JULY 2009

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Seattle's Alaskan Way Viaduct

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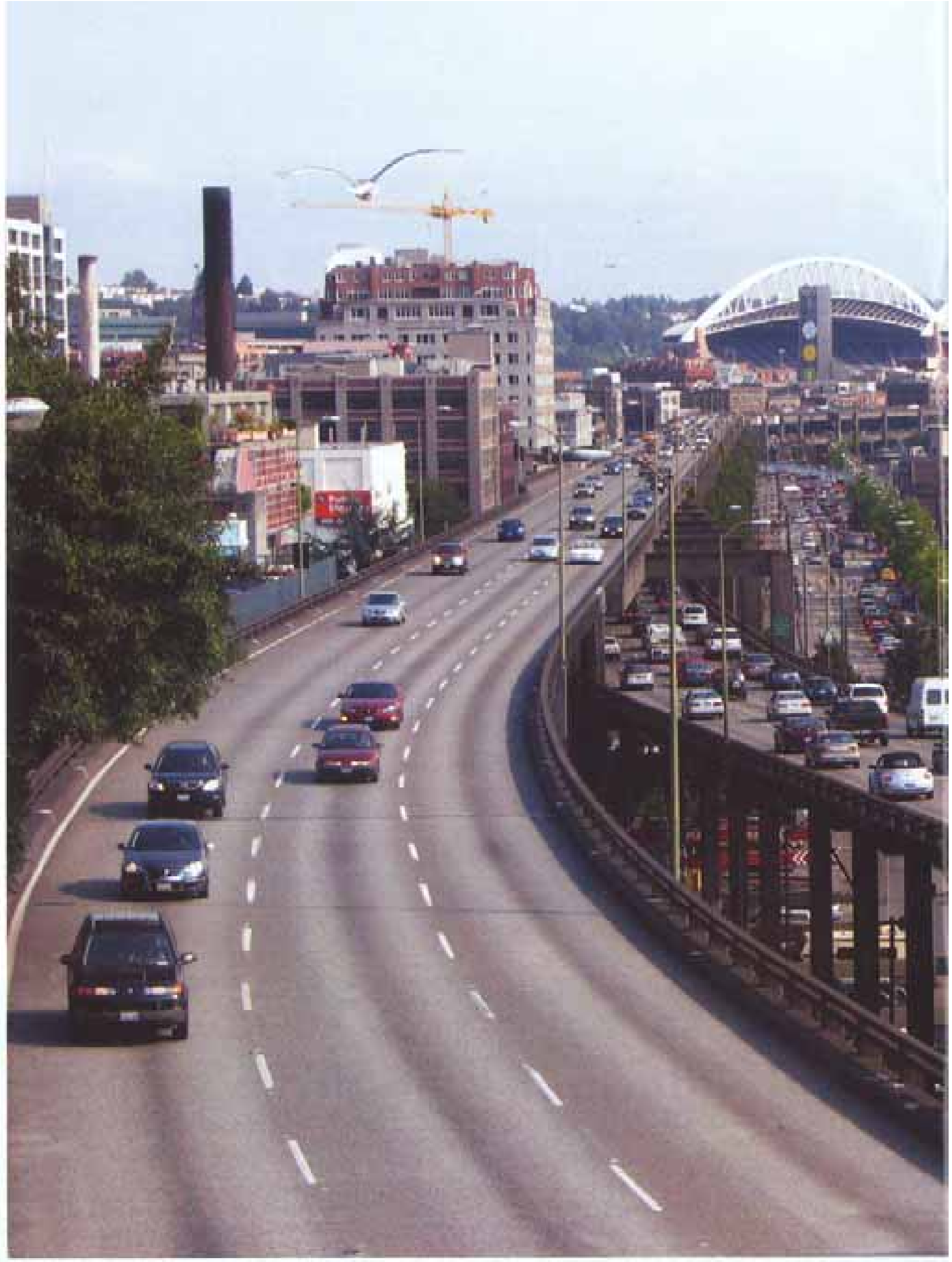
PROJECT SPOTLIGHT

Replacing the Alaskan Way Viaduct

An answer for Seattle's waterfront highway dilemma

By John White, P.E.



Looking south on the Alaskan Way Viaduct. Replacing a highway structure in a dense urban environment is one of the challenges faced by the program team.

For 56 years, the two-mile-long Alaskan Way Viaduct has stood along Seattle's downtown waterfront. It serves as a conduit for Washington's State Route (SR) 99 and provides an elevated way into and through downtown for more than 110,000 vehicles per day.

Daily wear and tear has taken its toll on the two-tiered structure, and mid-1990s studies showed that the viaduct was nearing the end of its useful life. The early discussion of replacement was jolted, however, by the 6.8-magnitude Nisqually earthquake, which shook the Puget Sound region in 2001. The earthquake caused damage to the viaduct's joints and columns and to the adjacent seawall, which holds back the soils in which the viaduct's foundations are embedded. The decision was clear — the viaduct needed to be replaced.

For eight years the state and city worked to find a solution that would serve many competing interests; one that would continue to move people and goods; allow the city to reclaim its historic waterfront; limit construction disruptions; and be fiscally responsible.

During this time the technology to bore tunnels deep underground at ever increasing sizes was being used on projects throughout the world. These advances finally provided an answer for the viaduct replacement: take the highway underground and away from the waterfront. Not into just any tunnel, however. If built today, the proposed bored-tunnel section of SR 99 would be constructed utilizing the largest diameter tunnel boring machine in the world.

Several challenges, few solutions

After the 2001 Nisqually earthquake, the Washington State Department of Transportation (WSDOT) and the Seattle Department of Transportation began examining more than 70 options for replacing the seismically vulnerable viaduct and the adjacent seawall. These included elevated, underground, and surface options.

One of the difficulties in finding a replacement was due to Seattle's unique geography. The city has an hourglass shape, with downtown sitting in the middle between Puget Sound and Lake Washington. The city has only two major north-south routes — SR 99 and Interstate 5 — so maintaining the viaduct is critical. The viaduct also provides access to the northwest part of the city, as well as the Port of Seattle's cargo shipping terminals near the southern end of the structure.

The numerous options were eventually narrowed to two — a new elevated structure, and a cut-and-cover tunnel. At the time, WSDOT and the city agreed that the preferred option was the cut-and-cover tunnel, but cost presented a barrier. The state and city had committed funding to replace the viaduct, but the cut-and-cover tunnel's cost exceeded that commitment. The city, however, did not want to lose the opportunity to reclaim one of its most valuable assets, the historic waterfront on which the viaduct stands. An advisory vote was held for Seattle voters to resolve the impasse.

Residents were presented with the options, but the vote did not require voters to choose; instead, it presented the elevated structure and tunnel as separate choices on which residents could vote. The result was a rejection of both. In the aftermath of this defeat, the governor, King County's executive, and Seattle's mayor found a way to move forward.

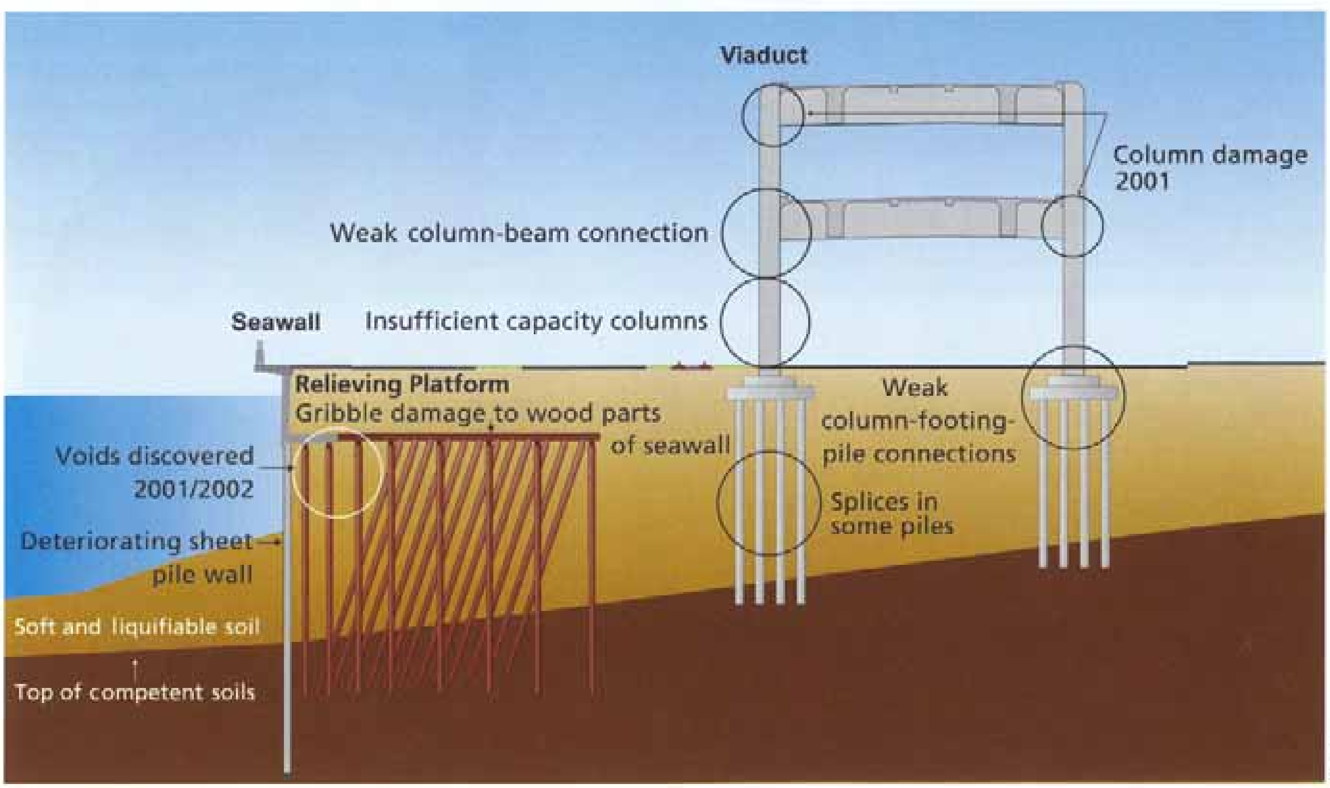
The elevated and tunnel options had similar components at the north and south ends of the corridor. The three executives agreed that they could move these elements forward, thereby removing almost half of the vulnerable structure, while reexamining how to replace the section on the downtown waterfront, a segment dubbed the "riddle in the middle." The state, county, and city DOTs then took a step back and looked at ways to improve the downtown transportation system as a whole, centered on SR 99 replacement options.

Paired with this new system approach was an extensive public outreach effort that included a 30-member stakeholder group, which provided feedback on potential options. This 13-month process culminated at the end of 2008 with two options: an elevated bypass and a surface and transit solution. Waiting in the wings was a twin-bored tunnel concept that seemed to meet all of the criteria desired in a solution except one — cost. Stakeholders, supported by a group of tunneling experts, asked that the tunnel continue to be analyzed, so the agencies engaged a wider group of tunnel experts to examine construction and cost estimate assumptions.

The SR 99 bored tunnel — a competitive solution

The project team knew a twin-bored tunnel was too expensive, but could a single bored tunnel suit the project's needs? The answer from tunnel experts was a resounding yes. Advances in tunnel technology meant a single bore could be built large enough to accommodate at least four lanes of traffic in a stacked configuration. In the years since the viaduct replacement program began, tunnel boring machines had been developing at a rapid rate, with a major increase in diameter, better ground control, and improved reliability. These machines could now safely excavate under almost any type of

Diagram of vulnerable points on the Alaskan Way Viaduct and seawall.



RAI: How will you control groundwater during boring?

WSDOT: The ground conditions 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. We also expect to find common materials, such as small rocks and boulders.

Generally, as the tunnel is bored, it is lined with pre-cast concrete. Gaskets on the concrete panel make the panel watertight. As each ring of concrete panels is completed, tail seals keep water, grout, and other materials from entering the tunnel.

The completed tunnel will have a state-of-the-art drainage system with pumps to remove water from fire sprinklers, and runoff from vehicles or surface water.

RAI: How will you monitor vibration and protect structures above the tunnel during construction?

WSDOT: This spring, we drilled geotechnical borings every 1,000 feet along the tunnel alignment. In June 2009 a second round of borings will begin. Once this work is complete, soil samples from every 100 to 400 feet along the alignment will help us determine where pre-construction ground stabilization should take place, and influence the installation of ground monitoring equipment. The samples will also aid the tunnel designers and tunnel boring machine contractor.

This summer we will also begin to survey existing buildings along the tunnel alignment to confirm the condition of underground structures, such as parking garages, building foundations, and basements. We will conduct a more extensive survey once the tunnel contractor is selected. Before construction begins we will install monitoring devices in buildings to detect any movement as the boring machine does its work underground.

soil, rock, or groundwater conditions. Tunnels have also proven themselves over many years in challenging seismic environments, a concern since Seattle has several faults within city limits. The decision was made to move forward with a single bored tunnel.

As the team mapped out the proposal, cost was foremost in their minds. Tunnels have been successfully completed in similar environments and with sizes approaching that of the proposed SR 99 bored tunnel, but the industry also has its cautionary tales of projects gone awry. For policy makers to agree to the proposal, they

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(above) A view from under the existing viaduct. (below) An early design concept for the SR 99 bored tunnel. This will be the first double-deck tunnel in the United States.

WSDOT

had to have confidence in the tunnel's anticipated cost. WSDOT employed an unconventional cost estimate validation process, which uses a combination of a base cost plus risk costs and the corresponding likelihood of occurrence, expressing planning level costs as a range rather than as single numbers. The ranges show the effect of risks if they occur and are supported by risk management plans to better control costs. Almost 30 percent of the bored tunnel's estimated cost of $1.9 billion accounts for the risk inherent in a preliminary design and for expected inflation during the years of project construction. The total cost for the viaduct replacement program, including the transit, city street, and waterfront improvements, is $4.24 billion.

When the new SR 99 bored tunnel opens to drivers it will signify a number of firsts: It will be the first double-deck tunnel in this country. The double-deck configuration is what allows the tunnel to hold four lanes of traffic, matching the number of lanes traveling through downtown on today's viaduct. The tunnel will be approximately 54 feet in diameter, making it one of the largest tunnels in the world. At almost two miles long, it will be one of the longest highway tunnels in the United States. It will have a state-of-the-art ventilation system that eliminates the need for ventilation shafts in the middle of the tunnel. Tunnel construction is expected to make extensive use of precast elements that are assembled within the tunnel construction operation, allowing for a high quality product built within an expedited construction timeline.

Perhaps the greatest advantage of the bored tunnel is the limited disruption it will cause to surrounding neighborhoods and businesses. Above- and below-ground viaduct replacements examined up to this point would have required extensive SR 99 closures to construct. By using a tunnel boring machine and moving the tunnel several blocks inland from the waterfront, it is now possible to keep the viaduct open during construction — an important consideration since it is an important freight route.

With the projects identified and the state, county, and city's roles established, the pressure is now on WSDOT to deliver. After eight years of discussion, WSDOT looks forward to meeting that challenge. Crews will begin constructing the SR 99 bored tunnel in 2011, and WSDOT expects to open it to drivers by the end of 2015. ▼

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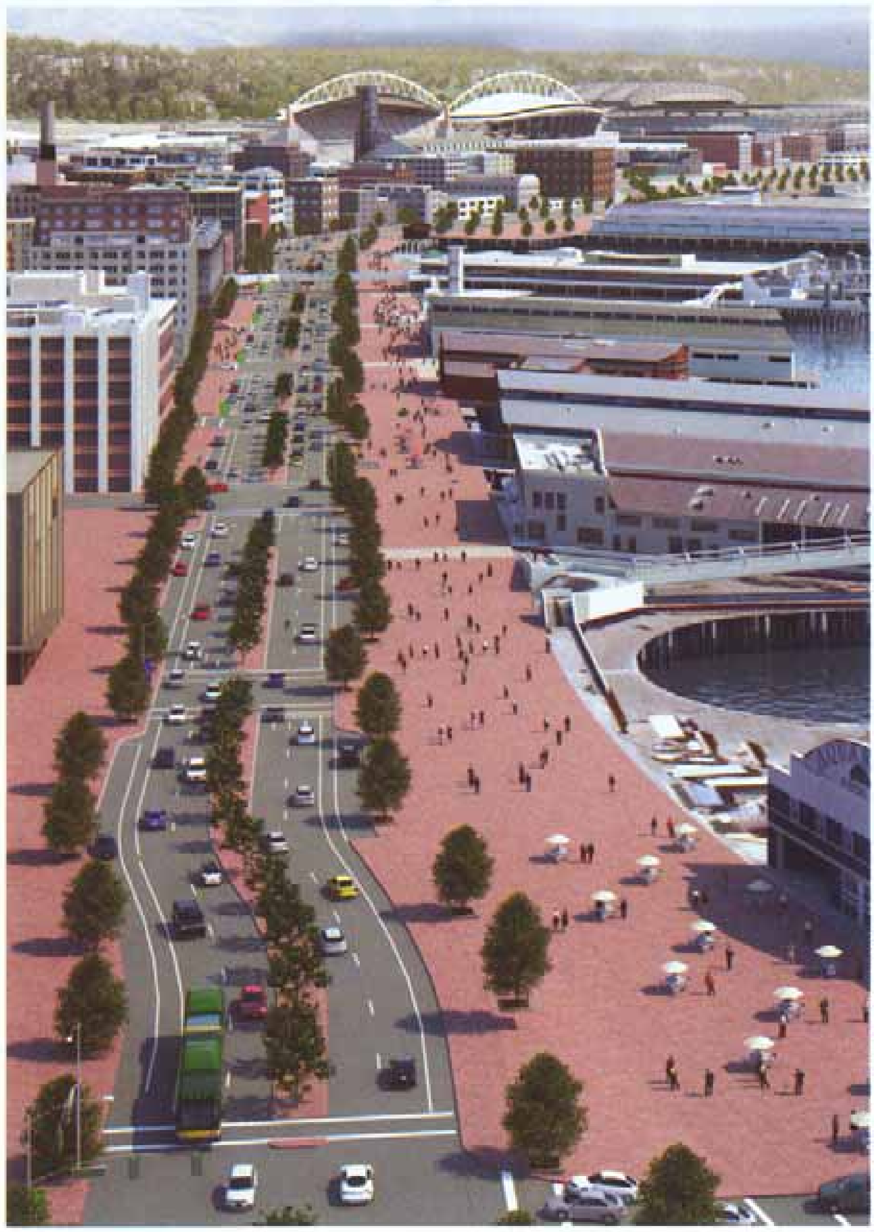
A rendering of Seattle's downtown waterfront after the SR 99 bored tunnel has been built and the viaduct removed. A new surface boulevard will be constructed in the footprint of the viaduct. The remaining space will be used by the city to create a new waterfront promenade.



Courtesy Washington Department of Transportation