YALE BRIDGE **HAER No. WA-87**
(Lewis River Bridge)
State Route 503 spanning the Lewis River
Yale vicinity
Cowlitz County
Washington

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

PHOTOGRAPHS

HISTORIC AMERICAN ENGINEERING RECORD
NATIONAL PARK SERVICE
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(Lewis River Bridge)

HAER No. WA-87

Location:	State Route 503 spanning the Lewis River, Yale Vicinity, between Cowlitz and Clark counties, Washington, beginning at mile point 27.84.
	UTM: 10/548680/5089700
	Quad: Yale Dam, Wash.
Date of Construction:	1932, rebuilt 1957-58
Engineer:	Harold E. Gilbert, C.E., Olympia, Washington
Fabricator:	Gilpin Construction Company of Portland
Owner:	Cowlitz and Clark counties were the original owners. The bridge was transferred to the Washington Department of Highways sometime in the late 1930s. Since 1977, the Washington State Department of Transportation, Olympia, Washington, has been the owner.
Present Use:	Vehicular and pedestrian traffic
Significance:	The Yale Bridge is the only steel short-span suspension bridge in the state, although there are many timber examples. It is rare in the sense that less expensive span types are usually chosen for short crossings but it was built economically, using cost-saving materials and construction techniques.
Historian:	Robert W. Hadlow, Ph.D., August 1993

History of the Bridge

The Yale Bridge is the only short-span steel suspension structure in Washington. It is rare to find this type of bridge at any location because mathematical calculations in stress analysis made in the course of designing a suspension span were tedious and time consuming. Rarer still is the placing of a suspension bridge in a remote location on what was at the time of construction, in 1932, a county road. But the Yale Bridge was an experiment in designing for economy. Its advanced system of tower main cable connections made erecting the bridge relatively simple and permitted the use of smaller diameter cables.[1]

The Yale crossing of the Lewis River between Clark and Cowlitz counties in southwest Washington is 55 miles north of Portland, Oregon, by way of roads through Vancouver, Washington. It became a local cause in the early twentieth century to build a bridge across the river as a means to link this heavily forested and remote area around Yale, in Clark County, with Yacolt, in Cowlitz County, and beyond to Vancouver. Citizens leagues in Yale and Yacolt presented their reasons for a bridge to their respective county commissioners, and in early 1917 the two governing boards decided to jointly finance a bridge.[2]

The county commissioners contracted with the Portland Bridge and Iron Company to erect a 275′ wood and metal deck truss with timber trestle approaches. Total costs for the structure, including labor and material for concrete piers, totaled about $15,000. Steel shortages causes delays during the First World War, but by Labor Day 1920, the bridge was completed and opened to traffic.[3]

In the early 1930s, the Northwestern Electric Company built a hydroelectric dam on the Lewis River twelve miles down river from the Yale bridge at Ariel. It was an arched structure with two 50,000-kilowatt electrical generators. A reservoir in the river canyon behind the dam, Lake Merwin, stretched back to the Yale bridge, raising water levels to 90′. With the backwaters flooding the bridge site the utility company proposed to the Cowlitz and Clark county commissioners that it either pay to raise the existing structure to accommodate the higher water level or that it would pay the counties an equal amount used towards erecting a new bridge.[4]

Design and Description

The county commissioners chose to build a new bridge and enlisted the State of Washington to draft the plans. Highway Department engineer Harold H. Gilbert designed the bridge. He also offered three design alternatives that provided economically built spans with an H-10 live-load rating. One was a 314' - 4" subdivided petite single truss based on the Queets Road bridge at Harlow. The second alternative was a two-hinged steel deck arch, and the third was a suspension bridge. All of the plans were suited for the Yale crossing with its deep water, where falsework for concrete arch or other steel truss spans was impracticable. Crews could assemble either the steel arch and the suspension span in cantilever fashion. The commissioners chose the latter plan. Construction was completed at a cost of $40,000 in 1932.[5]

The Yale Bridge, reading north to south, consisted of 132' of timber trestle, a 300' steel suspension span (with unloaded backstays), and 100' of timber trestle. The suspension towers are 88' - 9" high with the roadway giving a 50' clearance above the water. A laminated timber road deck measures 18' curb-to-curb. Concrete piers from the previous bridge were reused.[6]

The bridge tower legs are battered toward the centerline of the bridge. The center half of the legs consist of twin rolled I-beams riveted together with lace bars to form a box section. These I-beams are 24" deep spliced at quarter points into an I-section, consisting of four angles and a web plate. This I-section tapers from 24" at the splice to 14" at the end. They were attached to the piers with steel pins through cast steel rocker shoes that help eliminate bending stresses due to tower deflections and saved on the amount of steel costs. Below the deck, the tower bracing consists of steel angles and lacing arranged in an "X" pattern with the addition of a horizontal brace, all meeting at a mid-point and connected with rivets and gusset plates. A similar bracing arrangement was used above the deck, but the members were of lighter material. Finally, a light, Warren truss was used as top bracing between tower legs.[7]

The deck system's 20-panel, 7'-6" deep riveted Warren stiffening truss was constructed of rolled angle or rolled channel sections and batten plates. Connections at panel points were with gusset plates. The configuration made use of inexpensive and readily available components. Similarly, the deck floor beams are H-sections 20" deep, and deck bracing consists of rolled angles and lacing.[8]

The Yale Bridge's cable connection system furthered the county commissioners' goal of economic construction. The main cables consist of four 2-7/8"-diameter galvanized plow-steel ropes, two above each stiffening truss. But instead of running the entire length of the structure, from anchorage-to-towers-to-anchorage, they consist of separate sections. The backstay portions and main span portions were connected at the tops of the towers through steel castings and pins and linkages. The tower hardware's purpose was two-fold. Link-and-pin fasteners gave the ability to swivel the cables somewhat, simplifying construction. The more long-term reason for using discontinuous cables with cast tower connections was that the arrangement reduced wear on the cables because under load they were not sliding back and forth through more commonly used tower saddles. The pinned hinges at the tower-leg bases countered unbalanced forces. This further reduced materials costs because smaller diameter cables could be used.[9]

As another economizing measure, the Yale Bridge was designed with unloaded backstays. Timber trestles served as approaches instead of side-spans suspended by the backstay cables. Pyramid-shaped reinforced-concrete anchorages keyed into the river canyon's rock banks provided stable hold downs for the cables.[10]

Repair and Maintenance

The Yale Bridge served as a county-owned structure throughout the 1930s. The state of Washington assumed ownership and became responsible for maintenance by the early 1940s. Since it was originally built, the 300' suspended span has remained unaltered, but the timber approach spans were replaced in 1957 and 1958 with timber-decked steel-beam spans.[11]

A 1992 inspection report noted that the asphaltic concrete overlay is widely cracked, exposing the underlying timber deck to weathering. Ten percent of the deck has rotted, with members loose and deflecting under live load. Most steel chords were in "good" condition with some corrosion evident in the top flanges of longitudinal beams and minor surface rust on bottom flanges and webs. The main span deck expansion joint at the north tower has frozen, leading inspectors to fear that it might introduce load/stress conditions into the structure that were not considered in its design. The Yale Bridge continues to serve a rural, residential population, but is posted for speed and load restrictions.[12]

Data Limitations

There were few research resources that yielded historical information on this bridge. Newspaper coverage was marginal, most likely because of the bridge's isolated setting and its distance from Vancouver, the closest large city and county seat. Neither Cowlitz County or Clark County departments of public works possessed historical material on the bridge. Cowlitz County Historical Museum in Vancouver, however, had a useful index to the *Vancouver Columbian* newspaper. The Washington State Department of Transportation's Bridge Preservation Section files were the most helpful resource. They included collections of drawings, inspection reports, and correspondence.

Project Information

This project is part of the Historic American Engineering Record (HAER), National Park Service. It is a long-range program to document historically significant engineering and industrial works in the United States. The Washington State Historic Bridges Recording Project was co-sponsored in 1993 by HAER, the Washington State Department of Transportation (WSDOT), and the Washington State Office of Archeology & Historic Preservation. Fieldwork, measured drawings, historical reports, and photographs were prepared under the general direction of Robert J. Kapsch, Ph.D., Chief, HABS/HAER; Eric N. DeLony, Chief and Principal Architect, HAER; and Dean Herrin, Ph.D., HAER Staff Historian.

The recording team consisted of Karl W. Stumpf, Supervisory Architect (University of Illinois at Urbana-Champaign); Robert W. Hadlow, Ph.D., Supervisory Historian (Washington State University); Vivian Chi (University of Maryland); Erin M. Doherty (Miami University), Catherine I. Kudlik (The Catholic University of America), and Wolfgang G. Mayr (U.S./International Council on Monuments and Sites/Technical University of Vienna), Architectural Technicians; Jonathan Clarke (ICOMOS/Ironbridge Institute, England) and Wm. Michael Lawrence (University of Illinois at Urbana-Champaign), Historians; and Jet Lowe (Washington, D.C.), HAER Photographer.

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"Old Yale Span to be Scrapped for New Bridge." *Vancouver Evening Columbian*, 8 May 1931, 1.

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ENDNOTES

[1] H. O. Blair, "Short-Span Suspension Bridge Uses Prestressed Rope Cables," *Engineering News-Record* 111 (20 July 1933): 70-71; Conde B. McCullough, Oregon State Bridge Engineer from 1919 to 1936 designed three short-span suspension bridges for a U.S. Bureau of Public Roads-sponsored project to build the Inter-American Highway in the mid 1930s in Central America. McCullough wrote in the late 1930s and early 1940s that suspension bridges were a practical alternative for short crossings because more sophisticated mathematical calculations, using the Fourier-series or sine-series method of exact stress analysis, gave more accurate calculations than the traditional and less reliable elastic theory. It streamlined the designer's approach to determining a structure's specifications based on load requirements, roadway widths, and total length. The Fourier-series method was a short-cut because using it saved time, thus keeping down costs and making suspension bridges economical for short crossings. See Robert W. Hadlow, "Conde B. McCullough, 1887-1946: Master Bridge Builder of the Pacific Northwest," (Ph.D. diss., Washington State University, 1993), 216-17. See also Conde B. McCullough, Glenn S. Paxson, and Dexter R. Smith, *An Economic Analysis of Short-span Suspension Bridges for Modern Highway Loadings*, Technical Bulletin No. 11 (Salem, OR: Oregon State Highway Department [OSHD], 1938); and the following reports, McCullough, Paxson, and Smith, *Rational Design Methods for Short-span Suspension Bridges for Modern Highway Loadings*, Technical Bulletin No. 13 (Salem, OR: OSHD, 1940); McCullough, Paxson, Smith, *The Derivation of Design Constraints for Suspension Bridge Analysis (Fourier-series Method)*, Technical Bulletin No. 14 (Salem, OR: OSHD, 1940); and McCullough, Paxson, and Richard Rosencrans, *The Experimental Verification Theory for Suspension Bridge Analysis (Fourier-series Method)*, Technical Bulletin No. 15 (Salem, OR: OSHD, 1942).

[2] "The Story of Why Northern Clarke [*sic*] County Will Celebrate the Building of Yale Bridge," *Vancouver Evening Columbian*, 2 September 1920.

[3] Ibid.; "Yale-Yacolt Celebration Held Today," *Vancouver Evening Columbian*, 6 September 1920, 1.

[4] "New Power Dam on Lewis River Asked, Site Above Yale Bridge 1.75 Miles," *Vancouver Columbian-Sun*, 23 January 1951, 1; "Old Yale Span to be Scrapped for New Bridge," *Vancouver Evening Columbian*, 8 May 1931, 1. Pacific Power and Light succeeded the Northwestern Electric Company as the dam's owner.

[5] See "Layout of Yale Bridge over North Fork of the Lewis River between Clark & Cowlitz counties, Washington, Designed by H. H. Gilbert, Olympia, Wash., May 1931," designs A and B, in "Yale Bridge, No. 503/26," Corrsspondence Files, Bridge Pressrvation Section, Washington State Department of Transportation, Olympia, WA [WSDOT].

[6] H. O. Blair, "Short-Span Suspension Bridgs Uses Prestrsssed Rope Cables," *Engineering News-Record* 111 (20 July 1933): 70-71.

[7] "Yale Suspension Bridge, North Fork of Lewis River, between Clark & Cowlitz counties, Washington, Tower Details," sheet 10 of 13, in "Yale Bridge, No. 503/26," Correspondence Files, Bridge Preservation Section, Washington State Department of Transportation, Olympia, WA; F. H. Frankland, *Suspension Bridges of Short Span* (New York: J. J. Little and Ives Company for the American Institute of Stsel Construction, 1934), 14-15, 68-69.

[8] "Yale Suspension Bridge, North Fork of Lewis River, betwsen Clark & Cowlitz counties, Washington, Stiffening Truss Details," sheets 7-9 of 13, in "Yale Bridge, No. 503/26," Correspondence Files, Bridge Preservation Section, WSDOT.

[9] The cables each have a calculated tension of 114 tons due to live load, dead load, and temperature. They were designed for a 342-ton breaking strength. The Hazard Wire Rope Company of Wilkes-Barre, Pennsylvania manufactured the wire rope and prestressed it to 75 tons. See Blair, "Short-Span Suspension Bridge Uses Prestressed Rope Cables," 70-71; Frankland, *Suspension Bridgss of Short Span*, 14-15, 68-69.

[10] Blair, "Short-Span Suspension Bridge Uses Prestressed Rope Cables," 70-71; Frankland, *Suspension Bridges of Short Span*, 14-15, 68-69.

[11] "Yale Bridge, No. 503/26," Kardex Card File, and "Yale Bridge--Timber Spans," Obsolete File--Clark County, also in Bridge Preservation Section, WSDOT.

[12] "Yale Bridge, No. 503/26," Bridge Inspection Report for 1992, in Correspondence Files, Bridge Preservation Section, WSDOT.