

Alaskan Way Viaduct **REPLACEMENT** PROGRAM



Design of SR 99 Tunnel and Approach Structures

Western Bridge Engineers' Seminar

Sept. 5, 2013

Jerry Dorn

Design-Build Team

Owner:



Contractor:



Joint Venture:



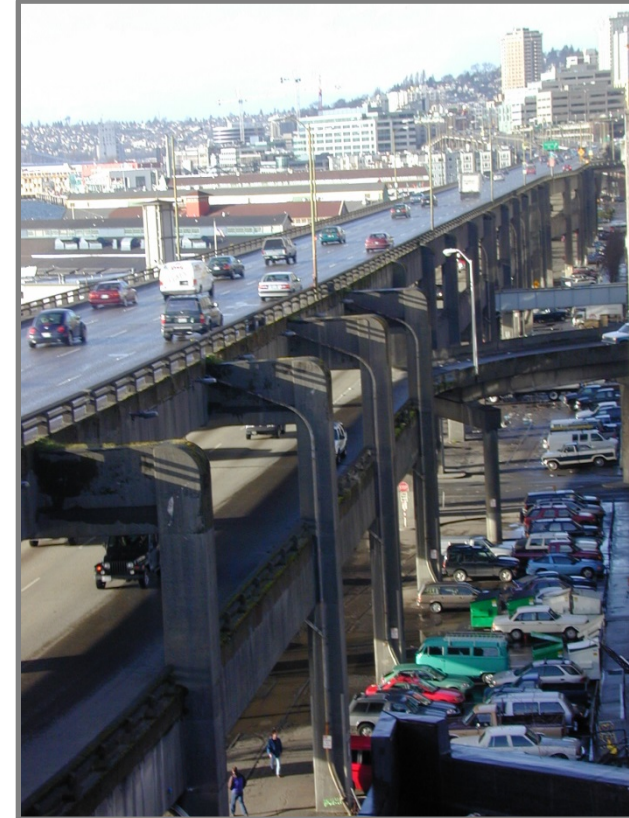
Designer:



Sub-Consultants:



Existing Alaskan Way Viaduct

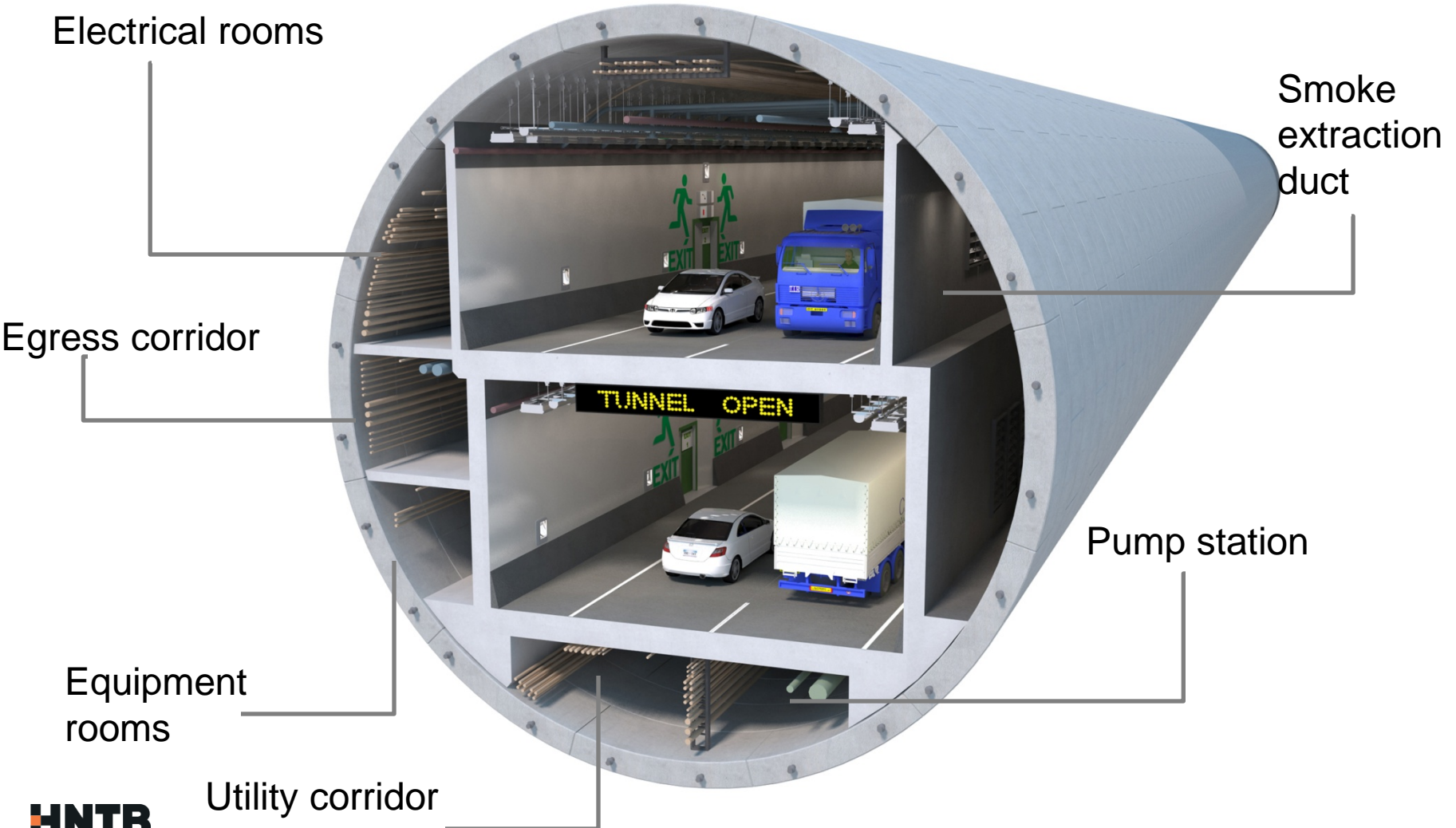


SR 99 Tunnel

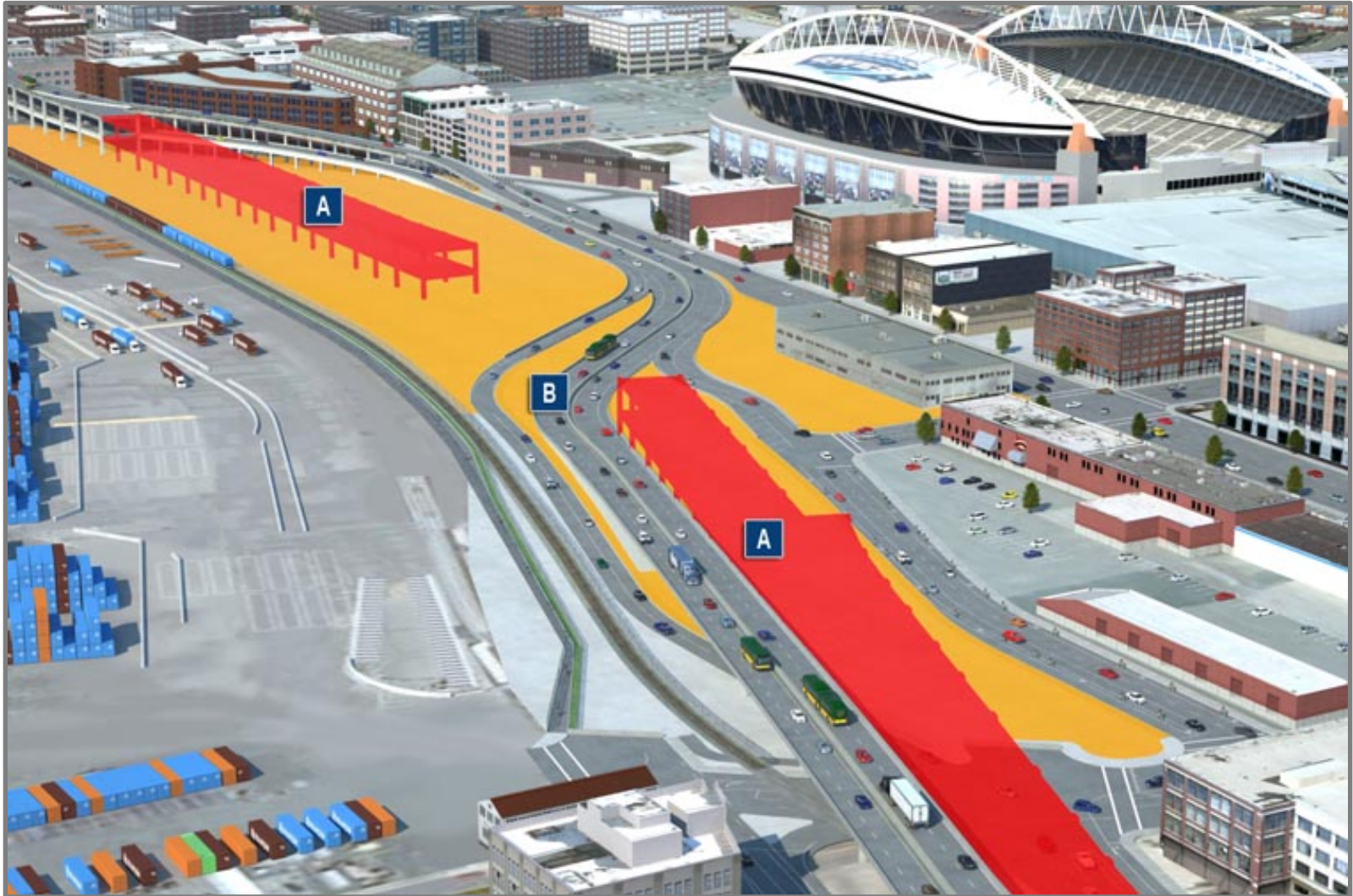
- Approximately two miles long.
- Two lanes with eight-foot safety shoulder in each direction.
- State-of-the-art safety systems.
- 1250 foot south approach
- 9300 foot bored tunnel
- 450 foot north approach



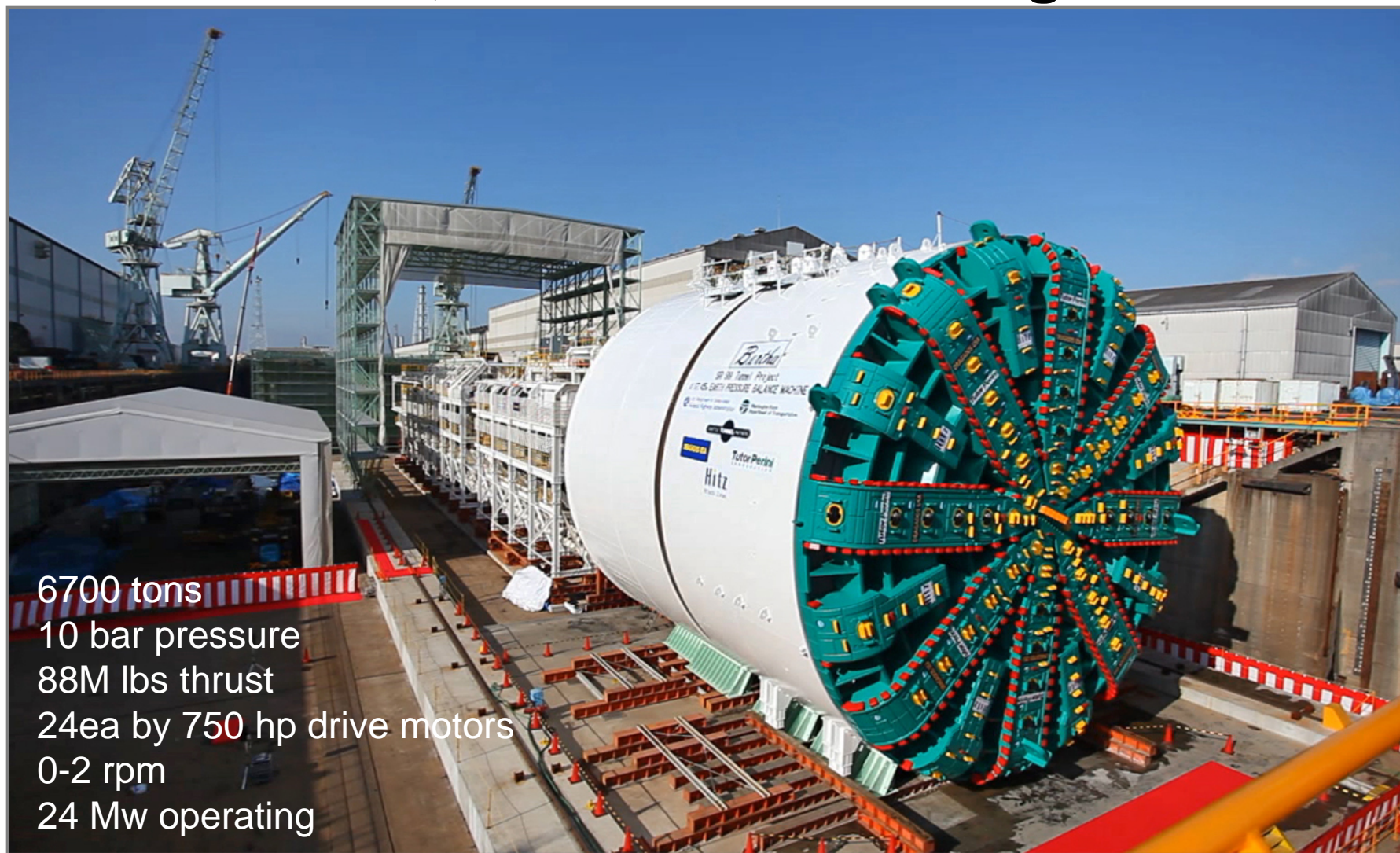
Tunnel Section



Construction Bypass

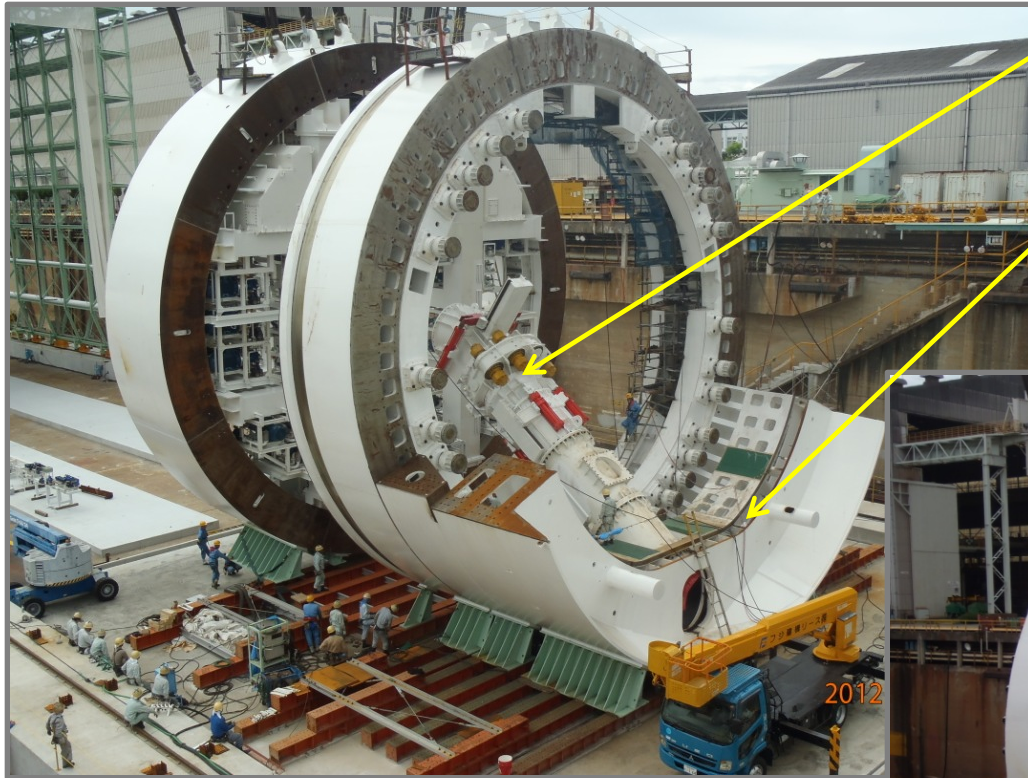


Meet Bertha, the SR 99 Tunneling Machine



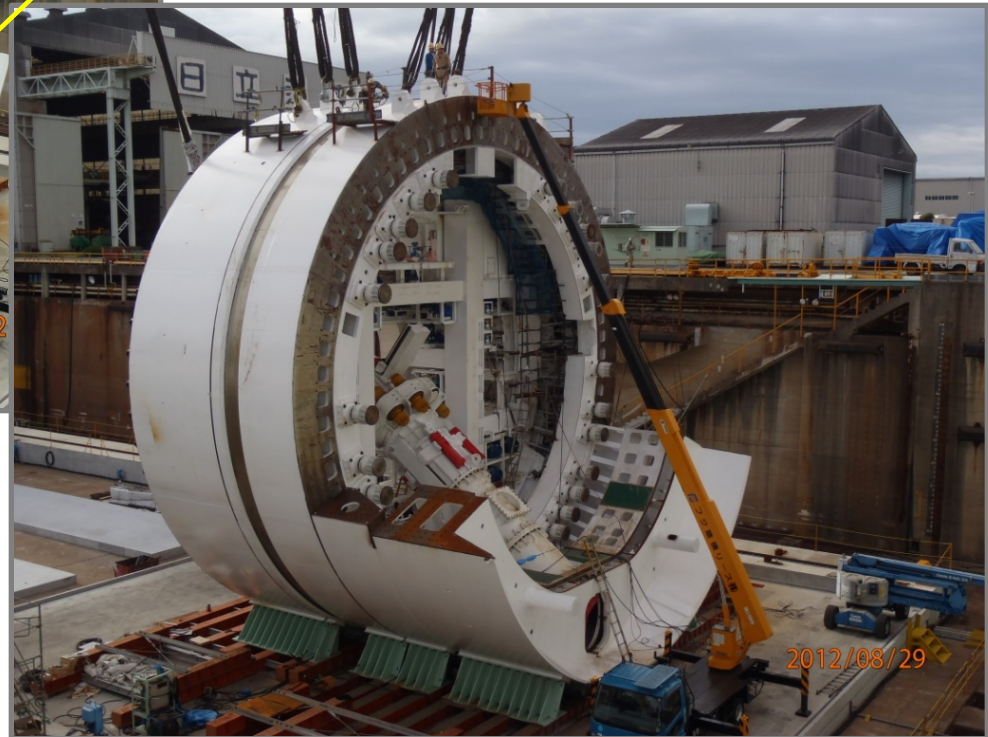
6700 tons
10 bar pressure
88M lbs thrust
24ea by 750 hp drive motors
0-2 rpm
24 Mw operating

Tunneling Machine Assembly in Japan



Screw Conveyor

Bottom of Muck Chamber



Tunneling Machine Assembly in Japan



Tunneling Machine Trailing Gear

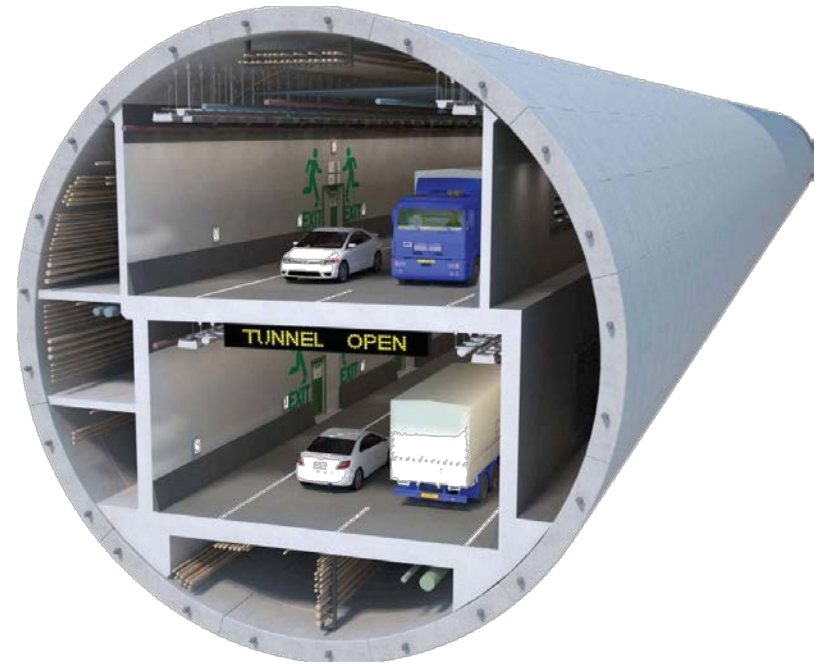


Tunneling Machine Delivery to Launch Pit



Tunnel Liner

Excavation diameter	57'3"
Internal diameter	52'
Segment thickness	24"
Grouting thickness	8"
Average ring length	6'5"
Number of segments	7+2+1
Tunnel length	9300'



Performance Objectives

SEISMIC DESIGN CRITERIA

Dual levels of design earthquakes:

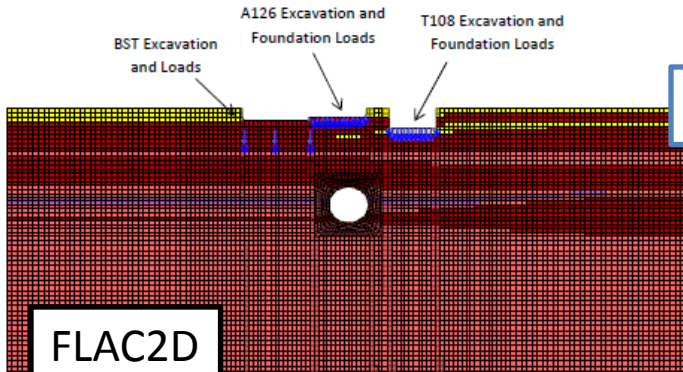
- 2500-year return events (rare earthquake) → Life Safety
- 108-year return events (expected earthquake) → Operational

Tunnel Liner Ring



Liner Design – Two Step Approach

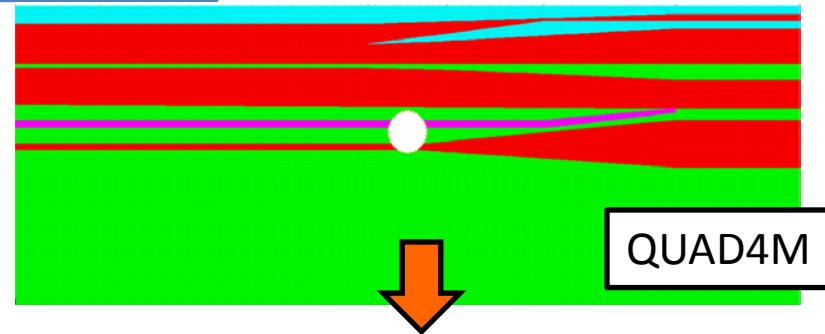
STATIC ANALYSIS



Step 1

Geotechnical Engineers

SEISMIC ANALYSIS

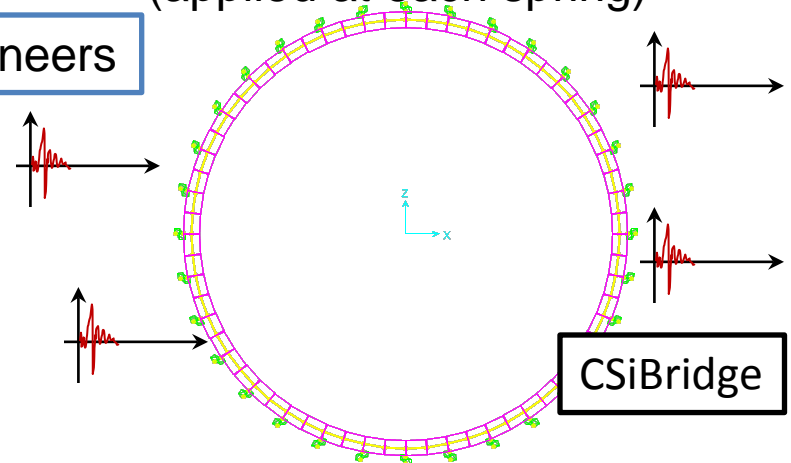
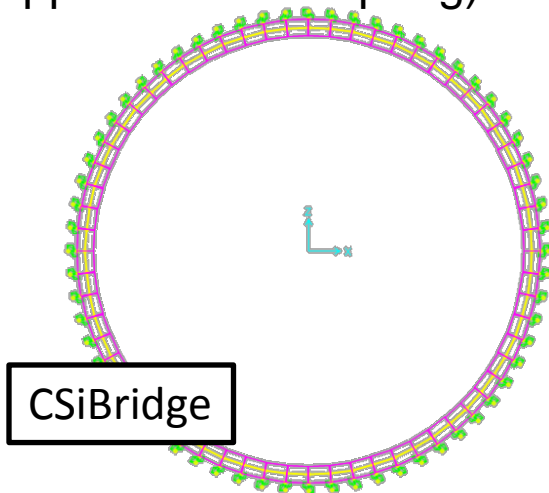


Soil and Hydrostatic Loads
(applied at each spring)

Step 2

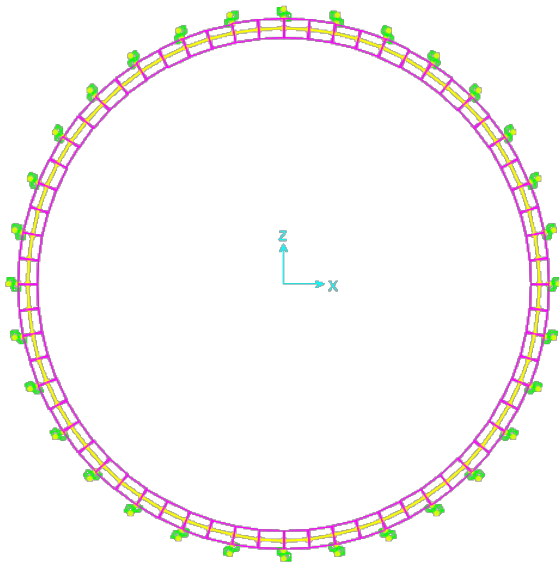
Structural Engineers

Ground Deformations
(applied at each spring)



Seismic Models

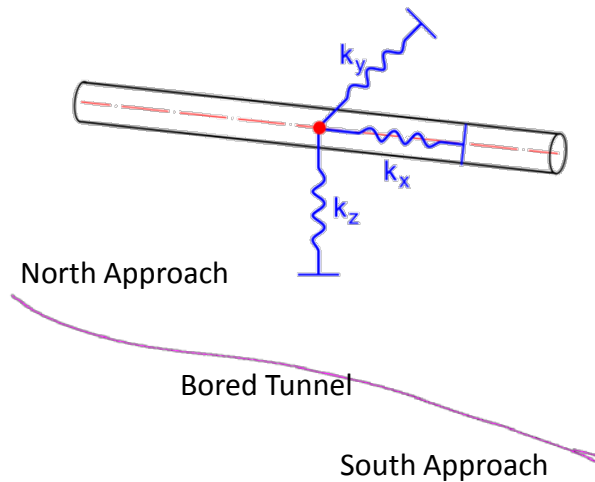
2D Section Model



Ovaling deformation

Bending and axial in the liner for Extreme Event load combination

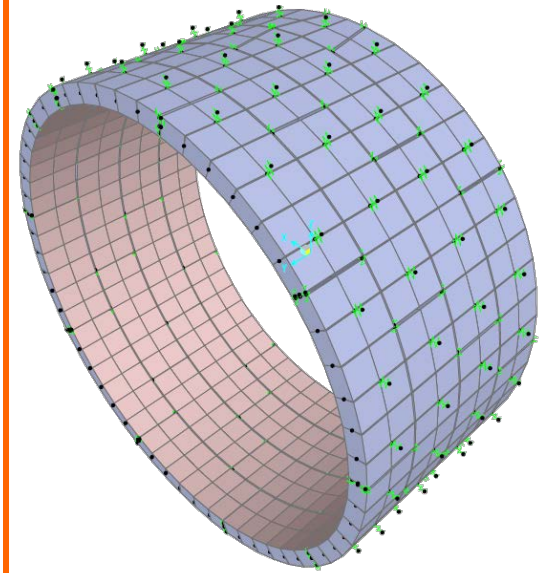
3D Spine Model



Obtain seismic forces in the line

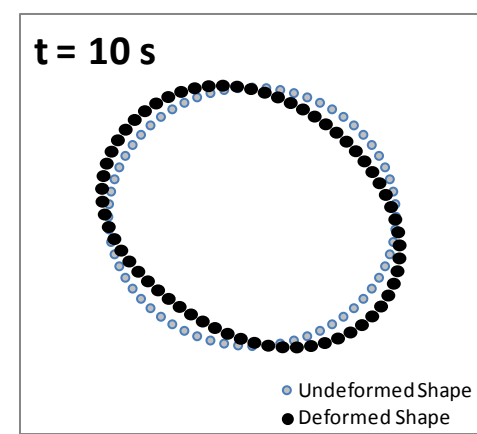
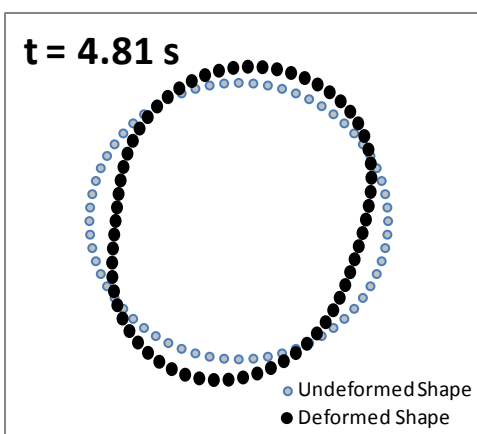
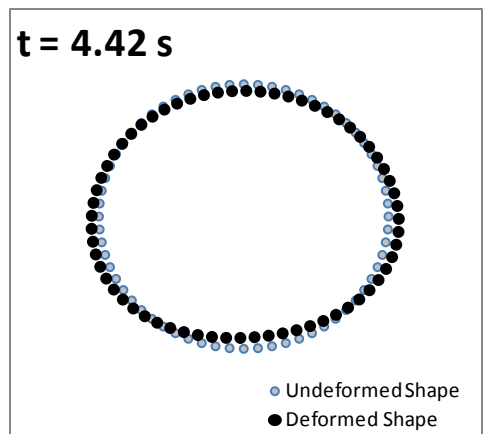
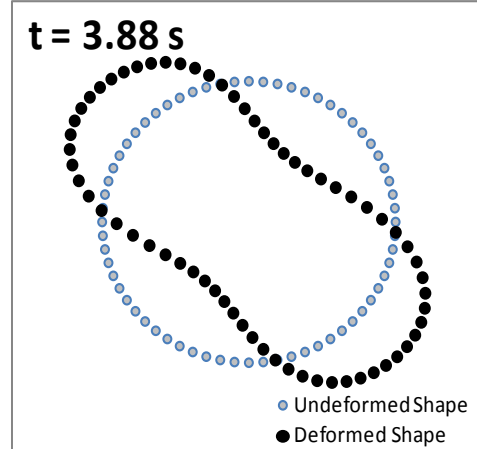
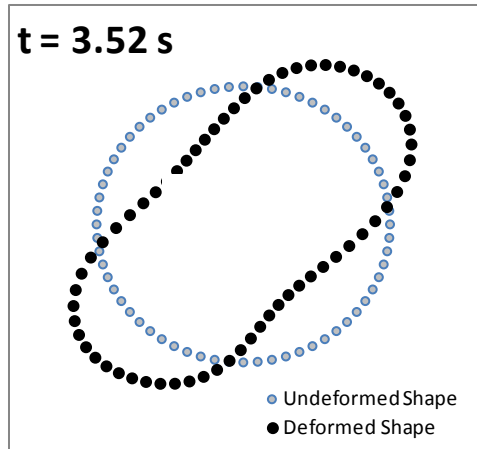
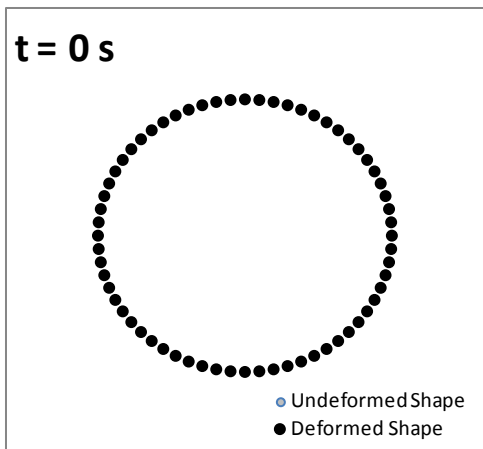
Evaluate displacements at the interface between liner and south and north headwall

3D FE Model



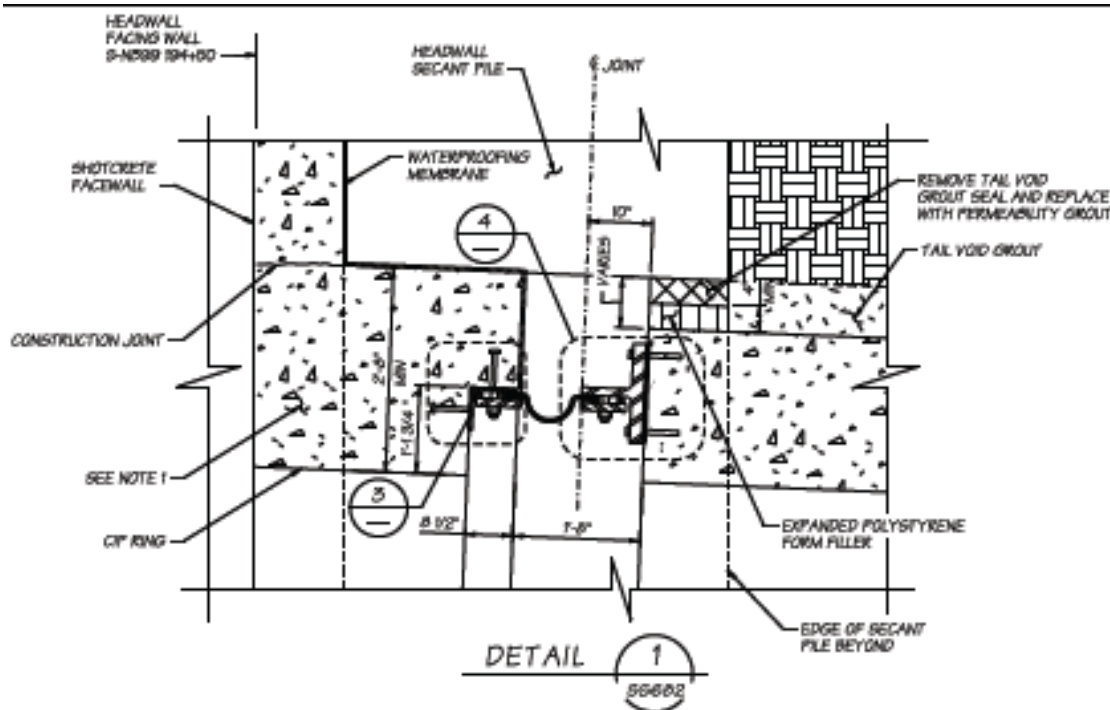
Predict the local behavior of the gaskets at the circumferential and radial joints

Seismic Results - Ovaling



3D Spine Model – Differential Displacements

	2500 yrp	108 yrp
Gap Opening	6.6"	0.11"
Gap Closing	8.6"	0.14"



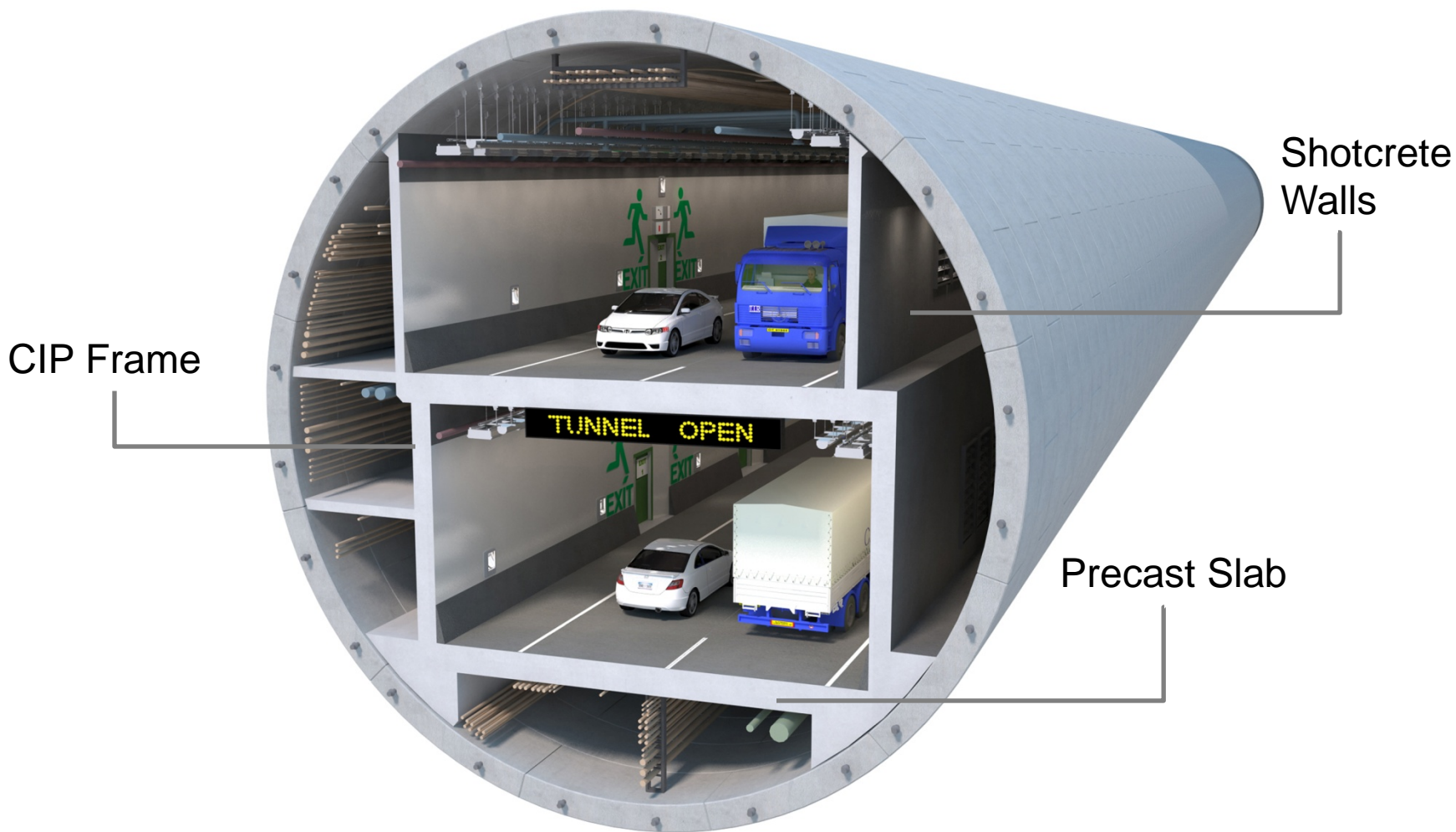
Ring Segments Pre-Cast Plant



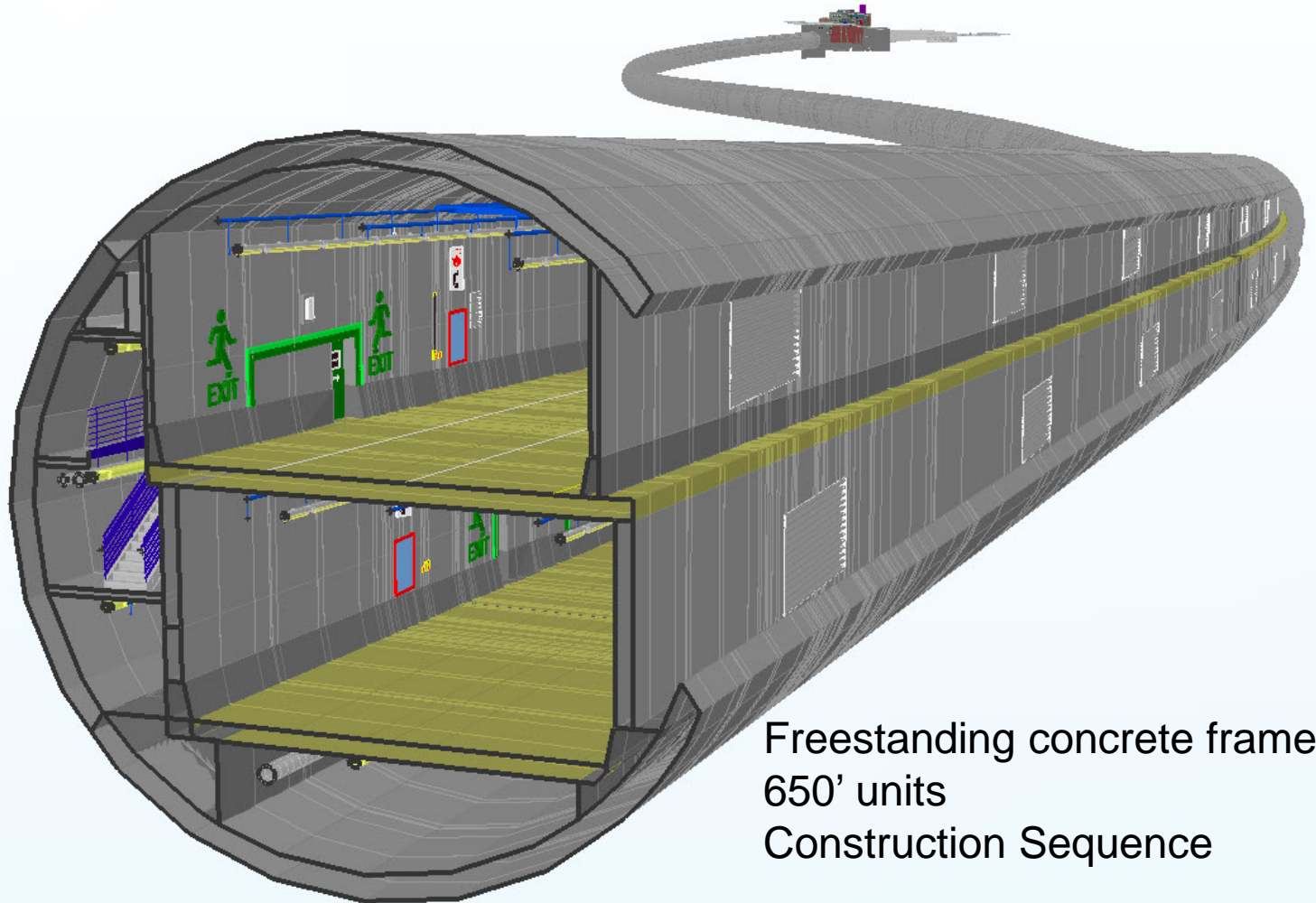
Tunnel Liner Segment



Interior Structures

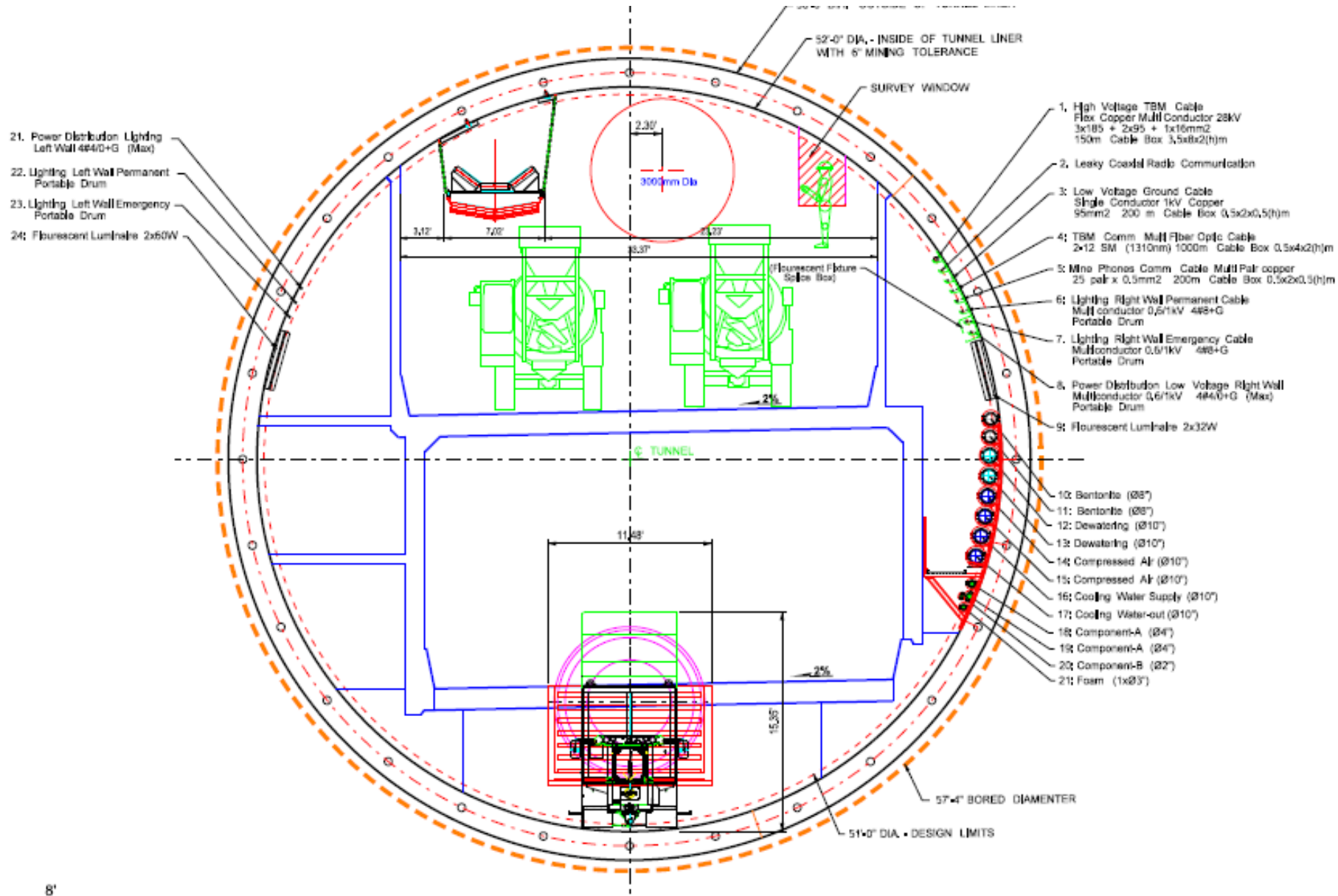


Interior Structures Design

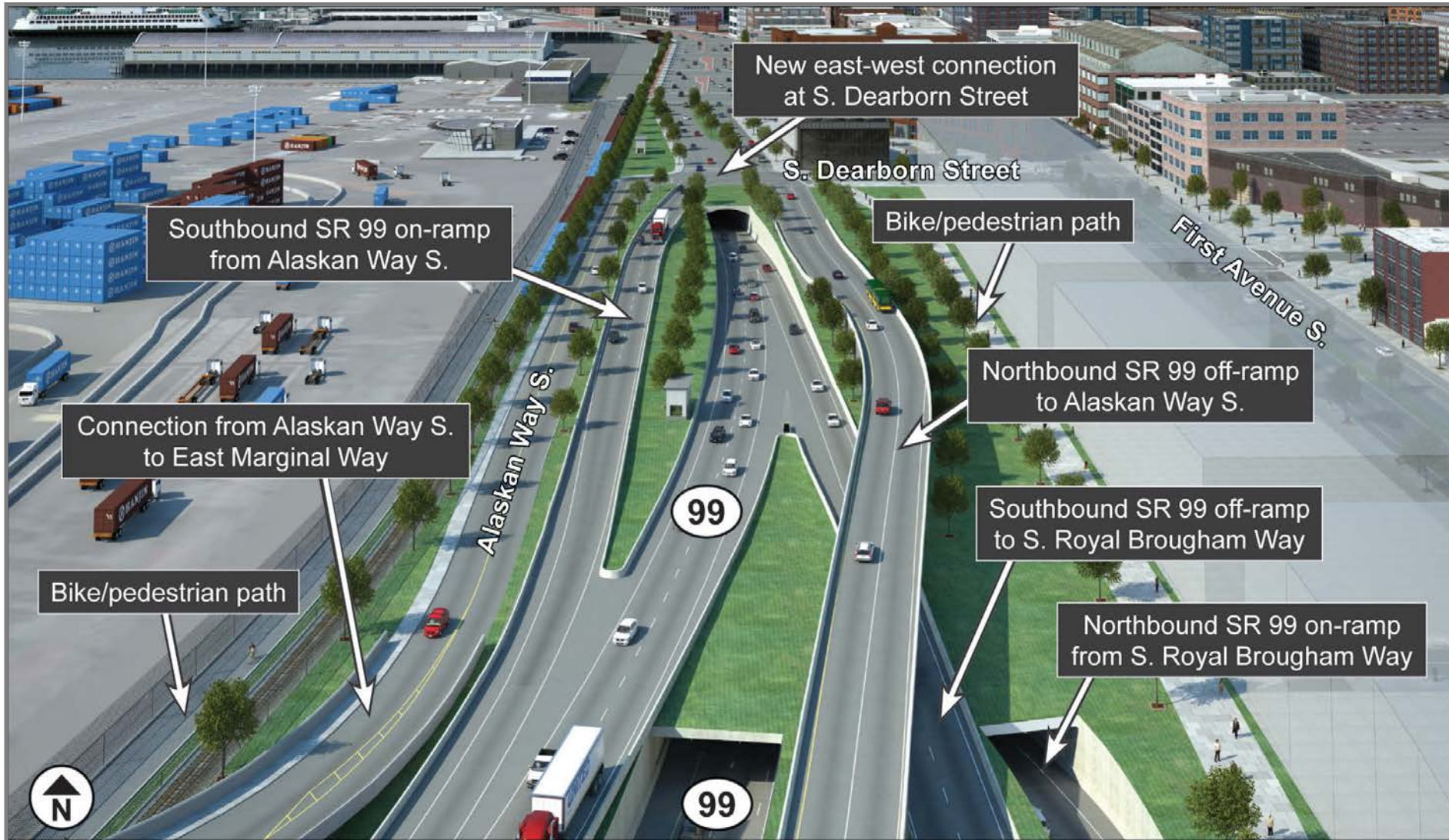


Freestanding concrete frame
650' units
Construction Sequence

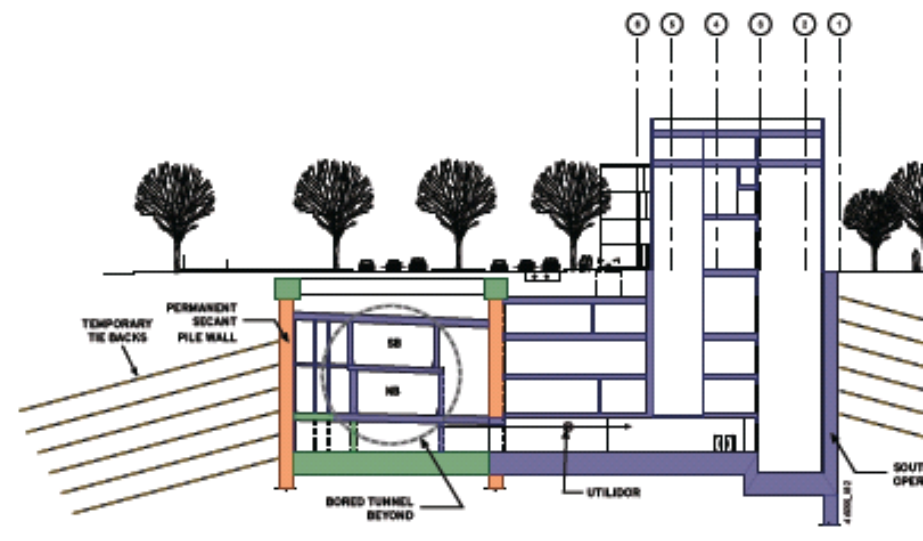
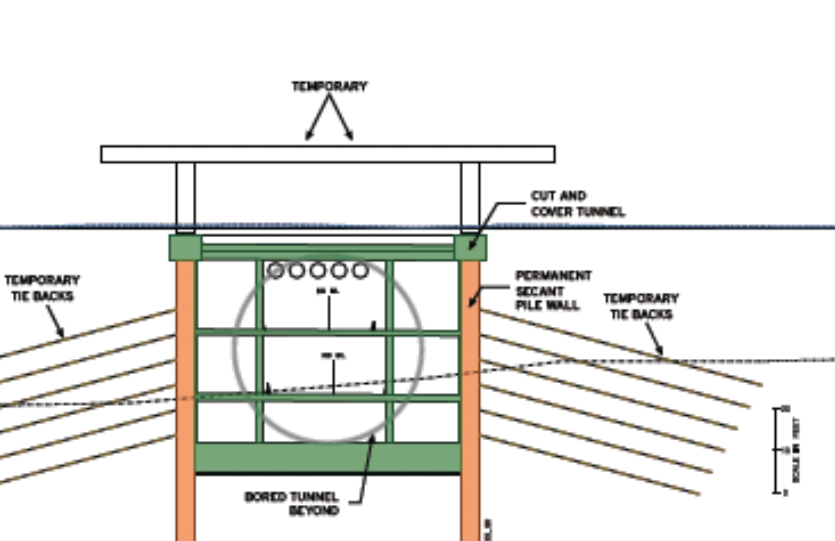
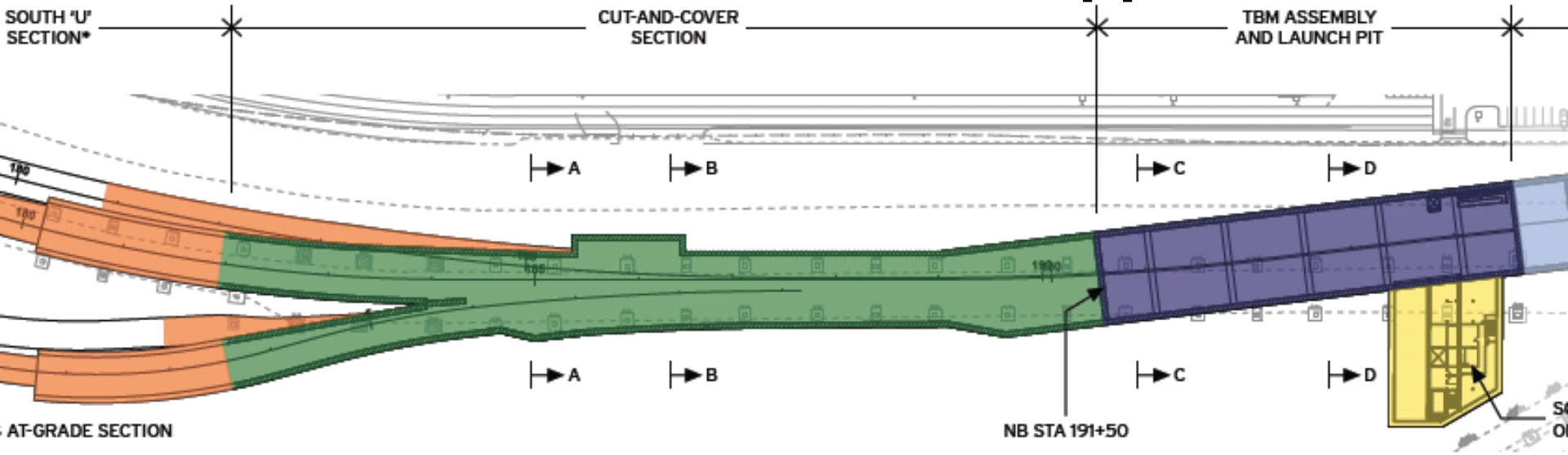
Alaskan Way Viaduct REPLACEMENT PROGRAM



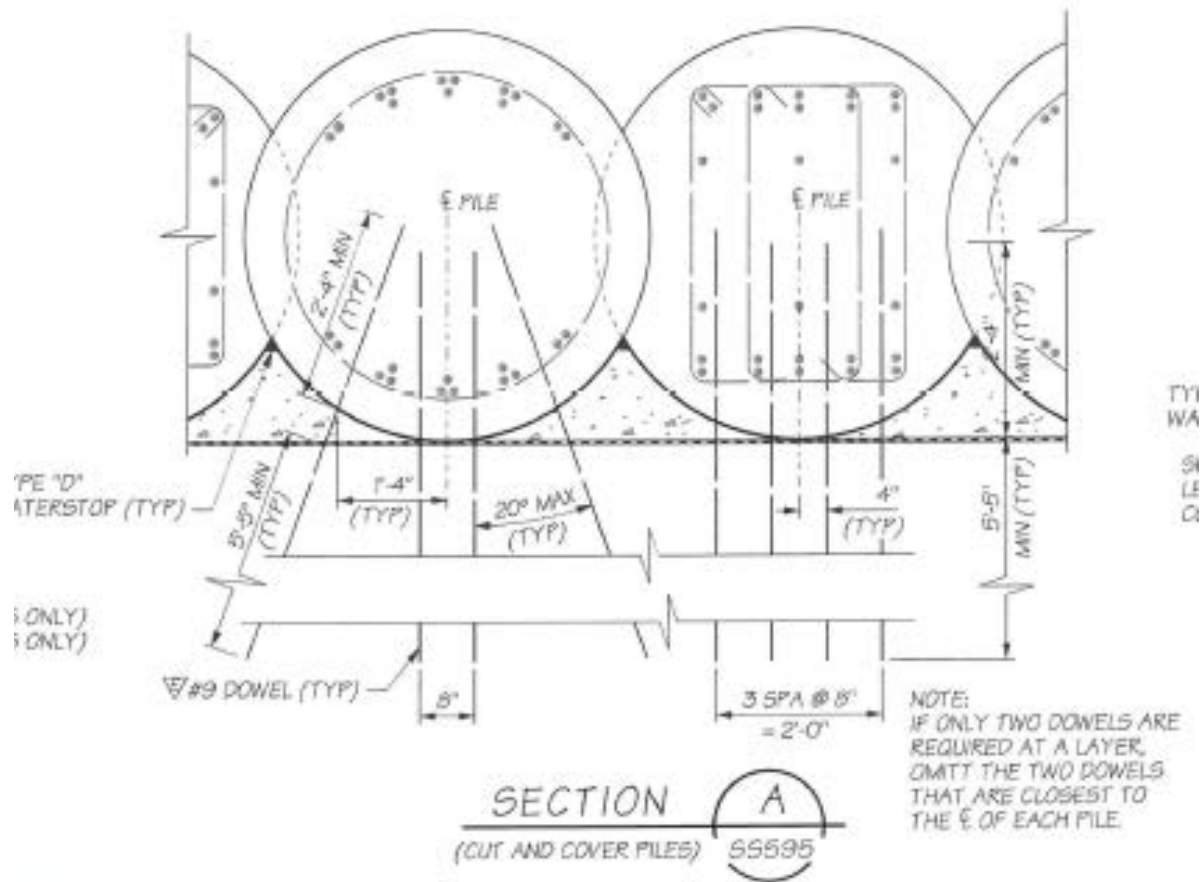
Approach Structures



Cross-Sections at South Approach



Approach Structure



Tunneling Machine Launch Pit



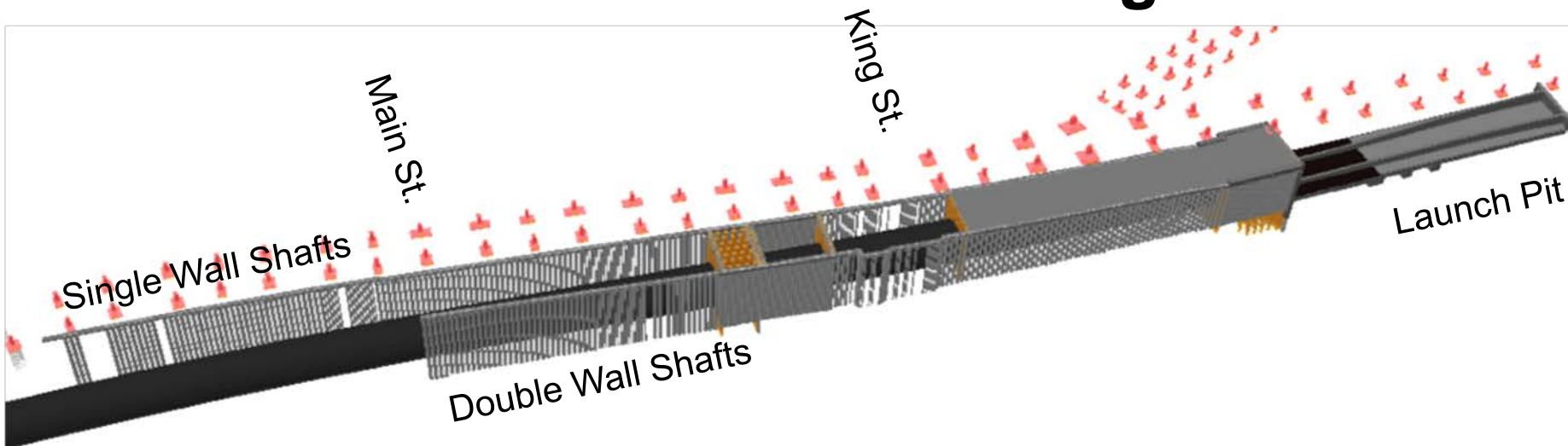
Machine in Launch Pit



Approach Structure Construction



South End Settlement Mitigation



Buoyancy Slab



The Start of Tunneling



Acknowledgements

WSDOT Structures: Tim Moore

Design Manager: Rich Johnson

South Approach: Tie Zong

Tunnel Liner: Yang Jiang

Tunnel Interior Structures: Tom Cossette

North Approach: Andrew Herten

Settlement: Carlos Herranz Calvo

Website:

www.AlaskanWayViaduct.org

Twitter:

@BerthaDigsSR99

Email:

viaduct@wsdot.wa.gov

Hotline:

1-888-AWV-LINE

