SR99 BORED TUNNEL

ALASKAN WAY VIADUCT AND SEAWALL REPLACEMENT PROGRAM

SEATTLE, WA

October 16, 2017

DRAGADOS

INDEX

DRAGADOS

Overall Project Description

DRAGADOS

The Alaskan Way Viaduct; the Nisqually Earthquake

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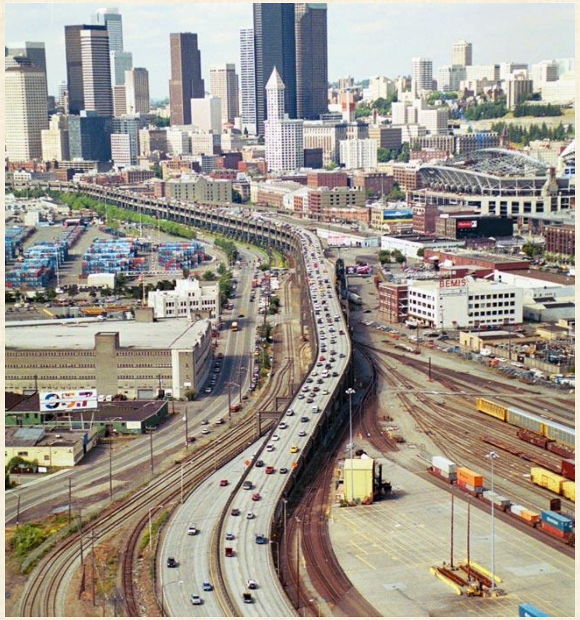
- Built in the early 50’s, the Alaskan Way Viaduct (AWV) is part of the State Route 99 that crosses downtown Seattle from South to North. It helped to relieve congestion of trains, trucks and wagons carrying cargo to and from ships.
- AWV used to carry 110,000 vehicles per day before demolition of the South ramp started, back in October 2011.



The Alaskan Way Viaduct; the Nisqually Earthquake

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- In 2001, the 6.8 Nisqually earthquake damages the AWV, which is closed several months for inspection and limited repairs. The Viaduct and Seawall replacement project begins.
- In 2009 After evaluating the several options proposed, Governor, King County Executive, Seattle Mayor and Port of Seattle CEO recommend replacing the viaduct's central waterfront section with a bored tunnel beneath downtown. State Legislature approves bored tunnel funding.

Procurement Process

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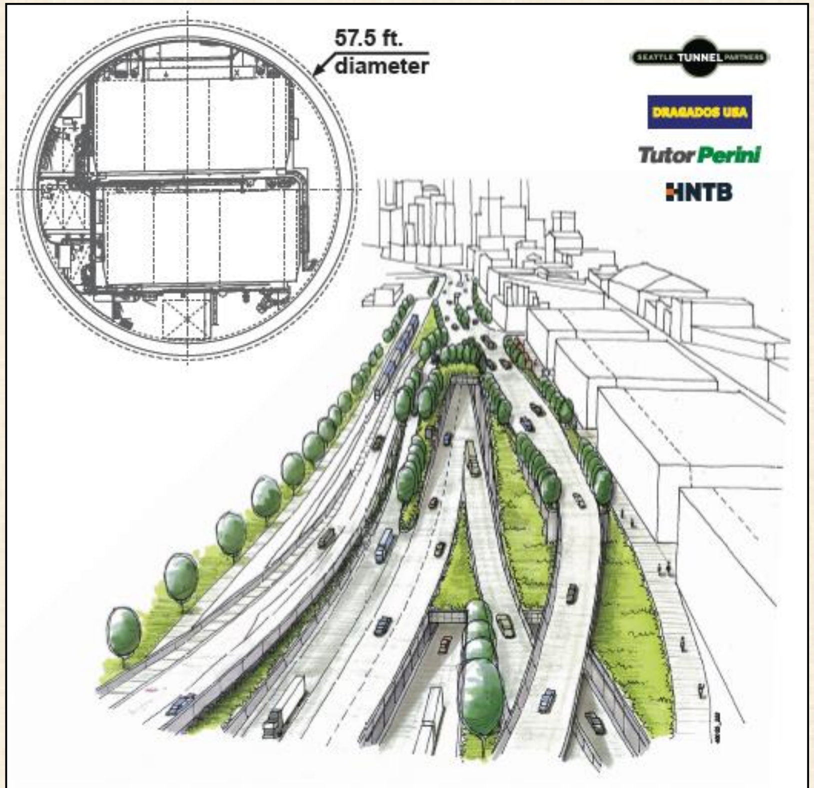

ALASKAN WAY VIADUCT SR 99 BORED TUNNEL ALTERNATIVE
BEST VALUE DETERMINATION (ITP Section 4.6)

9-Dec-10

CONTRACT: 7999
UPSET AMOUNT: $ 1,090,000,000.00

PROPOSER NAME	Apparent Best Value Score	Assigned Technical Credits	Proposal Price
Seattle Tunneling Group (STG)	1,050,150,002	38,152,000.00	$ 1,088,302,002.00
Seattle Tunnel Partners (STP)	1,018,123,002	71,577,000.00	$ 1,089,700,002.00

The successful Proposal will be the one calculated to have the lowest Apparent Best Value
APPARENT BEST VALUE DESIGN BUILDER Seattle Tunnel Partners (STP)
APPARENT 2ND BEST VALUE DESIGN BUILDER Seattle Tunneling Group (STG)

WSDOT

- **Led by:** Washington State Department of Transportation (WSDOT), in partnership with the Federal Highway Administration, King County, the City of Seattle and the Port of Seattle
- **Type of Contract:** Design-Build
- **Dollar Range:** $1.34 Billion
- **Project Funding:** Washington State and Federal Funds
- **Bid Date:** October 28th, 2010
- **Best value** determined in December 9, 2010
- **Contract signed**: January 6, 2011
- **NTP1:** February 7, 2011
- **NTP2:** August 23, 2011, after Environmental Impact Statement (EIS) is approved

Scope of Work

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- <u>TBM tunnel</u>

  57.35 feet diameter, 9.273 feet long, about **1,000,000 yd³ excavation**

- <u>North and South accesses</u>

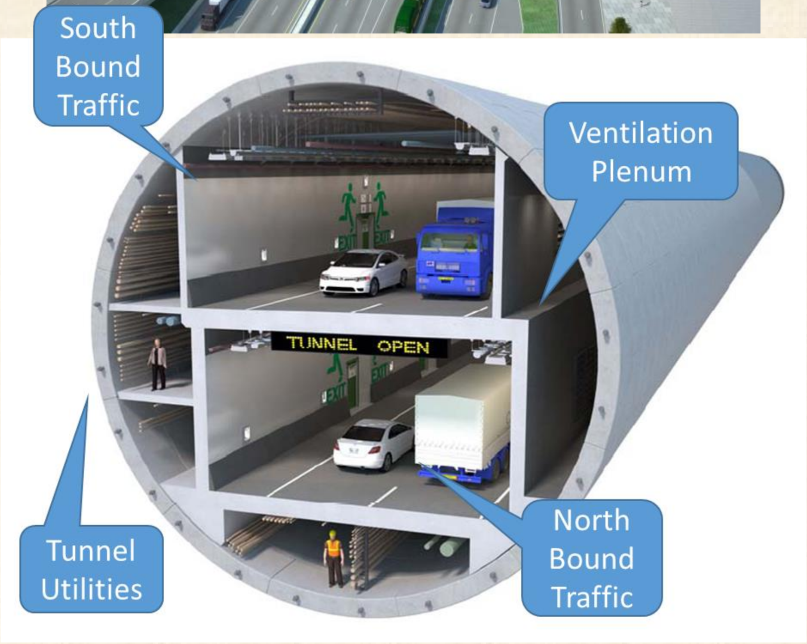
  540,000 yd³ excavation including slurry walls and secant piles plus concrete slabs, including Southbound off and Northbound on ramps at the South end

- <u>2 Operation buildings</u>

  North (78,205 ft²) and South (52,339 ft²)

- <u>Tunnel systems</u>

  Electrical, mechanical, ventilation, Gas monitoring, drainage and pumping, fire suppression, security, communication and Supervisory control and data acquisition (SCADA)



Bored Tunnel

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TBM “Bertha”, the Largest Ever Built

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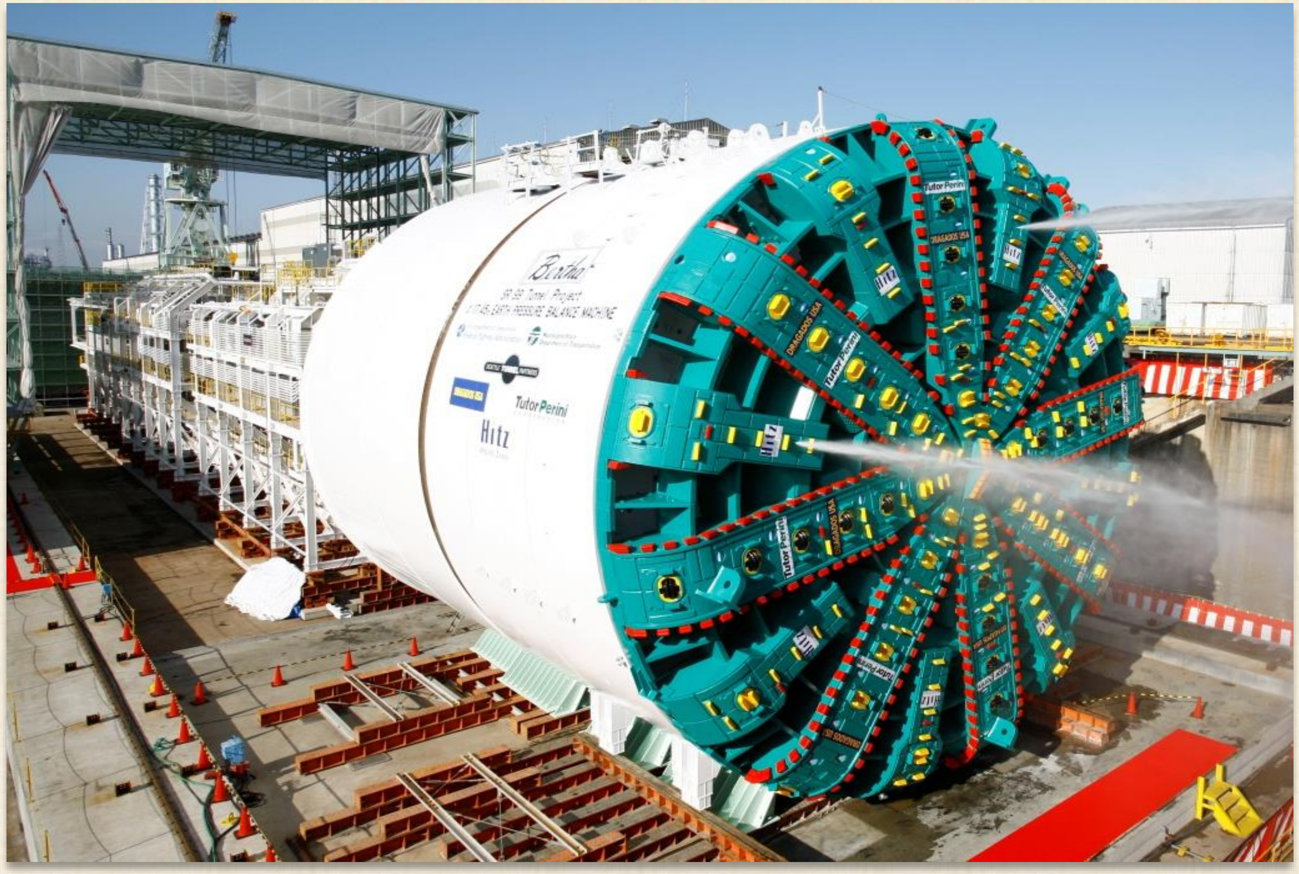
Manufacturer……………….. **Hitachi Zosen** (Japan)
Diameter ……………………… 57.35 ft. (17.5 m)
Length TBM + back up …. 368 ft. (112 m)
Total thrust ………………….. 392,000 kN
Max Torque ………………….. 147,000 kNm (202,000)
Installed power …………….. 22,600 kW
Weight …………………………… 7,000 t



Bored Tunnel

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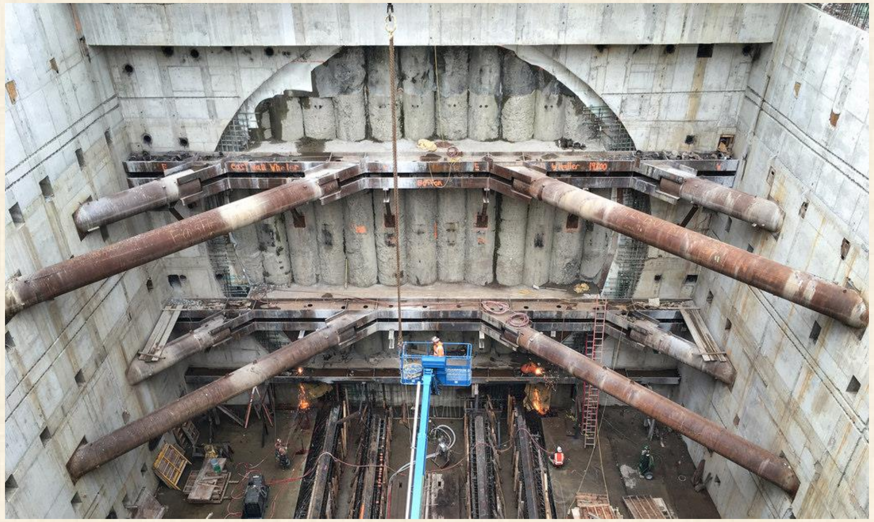

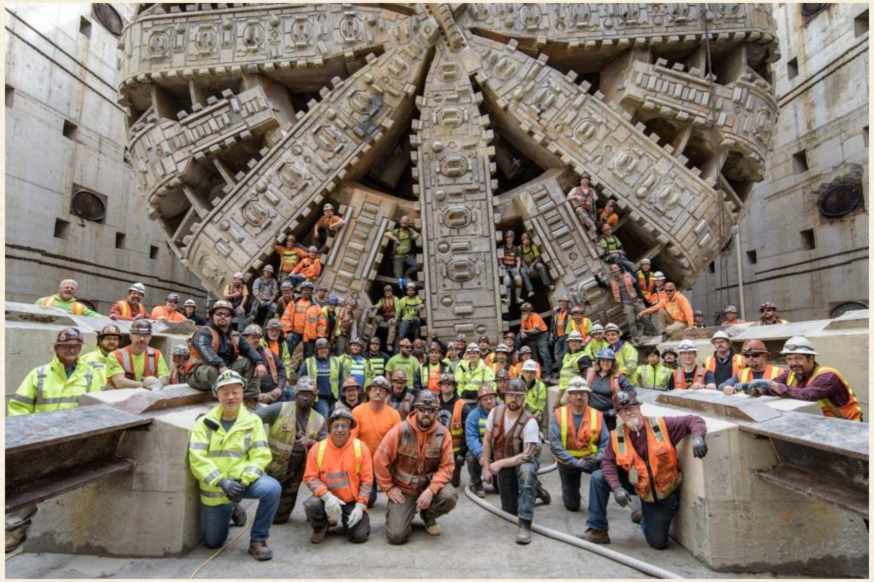

Tunnel Liner

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Tunnel Liner

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- DRACE, affiliate of Dragados, manufactured the 1,440 rebar reinforced concrete rings in Puyallup, WA, in JV with local precaster Encon Washington, LLC.
- **Precast concrete rings for this liner were the largest ever built** with 56 ft OD (17 m), 52 ft ID (15.8 m), 6.5 ft length and 10 segments each, for a total weight per ring of 375,000 pounds (170 Tons), being the heaviest piece 38,500 lbs (17.5 Tons).


SR99 BORED TUNNEL

Tunnel Liner – Concrete Details and Quantities

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- **Cement/Concrete Details**
  - 7,000 PSI
  - Product Name: MaxCem Cement - Type IS(X); (AASHTO M 240)
    - Standard Spec: 9-01.2(4), Concrete - Blended Hydraulic Cement
    - Product Description: Blended hydraulic cement: Lafarge North America, Seattle, WA: Distributed from Seattle, WA, Type IS(X); Pasco, WA, Type IS(X); Spokane, WA, Type IS(X); and Vancouver, WA, Type IS(X).
  - Product Name: Glenium 3400 NV (Concrete Admixture)
    - Standard Spec: 9-23.6, Concrete Admixture - Type F - Water-Reducing, High Range Admixtures
    - Product Description: Liquid high range water reducing admixture for concrete: Type F
  - Product Name: Rheomac SF 100
    - Standard Spec: 9-23.11, Concrete Admix - Microsilica Fume
    - Product Description: Dry compacted silica fume mineral admixture.
- **Concrete Quantities**
  - **116,395 cubic yards** total for the precast tunnel liner segments
    - 1,425 rings in total
    - 81.7 cubic yards of concrete per ring

Tunnel Logistics

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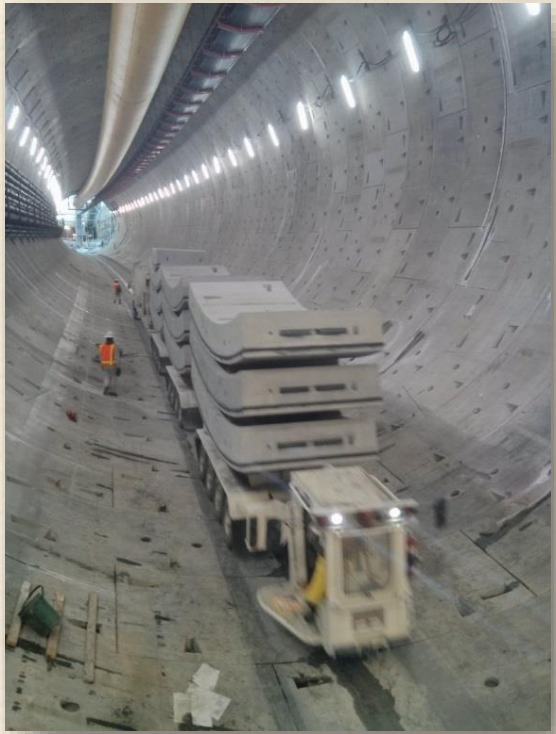
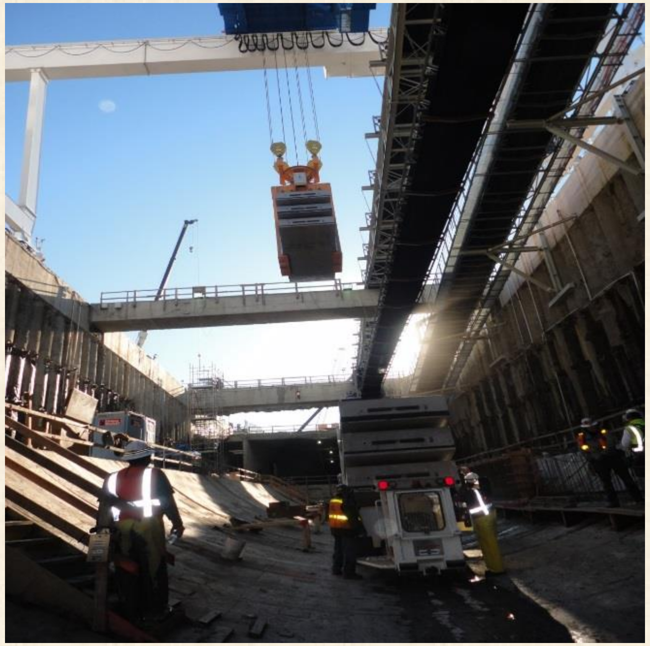
- Segments are hauled by track from Puyallup to the jobsite in Seattle.
- A 56 tons gantry crane lower segments down to the bottom of the assembly shaft to the top of the rubber tires vehicles which ship them to the TBM.
- Once in the TBM back up, segments are offloaded and a vacuum segments crane transports them to the segmentsfeeder, from where the segments erector grabs them by vacuum as well and install the inside the tail shield.





Tunnel Logistics Map

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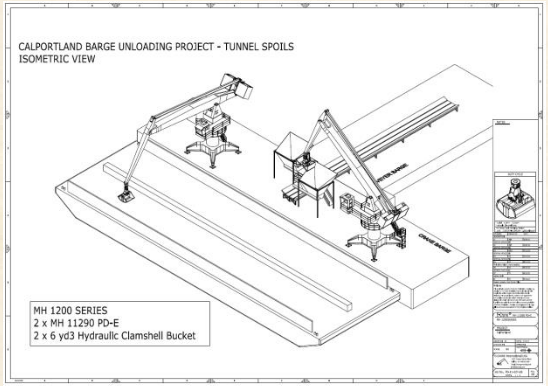

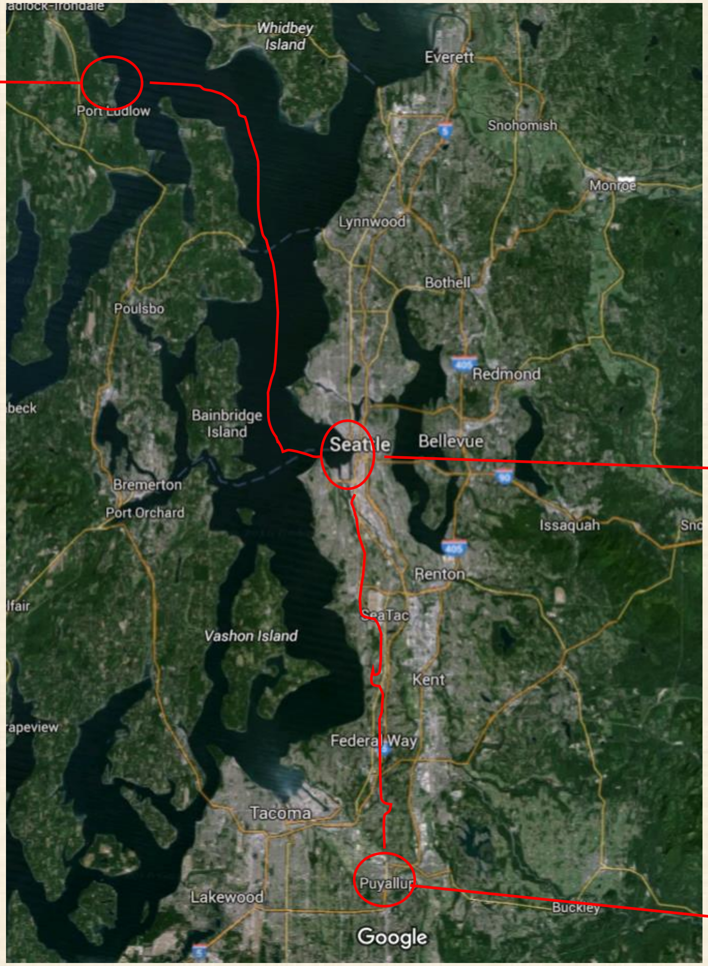

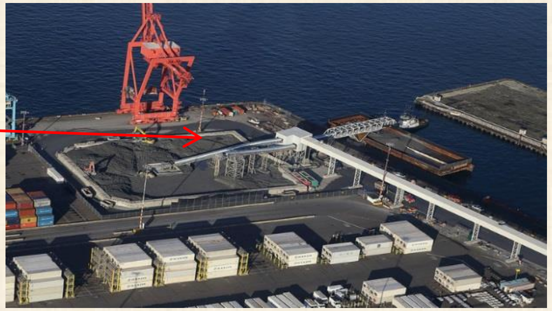

Mucking Out

Muck Disposal: Barging

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- The TBM screw conveyors transfer the muck from the excavation chamber to a continuous tunnel conveyor belt and an overland conveyor belt system, capable of handling 2,800 t/h, which loads the muck onto barges.
- A portion of adjacent T46 has been leased from Port of Seattle thru WSDOT to hold a temporary muck bin, used to dump muck in case of overflow, "contaminated" material or just lack of barges.
- Muck can be hauled by trucks or loaded onto barges by means of a reclaim conveyor.

Instrumentation & Monitoring

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Construction Monitoring Zone

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Technical Requirements TR2.52 defines allowable deformation tolerances, Alert level and Maximum level for each type of structure A or B along the alignment.

Real Time Monitoring

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- Surface and subsurface ground:
  - 03-NSSP, 04-ARSP
  - 05-INCL, 07-MPBX
- Surface structures and assets;
  - 01-MSMP, 02-ASMP, 09-TTM, 10-LLS, 11-CG, 13-MS
- Utilities
  - 16-USP (Primary), 22-USP (Secondary)
- Tunnel lining deformation
  - 08-LC, 12-SG, 17 TTL
- Groundwater
  - 06-PZ, 21-DW

SOLDATA

SEATTLE TUNNEL PARTNERS

Geoscope Symbol Key

Monitoring Point Type		Code	Symbol	
Manual Structure Monitoring Point	(MSMP)	01	Triangle	
Automatic Structure Monitoring Point	(ASMP)	02	Star 4	
Near Surface Settlement Point	(NSSP)	03	Occitan Cross	
Automatic Reflectorless Settlement Point	(ARSP)	04	Star 6	
Inclinometer (Group)	(INCL)	05	Square Star 8	
Piezometer & Observation Wells	(PZ)	06	Cross	
Extensometer (Group)	(MPBX)	07	Squared Star	
Load Cells	(LC)	08	Diamond	
Tiltmeter	(TTM)	09	Cross	
Liquid Level Sensor	(LLS)	10	Hour Glass	
Crack Gauge	(CG)	11	Square	
Strain Gauges	(SG)	12	Dodecagon	
Motion Sensor	(MS)	13	Hour Glass	
AWV Project Borings	(APB)	14	Square	
Deep Benchmark	(DBM)	15	Hexagon	
Utility Settlement Point (Primary)	(USP)	16	Square Star 8	
Tell Tales	(TTS)	17	Hexagon	
Seawall Monitoring Points	(SMP)	18	Occitan Cross	
Secondary Control Points	(SCP)	19	Hexagon	
Pile Survey Points	(PSP)	20	Star 4	
Dewatering Wells	(DW)	21	Cross	
Utility Settlement Point (Secondary)	(USP)	22	Star 6	
In-Place Inclinometer (Group)	(IPI)	23	Hour Glass	
Strandmeter	(SM)	24	Dodecagon	
Pike Adit Tilt Beams	(TTB)	25	Diamond	

<|-- *Main View*

Tunnel Systems

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Tunnel Fire, Life & Safety Systems

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TUNNEL VENTILATION
Single Point Extraction
8x500HP Centrifugal Fans
17 Jet fans
188 Tunnel Dampers
CFD designed

TUNNEL LIGHTING
Roadway Stainless Steel Linear Fluorescent Lighting
Emergency exit LED, SCADA controlled Exit Signs

Tunnel Fire, Life & Safety Systems (II)

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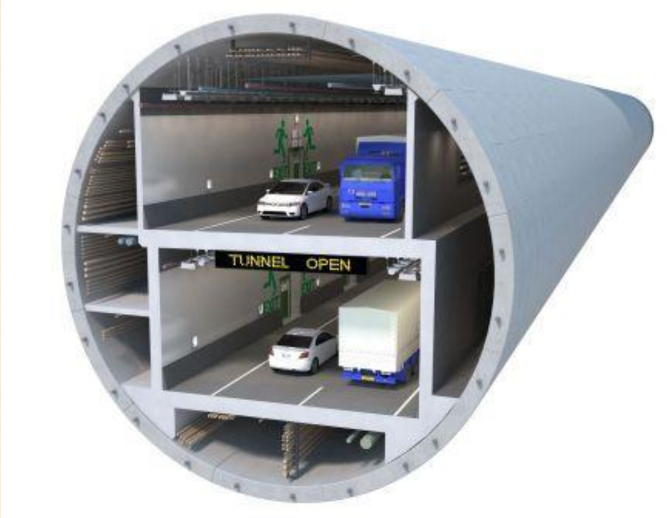
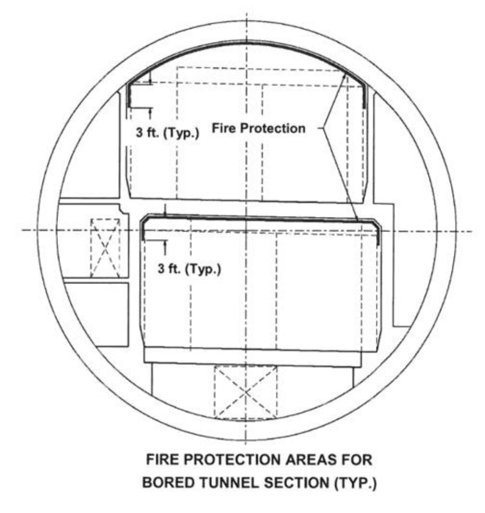
FIRE PROTECTION

Sprayed Fire Protection Material
Roadway Deluge Sprinkler System
Roadway Linear Heat Detector (LHD)
Wet sprinkler systems in Ancillary Areas





Tunnel Fire, Life & Safety Systems (III)

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TRAFFIC CONTROL SYSTEMS (SICE)

SCADA & Intelligent Traffic Systems (ITS)
- Automatic incident detection
- Traffic variable signs

Communications Infrastructure
- Radio
- Fiber Optic
- Emergency phones

Tolling Infrastructure
- Tolling gantries

Tunnel Interior Structure

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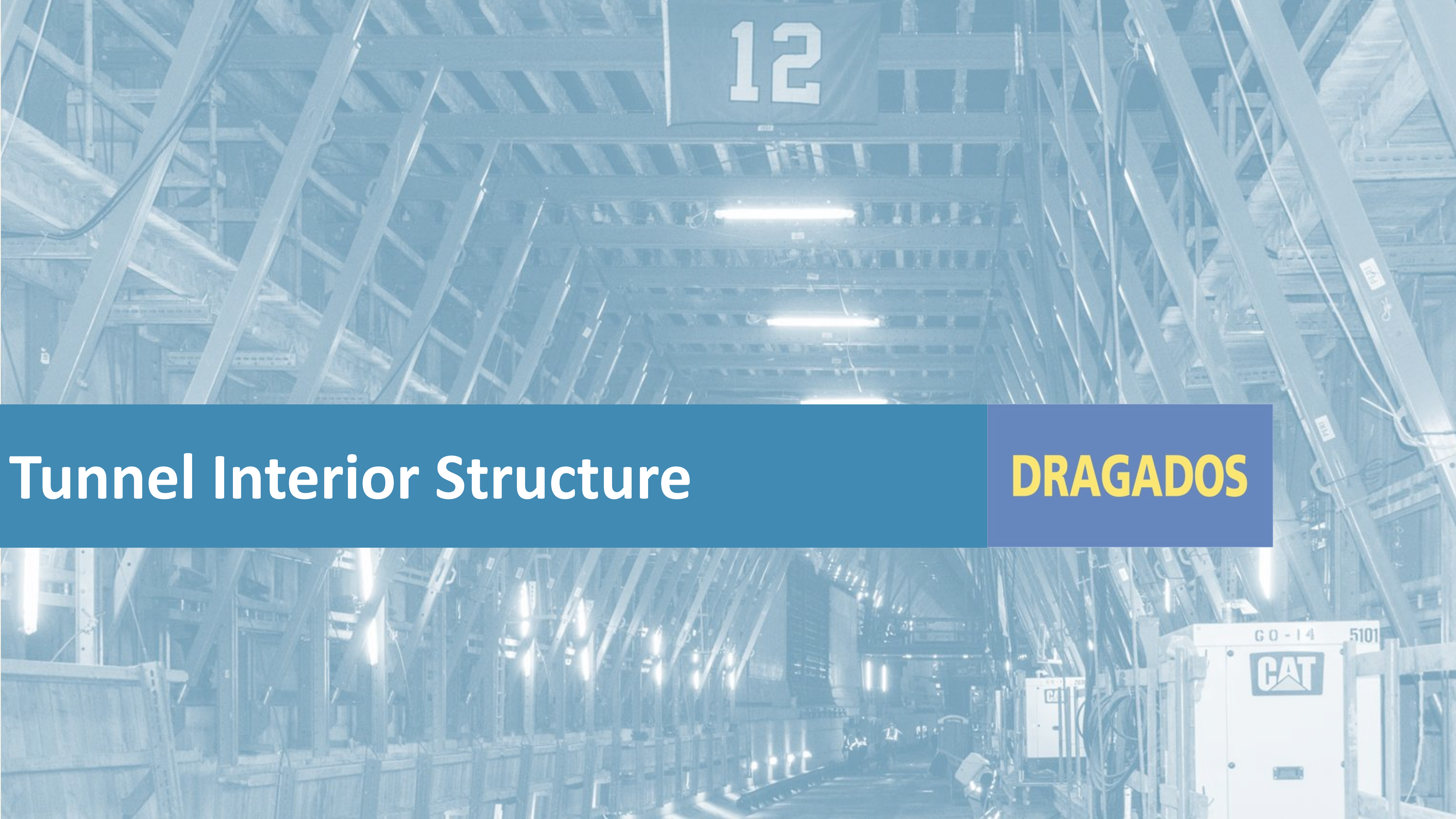
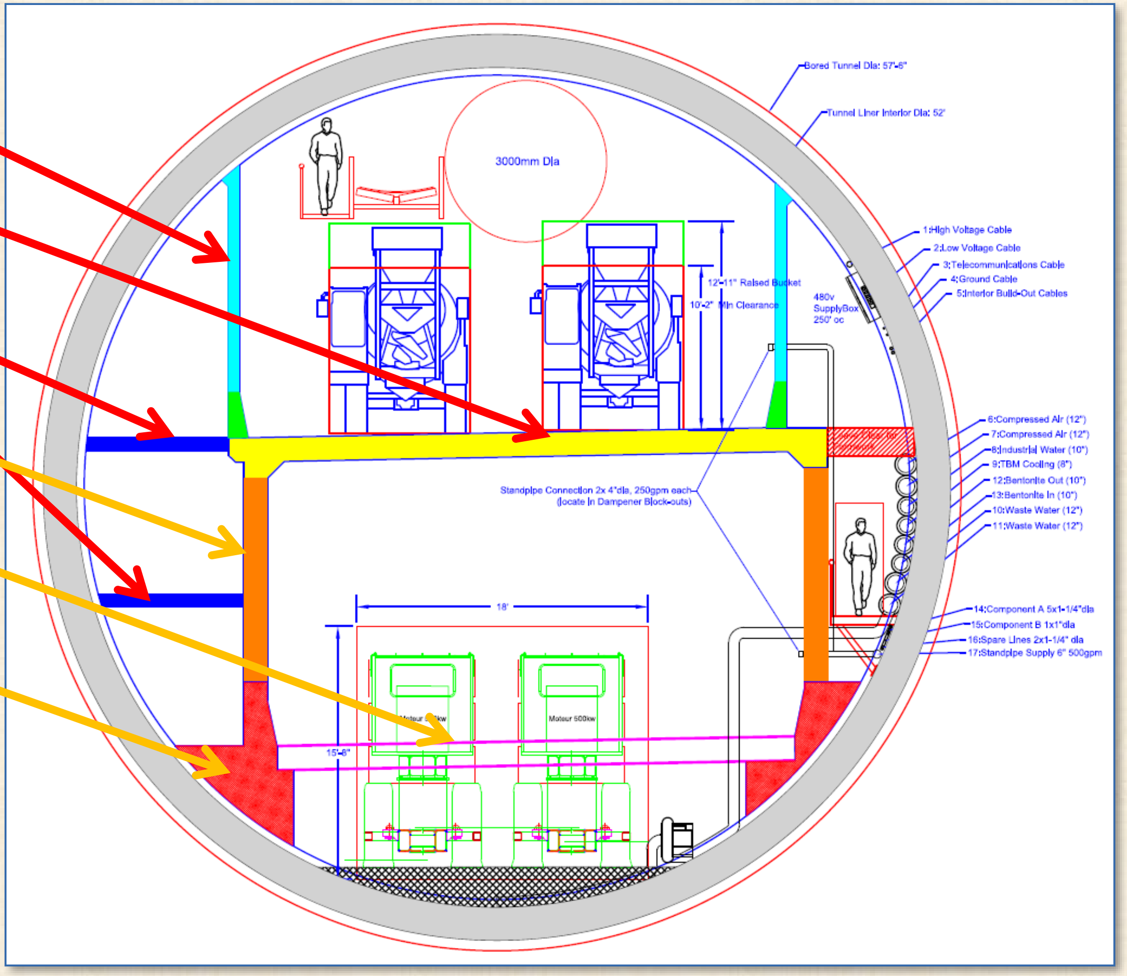


Structural Elements

- Upper Walls
- Upper Slab
- Egress Slabs
- Lower Walls
- Lower Deck
- Corbels



Construction sequence

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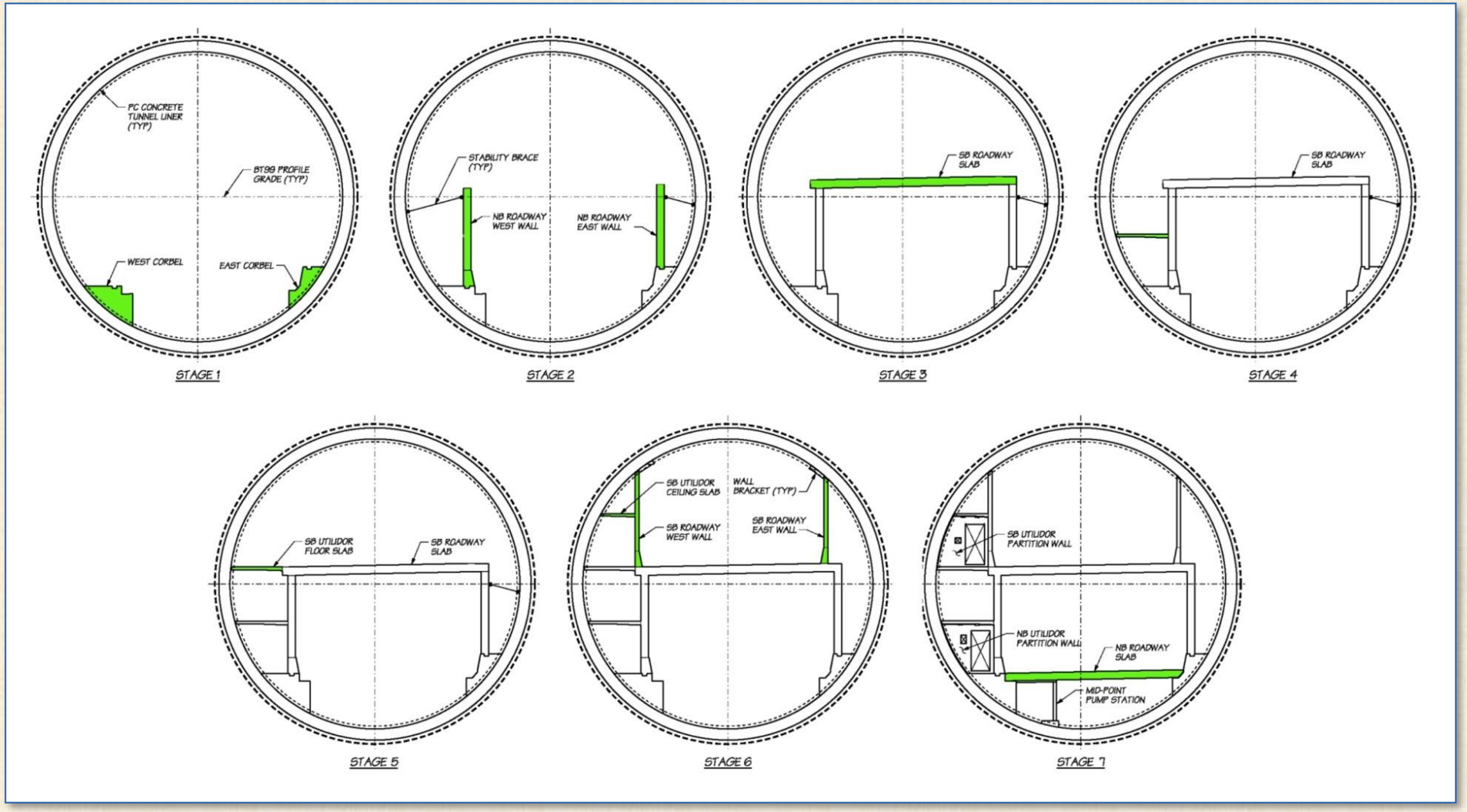
- PERI Formwork Systems provided all supporting equipment
- Cast In Place Structures
    - Corbels, Lower Walls, Upper Walls
        - Rebar Cages Fabricated on Surface
    - Upper Deck, Side Deck
        - Cages tied in Place
- Precast Structure
    - Lower Deck
        - Placed on Corbel
        - Closure Pours



PERI Formworks

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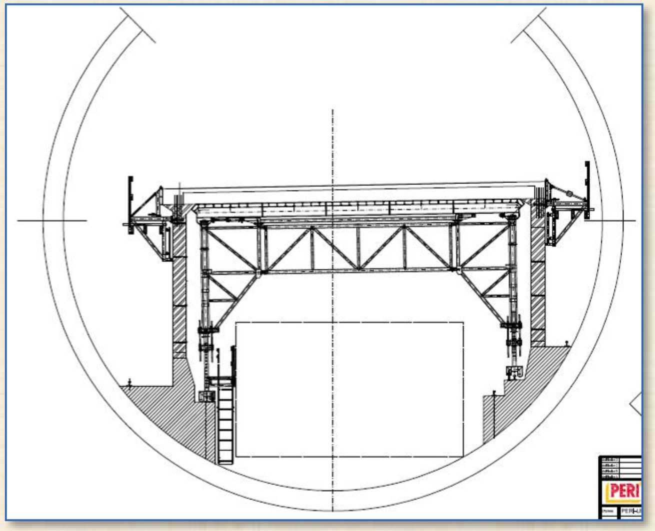
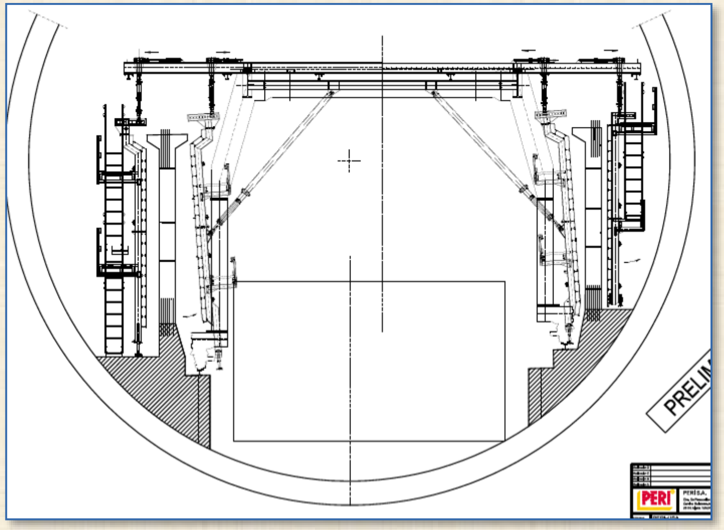
Plan Submittal Description	Units	QTY
Corbel Rebar Traveler	EA	1
Corbel Formwork Traveler	EA	1
Corbel Formwork L=54'	EA	2
Wall Rebar & Formwork Traveler	EA	1
Wall Formwork Walls L=54'	EA	2
Corbel Formwork and Rail Support		
Egress Slab Formwork		
Formwork Slab 1 L=54'	EA	6
Formwork Slab 2 L=54'	EA	6
SB Roadway Formwork		
Slab Formwork Top Slab L=54'	EA	6
Gantry For Bottom Precast Slab	EA	1





Fire Proofing

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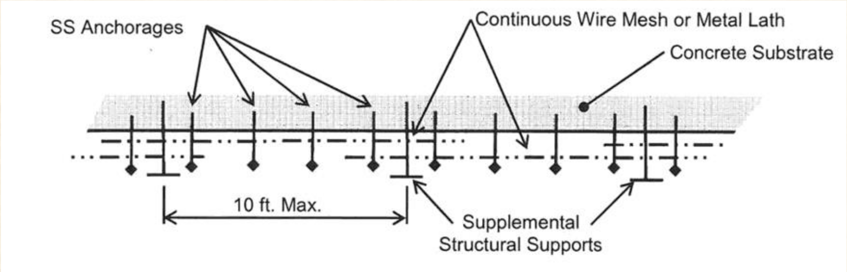
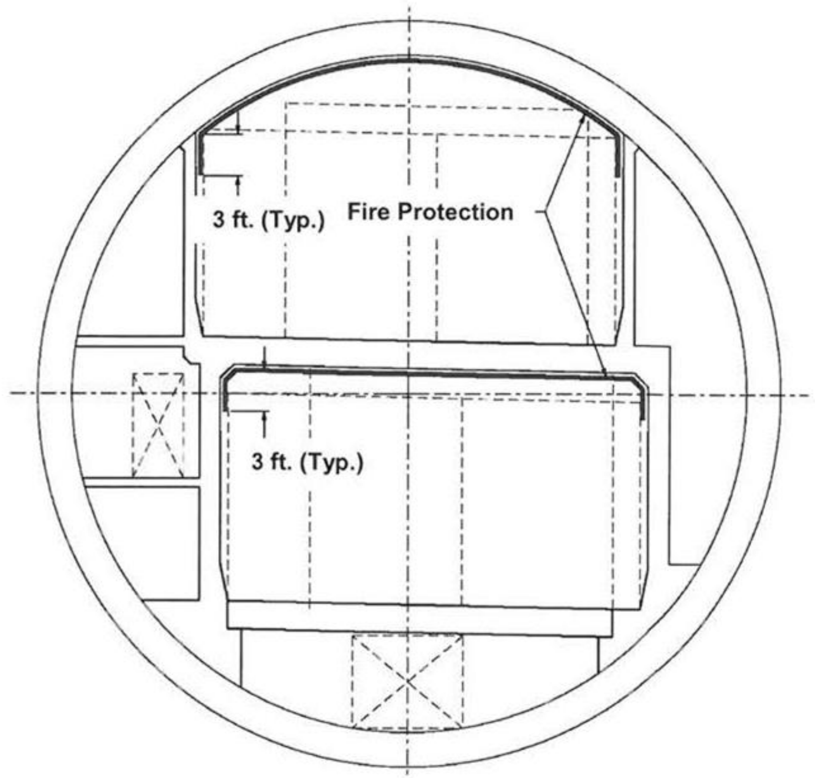
Sprayed Fire Protection Material
over Continuous Wire Mesh

Stainless Steel supplemental
structural supports @ 10ft.





FIRE PROTECTION AREAS FOR
BORED TUNNEL SECTION (TYP.)

Summary of Quantities – Interior Structure

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Concrete Volume

		VOLUME (54 ft)			VOLUME TOTAL (9270 ft)		
	AREA sf	cf	cy	m^3	cf	cy	m^3
WEST CORBEL	33.89	1,830.06	67.78	51.82	314,160.30	11,635.57	8,896.03
EAST CORBEL	18.24	984.96	36.48	27.89	169,084.80	6,262.40	4,787.95
WEST WALL	24.90	1,344.60	49.80	38.07	230,823.00	8,549.00	6,536.18
EAST WALL	20.07	1,083.78	40.14	30.69	186,048.90	6,890.70	5,268.32
SOUTHBOUND SLAB	55.35	2,988.90	110.70	84.64	513,094.50	19,003.50	14,529.22
NORTHBOUND SLAB	43.50	2,349.00	87.00	66.52	403,245.00	14,935.00	11,418.63
					1,816,456.50	67,276.17	51,436.33

Rebar Weight

	lb/ft	kg/m	(lb)	(kg)	TOTAL (lb)	TOTAL (kg)
WEST CORBEL	250.00	372.38	13,500.00	6,129.29	2,317,500.00	1,052,331.75
EAST CORBEL	135.00	201.08	7,290.00	3,309.82	1,251,450.00	568,259.15
WEST WALL	255.00	379.82	13,770.00	6,251.88	2,363,850.00	1,073,378.39
EAST WALL	210.00	312.80	11,340.00	5,148.61	1,946,700.00	883,958.67
SOUTHBOUND SLAB	93.00	138.52	5,022.00	2,280.10	862,110.00	391,467.41
NORTHBOUND SLAB	542.00	807.31	29,268.00	13,288.31	5,024,340.00	2,281,455.23
			80,190.00	36,408.00	13,765,950.00	6,250,850.60

Photos of Tunnel Interior Construction

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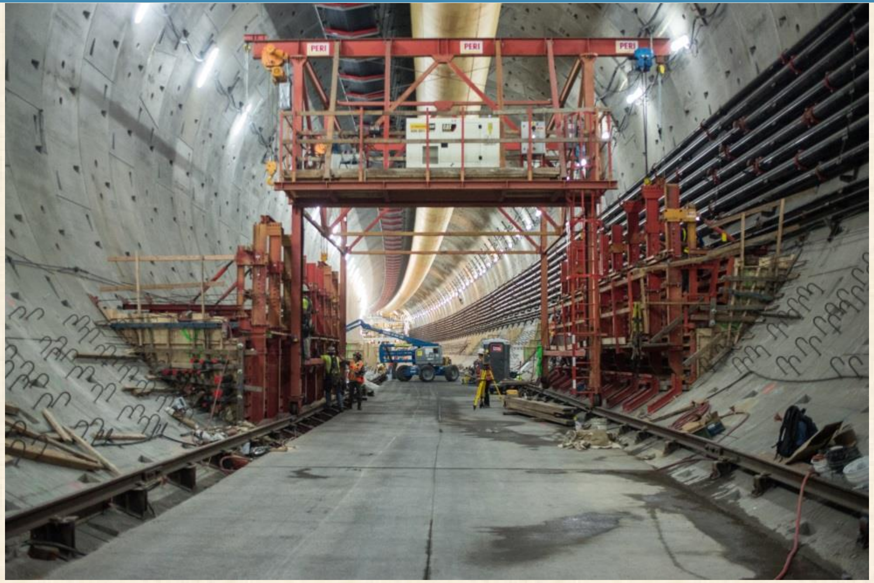

Fireproofing Installation

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Building a Highway Inside TBM Launch Pit

South Tunnel Portal

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North Tunnel Portal

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Before

In January 2014, Seattle Tunnel Partners' crews were building the north end of the SR 99 tunnel inside this giant pit a few blocks east of the Space Needle. The photo was taken on the north ledge of the pit, looking south toward downtown Seattle.

January 2014

August 2016

This is the same location two-and-a-half years later. The north end of the tunnel now lies beneath the SR 99 tunnel's north portal operations building, and new sections of Harrison Street and Sixth Avenue North.

After

North Tunnel Portal

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Questions?