Steel Bridge
Spanning Willamette River on Oregon Route 99
Portland
Multnomah County
Oregon

HAER OR-21

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WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
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HISTORIC AMERICAN ENGINEERING RECORD

STEEL BRIDGE
HAER OR-21

Location:	Spanning Willamette River on Oregon Route 99, Portland, Multnomah County, Oregon UTM: Portland, Oregon Quad. 10/524890/5042580
Date of Construction:	1910-12
Structural Type:	Double-deck, vertical lift bridge
Engineer:	Waddell & Harrington, Kansas City, Missouri
Fabricator:	American Bridge Company, Pittsburgh, Pennsylvania
Builder:	Substructure--Robert Wakefield & Co., Portland, Oregon Superstructure--Union Bridge & Construction Co., Kansas City, Missouri
Owner:	Oregon-Washington Navigation Company (later, part of the the Union Pacific Railroad) and Southern Pacific Railroad. Multnomah County leased the roadway deck from 1913 until 1950, at which time the lease was turned over to the state.
Use:	Lower deck--railroad bridge Upper deck--vehicular and pedestrian bridge
Significance:	The 1912 Steel Bridge is significant for its vertical lift design. This is a double-decked bridge; the lower deck is a railroad deck while the upper deck is used for highway and light rail traffic. The two decks may be lifted at the same time, or the lower deck may be raised independently of the upper deck, telescoping into the latter. The Steel Bridge was the first bridge built with this independent lifting system and is the only one of this type existing in the United States today. This type of bridge was designed by J.A.L. Waddell, who engineered the South Halstead Street Bridge in Chicago, Illinois, the first significant vertical lift bridge in the United States.
Project Information:	Documentation of the Steel Bridge is part of the Oregon Historic Bridge Recording Project, conducted during the summer of 1990 under the co-sponsorship of HABS/HAER and the Oregon Department of Transportation. Researched and written by Gary Link, HAER Historian, 1990. Edited and transmitted by Lola Bennett, HAER Historian, 1992.
Related Documentation:	See also HAER OR-55, Willamette River Bridges.

HISTORY

Because navigable waterways are under the jurisdiction of the federal government, an enabling act by Congress, passed February 2, 1870, was required to allow for the building of bridges across the Willamette River at Portland. In the following decade several bridge-building companies formed and made plans to span the river, but no bridges were built. Lack of money was sometimes the reason for these failures, but for the most part it was due to opposition by ferry operators fearing the loss of their businesses, and navigation interests (railroads and shipping) which feared bridges would impede river traffic. The two were supported by the opinion of the U.S. Army Corps of Engineers, Portland District, which agreed that bridges would obstruct navigation.[1]

In 1880 the Pacific Bridge Company began constructing a bridge across the Willamette River at the foot of Morrison Street for the Willamette Iron Bridge Company. Federal Judge Matthew Deady handed down an injunction halting construction in March 1881. Judge Deady wrote that, according to the act that admitted Oregon to the Union on February 14, 1856, the river was a common highway and should remain unobstructed. In 1885 the U.S. Supreme Court decreed that the admission act did not prohibit bridges. Construction of a bridge at Morrison Street was begun again and the bridge was completed April 7, 1887. One year later the Supreme Court overturned Judge Deady's ruling of 1881. Legal obstacles to bridging the Willamette River were gone.[2]

On July 10, 1888 the next bridge across the Willamette was opened. This was a double-decked swing span owned by the Oregon Railroad and Navigation Company. The lower deck was used by the the railroad. The upper deck was opened in 1889 for highway and streetcar traffic. The streetcar line, built by C.F. Swigert, was Portland's first electric rail car line. Multnomah County paid a monthly rental of $350.00 to the railroad to end tolls on the bridge.[3]

This first steel bridge was built for the railroad loads of 1888, and by 1909 was inadequate for modern loads. The Oregon-Washington Railroad and Navigation Company planned to build a new line to Puget Sound, but there was no space at the east end of this bridge for the rails to turn northward downstream. On August 17, 1909 the railroad secured a franchise from the Port of Portland Commission to erect a new bridge near the site of the existing one. As a condition to this franchise, the commission required that the bridge include an upper deck for vehicle traffic. In 1910 the railroad agreed to a land swap with the city of Portland. The city vacated the ends of fourteen streets for ramps for the new railroad bridge, and the railroad moved a section of its track to give space to the city to build ramps for the proposed bridge at the end of Broadway Street.[4]

The new Steel Bridge opened for railroad traffic on July 21, 1912. On August 12 the upper deck opened to highway traffic, and the streetcar line opened September 8. In October 1912 the city of Portland entered into an agreement with the Oregon-Washington Railroad and Navigation Company to rent the upper deck for $44,000 annually. The following January, after the state legislature relieved the city of bridge responsibilities, Multnomah County assumed rental at $48,868. By 1920 annual rent had raised to $62,250, and by 1934 the fee increased to $72,000. That year the county gave notice that it would not renew the rental agreement at such a high price. It threatened to discontinue renting the top deck at all, and to barricade the deck from traffic. The railroads negotiated, (by this time the bridge was owned jointly by the Union Pacific and Southern Pacific railroads) and dropped the rent to $47,090. On February 28, 1941 the state reached an agreement with the railroads to become the new lessee of the upper deck. The effective date of the agreement was delayed by war conditions and did not occur until August 11, 1950, when the deck was declared a state highway. The state planned to make the Steel Bridge and Harbor Drive part of Interstate 5. Plans were changed in favor of an east bank freeway and construction of the Marquam Bridge. The opening of the Marquam in 1967 cut daily traffic on the Steel Bridge by 20,000 vehicles per day.[5]

DESCRIPTION

The Steel Bridge is a double-deck, vertical lift span bridge. The swing span design of earlier Portland bridges was forgone in this case because the vertical lift had proved in other cases to be faster in operation, and had no central pier to obstruct the channel as did swing spans. A bascule design could not be used as the bridge was required by the Port of Portland to have two decks. The Steel Bridge was designed by Waddell & Harrington, consulting engineers from Kansas City, Missouri. Waddell & Harrington owned the patent on the lift span design on the Steel Bridge, but Oregon-Washington Railroad and Navigation Company engineers helped in the overall design of the bridge.[6]

The lift span is a 211-foot long steel through Pratt truss, flanked on both sides by a steel lift tower. The towers rest on piers and the adjacent fixed spans. These two spans are also steel Pratt trusses, each 287' long. The approaches are deck girder spans, except for the 250 feet of filled retaining wall at the west end at Glisan Street. The piers are concrete, and rise 22 feet from low water.[7]

The railway portion of the Steel Bridge forms the lower deck for the three spans across the river. When fully suspended the lift section of the deck is 52½' below the main deck and 26 feet above low water. When lifted, this deck raises 46' for a vertical clearance of 72 feet above low water. It is suspended by steel hanger columns at eight panel points on each side. Cables are attached to the tops of these hangers. These cables pass up through the corresponding columns of the upper deck, over sheaves (large pulleys) that top the truss at each panel point, then across to traction sheaves at the tower ends of the truss. From under these sheaves the cables pass up over sheaves on top of the towers, then down to the their counterweights, to which they are attached. During operation, as the counterweights descend, the cables pull the lower deck hangers up through the columns of the upper deck, in a process called "telescoping."[8]

The upper deck of the lift span has five sections. The central section, between the trusses, is 28' wide. Outside the trusses are 11-foot wide roadways, originally designated for horse-drawn traffic. On the outside of these are 6-foot wide sidewalks. The outside roadways and sidewalks are supported by floor beams cantilevered out from the trusses. This deck is suspended by cables at each corner. These cables pass up over the main sheaves near the top of the towers, then down to the upper deck counterweights. When fully lifted, the upper deck raises 93', and the telescoped lower deck is 139' above low water.[9]

The tower posts rest on the two channel piers. At each tower the posts are braced to two inclined back legs which rest on the adjacent fixed spans. At the top of the towers the posts are connected to the back legs by 20-foot long girders. Topping the corners of each tower are four 6'-4" diameter sheaves, which carry the lower cables. The main sheaves (14' in diameter), which carry the cables of the upper deck, are located at the posts just below the top of the towers.[10]

Inside each tower two concrete counterweights are suspended above the end of the adjacent fixed span. The larger of the two is connected by cables to the upper deck. It is 40' high, 29'-10" wide, and 10'-4" thick. Originally these counterweights weighed 1,712,500 pounds, but over the years over 65 tons have been added to adjust for upper deck weight changes. The smaller counterweight for the lower deck hangs above the other, and passes behind it when descending. This counterweight is actually in four sections, suspended 1" apart from each other.[11]

The operating machinery for the lift span is housed atop the center of the lift span truss. The operator's house is suspended just below this machinery house, and the operator has full view of the deck in both directions. Two 200-horsepower motors power each deck. The lower deck motors are located in the downstream side of the house, the upper deck motors in the upstream side. However, a common shaft enables each set of motors to power either deck. The upper deck is lifted by cables that pass out of the machinery house from a main drive sheave. The cables run along the top of the truss to sheaves at the tower ends, passing under these sheaves, then up along the tower posts, and are connected to the posts just below the main sheaves. When the drive sheaves in the machinery house pull these cables, both decks are lifted. To raise only the lower deck, the machinery operates shafts that run out towards each tower. A the ends of these shafts, bevel gears operate a transverse shaft. Drive sheaves located at the ends of the transverse shafts operate the lower deck cables, the paths and operation of which have been described above.[12]

The two fixed spans are 287-foot long Pratt trusses. Unlike the lift span, these trusses are between the upper and lower deck. On the east span the truss is 34' wide center to center of members, at the river end, and 71½' wide at the shore end. This allows the railroad tracks of the lower deck to begin their north and south curves once they clear the bridge. Similarly, the west side is 34' wide at the river end and 42' wide at the shore end, so the tracks may turn northward once clear.[13]

The approaches, like the fixed spans, have concrete decks. The east side approaches connect the bridge to Oregon Street, Holladay Street and Williams Avenue. The west side approaches connect the bridge to Glisan Street, Everett Street, and Third Avenue. Tri-Met's MAX, Portland's light-rail transit line also crosses the bridge.

CONSTRUCTION

For design, supervision of construction, and royalty for their lift-span patent, the firm of Waddell and Harrington received $90,000. The American Bridge Company of Pittsburgh, Pennsylvania fabricated the steel superstructure, which was erected by the Union Bridge Company of Kansas City, Missouri. Robert Wakefield and Company of Portland, Oregon, constructed the substructure. Erection was supervised by the engineering department of the Oregon-Washington Railroad and Navigation Company. Total cost of construction was $1,704,105.[14]

The four concrete piers rise 22' above low water. The two channel piers were set by open dredging, each supported by concrete-filled cribs 36'x72'. These piers, along with the east shore pier are set in cemented gravel. The west shore pier is founded on piles.[15]

Work on the superstructure began on April 1, 1911. The fixed spans were erected from an "A" frame set on a barge on the river. For the lift span, a falsework system of four Howe trusses were built on supports which were cantilevered outward and upward from the channel piers, anchored to the fixed spans. The bottom of the Howe trusses were 115½' above low water to allow ships to pass under during construction. A traveler working on top of the Howe truss falsework erected the lift span and part of the towers. For erection of the tops of the towers and placement of the tower sheaves, a 150-foot high tower was built on top of the falsework. Material was delivered to the traveler via a temporary tramway built on the main deck of the fixed spans.[16]

The counterweights for the lower deck were constructed in sections on the upper deck and hoisted into place. The upper deck counterweights were constructed in place. Falsework supported the bottom of the platform on which the counterweight was constructed. The bottom of the formwork was filled with 13" of sand. After the counterweight was constructed, the cables were attached with six inches of slack, to make attachment easier. After the cables were attached, the sand was let out of the bottom of the platform, thus lowering the counterweight and taking the slack out of the cables.[17]

RENOVATIONS

For the most part the steel superstructure of the bridge remains intact form the original construction--all cables of the upper deck and four of the lower deck were replaced in 1943, and the four main sheaves were replaced in 1947. But the roadway deck and approach system are completely changed. In 1949 through 1951 both east and west approaches were renovated. By 1950 the west side of the bridge, in addition to the original approach to Glisan Street, was connected to N.W. Front Avenue, Everett Street, and Harbor Drive (Harbor Drive no longer exists). The following year approaches were completed on the east side to Oregon Street, Holladay Street and Williams Avenue.[18]

In June 1984 the Oregon State Highway Division and State Bridge Section conducted major renovations on the Steel Bridge. Tri-Met of Portland desired to place a light transit rail across the bridge. This coincided with scheduled long-needed repairs. The porous decks of the fixed spans and approaches allowed water to seep through for decades, rusting the steel superstructure underneath. The state and Tri-Met cooperated with the Union Pacific Railroad in the project. Union Pacific kept one engineer on site through completion, and all steps were subject to approval by the railroad.[19]

The deck of the lift span was steel grid filled with concrete. The fixed span decks were asphalt-topped wood planks, as were the approach decks, except for a section at the beginning of the Glisan Street approach on the west end and a section of the Holladay Street ramp on the east end. At the west end the decks were removed and replaced with concrete. One span of the Glisan Street approach was replaced with two new spans and towers, to give more clearance for Front Street traffic, which passed underneath. A new approach was constructed for the light rail transit (LRT) line to N.W. First Avenue, and an existing ramp from Front Street was removed. A pedestrian walkway was reconstructed to pass under the LRT ramp from the Glisan Street approach, then back up to the sidewalk on the south side of the bridge.[20]

On the lift span, a new steel grid deck replaced the old one between the trusses. All stringers were replaced by ones of higher strength steel, placed directly beneath the LRT rails. The grid of the deck outside the trusses remained intact. The gate tender houses on the deck were removed and replaced by one above the deck on the west tower. Renovations to the deck were performed without obstructing river traffic. The weight of the span after repairs could not exceed its weight beforehand, or the balance of the lifting system would be disrupted.[21]

Repairs to the east side were much the same as the west. One section of deck on the Holladay ramp was already concrete. This section was overlaid in concrete to seat the LRT rails. The LRT line required a ramp to N.E. Holladay Street, so the existing ramp was widened to allow for use of vehicular traffic also.[22]

One-quarter of the steel girders in the deck system were replaced. Decades of rusting had deteriorated many members. Along the entire length of the new construction work from 1st Avenue to N.E. Holladay Street, the surface was slotted for the rails of the LRT. As the LRT is electrically powered, the slots were lined with elastomeric plastic to prevent the electricity from reaching and corroding the steel superstructure and reinforcment. In addition to stuctural renovations, the original steel sidewalk handrails were removed and replaced with new rails which were exact reproductions.[23]

ENDNOTES

1. Fred Lockley, The History of the Columbia River Valley From The Dalles to the Sea (Chicago: S.J. Clark, 1928), 3 vols., p.534; Percy Maddux, City on the Willamette (Portland: Binfords & Mort, 1952), pp.177-178; William F. Willingham, Army Engineers and the Development of Oregon: A History of the Portland District, U.S. Army Corps of Engineers (Washington, DC: Goverment Printing Office, 1983), pp.51-53.

2. "A Sketch of the History and Construction of the Willamette River Bridges," Oregon Historical Society Collection, 14 January 1960; Lockley, pp.535-536.

3. E. Kimbark MacColl, The Shaping of a City: Business and Politics in Portland, Oregon 1885-1915, (Portland: The Georgian Press, 1976), pp.151-152.

4. "Brief History of the Steel Bridge," typed one-page enclosure to letter dated March 6, 1950, R.H. Baldock, State Highway Engineer to Henry F. Cabell; W.P. Hardesty, "The New O.W.R. & N. Bridge at Portland," Engineering News, 68 (December 12, 1912) p.1100; E. Kimbark MacColl, Merchants, Money and Power: The Portland Establishment 1843-1913, (Portland: The Georgian Press, 1988), pp.429-430.

5. "Oregon to Carry Out Plans for Redecking Steel Span," Oregonian 8 Feb 1950, p.17; Jack Ostergren, "Unusual, Busy Steel Bridge Designed for Double Duty," Oregon Journal 25 Jun 1958, p.10; Oregon Department of Transportation, General Records Office, Steel Bridge File, letter dated July 8, 1949, J.R.H. Baldock, State Highway Engineer to Union Pacific Railroad Company; and "Brief History of the Steel Bridge," typed one-page enclosure with letter dated March 6, 1950, R.H. Baldock to Henry F. Cabell. State officials in 1950 were dismayed at the agreement reached nine years earlier. According to the contract, in addition to assuming maintenance of the deck, the state was to pay $18,000 more in annual rental than Multnomah County had. Highway Commission Chief Council J.M. Devers quipped, "Personally, I think we are relieving ... Multnomah County of too many street and highway burdens. I am told that [the county] now nearly has to get a search warrant to find a road on which to spend the money it gets out of the highway fund." The state considered buying the upper deck outright, but plans for this were discarded after long-term cost studies were done. -- Baldock to Union Pacific Railroad Company; quote, J.M. Devers to R.H. Baldock, letter dated July 19, 1949, General Records Office, ODOT; "1941 Contract Haunts Board," Oregonian 8 Feb 1950, p.17.

6. W.P. Hardesty, p.1104; George Hool and W.S. Kinne, Moveable and Long-Span Steel Bridges, (New York: McGraw-Hill Book Company, Inc., 1943), p.158.

7. ODOT, Environmental Section, Bridge File #2733, "Engineering Antiquities Survey," April 1983.

8. Hardesty, pp.1101-1102; Hool and Kinne, pp.167-168.

9. Hardesty, p.1101; Hool and Kinne, p.168.

10. "Steel Bridge: Crossroads of Commerce," Oregonian 13 August 1944, p.6.

11. "Steel Bridge Repairs Made," Oregonian 24 February 1947, p.13.

12. Hardesty, p.1102.

13. "Engineering Antiquities Survey," April 1983; Hardesty, p.1101.

14. ODOT, Environmental Section, Bridge File #2733, "Steel Bridge," typed fact sheet.

15. Hardesty, pp.1100-1101.

16. Hardesty, pp.1103-1104.

17. Hardesty, p.1104.

18. "Steel Bridge: Crossroads of Commerce," Oregonian 13 August 1944, p.6; "Steel Bridge Repairs Made," Oregonian 24 February 1947, p.13; "Steel Bridge Used to Rise," Oregonian 27 March 1949, p.24; "Two More Steel Bridge Ramps Open to Automobile Traffic," Oregonian 25 October 1951.

19. Terry Shike, Assistant State Bridge Engineer, interview August 16, 1990; "Steel Bridge Remodel Challenges Engineers," VIA, Newsletter of the Oregon Department of Transportation, May 1985, p.4.

20. Ibid.

21. Ibid.

22. Ibid.

23. Ibid.

ADDENDUM TO
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