SR99 BORED TUNNEL

ALASKAN WAY VIADUCT AND SEAWALL REPLACEMENT PROGRAM
SEATTLE, WA
October 16, 2017
Overall Project Description
The Alaskan Way Viaduct; the Nisqually Earthquake

• 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.
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 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

- **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

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

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

- **2 Operation buildings**
  North (78,205 ft²) and South (52,339 ft²)

- **Tunnel systems**
  Electrical, mechanical, ventilation, Gas monitoring, drainage and pumping, fire suppression, security, communication and Supervisory control and data acquisition (SCADA)
Bored Tunnel
TBM “Bertha”, the Largest Ever Built

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

*Evolution of EPB TBMs.*

- **D=21 ft.** VALENCIA SUBWAY 1990 Dragados
- **D=31 ft.** MADRID SUBWAY 1994 Dragados
- **D=39.5 ft.** BARCELONA SUBWAY 2002 Dragados
- **D=49.25 ft.** M-30 MADRID 2005 Dragados
Bored Tunnel
Tunnel Liner
• 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).
Tunnel Liner – Concrete Details and Quantities

• **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

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

DRAGADOS
Tunnel Fire, Life & Safety Systems

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)

FIRE PROTECTION

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

- Upper Walls
- Upper Slab
- Egress Slabs
- Lower Walls
- Lower Deck
- Corbels
• 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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Fire Proofing

Sprayed Fire Protection Material over Continuous Wire Mesh

Stainless Steel supplemental structural supports @ 10ft.
### Concrete Volume

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### Rebar Weight

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Fireproofing Installation
Building a Highway Inside TBM Launch Pit
South Tunnel Portal

- Southbound lanes
- Northbound lanes
- Southbound off-ramp
- Northbound on-ramp
- Northbound off-ramp
North Tunnel Portal

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
Questions?