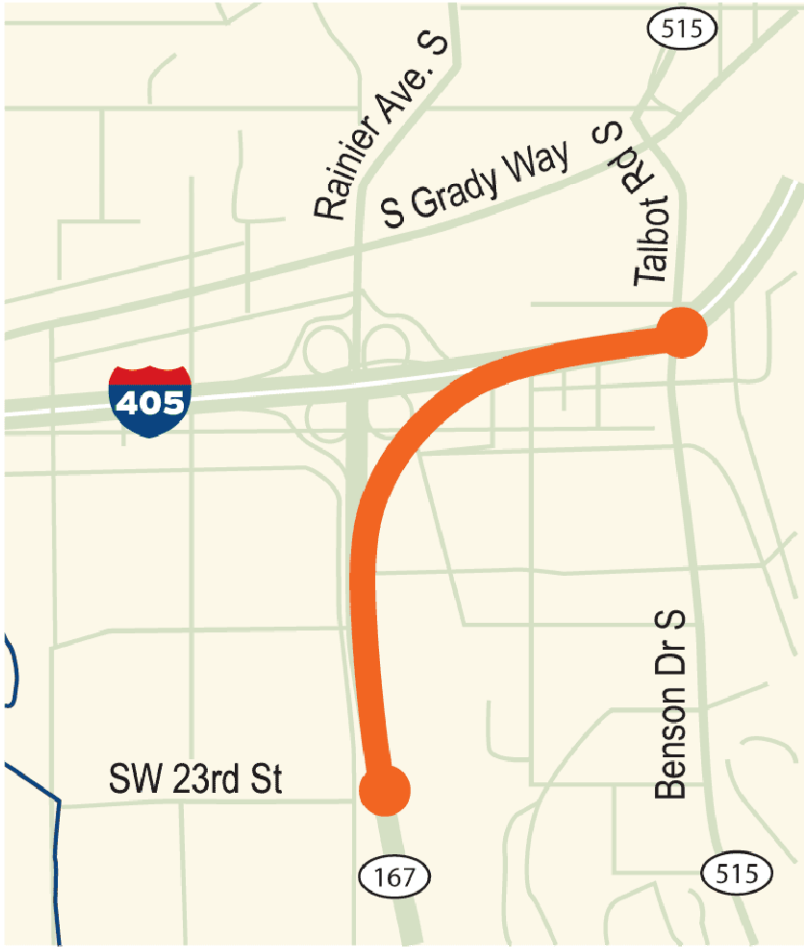
Project Background

- Project to improve traffic near the I-405/ SR 167 Interchange in Renton, Washington
- Will directly connect express toll lanes on I-405 to HOT Lanes on SR 167
- Construction and design = $116M
- Expected completion in mid 2019
- Also includes
  -Seismic retrofit of existing Talbot Road Bridge
  -15 foot wide fish culvert
  -150,000 cubic yards excavation



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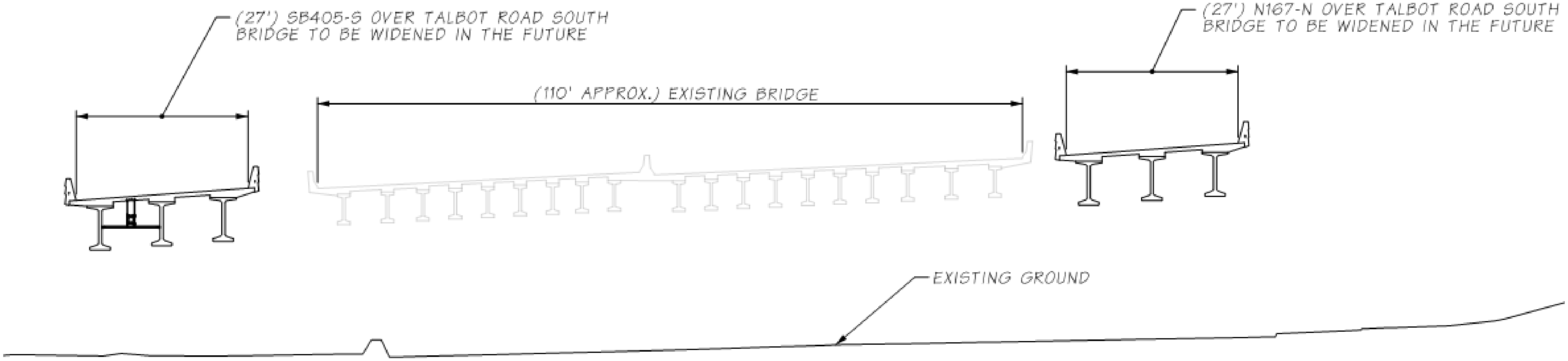
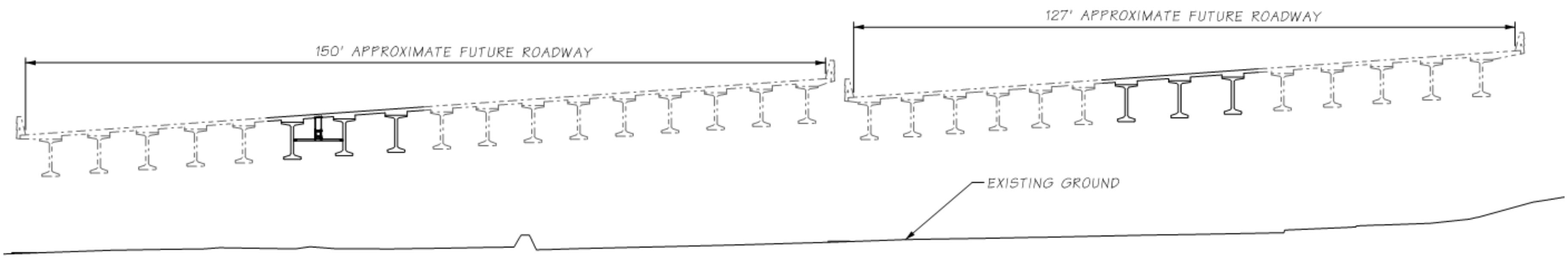
Bridges over Talbot Road S.

- Talbot Bridges
  - Two similar bridges on either side of I405 over Talbot Rd S.
  - Single span (175ft)
  - 27ft wide roadways
  - 3 WF83G Girders
  - Drilled shaft foundations
- Talbot Bridge Retrofit
  - Add girder stops
  - Add seat extensions
  - Strengthen cap beams by widening
  - Add FRP around existing columns to increase shear and displacement capacity

Bridges over Talbot Road S.



TYPICAL SECTION



TYPICAL SECTION-FUTURE

Noise Wall Relocation

- Noise wall was built in 2010
- Existing wall was still in sound condition
- Decided to move wall panels
  - Chipped out grout, removed panels from shafts
  - Numbered and stored panels
  - Installed panels on new shafts that had to be customized for bottom of panel conditions
  - Cut several panels to the correct height and width

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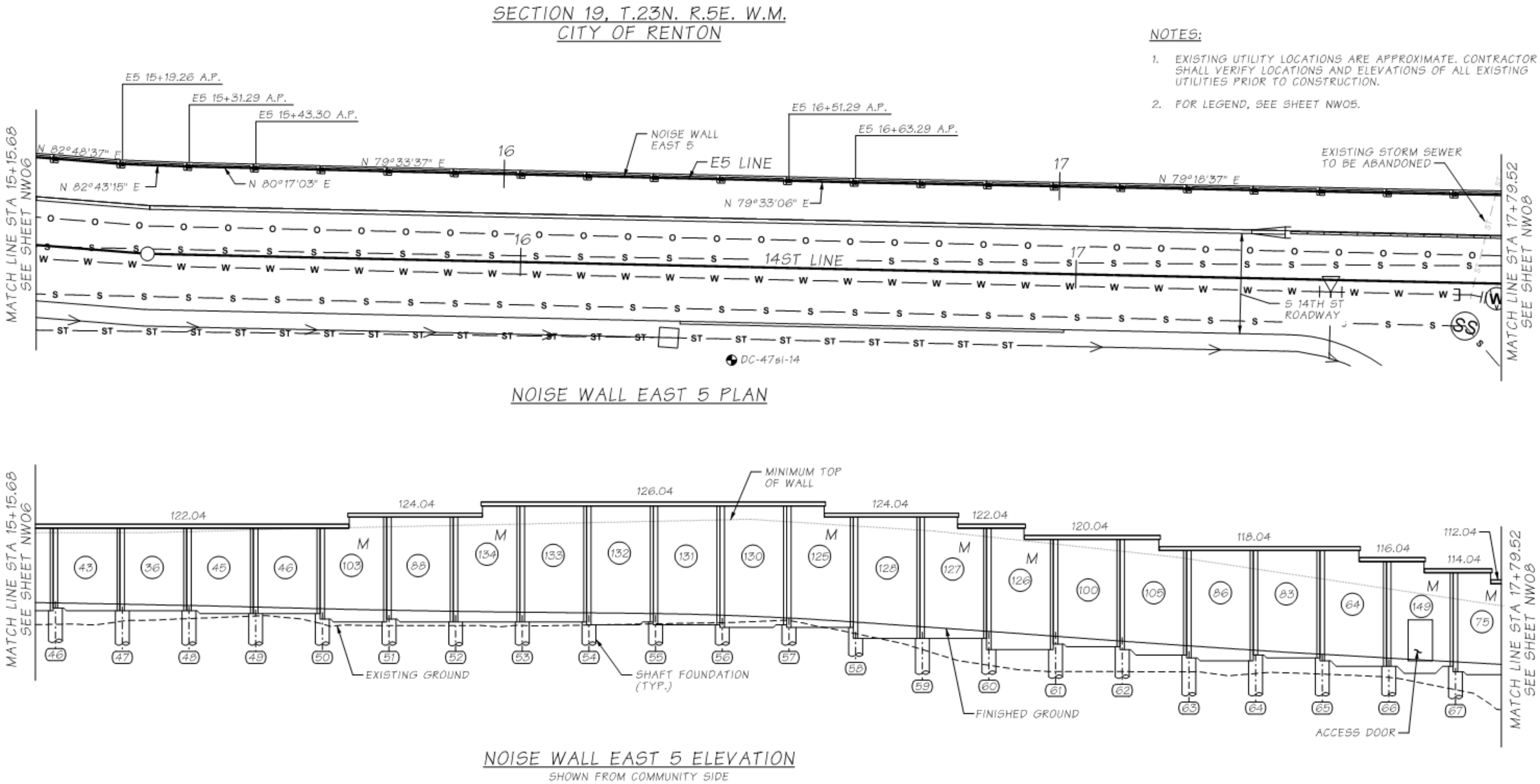
Noise Wall Relocation- Plan and Elevation



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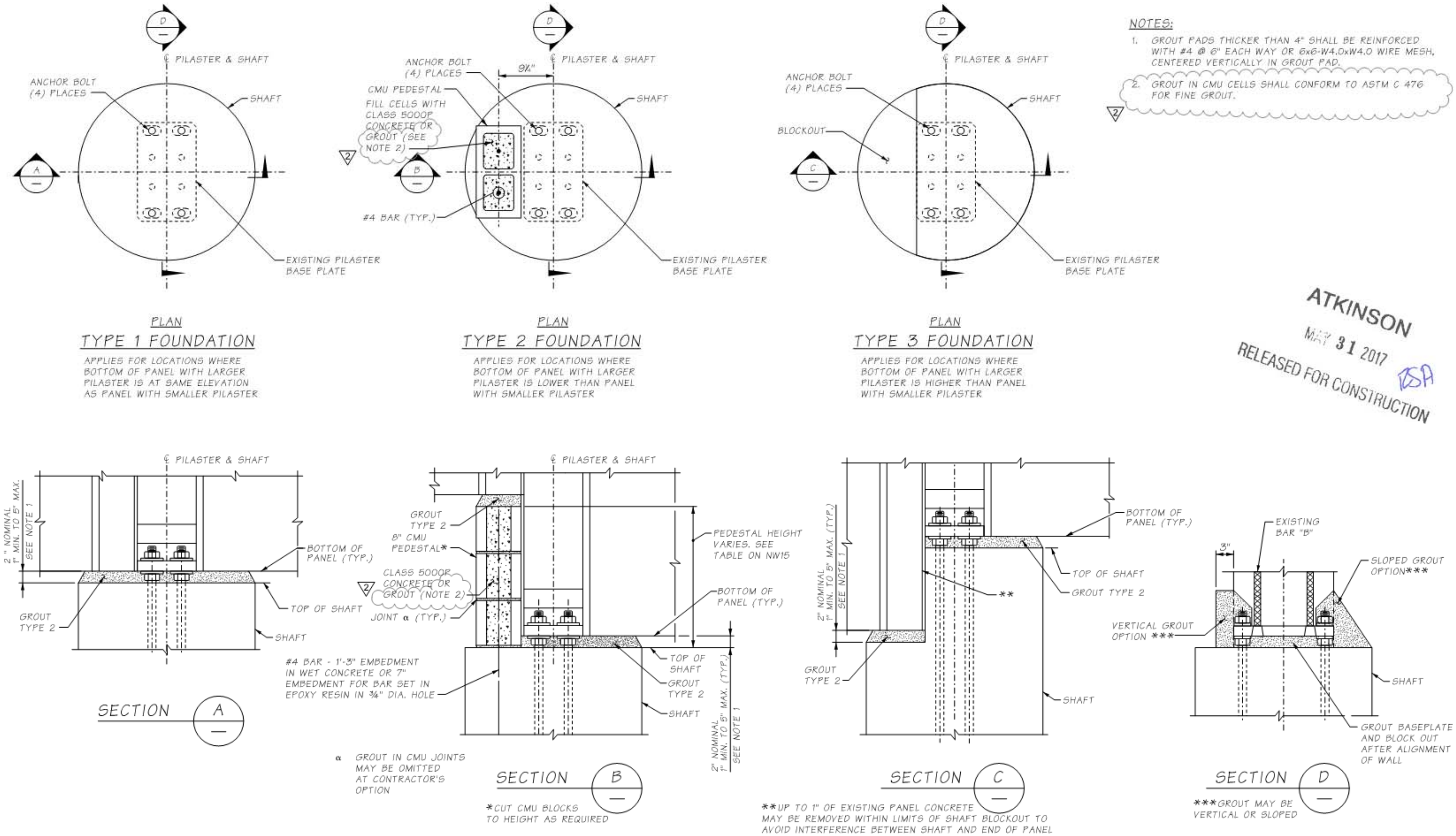
Noise Wall Relocation- Drilled Shafts



Flyover Bridge

- 56 feet wide roadway
- 6 WF95G Girders
- 11 spans (149ft:174ft)
- 2 columns per bent
- 3 post tensioned straddle bents
- 2.5 M (8'-3") diameter drilled shafts ranging from 25ft-85ft depth

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Flyover Bridge- Geofoam Approach

- 50 feet wide SR167 Approach
- Ranges from 8ft-34ft above adjacent ground surface
- Was used in order to limit settlement (zero net load)
- GeoEngineers evaluated compressive stress throughout the geofoam using 3D finite element software PLAXIS 3D v2.2
- EPS19 was used, determined based on the compressive resistance at 1% deformation
- Panels designed as non structural walls

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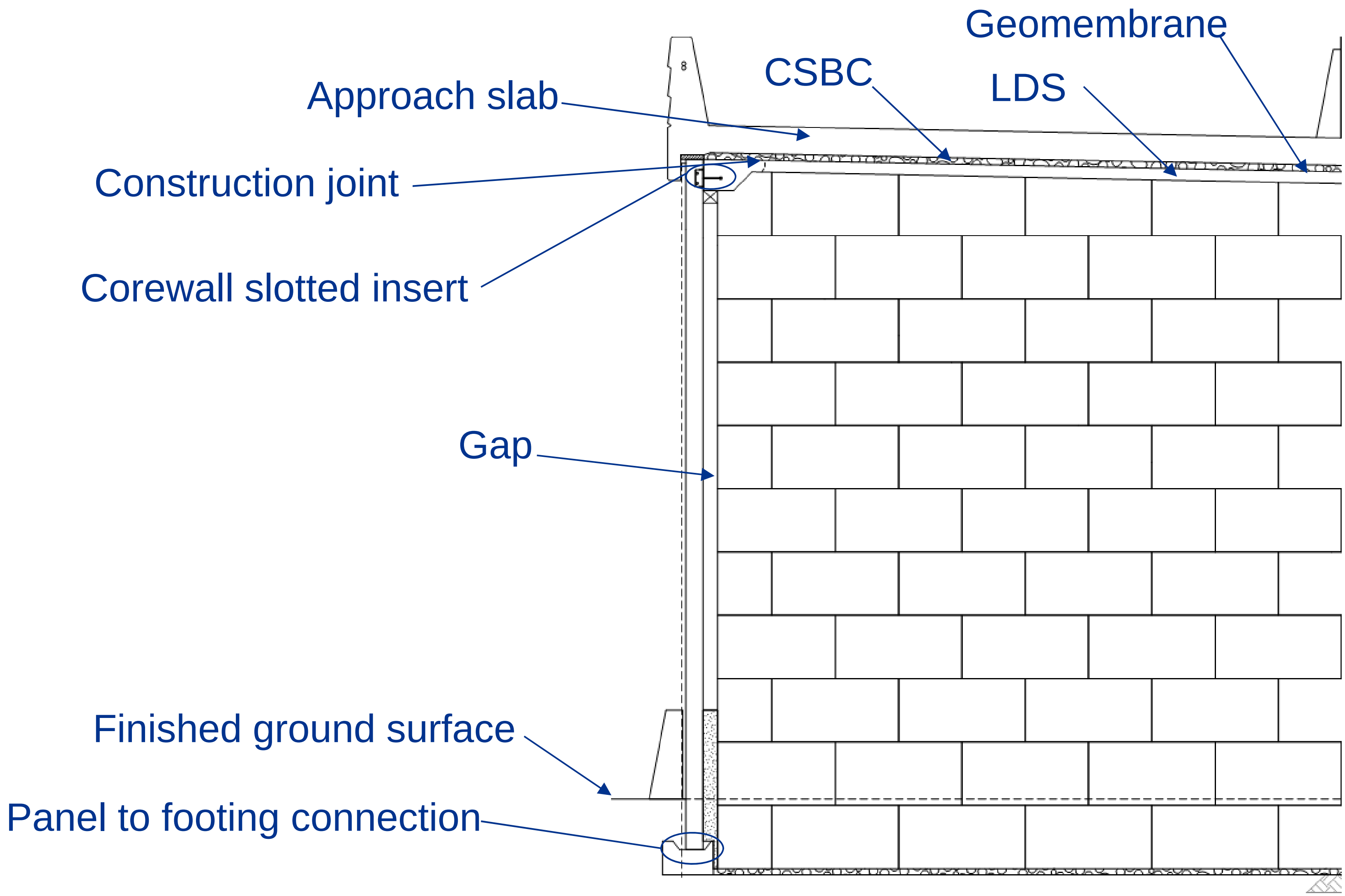
Geofoam Approach- Cross Section



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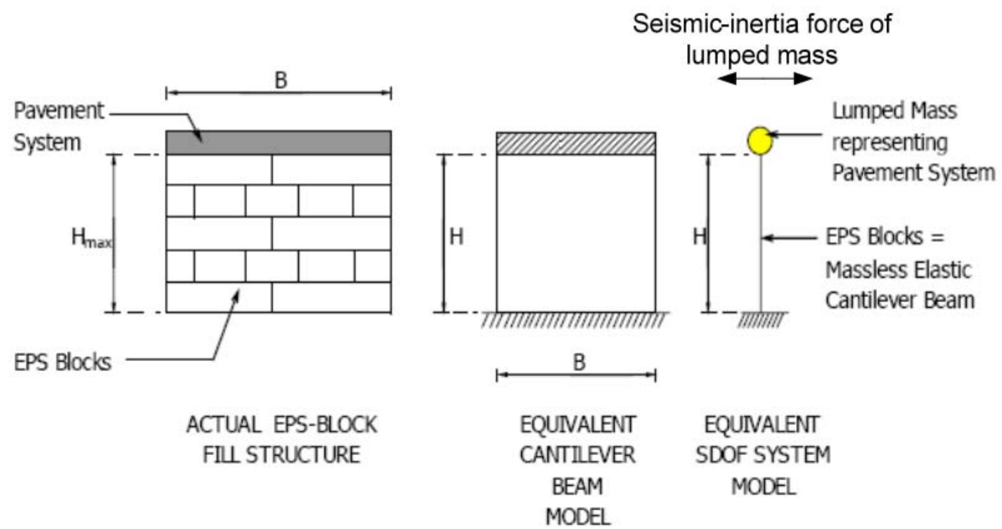
Geofoam Approach- Lateral Load Design

- Controlled by seismic loads
- Site specific response spectrum provided for approach
- Treat embankment like a SDOF system
- Need the period for various wall heights to design the embankment



Raid, H.L.,and Horvath, J. S. (2004). "Analysis and Design of EPS-Geofoam Embankments for Seismic Loading." *Geotechnical Engineers for Transportation Projects(GSP 126): Proceedings of Geo-Trans2004. M.K. Yegian, and Kavazanjian, eds.,* ASCE/GEO Institute, Reston, VA,2028-2037

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Geofoam Approach- Period Equation

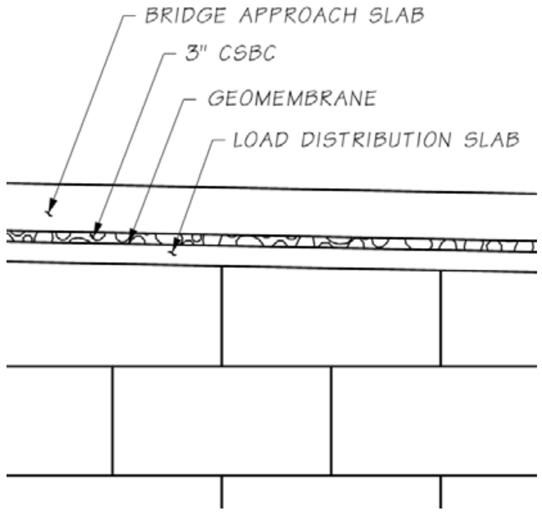
$$T_0 = 2\pi \left\{ \frac{\sigma'_{v_0} H}{E_{t_i} g} \left[4\left(\frac{H}{B}\right)^2 + \left(\frac{12}{5}\right)(1+\upsilon) \right] \right\}^{1/2} \quad \textbf{(4.24)}$$

where

T_0	=	resonant period of the SDOF system
H	=	height of embankment
E_{t_i}	=	initial tangent Young's modulus of the EPS
g	=	gravitational constant = 9.81 m/s^2 = 32.2 ft./s^2
B	=	embankment width
υ	=	poisson's ratio for the EPS (typically taken to be ≈ 0.1 within the elastic range as is applicable for lightweight-fill applications)

Geofoam Approach- Interface Shear

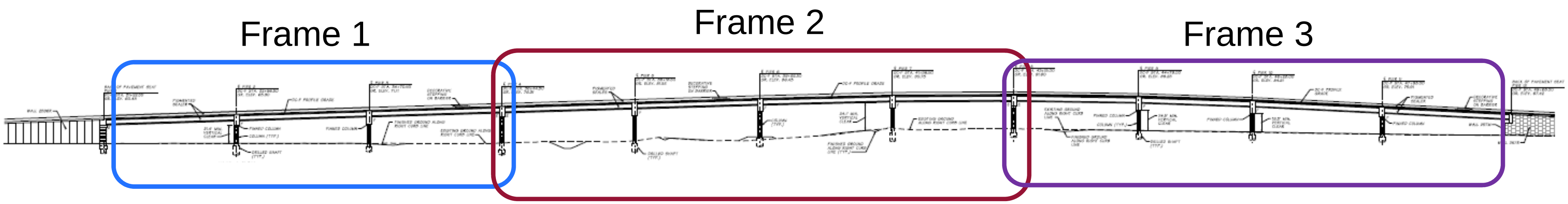
- Need to be able to develop the shear across all interfaces
- Geomembrane to load distribution slab potential slip plane
- In order to transfer shear through geofoam to geofoam interface need to glue blocks
- Determined the percent of blocks that needed to be glued.



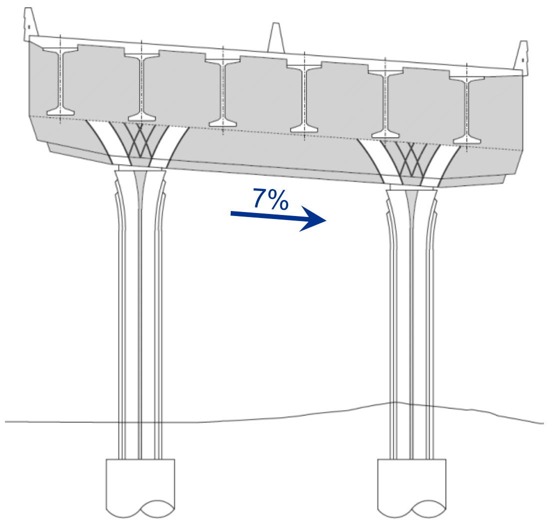
Flyover Bridge

- Span Arrangement:
  - Total 11 spans. Longest span = 175’-0”
  - 2 intermediate expansion joints
- 10 Intermediate Piers:
  - 7 typical bents
  - 3 post-tensioned straddle bents
- Horizontal curve alignment, R = 1063’-0”
- Cross slope = 7%

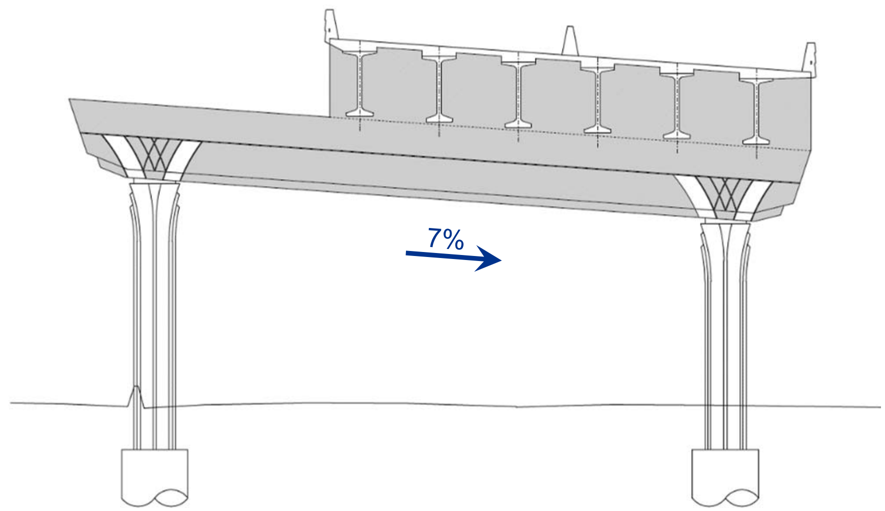
Flyover Bridge



BRIDGE ELEVATION



TYPICAL PIER ELEVATION

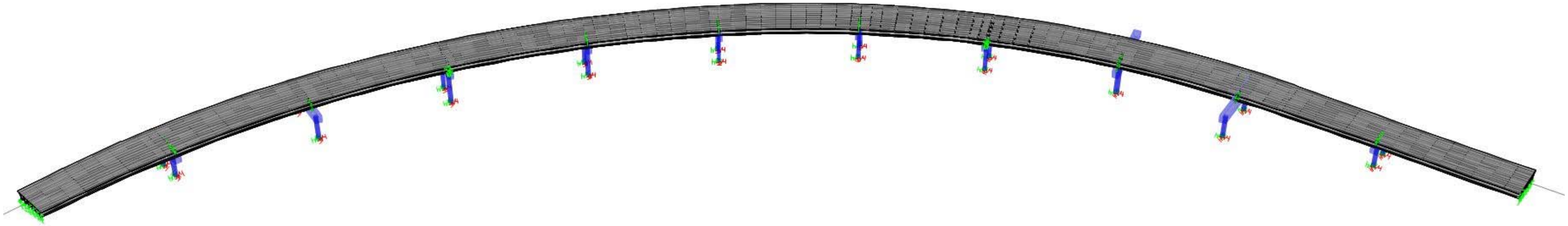


POST-TENSIONED STRADDLE PIER ELEVATION

- Column to column spacing: 28’ to 72’
- Column height: 24’ to 40’

Flyover Bridge

- CSIBridge 3D model



- Vertical & horizontal profiles
- Material properties
- Superstructure properties
- Crossbeam dimension
- Column heights and spacing
- Foundation springs

Balanced Stiffness

- AASHTO Seismic Guide Spec. 4.1.2:
  - Any two bents within a frame, $k_i / k_j > 0.5$
  - Adjacent columns within a bent, $k_i / k_j > 0.75$
  - Adjacent bents within a frame, $k_i / k_j > 0.75$

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Options

- Increase/Decrease Column Lengths
  - 1’-0” to 5’-0” of soil cover
  - Silos not used

Options

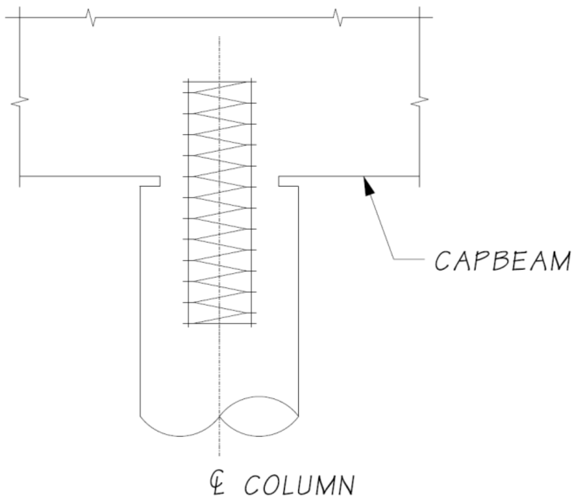
- Change Column Size
  - 5’ x 5’ column
  - 6’ x 6’ column at Pier 9 (PT straddle bent)

Options

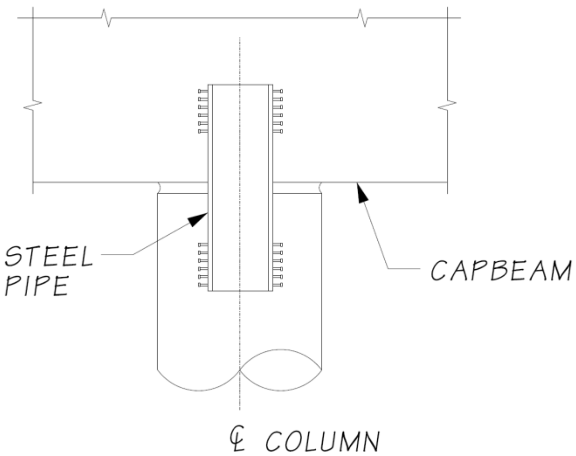
- Modify Column Boundary Condition
  - Pinned at all PT straddle bents
  - Pinned at piers adjacent to straddle bents
  - Fixed at remaining piers

Pin Connection Options

- Reduced concrete section
- Embedded pipe-pin
- Disk bearing



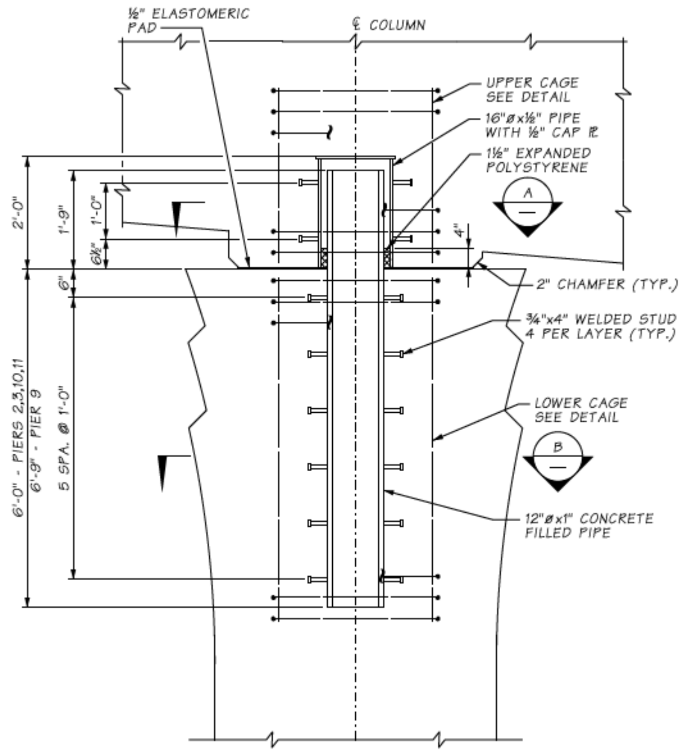
REDUCED CONCRETE SECTION



EMBEDDED PIPE-PIN

Pipe - Pin Connection[1] at Top of Column

- Concrete filled inner pipe
- Steel exterior can
- ½” elastomeric pad
- Additional reinforcement



COLUMN PIPE PIN DETAIL
PIERS 2,3,9,10 & 11

[1]Seismic Design of Pipe-Pin Connections in Concrete Bridges by Arash E. Zaghi & M. Saiidi, Jan. 2010 (Dept. of Civil Engineering, University of Nevada)

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Construction Photos

Construction Photos

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- WSDOT
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Questions?

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Interface Shear-COF

Table 1. Summary of Interface Friction Factors (After Sheeley, 2000)

Interface	Peak Friction Factor	Residual Factor
Foam-Foam, 20 kg/m^3 (dry)	0.85	0.70
Foam-Foam, 20 kg/m^3 (wet)	0.80	0.65
Foam-Foam, 30 kg/m^3 (dry)	0.85	0.65
Foam-Foam, 30 kg/m^3 (wet)	0.75	0.65
Foam-Foam with grips (20kg/m^3)	Not Recommended	
Foam-Foam with grips (30 kg/m^3)	Not Recommended	
Foam-Sand base (ϕ=35°)	$\leq \phi$	$\phi_{residual}$
Foam-Cast in Place Concrete	2.36	1.00
UV Degraded Foam-Cast in Place Concrete	0.87- <2.36	0.71- <1.00
Foam-Textured HDPE Membrane	1.00	~ 1.00
Foam-Smooth HDPE Membrane	0.29	0.23
Foam-Textured PVC Membrane	0.60	0.44
Foam-Smooth PVC Membrane	0.70	0.40

The results from this and previous investigations indicate that regardless of density, applicable normal stress levels or surface conditions a lower bound interface friction factor of 0.6 can be used for design. This

INTERFACE FRICTION PROPERTIES OF EPS GEOFOAM

D. Negussey[1], N. Anasthas[2] and S. Srirajan[2]

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