Replacing The Alaskan Way Viaduct

Downtown Seattle

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Washington State Department of Transportation

2011 Western Bridge Engineer Seminar
September 25-28, 2011
The Arizona Grand Resort

Downtown Seattle looking NE across Elliott Bay

2 miles of reinforced concrete double deck structure built in stages during the 1950's

100kADT SR99

I5, freight mobility

Ballard-Interbay to Duwamish industrial center

Overview

- **Existing Viaduct**
- **Replacement Program**
- **South End Work**
  - **Elevated Viaduct**
  - **"Little h" Overcrossing**
- **Central/Waterfront Work**
  - **Cut-and-Cover Tunnels**
  - **Deep Bored Tunnel**

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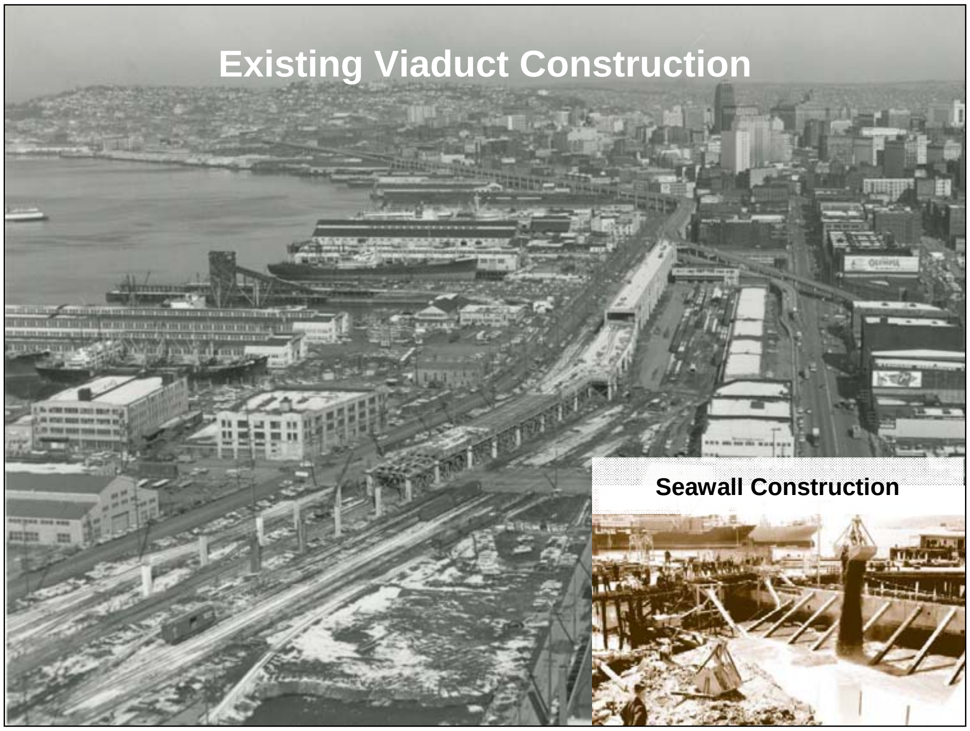
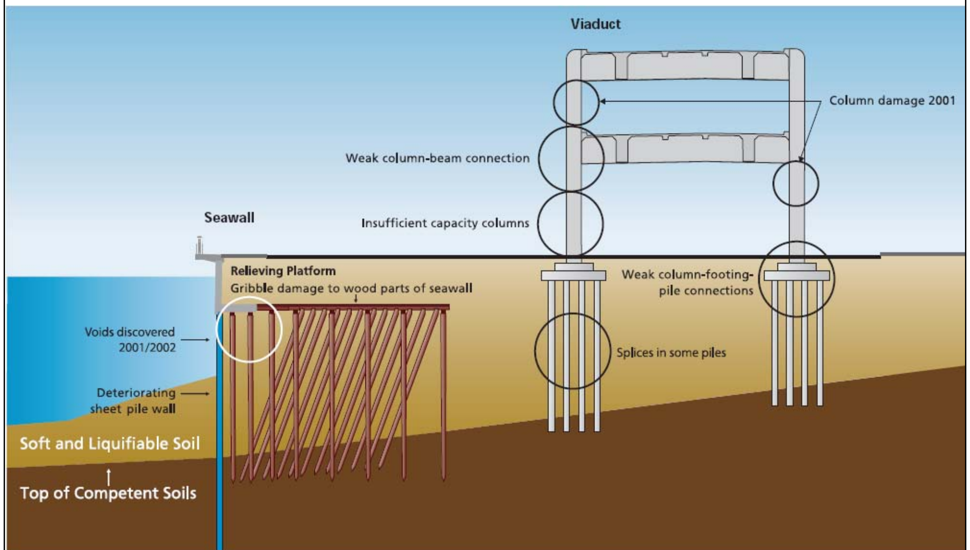
$3.1B state work
$4.2B state/county/city work



- Built on tidelands
- Seattle history of re-grading projects
- Waterfront trestle structures
- Seawall constructed in 1934

- 1905, neighborhood abandoned, area was filled and turned into a railyard
- Findings stored at UW Burke Museum

Structural Vulnerabilities



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- In this graphic, the darker shade of soil is competent soil – glacial till. The lighter shade is softer compressible soil, which is subject to liquefaction in an earthquake.
- The viaduct and seawall were seriously damaged in the 2001 Nisqually earthquake –
  - M6.8 quake with 40 sec of ground shaking
  - And the viaduct has moved several times since. In 2008, we strengthened four column footings, where the viaduct had settled approximately 5-1/2 inches.
  - The repairs have limited further settlement into the soil.
- Marine borers (gribbles and shipworms) are further weakening the seawall by eating away the (untreated) wood sections of it.
- Neither the viaduct nor the seawall can reliably withstand another major earthquake, and they cannot be safely retrofitted.

Replacement Program

2001 – Nisqually Earthquake, M6.8

2002 – Replacement planning began

2007 – South End “Moving Ahead” projects begin

2009 – Deep bored tunnel agreement

2013 – South end structures complete

2015 – Tunnel complete

2016 – Demolish remaining viaduct

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2001 - Nisqually quake and seismic vulnerability

Load restrictions

6 month inspection cycle

Column repairs

2002 - 76 options identified narrowed to 5

2007 – Moving Forward: Column repairs, Electrical line relocations, Battery Street Tunnel Maintenance, South End Viaduct, Transit Improvements

2009 – State, County, City, Port

2010 – South End awarded to Skanska

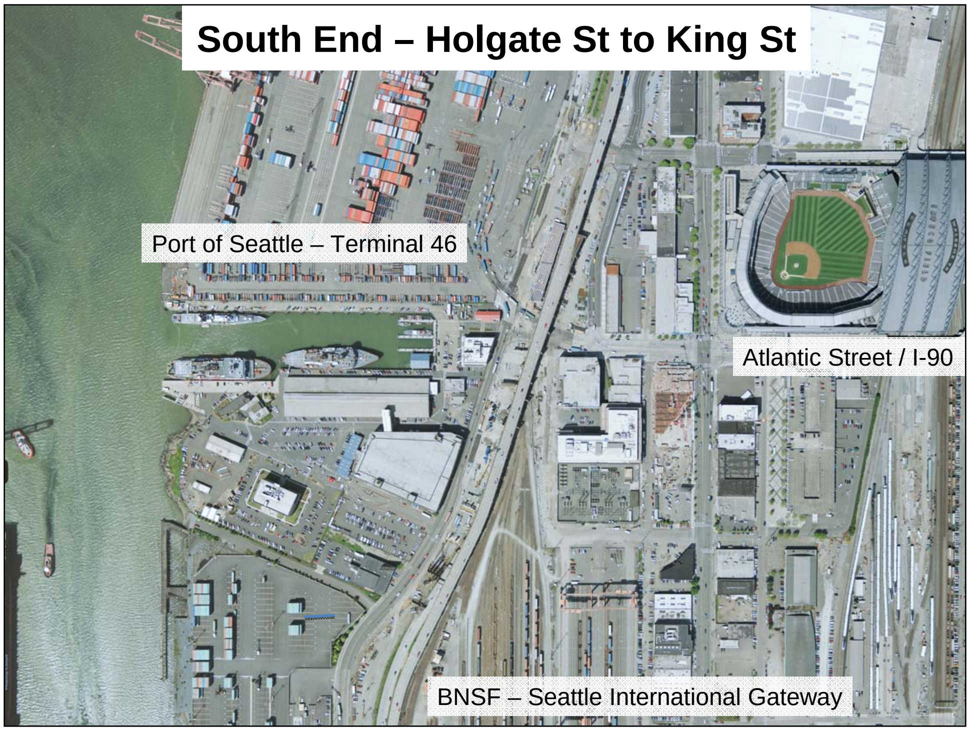
2011 - Design-build contract awarded to Seattle Tunnel Partners

Stakeholders

WDOT, COS, POS, BNSF, Transit, Private

Costs

Tunnel $1.9B
South End/Planning $0.9B
Demo/Surface $0.3B
State Total $3.1B
City $0.9B
County $0.2B
Total $4.2B



Demolish south half of viaduct - ~1 mile
Add 1900 ft structure, 100ft wide, 6 traffic lanes
Add 60,000 SF overcrossing
Crosses RR, Port gateway, city traffic.

Coast Guard slip

Mainline Contract
PCPS girders on deep foundations.
LRFD Guide Spec 1000-yr event, site specific design criteria
Skanska $115M - 4/2010 - $43M for viaduct
$225/SF

North end of the southern mile

No major disruption to SR99 traffic. (staging or construction activities/settlement)
Existing on/off ramps
Tail track adjacent to track

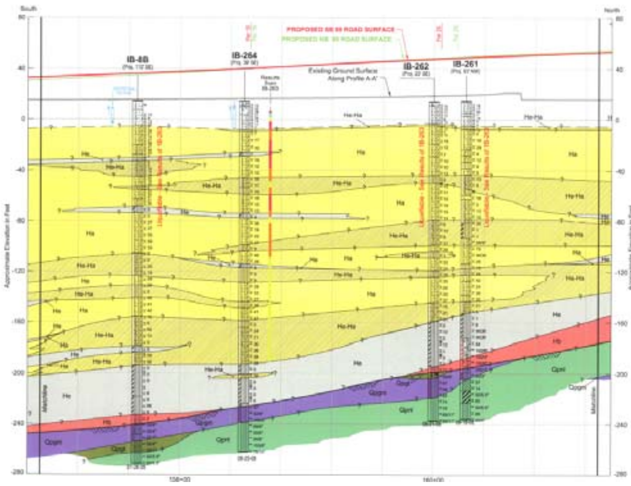
New structure along side in close proximity
Tail track relocated
Ramps converted with detour structure
Demo

Structure built full width
Little h overcrossing for Port bypass
Staging area and Launch Pit for TBM in Orange

Primary goal to maintain traffic on SR99 during construction.

Subsurface Profile

- 20 ft of historic fill
- 200+ ft of liquefiable soils
- 940 ton dragload
- 4 ft of lateral spread to the west
- Existing viaduct piles are supported on compressible soil



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Subsurface:

20 ft of fill incl. concrete, timber, sawmill byproducts

Elevated RR and roadways prior to turn of century when the land was a tideflat

Timbers from seawall, industry, existing viaduct

Liquefaction typically only considered to 80 depth.

Up to 18 in of soil settlement.

LRFD, Seismic Guide Specification, 1000-yr event, (2) site specific spectra.

This photos shows the proximity of new construction to the existing viaduct
Shaft drilling, pile driving, and ground improvement work are adjacent

Shaft Foundations

- 3 meter diameter shafts up to 145 ft deep
- Casing oscillator with cutting teeth specified

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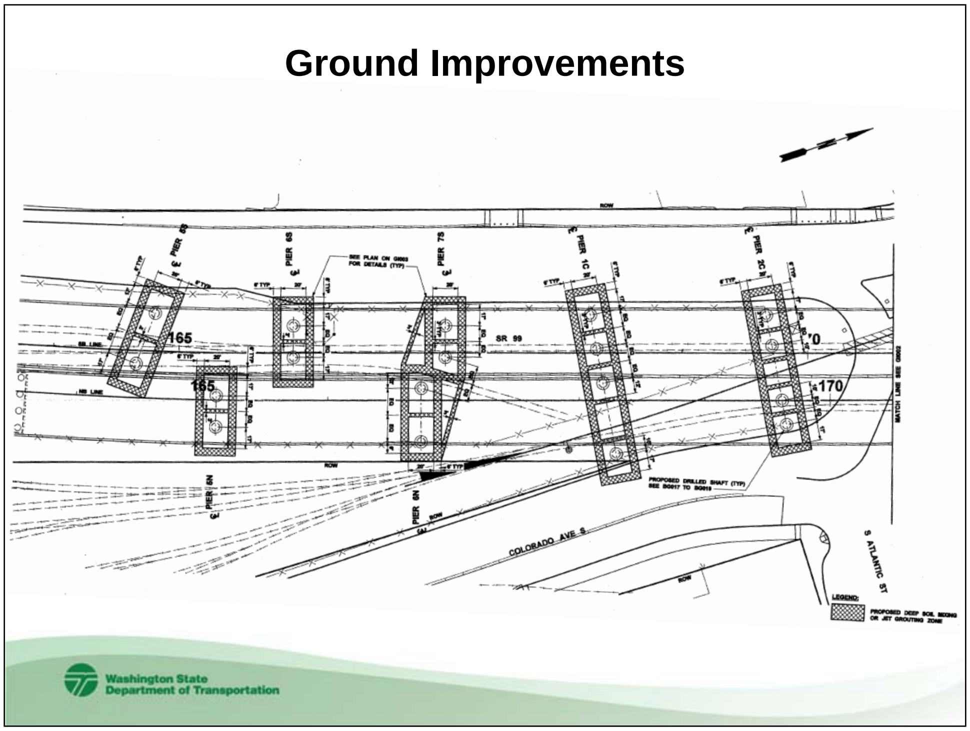
Single-column/single-shaft used up to depth of 145 ft.

3 meter diameter

Malcolm drilling

Cased excavation needed.
Oscillator required in the contract for wood debris, deep casing requirements, and vibration reduction.
1 ips PPV contract limit at existing viaduct.



Ground improvement needed near coast Guard Slip 36.

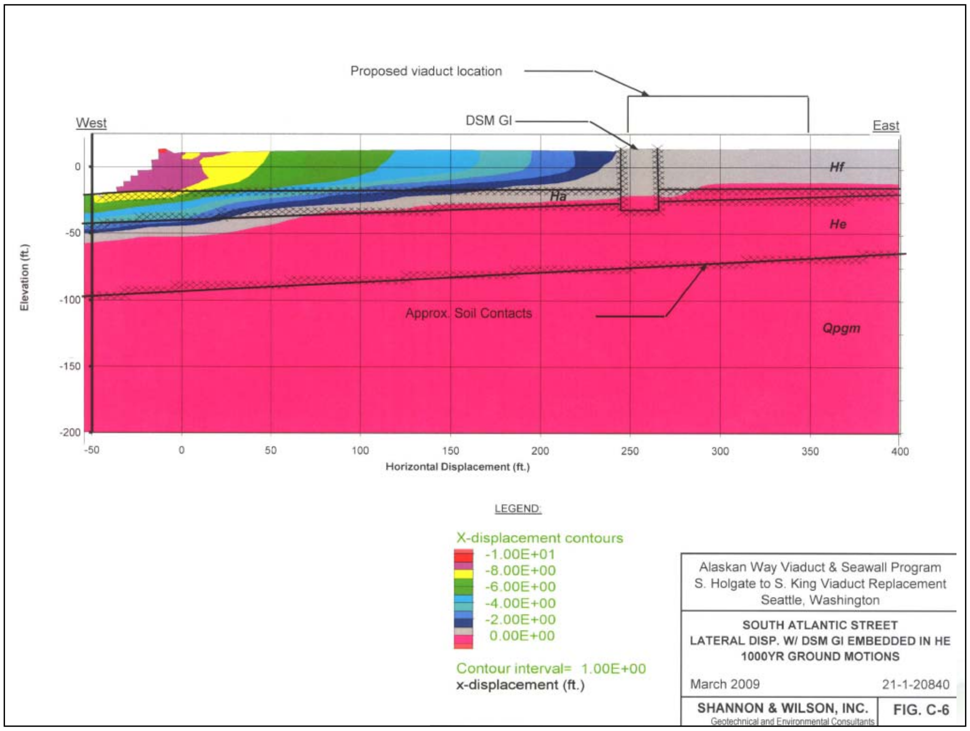
Utilities/ROW precluded a cutoff wall

6' thick exterior walls

$6.4M

CDSM cells constructed in stages

Jet grouting used as a closure between stages and in areas of low headroom.



This graphic shows lateral soil displacements under seismic-induced liquefaction.

4 ft of lateral spread expected w/o improved ground

The cells are extended into non-liquified layer

Designed for sliding/overturning structural capacity

300 psi at 28 day required strength for the soil-cement

Cutter head used rather than the auger

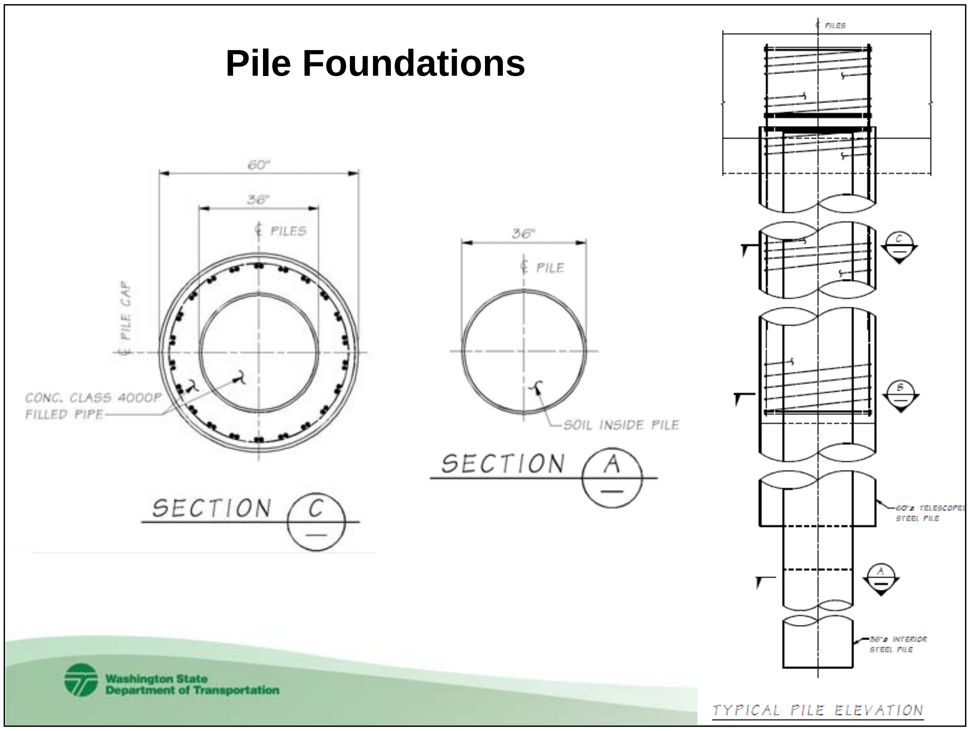
- Cutter penetrates obstructions
- Steerable with head speed adjustment
- Less construction vibration

Grout nozzle between heads

10’ pretrenching

Minimum overlap of 4”

Cement and bentonite silos



5’ diameter concrete/steel pile groups used where depths exceed 145 ft. Up to 270’.

Driven open ended with cutting shoe to minimize vibrations

Over 1,600 ton capacity

Telescoping piles used on higher capacity piles where deeper, harder driving conditions are encountered. (12)

Pile cleanout reduces hammer requirements and vibrations.

Over 2,400 ton composite capacity

Reinforcing provides flexural resistance at top.

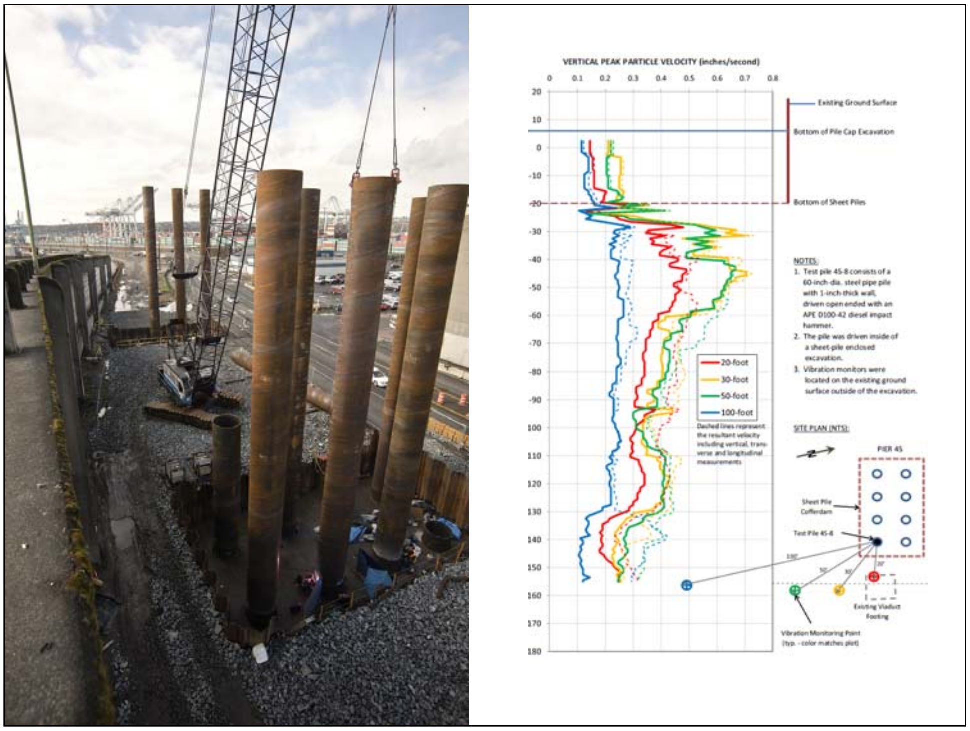
Steel pile provides axial resistance at bottom

940 ton DD carried by 5’, else carried by 3’.

Separate driving criteria

5’ tip at 235’ bgs
Cleaned out to 70’ bgs
Temporary centralizers used within pile
3’ tip at 270’ bgs

Combination of VT and UT testing of welds.



Notice proximity to existing viaduct, existing piles are susceptible to settlement. Shows 5’ dia. piles at Pier 4S

70 ton timber/concrete-follower piles with minimal embedment into competent layer.

Vibration limit of 1 ips PPV at existing viaduct

Settlement limit of 1” total, ½” differential within bent

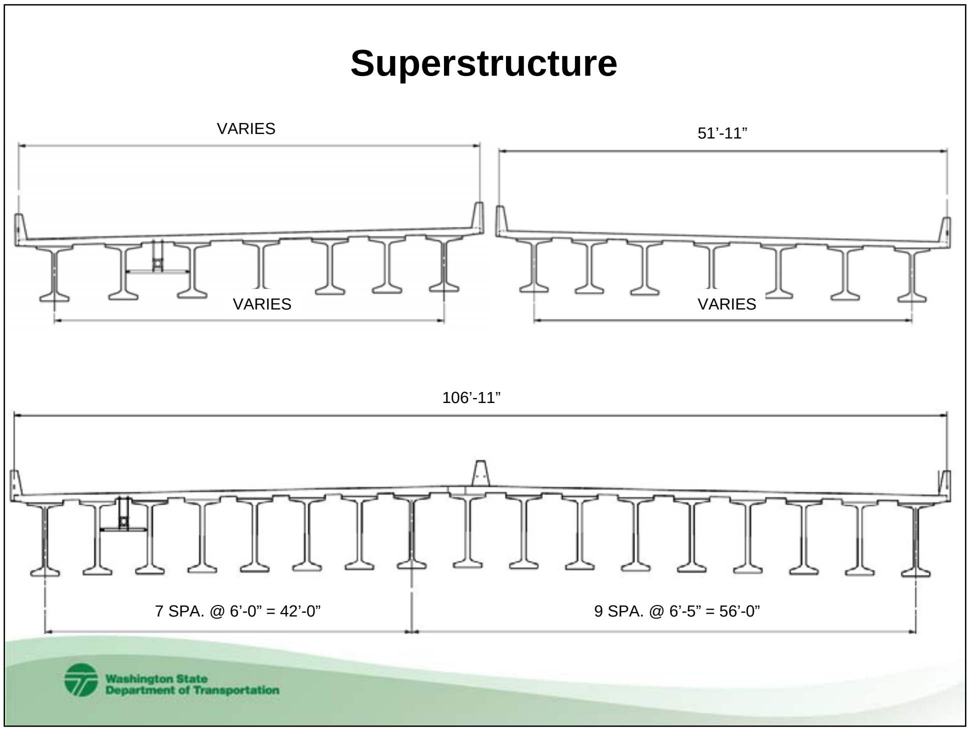
Measurement require 5, 10, 20, 50, 100ft during test pile

Monitor piers within 50ft of exc, 200ft of piles, before and after each drive

Cofferdams damped vibrations

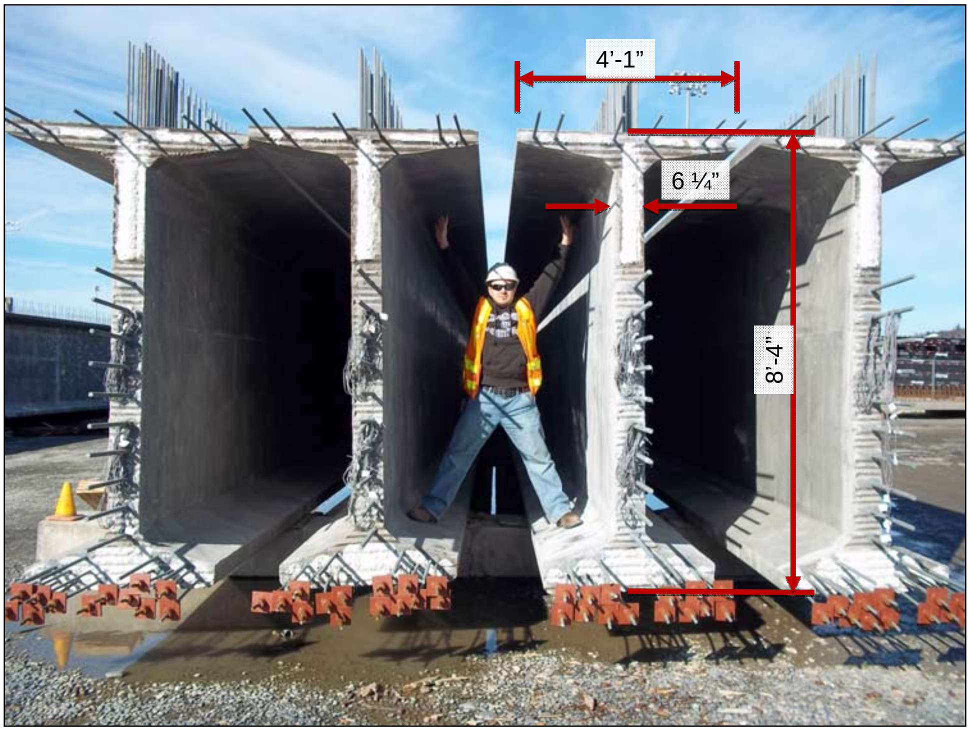
Settlements and vibrations were just within thresholds.

Micropile retrofits.



210' main span crossed Atlantic St:

BNSF tailtrack crosses obliquely



WF100G girder

3,600 kips of prestress force, 80+ 0.6”ø strands

First WSDOT use of this new girder series.

GWU research

-205 ft length

-250+ kips

-16'+ of vertical clearance depending on camber.

- Raised a signal span-wire

V Van Dyke

Adjustable-width trailer axles.

First 2 WF100G girder set in place

2 set per night governed by the number of specialty trailers (otherwise 8 per night)

Span of variable depth girders in place.

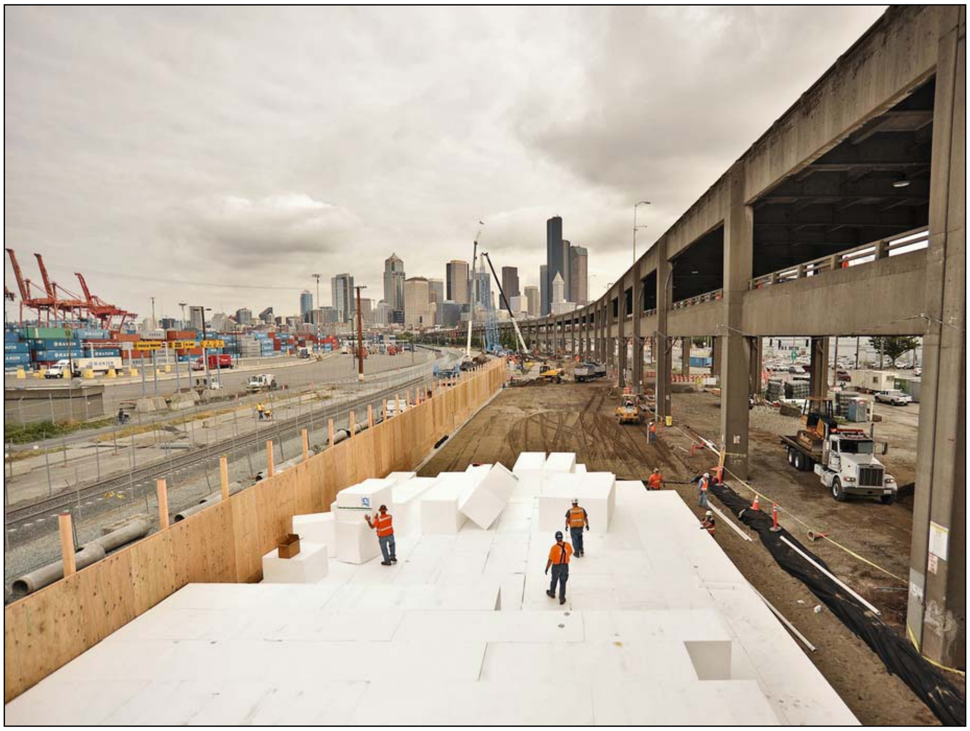
Typical flange forms used, custom web form inserts used.

Girder Cost:

WF74 = $400/LF

WF74-100 = $490/LF

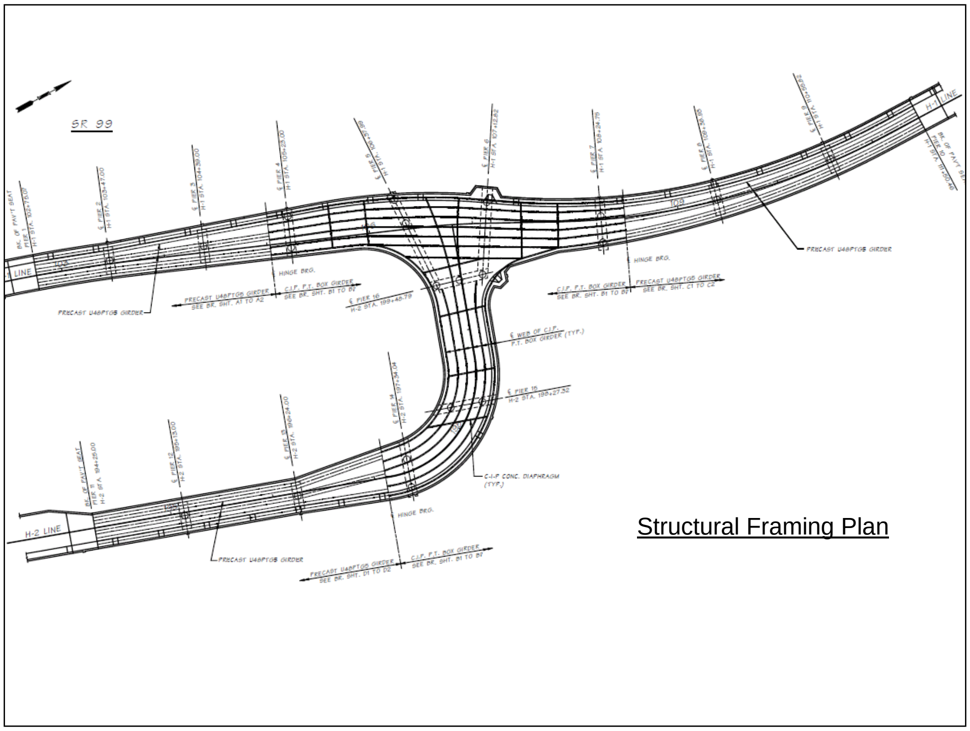
WF100 = $600/LF



Expanded polystyrene (geofoam) fill used to mitigate consolidation settlement effects on existing structure.

Provides Port traffic crossing of tail track

Provides East Marginal Way crossing of tail track



Structural Framing Plan

3 legs are curved and straight PC P/T tubs cast integral with piers.

Central hub is Haunched CIP P/T box

Connected by in-span hinges.

Curve radii as low as 37

Central Waterfront Tunnel

- Approximately 2 two miles of deep bore and cut-and cover tunnel
- 100 year design life
- Designed to 2,500-year earthquake (approx 9M)
- 2011 Design-Build contract awarded to Seattle Tunneling Partners

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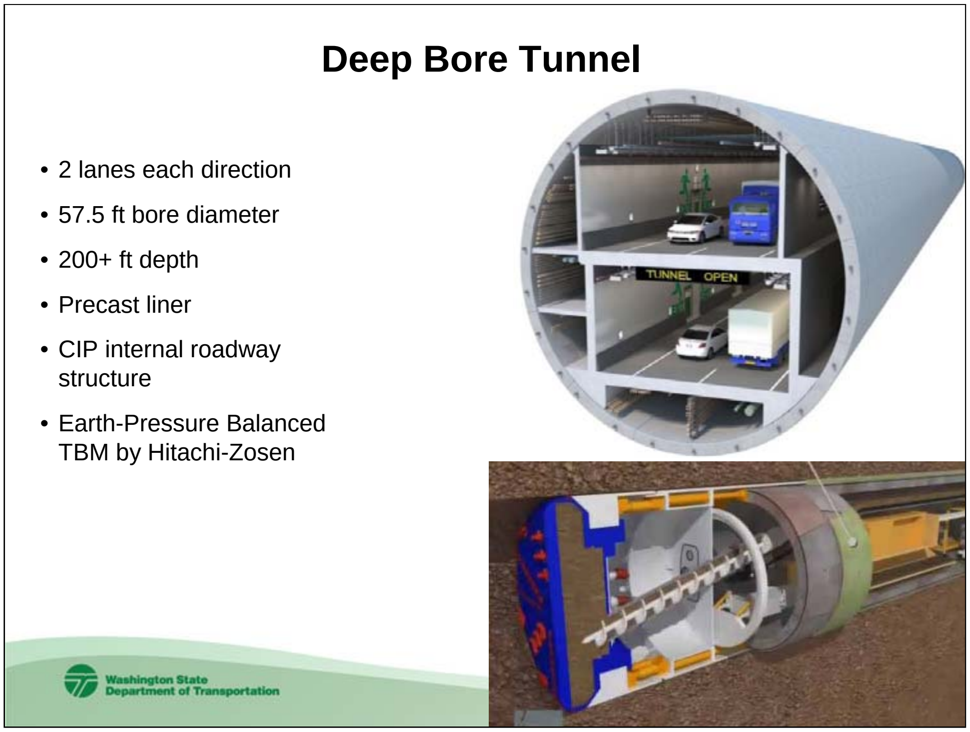
Speaker

- The proposed bored tunnel would minimize construction disruptions for businesses and the traveling public. It would allow us to keep SR 99 and the viaduct open to traffic during construction.
- The bored tunnel would also maintain a vital route for people and goods through downtown Seattle, while also improving the environment of the downtown waterfront and opening it up for public use.

State-of-the-art safety systems

- The tunnel is being designed to withstand an earthquake that only happens every 2,500 years on average (in the range of a 9.0 on the Richter scale) without collapsing.
- We've coordinated with emergency services throughout design. The tunnel would include a 24-hour control center providing a direct link to emergency responders.
- Emergency exits every 650 feet would provide access to secure waiting areas.
- Tunnel would include the latest technology for ventilation, fire detection and suppression, security and lighting systems.

- **STP = Dragados-Tutor Perini-HNTB**



100-year design life

Life Safety at 2,500-yr, operational at 100-yr

10 panels per ring

9273 LF of Tunnel

Ring width 6.53’

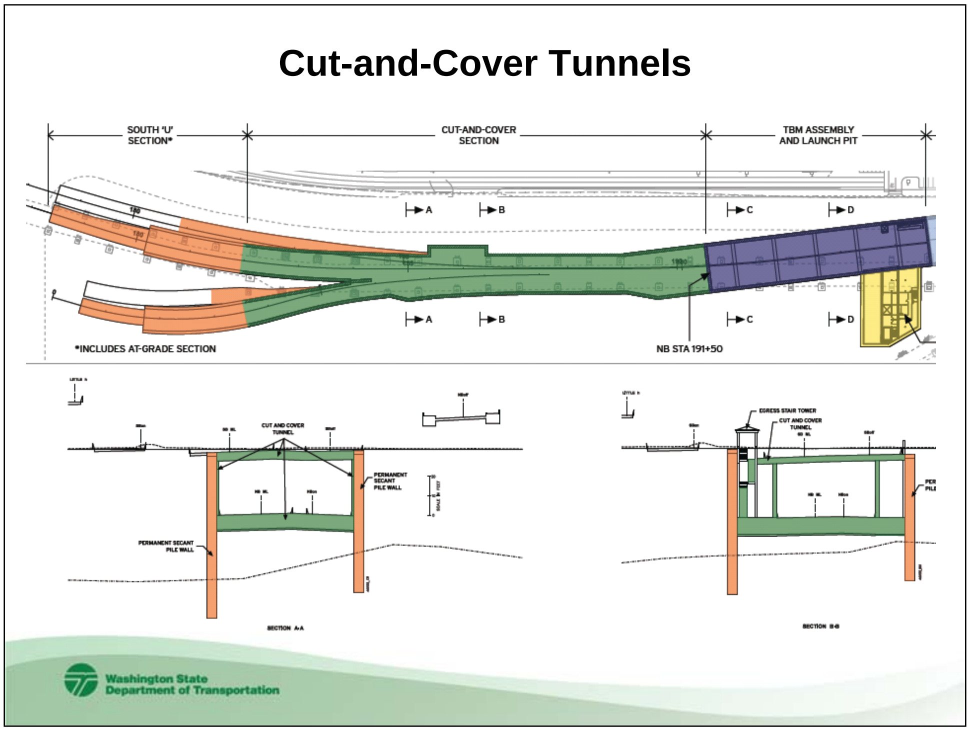
Number of Rings 1420

Total Number of Panels 14,200

Each Panel 18.2’ by 6.53’ by 2’ (9 cy/panel)

~125,000 cy

f’c at 56 days 12,000 psi w/5% microsilica



Oscillated drilled shafts for secant pile wall

Groundwater and Buoyancy

Internally braced during construction

Tipped into till for liquefaction

Design

100-yr design life, w/ liquefaction------------

Life Safety at 1,000-yr, operational at 100-yr


Questions?