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A world of experience
Learning from local and international tunnel projects

For the Alaskan Way Viaduct's central waterfront replacement, between S. King Street and the Battery Street Tunnel, there is an ongoing environmental process that is reviewing three alternatives – a bored tunnel, cut-and-cover tunnel and an elevated structure. If the bored tunnel alternative is chosen, we would move SR 99 into a bored tunnel beneath downtown, reconnect the street grid at the ends of the tunnel and remove the viaduct along the waterfront.

As preliminary design and the environmental process moves forward, we will benefit from lessons learned by other tunnel projects that have been completed or are underway. Several international tunnels have been completed in similar environments and with sizes comparable to the proposed SR 99 bored tunnel. From projects in the United States, including Seattle's Sound Transit Beacon Hill Tunnel and the downtown transit tunnel, to projects in Germany, China and Spain, advances in tunnel technology and experience are being made around the world.

In addition to technology and construction, we would also benefit from lessons learned about how to manage large transportation projects on time and on budget. We know that many infrastructure projects, including those with tunnels, have been completed under budget, but also that many have gone over budget. WSDOT understands this issue and, as a result, developed the Cost Estimate Validation Process (CEVP®) in 2002. Additionally, WSDOT has proactively met with teams from large infrastructure projects around the country and made significant changes to how the agency manages such projects to address the special needs of large, complex urban infrastructure projects.

This tunnel boring machine is 50.6 feet in diameter and is similar in size and type to the machine we would use to build the proposed SR 99 bored tunnel.

Cross section of proposed SR 99 bored tunnel. (early design concept)

Learning about construction

Tunnels with similar sizes

There are a number of successful tunnel projects with sizes similar to the proposed SR 99 bored tunnel. The bored tunnel itself would be designed with an approximate interior diameter of 52 feet and approximate length of 9,100 lineal feet. The tunnel's depth would range between 60 and 200 feet

Tunnel projects of similar sizes include:

- *Shanghai Yangtze River (China):* Includes two bores, each about 5 miles long with a 50.6-foot diameter.
- *Fourth Elbe River Tunnel (Germany):* Includes a single bore with a length of about 2 miles and a 46.6-foot diameter.
- *Madrid M30 (Spain):* Includes bores with a length of about 5 miles and a 49.9-foot diameter.

Tunnels constructed in similar environments

Numerous tunnel projects, including several in Seattle, have successfully excavated ground conditions similar to those anticipated for the the proposed bored tunnel. The ground conditions along the tunnel route include soft soils at the tunnel's southern entrance, then hard and dense glacier-deposited soils for the remainder of the alignment and at the north entrance. During tunnel construction, we would expect to find materials normally present in glacial soils, such as small rocks and boulders.

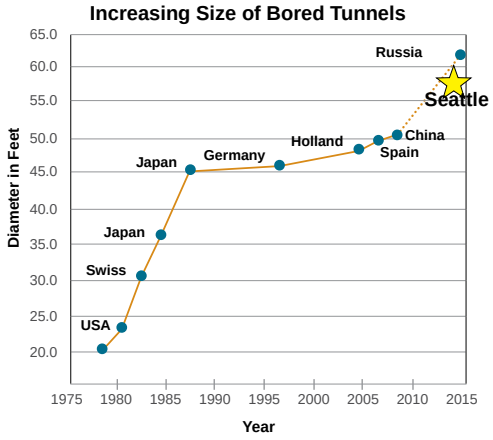
More than 150 tunnels have been completed in Seattle since 1890, mostly in glacial soils. International and local tunnels constructed in similar soil as the proposed bored tunnel include:

- *Sound Transit Beacon Hill Tunnel, Metro Transit Tunnel and Mercer Street wastewater tunnel (Seattle)*: Ground conditions of glacial sand, silt, clay and other soils similar to the hard and dense soils along most of the proposed SR 99 bored tunnel alignment.
- *Grauholz Tunnel (Switzerland):* Ground conditions of glacial sand, clay and silts.
- *Shanghai Yangtze River Tunnel (China):* Ground conditions of clay, sand and rubble that are similar to soils at the south entrance of the proposed SR 99 bored tunnel.
- *Fourth Elbe River Tunnel (Germany):* Ground conditions of sand and clay with boulders and obstructions.

Advances in technology

As more projects are completed, tunnel boring technology will continue to experience advances and improvements. Tunnel boring machines have been developing at a rapid rate with a major increase in diameter, better ground control, and improved reliability. These machines can now safely excavate almost any type of soil, rock or groundwater conditions.

Technological advances can be expected to continue into the future. For example, a 62.3-foot diameter boring machine to construct a Russian tunnel is in design. Advances in technology, as well as lessons learned from other tunneling projects, would help us build the bored tunnel safely, efficiently and successfully.



Learning from cost and schedule problems

Prior to the state legislature's approval of the Nickel Program, which funded more than $3.9 billion in transportation investments across the state, WSDOT set up a number of programs and processes to ensure that projects were delivered on time and on budget. These programs were established after agency managers visited large infrastructure projects around the United States to understand how projects were successfully managed and what went wrong when budgets and schedules were not met.

Key elements of WSDOT's management program include:

- Cost estimating – WSDOT developed the internationally recognized Cost Estimate Validation Process (CEVP®), which uses outside experts to help establish a "base cost" for a project and to identify and quantify risks and opportunities that may add to or subtract from the base cost. CEVP® can establish a more realistic budget at the early stages of a project and identify risks, opportunities and issues that need to be actively managed.
- Risk management – When risks are identified in CEVP®, plans are developed to mitigate, avoid, transfer, or accept these risks. The result can be a better managed project that is less vulnerable to surprises.
- Project delivery – WSDOT's procedures and tools for delivering projects include a project delivery system, which uses proven industry tools and standards.
- Direct management – Large projects take dedicated project teams, so WSDOT established dedicated project teams to better manage these large projects using practices different from those normally required for a smaller capital project.

Examples of tunnel projects that have been completed under or close to their early estimate/budget as a result of better management include:

- *Mt. Baker Ridge Tunnel (Seattle):* 54 percent under estimate.
- *Mercer Street Sewer Tunnel (Seattle*): 23 percent under estimate.
- *Red Line North (Boston):* 30 percent under estimate.
- *Dorchester Sewer Tunnel (Boston*): 19 percent under estimate (not yet complete).
- *Metrowest Tunnel (Boston):* 9 percent under estimate.
- *Boston Harbor Project (Boston):* 4 percent over estimate.
- *Southwest Corridor (Boston):* 1 percent under estimate.
- *Metro Gold Line East (Los Angeles):* On budget.

However, we are well aware of projects that exceeded their early estimate/budget.

- *Red Line 3 Subway (Los Angeles):* 11 percent over baseline.
- *Hiawatha Airport tunnels (Minnesota):* 23 percent over baseline.
- *63rd Street Transit Connector (New York City):* 29 percent over baseline.
- *Silverline Subway (Boston):* 90 percent over baseline.
- *Tren Urbano Subway (Puerto Rico):* 133 percent over baseline.

Problems on these and other international projects have led to the processes, noted above, that WSDOT uses to establish cost and schedule control with accountability.

WSDOT consults worldwide tunnel experts

The Alaskan Way Viaduct and Seawall Replacement Program team held a three-day construction strategies workshop in March, bringing together several national and international experts on tunneling to get their feedback on the proposesd SR 99 bored tunnel.

Tunnel experts from Italy, Germany and the United States were invited to Seattle for the workshop. They weighed-in on bored tunnel delivery strategies, contracting methods and technological considerations. By having these experts all in the same room, the goal was to:

- Identify potential innovative project delivery and contracting methods;
- Advise on the scope, size and complexity of potential contract packages;
- Consider risks and risk management strategies; and
- Advise regarding necessary strategies and actions to meet program goals.

The program team is challenged to meet an aggressive delivery schedule for the viaduct's central waterfront replacment, which is expected to be begin construction in 2011. The team is gathering and refining information and conducting technical investigations and right of way research to move the project through the environmental process.

Tunnel workshop members review materials from the WSDOT project team.

Comments or questions?

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