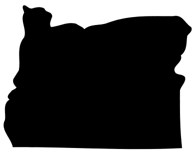
CONCRETE BRIDGES *in Oregon*



by Ray Bottenberg, Oregon Department of Transportation

The earliest bridges in Oregon were made from readily available timber, but their useful life was limited due to decay in western Oregon's damp weather. A good example is provided by two of Portland's first three Willamette River bridges, built of timber in 1887 and 1891 with neither one lasting 20 years. Oregon surely needed longer-lasting bridge materials.

The Early Years

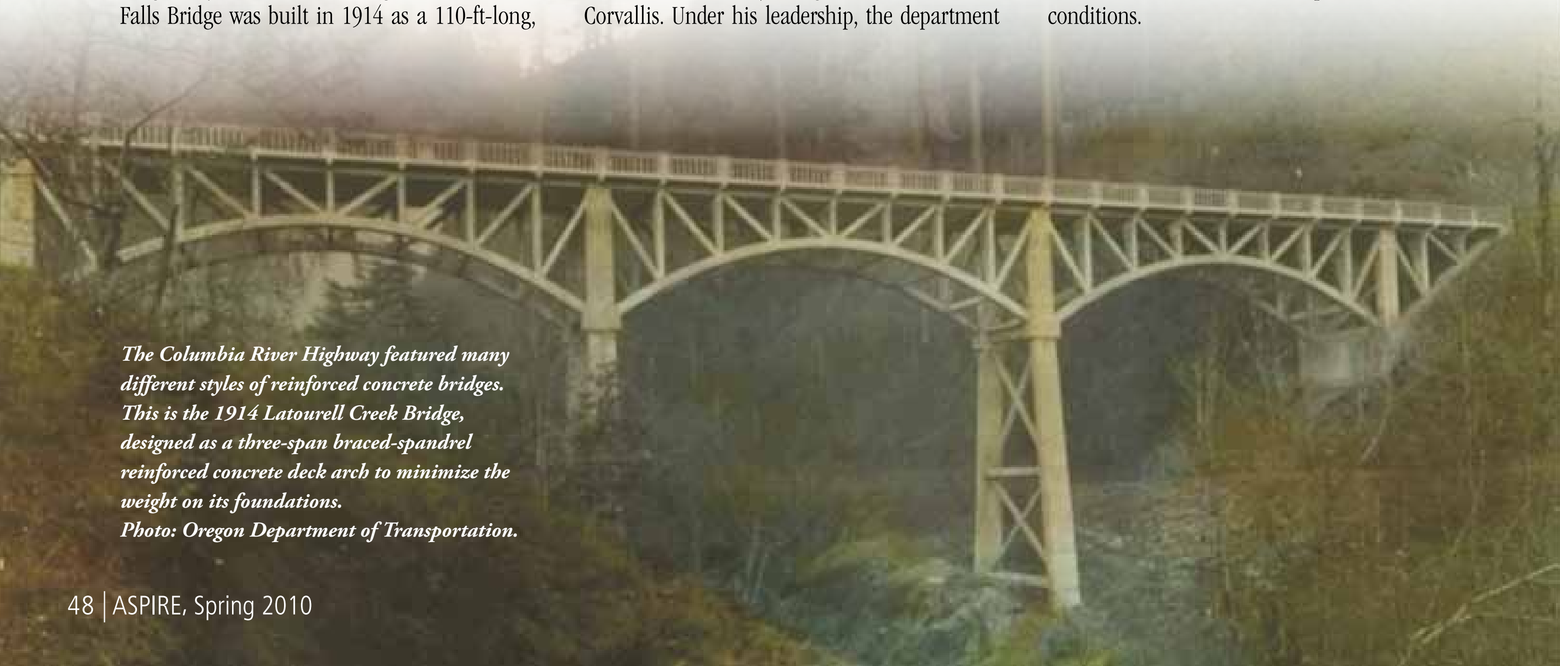
Reinforced concrete became widely recognized as a long-lasting bridge material after the first reinforced concrete bridge was built in the United States in 1889. There is some record of small reinforced concrete bridges and box culverts built in Oregon before 1900, with several still in use. The use of reinforced concrete was greatly accelerated by the 1913 formation of the Oregon State Highway Department (OSHD) by the Legislative Assembly. One of the OSHD's first major projects was the construction of the Columbia River Highway from 1913 to 1922. Championed by railroad executive Sam Hill from neighboring Washington, the rugged terrain of the new highway alignment, with its many waterfalls and streams, required numerous bridges. All of these structures were designed in reinforced concrete and most complement the stunning scenic beauty of their locations.

The Shepperd's Dell Bridge was built in 1914 as a 150-ft-long reinforced concrete deck arch with a 100-ft-long main span. Designed by OSHD's Karl P. Billner, it is suggestive of later deck arch spans designed by Conde B. McCullough. The Bridal Veil Falls Bridge was built in 1914 as a 110-ft-long, three-span reinforced concrete through-girder, designed by Billner. The need to span both the falls and a lumber flume require a design whereby the parapet rails were actually the stiffening girders and carried the loads. The Latourell Creek Bridge was built in 1914. It featured a 312-ft-long, braced-spandrel reinforced concrete deck arch with three 80-ft-long main spans and short approaches at each end. Billner followed the principles of French bridge expert Armand Considère. This resulted in a lightweight structure to accommodate poor foundation conditions. The Moffett Creek Bridge was built in 1915 as a 205-ft-long reinforced concrete deck arch with only 17 ft of rise in the 170-ft-long main span. Designed by OSHD's Lewis W. Metzger, it was the longest span, three-hinged, reinforced concrete arch in the United States at the time, with only one longer on record in Germany.

In 1917, a major initiative for "getting Oregon out of the mud" was started with legislative approval of a $6 million highway construction bond issue. In 1919, the lawmakers increased the bond amount by $10 million, instituted the nations' first gasoline tax of 1 cent per gallon dedicated to highway funding, and submitted a referendum to create a military highway along the Pacific coast. On April 9, 1919, OSHD hired the head of the Oregon Agricultural College (OAC) civil engineering program, Conde B. McCullough, to be the Oregon State Bridge Engineer. McCullough was an Iowa State College graduate, who had begun his career with Marsh Bridge Company of Des Moines, Iowa, and later worked for the Iowa State Highway Commission before joining the staff at OAC, in Corvallis. Under his leadership, the department constructed an impressive collection of reinforced concrete bridges throughout the state. His reinforced concrete deck arches and tied arches are well known for their elegant architectural qualities in harmony with their natural settings, and heavy load capacity. In addition, many reinforced concrete deck girder (RCDG) bridges were constructed for spans up to 50 ft. Reinforced concrete slab bridges and box culverts were used where suitable.

The 1920s

Beginning in the late 1920s, McCullough adopted several practices to control cracking in his arch bridge designs. One was to use the "Considère hinges" to reduce built-in bending stresses in the arch ribs. The hinges were hourglass-shaped articulation points that reduced built-in bending stresses in the arch ribs during construction. They were welded and encased in concrete once the dead load was applied to the arch. Another such practice involved the hangers that suspend the deck from the arch ribs on tied arches. The steel reinforcement of the hangers was placed, but the concrete was delayed until after the dead load was applied to the arch. By doing this, the concrete was not subject to tensile strain caused by the dead load. In bridges such as the Wilson River Bridge at Tillamook in 1931, these practices helped McCullough pioneer the use of reinforced concrete for tied arch structures. With the horizontal thrust of the arches resisted by the deck rather than the earth, the tied arch was ideal for locations with poor foundation conditions.



The Columbia River Highway featured many different styles of reinforced concrete bridges. This is the 1914 Latourell Creek Bridge, designed as a three-span braced-spandrel reinforced concrete deck arch to minimize the weight on its foundations. Photo: Oregon Department of Transportation.

The 1930s

In 1931 and 1932, McCullough experimented with the principles of Eugène Freyssinet during construction of the Rogue River Bridge at Gold Beach, on the Oregon Coast Highway. In the Freyssinet method of concrete arch construction, a short section of the arch ribs was left open at the crown, then jacks placed in the openings were used to lift the halves of the arch ribs away from each other just enough to compensate for creep and shrinkage, dead load shortening, and temperature stresses. After jacking, the reinforcement from each arch halve was connected and the crown of the arch closed with a final concrete placement. The result was a slender arch design and the first U.S. application of the Freyssinet method, a precursor to modern prestressed and post-tensioned structures.

In 1934 through 1936, a massive Public Works Administration (PWA) project was undertaken to build five major bridges to replace ferries on coastal bay and river crossings. Structures were built across Yaquina Bay at Newport, the Siuslaw River at Florence, the Umpqua River at Reedsport, Coos Bay at North Bend, and Alsea Bay at Waldport. McCullough and his staff designed these structures in 6 months, working two shifts per day. Total cost was $5,400,000. The 3260-ft-long Yaquina Bay Bridge has three steel arch spans over the marine channel, five reinforced concrete deck arch spans south of the main spans, and RCDG approach spans. The 1568-ft-long Siuslaw River Bridge has a steel bascule movable span over the marine channel, one reinforced concrete tied arch span on each side of the main span, and RCDG approach spans. The 2206-ft-long Umpqua River Bridge has a steel swing movable span over the marine channel, two reinforced concrete tied arch spans on each side of the main span, and RCDG approach spans. The 5305-ft-long Coos Bay Bridge has a steel cantilever span over the marine channel, six reinforced concrete deck arch spans south of the main span, seven reinforced concrete deck arch spans north of the main span, and RCDG approach spans. The 3028-ft-long Alsea Bay Bridge had three reinforced concrete tied arch spans over the marine channel, three-reinforced concrete deck arch spans each side of the main spans, and RCDG approach spans. This bridge was replaced in 1991 as a result of extensive corrosion damage. Due to public outcry at the loss of the community's icon, a cathodic protection program was developed to protect the remaining structures.

After the McCullough era ended in 1936 and through the 1950s, most construction was RCDG and slab type bridges. The design philosophy of this time was to produce the most economical structure that met the design codes of the day, with less attention paid to aesthetics. While economical designs stretched construction funds, a long-term consequence was that these bridges typically were not serviceable enough when actual live loads began to increase. As a result, bridge inspectors began finding structural cracks wider than 0.025 in., which spurred the Oregon Legislature in 2001 and 2003 to fund the Oregon Transportation Investment Acts (OTIA I, OTIA II, and OTIA III), investing $3.132 billion in roads and bridges and replacing or repairing nearly 500 bridges. (See Winter 2008 issue of *ASPIRE*.™)

The 1950s and Beyond

In 1954, OSHD prestressed concrete beam designs were used to build Willow Creek Bridge with three 98-ft-long spans on the Columbia River Highway near Arlington and the 93-ft-long span Haines Road Undercrossing in Tigard. Using concrete compressive strengths of 5000 psi and prestressing strand of 7/16-in.-diameter prestressing strands with an ultimate tensile strength (UTS) of 200 ksi allowed considerably longer spans than with 40 ksi yield strength reinforcement. Also in 1954, a Bureau of Public Roads design for a 60-ft span precast concrete beam, post-tensioned before placement, was used to build Ten Mile Creek Bridge on the Oregon Coast Highway near Lakeside in Coos County.

The 1966 Columbia River Bridge at Astoria includes a 2.1-mile-long section of 80-ft-span AASHO Type III precast, prestressed concrete girder construction in the shallow middle of the river, shown here during construction. The south approach of the bridge also includes a 1095-ft-long section of AASHO Type II and Type III precast, prestressed concrete girder construction. The bridge was built jointly by the states of Oregon and Washington.

OSHD produced standard drawing designs when different types of sections reached common usage. These standards included American Association of State Highway Officials (AASHO) Type II, III, IV, and V precast girders by 1957, hollow precast slabs by 1962, bulb-tee girders in 1966, channel beams in 1967, and box beams in 1986. The bulb-tee girder design was updated in 1984 to provide optimized "tee" and "I" girders, which have largely replaced the AASHO sections. By 1959, 7/16-in.-diameter prestressing strand with 270 ksi UTS was common, and by 1966, ½-in.-diameter strand was in use. Currently, standard designs are available for girders that can span up to 183 ft, making use of 0.6-in.-diameter strand.

In 1970, OSHD built eight cast-in-place, post-tensioned concrete box girder bridges and one combination cast-in-place, post-tensioned box girder and spliced, post-tensioned precast girder beam bridge.

The 1982 Glenn L. Jackson Memorial Bridge over the Columbia River at Portland was designed partly by Sverdrup and Parcel and Associates and

The 1932 Rogue River Bridge at Gold Beach was the first U.S. application of the Freyssinet method of reinforced concrete arch bridge construction, which introduced stress into the partially cured arch ribs. It was a precursor to modern post-tensioned concrete construction. Photo: Oregon Department of Transportation.

partly by OSHD, and funded jointly by the states of Oregon and Washington. It is partly a cast-in-place, post-tensioned, segmental concrete box girder and partly a precast, post-tensioned, segmental box girder bridge. The 11,750-ft-long structure boasted a 600-ft clear span over the navigation channel.

During the last decade, two precast concrete segmental post-tensioned deck arch bridges have been built along the Oregon Coast, Cook's Chasm Bridge near Yachats with a 126-ft-long main span and Spencer Creek Bridge near Newport with a 140-ft-long main span. (For more information on this project, see the Winter 2010 issue of *ASPIRE*.)

For a century, Oregon has played an active role in the evolution of concrete bridge design and construction. In 1913, construction of the scenic Columbia River Highway began, relying heavily on reinforced concrete structures to span the many streams, chasms, and mountainsides of the Columbia Gorge. From 1919 to 1936, the renowned concrete arch expert, Conde B. McCullough, headed the OSHD Bridge Section and produced many beautiful bridges that are still in service today. During the past decade, there was a tremendous amount of prestressed concrete girder construction as the state updated many major freeway structures. All of these things point to a future that makes extensive use of both reinforced and prestressed concrete and could include longer span concrete structures, incorporation of a larger variety of precast components, additional aesthetic solutions, and more preservation work so that future generations can enjoy Oregon's bridge heritage.

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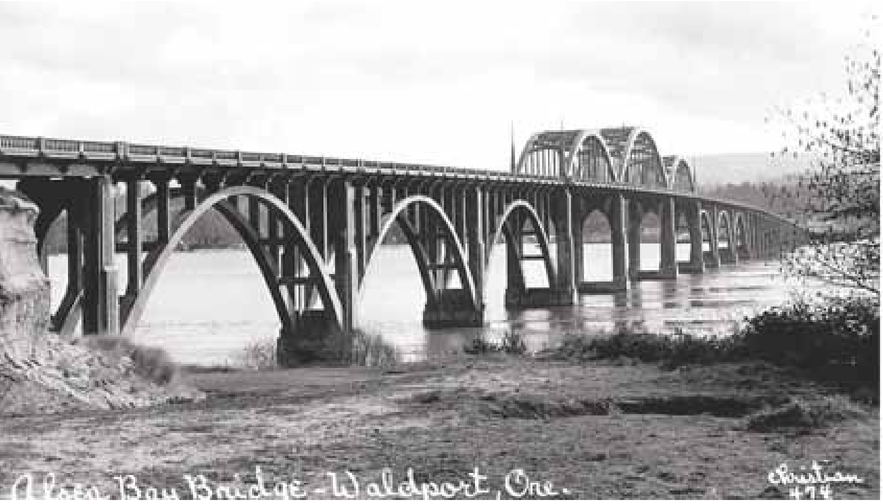
Seen from the north, the 1982 Glenn L. Jackson Memorial Bridge across the Columbia River at Portland was touted as the "first of a new generation of large segmental bridges."
Photo: Oregon Department of Transportation.

The Cape Creek Bridge on the Oregon Coast Highway is a 619-ft-long, two-tiered reinforced concrete arch inspired by the Roman aquaduct near Nimes, France. The bridge, completed in 1932, is still in use today.
Photo: Henry G. Russell.



The 1936 Alsea Bay Bridge, shown on left, at Waldport was one of five bridges built simultaneously under a large Public Works Administration project that eliminated five ferries along the Oregon Coast Highway. Designed by Conde B. McCullough and his staff to complement their natural settings, all five bridges included reinforced concrete arches. The Alsea Bay Bridge was replaced in 1991 with a new bridge, shown on right, that features post-tensioned concrete box-girder approaches.
Photos: Oregon Department of Transportation.