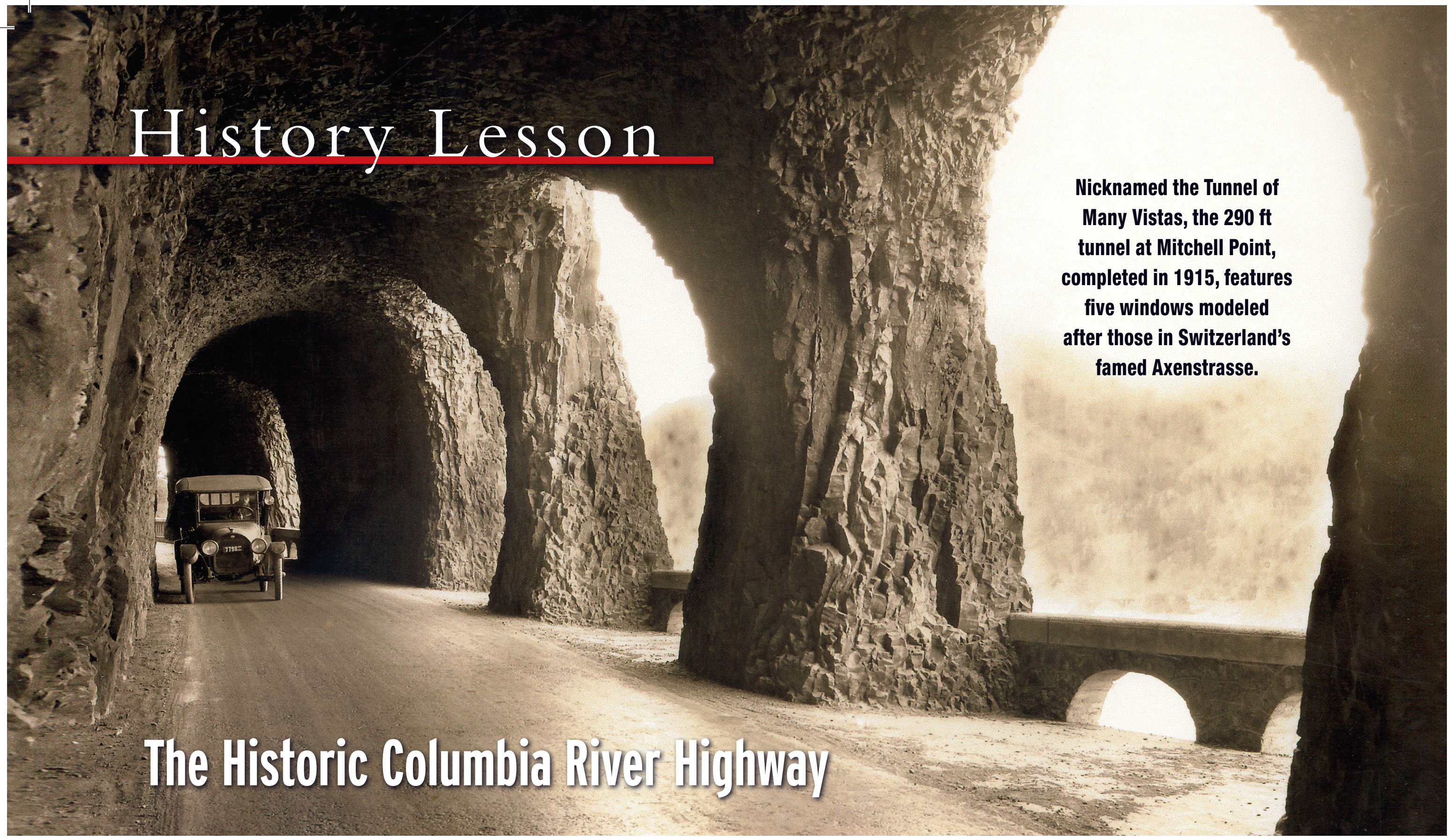


Nicknamed the Tunnel of Many Vistas, the 290 ft tunnel at Mitchell Point, completed in 1915, features five windows modeled after those in Switzerland's famed Axenstrasse.

The Historic Columbia River Highway

CARVED BY VOLCANOES and floods, the Columbia River Gorge is one of America's premier landscapes, rising more than 4,000 ft. Extending along more than 80 mi, the gorge encompasses both rain-soaked forests and drier, rolling vistas.

What is nearly as remarkable is that this remote, scenic landscape at the border between Oregon and Washington would demonstrate to an entire nation that public roadways can be as beautiful as the environments they traverse. But the Historic Columbia River Highway set the precedent for how infrastructure can mesh with the landscape rather than mar it.

"This is the first scenic highway designed in the country," says Mark Libby, P.E., M.ASCE, the president of ASCE's Oregon Section. "It became the prototype or the template for scenic highways. Much of what is done in state or federal parks or by the Forest Service is borrowed from what was done on this project."

Work on the highway began in 1913 and was completed in 1922 at a cost of $11 million. The highway was dedicated in 1916, and the Oregon Department of Transportation (ODOT) has scheduled centennial events throughout this year. A technical tour of the Historic Columbia River Highway and the Bonneville Dam on September 28 has been organized as part of the ASCE 2016 Convention, which will be held in Portland September 28–October 1 (visit www.asceconvention.org).

Constructing the 73.8 mi highway was the work of several visionary business leaders, along with talented engineers and road builders. But its driving force was Sam Hill, a businessman who was long an advocate of improving the road system in the Pacific Northwest. From his base in Seattle, he established the Good Roads Association in 1899, and in 1907 he helped create the country's first department of highway engineering, at the University of Washington.

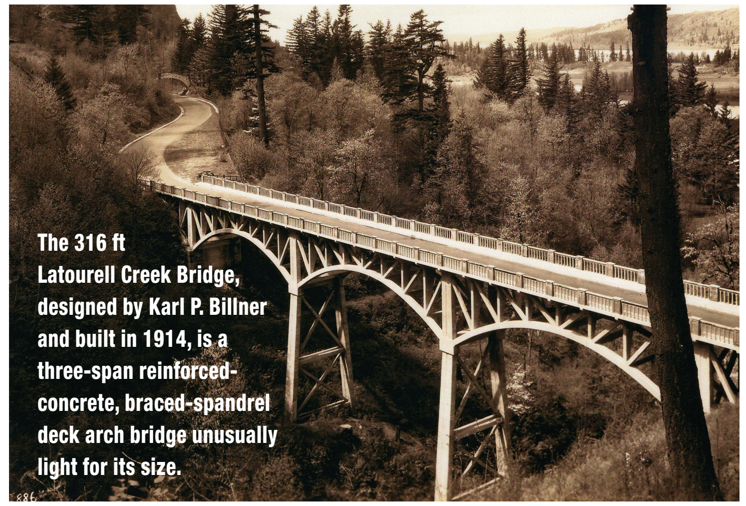
As interest in a roadway along the gorge heading east from Portland grew in the early years of the century, Hill hired the veteran engineer Samuel Lancaster, who happened to be the University of Washington's first highway engineering professor. Lancaster was as driven as Hill to marry nature with structure. "There is but one Columbia River Gorge [that] God put into this comparatively short space, [with] so many beautiful waterfalls, canyons, cliffs and mountain domes," he wrote. He envisioned a highway that would make "men from all climes . . . wonder at its wild grandure [sic]."

To attract the interest of state leaders, Hill asked Lancaster to test a new road surface called asphaltic macadam at Hill's country estate, Maryhill, which overlooks the river from a bluff on the Washington side. Hill invited lawmakers to Maryhill in February 1913 to observe what a modern road could look like. Impressed, state leaders formed the Oregon State Highway Commission, and work on the highway began later that year. By that September Lancaster, the consulting engineer for the entire highway, had begun to survey the westernmost portion of the road alignment—from Troutdale to the Multnomah County line.

From the outset Lancaster was determined to capture the awesome beauty of the gorge and design the roadway to work with it. As the nomination form for landmark status in the National Historic Landmarks Program points out, Lancaster and his crew "literally pulled themselves over the rocky and wooded terrain—taking photographs, drawing up blueprints, and always planning for a roadway that would blend subtly with the environment."

Lancaster established very detailed requirements for the design of the highway, including a maximum grade of 5 percent and a minimum turning radius of 200 ft on curves (reduced to 100 ft in a few places).

Construction began in October 1913, and Lancaster soon had his first opportunity to implement his ideas. The highway was set to pass the massive 725 ft promontory known as Thor's Heights. From its summit one could see up and down the river for 40 mi. But Lancaster couldn't locate his road at the base of the mountain because the Oregon–Washington Railroad & Navigation Company already had tracks there. So he designed a road that would circle the top of the cliff, which was later renamed Thor's Crown and then Crown Point.



The 316 ft Latourell Creek Bridge, designed by Karl P. Billner and built in 1914, is a three-span reinforced-concrete, braced-spandrel deck arch bridge unusually light for its size.

Robert Hadlow, a historian for the ODOT whose research was used in the nomination in the National Historic Landmarks Program, has authored several Historic American Engineering Record reports on the highway, as well as an oral history. He notes that Lancaster designed a curving, 560 ft viaduct that hugged the summit of Crown Point. The substructure of the viaduct, Hadlow notes, provided retaining walls for the roadway. The walls were built with 28 reinforced-concrete slabs having spans of 20 ft, which also made it possible for a sidewalk to ring the road. In 1918, at the top of the promontory, the Portland architect Edgar M. Lazarus built an octagonal building, Vista House, to serve as a memorial to Oregon pioneers and as an observation lookout.

In many instances Lancaster tackled steep grades by routing the highway through a series of symmetrical horseshoe bends, or loops. The road curves were even banked at slopes of 5 to 6 degrees to make them easier for cars to manage. It was a new idea in this country, says Larry Magura, P.E., D.WRE, M.ASCE, a former president of ASCE's Oregon Section. Lancaster probably borrowed the idea from a tour of European roads that he and Hill took prior to starting work on the highway.

These "figure-eight loops," according to the National Historic Landmarks Program nomination form, were built "with an elaborate system of concrete curbs, gutters, and drop inlets, along with tiled drains and culverts, to keep water from standing on the pavement and causing road deterioration and safety hazards." Further, the highway was paved with Warrenite, "a two-inch layer of course-graded tar and aggregate mixture," which was put down while still hot over the original macadam roadway and then sealed with a "flush coat" of asphalt. Even today, Warrenite remains exposed and functional along portions of the highway.

The scenic highway passes more than half a dozen waterfalls. Bringing cars in proximity to such scenery required the construction of 26 bridges and viaducts. Bridge engineers created a variety of unique structures that responded to the particular demands of the locations. Highlights include the 316 ft Latourell Creek Bridge, designed by Karl P. Billner and built in 1914, a three-span reinforced-concrete, braced-spandrel deck arch bridge with three 80 ft parabolic rib arches. According to the historian Kenneth J. Guzowski, the braced-spandrel framing is more commonly found in steel deck arch construction and in this case resulted in a bridge that was uncommonly light for its size.

In 1915 at Moffett Creek, where the river gorge narrows, the highway commission engineer Lewis W. Metzger designed "one of the longest, shallowest three-hinged arches in the world," Hadlow writes, "with a clear span of 170 feet and a rise of only 17 feet." Unique among bridges in the Northwest, Metzger "used massive cast-iron hinges at the haunches and at midspan, with large steel pins to carry the load."

"One of the things that ties together all of those bridges is

Vista House, one of the signature features of the Columbia River Highway, tops the 725 ft Crown Point, which is ringed by a portion of the highway built atop a curving viaduct.

COURTESY OF DAVID SELL COLLECTION, *OPPOSITE AND ABOVE*; LIBRARY OF CONGRESS PRINTS AND PHOTOGRAPHS DIVISION, *RIGHT* they're all reinforced concrete," says Jeanette Kloos, the president of Friends of the Historic Columbia River Highway, a nonprofit advocate for the highway's restoration. Steel truss bridges of the type built at the Sandy River in 1912 and 1914 are more typical of the era. "To go into reinforced concrete was a departure from what was happening elsewhere."

Perhaps the most impressive element of the original highway work was the construction of several tunnels through the basalt rock formations forming the gorge. At the Oneonta Bluffs, at the eastern end of the gorge's belt of waterfalls, Lancaster faced a protruding basalt formation that prevented his road from continuing eastward. He planned to drill a 125 ft tunnel as a straight bore through the bluff, but the basalt rock was fragile and could have broken into small pieces during drilling. There was only 18 ft of rock, Hadlow writes, between the outer wall of the proposed tunnel and the cliff face, and given that the railroad was immediately adjacent, there was concern that boring the tunnel might cause an avalanche of rock onto the track. To solve the problem, Lancaster injected concrete into the crevasses to hold the basalt together during drilling.

John Arthur Elliott, a former student of Lancaster's at the University of Washington, largely took over the siting of the highway west of the Multnomah County line. On this side the biggest challenge was a large basalt headland called Mitchell Point. The grade up was so steep that gasoline couldn't reach some engines, and drivers weren't sure their brakes could handle the dicey descent. According to a 2009 oral history of the highway completed by Hadlow and Amanda Joy Pietz, Elliott noted that "a great many machines were turned back when the man at the wheel took a look at the narrow, winding and rocky path with a wall of rock and gravel on one side and a death-dealing abyss on the other."

Elliott, like Lancaster, wanted to keep the grade below 5 percent. The solution was to cut a ledge into the cliffside, construct a 192 ft reinforced-concrete slab viaduct, and then bore a 290 ft tunnel through Mitchell Point. Elliott was inspired by Switzerland's famous Axenstrasse, but he hoped to do the Swiss one better. The Axenstrasse had support pillars between its three adits, or windows. Elliott created five windows with no support, and he bored a curving tunnel so that "drivers approaching the tunnel from either end had a head-on view of the central three windows and the rock columns that separated them," according to Hadlow and Pietz's history. The effect was to create constant illumination during daylight, some of the light appearing mysteriously from windows around the bend that drivers couldn't yet see. Construction of the tunnel was completed in 1915, and its five windows inspired its nickname, the Tunnel of Many Vistas.

The highway was a success, one of the great road-building achievements of the early decades of the 20th century. At first, Kloos says, traffic volume was so low that people would park their cars in the middle of a bridge and get out to admire the scenery. "It didn't stay that way for very long," she points out. "By the thirties, there was so much traffic they were starting to think about and work on building a straighter water grade route so you could get from here to there faster."

The need for a larger road to accommodate more traffic coincided with the 1937 opening of the Bonneville Dam. (See "Empowering the People: The Bonneville Dam," by Brett Hansen, *Civil Engineering*, June 2010, pages 40–43.) Building the dam shifted railroad alignments, which in turn affected road development. Together, these two factors altered the Columbia River Highway's fate.

A two-lane route at the waterline was opened to accommodate larger cars and increased traffic. In the middle decades of the 20th century, the story of the highway was about give and take. While some new iconic structures were added, for example, the 837 ft Toothrock Tunnel, which is illuminated by electric light from the dam, other structures were lost. The tunnel at Mitchell Point was blasted away, and the Mosier and Oneonta tunnels were closed because of safety concerns. (The Oneonta reopened to pedestrians in 2009.) During the 1960s and 1970s the two-lane road was expanded to four lanes, and by 1980 it had become Interstate 84.

Most of the original highway remained. However, it was divided into portions, some open to cars but others only to hikers or cyclists. Many cyclists attempt to ride their bikes from one segment of the old highway trail to the other, even though this requires that they brave the shoulder of I-84 itself. "It's not very pleasant," Kloos says of the experience.

In the 1980s the state began restoring the segments of the old highway and reconnecting them into one recreational asset. According to Friends of the Historic Columbia River Highway, the state hired a master mason to oversee repair on the portions of the highway still open to cars. Concrete spindles were replaced on most of the bridges, rock walls were repaired, and a new "two-rail, steel-backed wooden guardrail was crash-tested and installed," explains Kloos. By 1996 the abandoned portion of the old highway between the dam and the city of Cascade Locks was reopened.

COURTESY OF OREGON DEPARTMENT OF TRANSPORTATION

Now, only 10 mi remain for restoration—between Cascade Locks and Hood River. The western half of that stretch is being completed in two stages. A 1.5 mi, $2.8-million trail restoration project will be completed this September, and a 3.5 mi section is to be completed in 2018.

Stitching the rest of the trail together involves dealing with the challenging topography. Much of it abuts steep rock walls, a busy interstate, or both. "From the standpoint of our design challenges, this is a picture of the whole project," says Tova Peltz, P.E., G.E., C.E.G., a regional geoenvironmental manager for the ODOT. "We're trying to develop contemporary design that honors the historic aesthetic that fits around our natural resources and our natural hazards."

Those hazards include the steep talus slope of Shellrock Mountain, which looms over I-84. The highway curves a bit to slip around the mountain, and the shoulder narrows to 3 or 4 ft. At present a large structure built with Bin-Walls—gravity-type metal retaining wall panels manufactured by Contech Engineered Solutions, of West Chester, Ohio—and equipped with a rockfall catchment fence safeguards the interstate from any loose rock on the talus slope above. To build a trail in an area that does not appear to have the space for one, ODOT engineers will construct the trail on top of the Bin-Wall structure. The rockfall protection will then be shifted up the slope to guard both the highway and the new trail.

From there the ODOT plans to build an 800 ft long reinforced-concrete viaduct that will ascend from I-84 to a secluded trail called the Mossy Road. Although it's located just 40 ft above the interstate, the trail feels worlds away. To bring the trail back down to the riverside, a ledge will be blasted into the cliffside at Lindsey Creek.

Peltz says the structure will be relatively straightforward; the challenge was determining the alignment. "The amount of time all of the members of the design teams have spent walking alignment alternatives and discussing options [is such that] years and years have gone into establishing the alignment," she explains. The effort involved "going back and forth, climbing through a lot of poison oak and down a lot of rocky slopes to decide what the best alternative was going to be." Those design teams included structural engineers, geologists, geotechnical engineers, landscape architects, and trail designers.

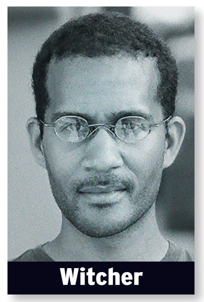
The final 5 mi of the trail may prove even more challenging. In the 1960s the tunnel at Mitchell Point was, as mentioned above, blasted away to facilitate the expansion of what would become I-84. Today's engineers are now faced with the same challenge that Elliott faced 100 years ago: how to circumvent Mitchell Point. They're considering the same solution: a tunnel. If the ODOT opts for a tunnel, engineers would probably push it farther back into the slope (which would mean lengthening the tunnel to a quarter of a mile) because the demolition of the original tunnel may have fractured some of the rock nearby, making boring more hazardous.

The last segment carries an estimated cost of $32 million, and funding has not been secured. Thus, it may be another decade before the last portion of the venerable highway and trail system is complete.

But Oregonians appreciate how close they are to bringing the highway full circle to its roots. The highway's centennial was celebrated this past June with a caravan of vintage automobiles, speeches by two former Oregon governors, and an artillery salute (echoing the cannon fire of the original dedication, in 1916). Communities along the route hope the connected trail will lure more travelers and cyclists.

Peltz sees the highway as an incredible resource. "It's so cool to be able to look at this amazingly designed civil works project that's 100 years old and get to add to it and contribute to expanding it and making it accessible to more people."

The Historic Columbia River Highway was accorded landmark status by ASCE in 1984 in its Historic Civil Engineering Landmark Program and by the U.S. secretary of the interior in 2000 in the National Historic Landmarks Program. —T.R. WITCHER



T.R. Witcher is a contributing editor to Civil Engineering.