Oregon Historic Highway Bridges
(Conde B. McCullough) BRIDGES)
Salem
Marion County
Oregon

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Historic American Engineering Record
National Park Service
U.S. Department of the Interior
Washington, DC 20013-7127

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HISTORIC AMERICAN ENGINEERING RECORD

OREGON HISTORIC HIGHWAY BRIDGES
(CONDE B. McCULLOUGH)
HAER OR-54

Location:	Spanning various bodies of water throughout the State of Oregon
Dates of Construction:	1920s and 1930s
Structural Types:	Various reinforced-concrete and/or steel, arch and/or truss spans
Engineer:	Conde B. McCullough, Oregon State Highway Department
Owner:	Oregon Department of Transportation
Significance:	Conde B. McCullough, Oregon State Highway Department Engineer and Administrator from 1919 to 1946, was a significant American innovator in concrete bridge design. Influenced by his early years at Iowa State College and in the Iowa State Highway Commission, by the concrete bridges of the early Columbia River Highway, and by European concrete design and technology, McCullough designed bridges that combined technological advances with an artistic aesthetic.
Project Information:	Documentation of Oregon Historic Highway Bridges 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 Robert W. Hadlow, HAER Historian, 1990. Edited and transmitted by Lola Bennett, HAER Historian, 1992.
Related Documentation:	See also individual HAER reports OR-10, OR-14, OR-27, OR-29, OR-30, OR-31, OR-32, OR-33, OR-34, OR-35, OR-36, OR-37, OR-38, OR-39, OR-41, OR-42, OR-44, OR-45, OR-46

CONDE B. McCULLOUGH: OREGON'S BRIDGE BUILDER

Conde Balcom McCullough was one of the leading twentieth-century bridge engineers in the United States between the two World Wars. His work in the state of Oregon, hundreds of bridges, including over thirty arched spans, became part of one of the nation's most modern highway systems at a time when the sales of automobiles in this country was growing exponentially. McCullough was foremost an engineer, but he also had interests as diverse as the study of law and Mayan culture. He lived life simply for life's sake and had a genuine compassion for mankind.

McCullough was born on May 30, 1887 at Redfield, Dakota Territory, in the southeastern portion of present-day South Dakota. His mother was Lena Balcom. His father, John, was a doctor of medicine and a Presbyterian minister. McCullough's paternal grandparents were Scots-Irish who emigrated from the one of the Protestant counties of Ireland in the nineteenth century.[1]

Lena McCullough supposedly named her first and only child after a Frenchman who was a character in a book read when she was pregnant. Balcom, his middle name, was his mother's maiden name. For most of his life, McCullough's friends and acquaintances called him by his initials "C.B." or simply "Mac."[2]

In the 1890s, McCullough's parents moved to Fort Dodge, Iowa and it was there that he received his primary and secondary education. During those years his father practiced medicine and pursued a second career as a doctor of divinity. John planned to combine his diverse vocations and become a medical missionary. His hopes were cut short when a serious accident left him crippled. He died a few years later. McCullough, still a young boy, then had to take odd jobs to support his mother.[3]

After graduating from high school in 1905, McCullough worked for the Illinois Central Railway in Illinois and Indiana. He served as a surveyor's assistant, a rodman, a chainman, and an instrument man. In 1906 he enrolled in the Civil Engineering program at Iowa State College (now Iowa State University), in Ames. There, he pursued a Bachelor of Science in Civil Engineering. McCullough enrolled in a variety of courses, including the humanities, mathematics, chemistry, and fields of civil engineering. By his senior year he had completed studies in surveying, drawing, railway engineering, and structural design. The faculty recommended that students who completed the structural design course would "be of some service in the drawing room of a bridge company during the summer vacation."[4]

McCullough's final semester included a course entitled "Arched and Reinforced Concrete." In it, he studied the design of stone, brick, and reinforced-concrete arches, using a text by Iowa bridge engineer, James B. Marsh. He was graduated from Iowa State College in 1910. His first professional job began later that year as an engineer with the Marsh Engineering Company of Des Moines, Iowa, a major regional bridge designing and building firm. Marsh would greatly influence McCullough's philosophy of bridge design for the next thirty-five years.[5]

James B. Marsh was an 1882 graduate of Iowa State College's predecessor, Iowa Agricultural College, with a Bachelor of Mechanical Engineering degree. After leaving college, he designed and marketed truss spans for the King Bridge Company of Cleveland, Ohio. By the 1890s he was that firm's "General Western Agent and Contracting Engineer." Marsh resigned from King in 1896 to establish his own consulting and contracting practice. In 1904, he founded the Marsh Bridge Company, later known as the Marsh Engineering Company, of Des Moines, Iowa. Shortly, Marsh began to specialize in reinforced-concrete structures and designed city bridges for Kankakee and Peoria, Illinois; Kenosha, Wisconsin; and Waterloo, Iowa. He also undertook a number of contracts with the Iowa State Highway Commission.[6]

Engineer Daniel B. Luten also popularized the use of reinforced concrete in constructing arch bridges at the turn of the century. He promoted them as something akin to the old-fashioned masonry arch, claiming that unlike steel truss spans, they were durable and unaffected by weather and floods. His success with this technique, along with the economic production of concrete by the early 1900s, probably influenced Marsh in his decision to specialize in the design of reinforced-concrete structures. Marsh believed that he could produce this type of arch bridge at a cost comparable to that of steel and iron spans. He promoted it as being frost-proof, flood-proof, and fire-proof--a permanent structure that required little maintenance.[7]

Luten received a number of patents for reinforcing techniques that he used in concrete arch bridges. He sued Marsh and other contractors whom he believed infringed on his rights to his designs. Eventually, in 1912, a federal judge in Iowa ruled that Luten's claims were invalid. Meanwhile, Marsh had patented a reinforced-concrete bridge commonly called the "Rainbow" or "Marsh" arch. It consisted of a through arch or half-through arch span that used angle steel and lattice work as its main structural reinforcement. Around this was poured concrete to give the ribs rigidity. In addition, Marsh patented designs for the use of slidable wear plates, where the arches passed through the decks, to allow for expansion and contraction of the structure in severe weather conditions.[8]

Marsh also designed a through tied-arch or bottom-chord arch span that connected the bases of the arch ribs to the tops of the piers by steel rocker shoes. They were "tied" by bottom chords added to the deck to resist horizontal thrust. This type of span left a relatively high and unobstructed channel beneath the structure and did not require massive piers that were normally required in arch spans. In 1983 the Historic Preservation Department of the Kansas State Historical Society determined that Marsh had constructed nearly one-hundred rainbow arches, mostly fixed spans, in Kansas, Iowa, Minnesota, and Wisconsin, from the 1910s to the 1930s. Marsh died in 1936.[9]

McCullough left the Marsh Engineering Company in 1911 to become an assistant engineer for the Iowa State Highway Commission. This board came about in 1904 to oversee road and bridge construction on state highways and was an arm of Iowa State College. A complete reorganization of the ISHC followed in 1913, when the state legislature saw a need for the commission to oversee improvements on all routes, including county roads. At that time it was also made separate from the state college. The commission, under the leadership of Thomas H. MacDonald, hoped to standardize construction methods, thereby reducing costs, especially in bridge building projects. McCullough became "Designing Engineer" after the reorganization. He created a number of standardized bridge and culvert plans using reinforced-concrete. Within five years, the commission reported that federal government engineers believed Iowa had "the best bridges and culverts of any state in the Union." Iowa Highway Engineer, Thomas H. MacDonald, at the same time, saw great promise in McCullough's work and promoted him to Assistant Highway Engineer. MacDonald left Iowa, in 1919, to become Chief of the U.S. Bureau of Public Roads that oversaw highway construction throughout the country.[10]

President Woodrow Wilson selected MacDonald to become Chief of the Bureau of Public Roads, an agency within the U.S. Department of Agriculture that oversaw the construction of interstate roads throughout the country. The BPR had just received a mandate to expand its role with the passage of the Federal-Aid Road Act of 1916. Iowa, during the years that MacDonald was highway engineer, became one of the first states in the midwest with an improved system of roads. His success drew the attention of many in Washington, D.C., including Wilson.

In 1916, McCullough became licensed as a Professional Civil Engineer. At that time, he, his wife of three years, Marie Roddan, and his infant son, John Roddan McCullough, left Iowa for Corvallis, Oregon. There, McCullough became an assistant professor of civil engineering at the Oregon Agricultural College. He taught engineering courses and conducted research in bridge design. Within a few years he was promoted to head of the civil engineering program at OAC. He also began to do some part-time consulting work with the newly-organized Oregon State Highway Department. He became good friends with Charles Purcell, who had been an engineer working in road construction research for Washington State entrepreneur and roads enthusiast Samuel Hill, and was Oregon's first State Bridge Engineer, beginning in 1913. Purcell left the OSHD in 1915 for a post with Multnomah County, based in Portland. By 1917 he went to Washington, D.C. to work in the Bureau of Public Roads. Purcell later became designer and chief engineer for the San Francisco-Oakland Bay Bridge project.[11]

In 1916, Congressional appropriations for cooperative road-building projects with states totaled $85 million. The goal was to improve highways throughout the country for an increasing number of motor vehicles on public roads. A year later the Oregon state legislature approved the Oregon State Highway Commission's request for a the sale of $6 million in bonds to build highways in Oregon. Two years later it approved another issue worth $10 million. The state also adopted a gasoline tax, the first in the nation, as a source of income for highway construction and maintenance. Since the time Purcell left the department the OSHC had appointed no one as state bridge engineer. Yet, with the great increase in road and bridge building funds the OSHC needed to employ more engineers and draftsmen in all sections of the highway department. Herbert Nunn, State Highway Engineer, offered McCullough the State Bridge Engineer's position in the spring of 1919. He accepted Nunn's offer and began work in Oregon's state capital, Salem, on April 9, 1919. McCullough brought with him a strong conviction that called for following an economic approach to highway bridge construction. He concluded, after years of studying bridge technology, that concrete or concrete-composite spans provided long-range low costs that he believed necessary in construction of publicly owned structures. While in Iowa, he also perfected a philosophy of bridge design that became the underlying theme of virtually all bridges that he created while in Oregon. Nevertheless, he also believed in designing spans that were both functional and pleasing to the eye.

In 1915, McCullough wrote that bridge approaches were just as important from an aesthetic standpoint as they were for safety considerations. He believed that in the past "others had paid too little attention" to this aspect of bridge design. Approaches, especially on older narrow spans, should announce to motorists that they are leaving a relatively wide roadway and entering something that is comparatively narrower. He wrote that all too often, engineers used "effusive ornamentation" of bridges themselves, but had no concern for the approaches.[12] He believed that a more restrained use of decorations on the whole structure was a better practice.

McCullough carried forth the idea that from an architectural standpoint, the fixed reinforced-concrete arch offered lines of "quiet, simple dignity." He later wrote that engineers, in designing bridges, must consider their settings. Road alignments that offered views of the spans, along with natural landscapes, should influence the types of structures that they chose to build. Once again, aesthetics became a determining factor in McCullough's philosophy of bridge design. The reinforced-concrete arch was his medium of expression because of its simplicity, its engineering qualities, and its low maintenance costs.[13]

Shortly after McCullough moved to Salem, he saw the opportunity to hire nearly one dozen engineers for the bridge section of OSHD. He had close ties with the administration of OAC since he had been chairman of the civil engineering program and won approval from the OAC Board of Regents to "liberate" the entire graduating structural engineering class to immediately begin work with the bridge section. Four of the five class members joined McCullough in what would be many years of employment with the OSHD.[14]

A corps of young scholars, Ellsworth "Rick" Ricketts, P.M. "Steve" Stephenson, Raymond "Peany" Archibald and A.G. "Al" Skelton, left school for Salem, two months prior to their June

1919 graduation. Meanwhile, McCullough had divided the state into three maintenance districts and posted Ricketts, Skelton, and Stephenson, respectively, to field offices in the northwest, southwest, eastern sections of the state. All three were responsible for supervising bridge construction and maintenance in their districts. Archibald remained on the staff in the state capital.[15]

McCullough also brought in former classmates from his days at Iowa State College for his Salem team. Owen A. Chase became Chief Design Engineer, William Reeves served as Office Engineer, and Merle Rosecrans was Assistant Bridge Engineer. With a close-knit group of close friends and students, the State Bridge Engineer began to design hundreds of reinforced concrete, timber and concrete composite, and timber spans, in an effort to create a modern primary and secondary highway system for the state of Oregon.[16]

Private citizens sparked interest in a major road building project in Oregon in 1913. A few years earlier, millionaire Samuel Hill hired engineers Samuel Lancaster and Charles Purcell to research road construction methods and build demonstration roads on his estate, Maryhill, on the Washington side of the Columbia River, one-hundred miles east of Portland. Hill had been an early proponent of the Good Roads Movement in the state of Washington and lobbied for improvements in highways throughout the United States. He also envisioned a modern road along the Columbia Gorge from his property to the Portland vicinity. Hill hoped that it might eventually continue eastward and become part of an interstate and international system of highways. He had found highways along the Rhine River in Germany that provided both efficient travel and offered a glimpse of the region's natural beauty. Hill hoped to recreate what he saw there on the Columbia Gorge.[17]

Hill's efforts to persuade the Washington legislature to fund his construction project failed, and soon he lobbied the Oregon legislature with a plan to place the route along the south side of the Columbia Gorge. Oregon approved of his ideas and soon Lancaster, by then Assistant State Highway Engineer, began to work closely with Hill to map out the Columbia River Highway. Purcell, as State Bridge Engineer, and his assistants, K.P. Billner and L.W. Metskor, designed the spans along the highway. By 1919, when McCullough arrived in Salem, crews had completed the route as far as Hood River.[18]

In the 1919-1920 biennium, McCullough supervised the design of 162 bridges. Most were short spans, but four were reinforced-concrete deck arches. They were the first of twenty-five reinforced-concrete arch spans that McCullough designed during his sixteen years as state bridge engineer.[19]

At the same time that the OSHC began construction of the Pacific Highway from Portland to the California state line, later U.S. Highway 99, it initiated road building projects in the eastern and sparsely populated two-thirds of the state. Western Oregon, primarily consisting of the coast, the Willamette Valley, and the Rogue River Valley, has moderate temperatures with intermittent rain throughout the year. In the east the climate is more severe, with hot, dry summers, and cold winters. These differences in weather, due to geographical features, caused McCullough to consider the location of a proposed structure in designing it.[20]

McCullough's philosophy of bridge design dictated that estimated costs of construction and long term maintenance helped determine what types of spans that OSHD should erect. Both criteria formed part of a larger set of guidelines that McCullough had begun to develop during his years with the Iowa Highway Commission. Other concerns included stream behavior, requirements for navigation, motor vehicle traffic, and setting in choosing a type of bridge for a particular site.[21]

The bridge section, during the 1920s and 1930s, avoided the use of uncovered timber spans, even though their costs of construction were minimal in comparison to reinforced-concrete, or steel girder structures. They decayed rapidly in the humid regions and warped in the arid sections of the state. Only in portions of western and southern Oregon, where there was a ready supply of timber did the OSHD recommend their use. Instead, it preferred to build reinforced-concrete or composite concrete and timber spans. Inexpensive long range maintenance costs of reinforced-concrete, McCullough believed, outweighed their initial high costs.[22]

Many of the bridges designed by McCullough on the state's primary road system were reinforced-concrete arch spans. His first, begun in June 1919, was the 113-foot Rock Point Arch, spanning the Rogue River on U.S. Route 99, near the abandoned townsite of Rock Point in Jackson County. It was a ribbed deck arch that followed classic lines with semi-circular arched curtain walls and urn-shaped balusters in the railings. The main span was anchored to the rock walls of the stream bed, so it did not require oversized piers to withstand horizontal thrust. McCullough repeated his general design for this structure at three more sites in the next two years. Two of those, the Mosier Creek and Dry Canyon Creek ribbed deck arches in Wasco County, were McCullough's major contribution to the Columbia River Highway project. All three early spans represent the essence of McCullough's work in Oregon. As substantial structures, they were at once part of and separate from their surroundings. Each could stand on its own merit as a tribute to what advances had been made in reinforced-concrete bridge design--the contributions of Luten, Marsh, and Swiss engineer Maillart. Yet, they also provided McCullough's canvas for what he called "pleasing site elevation outlines," when roadway approaches afforded clear views of the spans' arches and spandrel columns.[23]

It is evident that by the mid 1920s McCullough preferred to decorate his reinforced-concrete spans with architectural details. Instead of plain balustrades, he used gothic-arched or segmental panels, or urn-shaped balusters to support beveled hand rails. These components were pre-cast and assembled at the site. Similarly, he attached rows of concrete dentils or added decorative brackets below the outer edges of the road decks.

In 1922, McCullough received his opportunity to create the longest series of reinforced-concrete ribbed deck arches yet built in Oregon. At Myrtle Creek in Douglas County he designed a course of three 130-foot spans, with approaches, over the South Umpqua River on the Pacific Highway. There, he saw that the naturally wide and solid rock stream bed leant itself to multiple arches because he could anchor piers without worrying about settling because of unstable substrata. He also believed that his choice, rather than a more traditional series of steel-truss spans, was just as economical and more aesthetically pleasing. The bridge complimented its setting.[24]

Two years later, at Winchester, over the North Umpqua River in Douglas County, McCullough chose a deck arch structure for reasons identical to those for the Myrtle Creek bridge. Yet, his use of architectural details at the earlier bridge pales in comparison to those found at Winchester. The seven 112-foot ribbed deck-arch spans show gothic-arched curtain walls and railing panels, and rows of dentils. In addition, McCullough added pedestrian observation balconies above each abutment pier. He decorated them with Tudor panels, inlaid with diamond-shaped red tiles. Again, as he had done at Myrtle Creek, McCullough sought to take advantage of the natural beauty of the bridge's setting by creating a course of rolling arch spans that complimented its hilly tree-covered surroundings.[25]

McCullough diverged from the deck arch form in designing a span that was built across the Willamette River at Oregon City in 1922. There, an old iron chain suspension bridge had outlived its usefulness. The State Bridge Engineer devoted two years of study to determine the appropriate type of structure for this crossing between Oregon City and West Linn. He rejected the use of a deck arch span because the river's main channel received steady use for shipping and could not be blocked with falsework for the duration of construction. Pulp and paper mills, in the vicinity of the crossing, emitted sulphur dioxide gas into the atmosphere that would be highly corrosive to any structure that had exposed steel plates or cables.[26]

McCullough decided to construct a steel half-through arch with gunite encasement, to protect it from corrosion. He found it advantageous to use the old suspension bridge's anchors, wooden towers, and main cable chains in erecting the massive, 360-foot hollow box-girder ribs of the main span. The depth of the river channel prevented him from using a traditional falsework and centering. Once it was complete he had workers cover the steel members of the bridge with wire mesh and sprayed them with gunite, a mixture of sand, cement, and water, to seal the corrosion-prone metal from the harmful sulphur dioxide. It also made the span appear to be a reinforced-concrete half-though arch span.[27]

The bridge at Oregon City was the first, and is at present the only, example of a steel arch span with gunite covering in the state of Oregon. It was also the first span in which McCullough added entrance pylons or obelisks. These ornamental components demarcate for motorists the beginning of the span, and continue McCullough's long-held philosophy that bridge designers should have concern for the well being of the motoring public. The pylon, as a form of decoration, saw increased popularity in the 1920s, probably due to the world-wide interest in Egypt and Egyptian architecture and culture after the opening of King Tutankhamen's burial chambers in the early 1920s.

In November 1922, McCullough wrote to an acquaintance, Portland banker J.C. Ainsworth, about the bridge at Oregon City. He mentioned that he was "foolishly proud" of editorial comment that the structure received in the trade journal Engineering News-Record. He saw the construction of an arch as long as this without falsework as "an engineering problem ten to one more difficult than any problem presented by any other span [in the region]."[28] Nevertheless, he built it.

The Gillette Company of Chicago, Illinois published a textbook, in 1929, entitled Economics of Highway Bridge Types that McCullough had written because he saw need for a concise discussion of the topic for those in the field of highway engineering. He completed it not only for the practicing engineer, but also for the undergraduate college student. In the latter case, he hoped to create a thorough and comprehensive survey of construction types and to give the reader a general perspective of the subject prior to studying structural design.[29]

The OSHD completed the Columbia River Highway, the Pacific Highway, and routes in eastern Oregon by the early 1920s. Soon, it directed much time towards creating a 400-mile-long continuous route from the Columbia river to the California state line. At the end of the First World War, state legislators rallied around the call for a "motor road" along the coast as part of a greater national system to defend American borders from foreign invaders. Oregon's coastline was virtually inaccessible at many points and therefore unprotected. Small fishing villages dotted the shore, but even they existed as remote outposts, separated from each other by rocky headlands and timber covered hills. Oregon voters approved the sale of $2.5 million in bond obligations in 1919, to match federal military highway funds that Congress had set aside for construction of the "Roosevelt Coast Military Highway." Nevertheless, monies from Washington failed to materialize and local authority to sell construction bonds lapsed.[30]

By the early 1920s, the era of long-distance automobile touring exploded, adding another reason for seeing completion of the coast highway. A pleasure-seeking public lobbied for improved travelling between Portland and the ocean beaches and along the shoreline itself. Legislators convinced federal officials to help finance highway construction with local fuel tax revenues, bond issues, and Federal Aid Road Program funds. The OSHD constructed the road over the next eleven years. As part of the project, McCullough designed various small reinforced-concrete ribbed deck arch spans, including his first on the coast highway, in 1927, at

Depoe Bay.[31]

At six points along the proposed route for the coast highway, ferries had for years transported travelers across rivers and estuaries. By the late 1920s, private citizens and chambers of commerce, who envisioned completion of the road, bitterly complained to legislators about how unreliable were the ferries at Gold Beach, Coos Bay, Reedsport, Waldport and Newport. One critic saw the situation as abominable, and that the coast highway, in its "current state" would cause California tourists to avoid the clogged ferry crossings for more modern, safer routes to the east. The OSHC collectively called them a barrier to the growth and development of the region.[32]

The State Highway Commission, by June 1929, had studied various schemes that McCullough and his staff had drawn for a proposed structure over the mouth of the Rogue river, at Gold Beach, and selected a seven-span reinforced-concrete ribbed deck-arch structure. In November the War Department's Army Corps of Engineers, which oversaw construction of bridges over navigable waters, approved the plans. Contractors began excavations in January 1930, and completed the project two years later.[33]

McCullough employed the Freyssinet technique for pre-compression of arch ribs at the Bridge at the Mouth of the Rogue at Gold Beach. It was the first application of this method in the United States in which the action of hydraulic jacks placed at the crowns of the ribs, as a final step in construction compensated for shortening of them due to shrinkage of concrete, dead load, and settling.[34]

While Freyssinet had applied his method of arch rib pre-compression to various spans in Europe, he never performed a scientific experiment any of them to determine whether the actual amount of shortening equalled values that he had calculated. McCullough planned to make the bridge construction at Gold Beach a field study of the technique to determine its advantages and disadvantages in application. He found financial support from the U.S. Bureau of Public Roads, in Washington, D.C., where Thomas H. MacDonald, former Chief Engineer of the Iowa Highway Commission, was director. McCullough worked closely on the project with a friend, Albin L. Gemeny, who was Senior Structural Engineer with the Bureau's Division of Tests.[35]

In September 1931, engineers from McCullough's staff, including some recent recruits from the OAC Civil Engineering program, completed the pre-compression process and gathered data about the amount of stress exhibited throughout the structure. Two years later, McCullough and Gemeny produced a sixty-page document that reported their findings.[36]

McCullough never again used the Freyssinet technique of pre-compression while he was state bridge engineer. Some professionals have questioned the validity of his claim that it actually reduced the costs of construction on reinforced-concrete ribbed deck arches. At Gold Beach, it reduced the amounts of reinforcing bar and concrete used in the ribs, but the process proved just as expensive because it required additional skilled labor. Finally, if the Bureau of Public Roads had not provided financial support for the experiment, McCullough would probably not have conducted it.[37]

During the same period that McCullough designed and built the bridge at Gold Beach, he created three 120-foot reinforced-concrete tied-arch spans on the Oregon Coast Highway. At each location, over streambeds consisting of layers of gravel, it was impracticable to construct the massive piers needed for deck- or through-arch spans. So, he designed tied arches, similar to the Marsh Rainbow Arch, for the three sites. Construction on the first of these, the Wilson River Bridge at Tillamook, began in the fall of 1930. It was one of the first tied arches in the United States, and the first in the Pacific Northwest.[38]

Contractors began construction of another McCullough bridge over Cape Creek, on the Coast Highway, north of Florence. There, because of the offset nature of the stream bed in a canyon filled with unstable rock and gravel, he chose to create a traditional reinforced-concrete deck arch flanked by two-tiered deck girder spans. The many bents would disperse the load of the structure. While the method for construction of this span was similar to that of other McCullough bridges, its design was reminiscent of the Roman stone aqueducts of Europe, particularly that of the Pont du Gard near Nimes, France.[39]

McCullough and one of his design engineers, Edward S. Thayer, published a textbook entitled Elastic Arch Bridges, in 1931. In it, the authors described in detail the arch form from antiquity to the early twentieth century. Using structures that the OSHD constructed in Oregon as examples, they discussed the mathematical theory of elasticity as it applied to the design of arched bridges. They devoted one portion of the book to describing the advantages for using hinged instead of fixed arches in constructing bridges. Hinges, McCullough wrote, compensate for extraordinary stresses introduced to the structure by shrinkage of concrete and shortening of arch ribs under dead load. He preferred the "Considere" type of hinge, whereby bent reinforcing bar was bundled with steel hoops to resemble an hourglass. Around this was poured high-strength concrete. The result in three-hinged arches, for example, was that at the skewbacks and crowns of ribs McCullough placed hinges which functioned as articulation points, that would eliminate stresses on the span due to shrinkage and dead load. They allowed the ribs to "adjust" themselves only at these points. Later, crews would fix the hinges with a more dense concrete, creating a rigid structure that would be immovable under live loads. McCullough first used Considere hinges in 1931 on the three reinforced-concrete half-through arch spans of the Cave Man Bridge at Grants Pass.[40]

In 1933, at Oregon City, McCullough designed a 720-foot three-span steel through tied-arch structure over the Clackamas River. Eye-bar ties, that passed through holes cut in the webs of floor beams, contained lateral thrust of the steel box-girder arches. McCullough also featured gothic arch-shaped openings in the main piers and scored Art Deco entrance pylons. He entered a water color rendition of the structure American Institute of Steel Construction's contest for steel bridges costing less than $250,000. It won the organization's annual award of merit for being the "Most Beautiful Steel bridge" in its class for that year.[41] In the colored sketch of the span that he submitted to the institute, McCullough had an artist paint the steel arches green, After the bridge won the award he had maintenance crews repaint it to match the watercolor. This set precedent and for many years, OHSD painted all of its steel bridges green.[42]

In 1931, Lewis A. McArthur, an Oregon geographer and historian, suggested that state officials change the name of the Roosevelt Coast Military Highway to the "Oregon Coast Highway" to better reflect its true function. Even before completion of the highway it was assumed that the OHSD would replace the antiquated ferries at major crossings of bays or rivers at Coos Bay, Reedsport, Florence, Newport and Waldport. The state contemplated constructing one bridge each year, after the completion of the seven-arch span at Gold Beach in 1932. A year earlier, chambers of commerce, community clubs and other residents of the central and southerly coastal areas organized the Oregon Coast Highway Association, a regional chamber of commerce. This body pressed the OSHC to construct subsequent bridges on the shoreline route, but the commission had no funds for such undertakings, and believed that it would be of no use trying to sell bonds to raise money as the country was in the midst of a major depression.[43]

In late June 1932, the Oregon Coast Highway Association held a meeting at Waldport to discuss plans for pushing for construction of more bridges. Former Governor A.W. Norblad proposed building three bridges as a means to create a market for lumber production in the area. Samuel Dolan, an instructor in engineering at Oregon Agricultural College, and close friend of McCullough's, suggested charging tolls on the bridges as a means to help them pay for themselves. Local citizens did not greet warmly the proposal. The Highway Association pressed state officials to appeal to the Reconstruction Finance Corporation for funds. President Herbert Hoover created the RFC, in 1932, to help banks, railroads, and other key economic institutions in business. Nevertheless, Hoover lost his bid for reelection that year and his successor, Franklin Delano Roosevelt, canceled the RFC. Charles L. McNary, Republican from Oregon, became U.S. Senate minority leader in March of that year and help spearhead a bipartisan campaign supporting Roosevelt's New Deal plans for national economic recovery. He wholeheartedly lobbied for the National Recovery bill and worked for its quick passage. The National Industrial Recovery Act helped industry re-absorb four million unemployed workers by creating jobs in a large program that oversaw the construction of roads, bridges, dams, and public buildings. The NIRA created the Public Works Administration to finance these projects with a $3 billion budget.[44]

At McNary's insistence, the OSHC applied to the PWA to fund construction of five major bridges along the coast. While McCullough's design engineers had already drawn up preliminary plans for a bridge at Waldport, they had none for the others. McCullough had kept close ties with Oregon Agricultural College, in Corvallis, by teaching night courses in the late 1920s. He was acutely aware of the abilities of his students and offered to those of high caliber, such as Ivan Merchant and A.E. Johnson, employment with the bridge section of OSHD. With the possibilities of federal financing for all five spans to replace the ferries, he doubled the size of his staff by bringing to Salem some of his experienced district engineers and recruiting the others. Because of limited office space, he split the team into day and night shifts and rushed to complete drawings for all of the bridges. They finished the plans in six months.[45]

Many coastal residents, however, believed that the bridges should be constructed of wood to help local lumber businesses. The State Highway Commission seriously considered using wood but decided it would not be practical for the region's climate. The high winds and damp salt air of the coast would cause maintenance costs to run too high. Bridges constructed from steel and reinforced concrete would last much longer than wood. Besides, state officials argued, the amount of wood required for the wooden falsework for the construction of steel and concrete bridges would be nearly as much as if the bridges themselves were made of wood. Still, lumber interests agitated. At a highway commission meeting in Portland they pushed for the use of wood on the coastal bridges. McCullough feared that if their pressure caused delay, the federal money would go elsewhere. In addition, the federal government would not approve the use of wood for the five bridges. Residents' fear of the loss of federal money, which for them would mean the loss of an anticipated influx jobs and business revenue, eventually caused them to support the proposal for the spans. The federal government granted final approval of the plans, and in the summer of 1934 contracts were awarded for the construction of five steel and concrete coastal bridges totaling $5,402,000.[46]

The original agreement with the PWA stipulated that the federal government would grant the state $1,402,000, and loan state $4,200,000 to be reimbursed through the sale of bonds. Within the state, however, the question of payments had not been resolved. Eastern Oregonians disliked the idea of saddling state residents with a general obligation to fund the construction of bridges along the coast highway. They preferred not to give monetary support for something that they had no use for. Western Oregonians saw tolls as unfair because the bridges were part of an ongoing highway improvement program for the whole state. In any event, increased highway revenues gave the state new confidence to pay back the loans, and the 1935 state legislature dropped any ideas of collection tolls on the bridges.[47]

For the five coastal bridges McCullough provided the inspiration for a variety of designs. As one has said, "Mac would lay out the overall job." For example, on the bridge for Newport, McCullough picked up a piece of paper and a pencil, and said, "'Now ... this it about what you are going to do.' ... And he drew this spandrel arch in there and the roadway and ... now, there it is, go ahead. ... And of course about every two or three weeks he'd come back to see how you were getting along."

McCullough created a unique design for each of the five bridges. All incorporated classic details with the popular Art Deco style of the 1930s. They seemed to "grow out of the land," wrote one historian, and "provide a natural continuity of land and space, respecting and enhancing the existing natural forms and forces." Each structure was unique, having an identity all its own, differing greatly from the other four. Nevertheless, the common bond shared among them all was McCullough's reliance on the arch, the age old form. In 1934, OAC presented McCullough with an honorary doctoral degree in Civil Engineering.[48]

The OSHC let contracts for the five bridges in the spring of 1934. Construction began almost immediately. At Waldport, McCullough planned a 3,028-foot structure with reinforced-concrete deck girder and deck arch approaches to a series of three reinforced-concrete tied arches over the navigable channel of Alsea Bay. For Newport, he created a 3,260-foot bridge across Yaquina Bay with a 600-foot steel central through arch flanked by steel deck arches.[49]

In the 1930s, both the Siuslaw and Umpqua Rivers still had much shipping traffic and required spans that would let tall ships pass along their navigable channels. In crossing the narrow and deep Siuslaw River at Florence, McCullough designed a bascule draw bridge as part of a 1,650-foot structure with deck girder approaches and a central span of two reinforced-concrete tied arches on either side of the moveable section. At Reedsport, the Umpqua River was wide and shallow. So, he designed a 2,213-foot bridge with a steel truss tied-arch swing span flanked by pairs of reinforced-concrete tied arches. Finally, at Coos Bay, McCullough constructed a 5,337-foot structure with a high-clearance, 793-foot steel cantilever truss main span.[50]

Contractors completed the five coastal bridges in 1936 and the Oregon Coast Highway, U.S. 101, became a continuous route the length of the state. The project held great significance for the people of Oregon. It provided jobs for people unemployed by the Great Depression, and aggregated over 2.1 million man hours directly on the bridges. In addition, it benefitted Oregon industries by consuming 16 million board feet of lumber, 54,000 cubic yards of sand, 110,000 cubic yards of gravel, and 182,000 barrels of cement. It was also expected that future revenue from tourism along the highway would increase greatly, to the benefit of both the state and the region. After construction of the bridges tourism jumped 72 percent in one year.[51]

The bridges also capped twenty-two years of construction on the Oregon Coast Highway. Concrete was the primary construction material not only for its durability in the climate but also for its beauty in form. McCullough gave much attention to appearance and called his bridges "jewel-like clasps in perfect settings, linking units of a beautiful highway."[52]

During the years of construction on the five coastal bridges, McCullough and Raymond Archibald, one of his design engineers, were in Central America on a project with the U.S. Bureau of Public Roads. Throughout the 1920s the U.S. government and those of Central American countries in the Pan-American Union pressed for construction of a continuous road connecting the republics of Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama, as the Inter-American Highway. Ultimately, it would become part of the Pan-American Highway, a continuous road from Alaska, through North America and Central America to Tierra del Fuego at the southern tip of South America. McCullough and Archibald left Salem in December 1935 for San Jose, Costa Rica, where they worked on the design of many structures for the proposed route, including three short-span suspension bridges. They returned to Oregon in the spring of 1937.

In 1934, Congress appropriated $1 million for the construction of a number a bridges along the route of the Inter-American Highway. McCullough's major contributions to the project included a self-anchoring, truss-type, eye-bar suspension bridge over the Rio Tamazulapa, in Guatemala; a cable suspension bridge with twin 330-foot spans over the Rio Choluteca, in

Honduras; and a single-span cable suspension bridge over the Rio Chiriqui, in Panama. The remoteness of each site limited the types of construction that he could employ. Local workers quarried native stone for the piers for all three bridges because of the extraordinary costs for transporting reinforcing bar and the components of concrete to the sites. He chose the suspension bridge form because he believed, through mathematical calculation, that it was the most economic alternative.[53]

All three bridges resemble each other, but the span in Guatemala is most typical of McCullough's past designs. He had made it a point to study Mayan culture while on the Inter-American highway project and became fascinated with Mayan art and hieroglyphics. Later, in Salem, he frequently lectured on the topic to civic organizations. On the eye-bar span over the Tamazulapa, McCullough used Mayan symbols to decorate entry pylons, panels for balustrades, and the towers. He once wrote that the treatment was "unusual but logical," because Guatemala was the center for Mayan civilization from A.D. 200 to 300. He introduced "in relief work," "variations and elaborations encountered in the embellishments of the Mayan structures." The treatment was not unlike that seen on the Oregon bridges, where he used gothic and Art Deco details, which were part of American and western European cultural heritage.[54]

When McCullough returned to Salem in the spring of 1937 he did not resume his duties as State Bridge Engineer. Glenn S. Paxson, one of his field engineers, had taken the post on a temporary basis when he left for Central America. Instead, McCullough was promoted to the post of Assistant State Highway Engineer, a role he had taken, in addition to his duties as bridge engineer, in 1932. Yet, by 1937 the OSHC made it a separate office, because of an expansion of the highway department. Paxson, then, officially became Bridge Engineer and held the post until 1953. Suddenly, McCullough was no longer directly involved in bridge design and became solely an administrator.

In the late 1930s and early 1940s, McCullough added to his research publications on economics of highway construction, including a bulletin on short-span suspension bridges and articles on composite timber and concrete structures for low-cost spans for county roads. He also authored a two-volume textbook, The Engineer at Law: A Resume of Modern Engineering Jurisprudence, with his son John. In 1928, McCullough earned a law degree from Willamette University, because of a personal interest about litigation in highway construction. By the early 1940s, he decided to write on the subject to make them "better engineers," by giving them a "broader outlook, one capable of more enlightened cooperation with the legal profession.[55]

McCullough's life centered around bridges and bridge design, though he did spend much time with his wife and son at their home in Salem. They built a house on West Lefelle Street in the mid 1930s. He lived there the rest of his life. He took a genuine interest in civic responsibility almost from the start of his career with the state highway department and became a member of the Salem Chamber of Commerce in 1923. In 1945 he was elected chairman of the city's first long-range planning commission that considered growth of Salem and its effect upon zoning ordinances, air and rail terminals, arterial streets, bridges crossing the Willamette river, and general aesthetic appeal. He was also a Rotarian, a Mason, and a confirmed Republican. He was one of the few state employees in Salem who took an interest in the city, at a time when many local business owners believed that civil servants were lazy and unworthy of their "large" salaries. But not so with McCullough, he outwardly expressed concern for the city and pledged his support to find solutions for its problems.[56]

McCullough did not fish or hunt, but he loved to garden. He also sang and played the piano when he got the chance, at conventions or informal gatherings, but not in organized groups. He was always full of wit and liked a good story. At one time, he wrote some fiction, patterning it after the serials found in the Saturday Evening Post, instead using an engineer as his hero, but none was ever published. He also had a passion for reading what many perceived as outlandish science fiction.[57]

McCullough's first love remained with engineering. Even though he had many extracurricular activities, his idea of recreation was work. He once wrote, "All fields of knowledge overlap. A profound understanding of any profession, therefore, requires a knowledge of many others. There is no narrower man than the specialist who knows naught outside his specialty."[58]

In early 1942, McCullough had a heart attack. All the years of sixteen-hour work days and endless packs of cigarettes had caught up with him. His doctor ordered him to quit the tobacco and work at a slower, less demanding pace. McCullough obeyed him for a few years, but finally told his wife, "If I have to live like this the rest of my life, I don't want to live." So, he fell back to old habits. Late in the afternoon of May 6, 1946, McCullough had a massive stroke. He had been working in his yard and came inside to clean up before supper. His wife found him slumped on the floor in the bathroom. He never regained consciousness and died that evening, less than a month short of his fifty-ninth birthday. Funeral services were held in Salem, and McCullough's ashes were interred in a local mausoleum.[59]

McCullough was someone who was deeply committed to anything that he did whether it be as a bridge designer or vestryman at Saint Paul's Episcopal Church. He had an active mind, always reading, listening, watching, and learning, be it Mayan culture or city planning. Some advice that he gave his son John during World War II bears out his philosophy,

> ... In the practice of law one never knows when certain miscellaneous information will become extremely useful. ... Offhand, it probably doesn't seem to you that anything which you are learning now could possibly be of value to you in trying a lawsuit later on ... you never can tell. [So,] learn everything you can about the Navy, about seamanship, and about navigation.[60]

Someone once asked McCullough if it gave him a great source of pride to "be able to drive up and down this state and see the great highways and beautiful bridges that [he] helped build." He replied,

> You know, my good sir, if we engineers had souls which I doubt, we might have to take to the back roads to keep from blushing every time we see some of the things we have done. But on the other hand, I'm kinda human like the rest of humanity, and I'll admit that there's at least one or two bridges I've had a hand in, and when I look at them, I kinda figure I'll have some alibi when I see St. Peter. Not all of 'em, you understand, but some of 'em did come out so good they make life worth living.[61]

McCullough loved his work and enjoyed life. Hundreds of bridges were built in Oregon during his years as state bridge engineer. Of those, thirty-two were arched spans. In 1947 the state dedicated the Coos Bay span as the "Conde Balcom McCullough Memorial Bridge" in his honor for his genuine contribution to the creation of the state's modern the state's highway system. Many of his bridges are listed in the National Register of Historic Places, and a number of them have been awarded ASCE status as National Historic Engineering Landmarks.

McCullough was the renaissance man. He willingly created bridges with a relatively new material, reinforced-concrete. Yet, he appreciated the smooth, comforting outline of a masonry arch. He combined the two, the new with the old, and gothic with modern, to create works the spanned the generations, examples of technology on the cutting edge, for all to see. In 1937, nine years before his death, C.B. McCullough penned to a friend his own view on the purpose of bridges, he wrote,

> . . . From the dawn of civilization up to the present, engineers have been busily engaged in ruining this fair earth and taking all the romance out of it. They have cluttered up God's fair landscape with hideous little buildings and ugly railroads. The highway builders have ruined all the fishing so that there is no place where one can go and get away from it all. As a last and final insult, there appears to be a movement on foot to clutter up the right of way with blazing artificial lights at night so that there will be no place on the road for the young folk to park and engage in their usual amorous avocations. Personally I am too old for this to make any difference, but, nevertheless, I deplore it.
>
> There is no romance nor poetry left in the world and I think the Democrats are going to carry the next election. The only reason that I am living at all is that the price of just an ordinary casket is so high at the present time that I can't afford to die.
>
> Personally, I am all for the old covered bridge. It wasn't wide enough nor strong enough to carry the loads, it is true, but it was long enough to reach from one bank of the river to the other, which is all that a bridge is supposed to do anyway. Ninety-nine and seven tenths percent of the people who travel over the rivers now would be a lot better off if they stayed at home in the first place. They simply travel the roads and burn up more gas so that we can build more roads for them to burn up gas on. It is a vicious circle. The whole thing is the responsibility for the engineers. If we only knew the truth, the decline of ancient Babylon and the complete dissolution of Sodom and Gomorrah were probably dated from the time when they formed the first engineering society. However, I don't know that there is anything we can do about it. The engineers will never stop as long as there is any timber left to make stakes out of, which last fact ought to make business good for the lumber industry.
>
> Yours in the interest of old covered bridges, winding trails, quiet pools and romance, ...[62]

CONDE B. McCULLOUGH (1887-1946)

CHRONOGLOGY OF CONDE B. McCULLOUGH

1887	Born in Redfield, Dakota Territory
1910	Bachelor's Degree in Civil Engineering, Iowa State College, Ames, Iowa
1910-1911	Employed, Marsh Engineering Company, Des Moines, Iowa
1911-1916	Designing Engineer, Iowa Highway Commission
1913	Married Marie Roddan
1916-1919	Professor of Civil Engineering, Oregon Agricultural College, Corvallis, Oregon
1919-1935	State Bridge Engineer, Oregon State Highway Department
1928	Bachelor's Degree of Laws, Willamette University, Salem, Oregon
1932-1946	Assistant State Highway Engineer, Oregon State Highway Department
1934	Honorary Doctor of Civil Engineering, Oregon State College, Corvallis, Oregon
1935-1937	Inter-American Highway Project, San Jose, Costa Rica
1946	Died, Salem, Oregon

CONDE B. McCULLOUGH BRIDGES IN OREGON

1920 **Rock Point Arch Bridge** (HAER OR-29), Jackson County, one 113-foot reinforced-concrete deck arch, total length 505'

1920 **Oswego Creek Bridge**, Clackamas County, one 130-foot reinforced-concrete deck arch, total length 330'

1920 **Mosier Creek Bridge** (HAER OR-28), Wasco County, one 110-foot reinforced-concrete deck arch, total length 182'

1921 **Dry Canyon Creek Bridge** (HAER OR-30), Wasco County, one 75-foot reinforced-concrete deck arch, total length 101'

1922 **Myrtle Creek Bridge**, Douglas County, three 130-foot reinforced-concrete deck arches, total length 547'

1922 **Oregon City Arch Bridge** (HAER OR-31), Clackamas County, one 360-foot steel half-through arch, total length 745'

1924 **Winchester Bridge** (HAER OR-33), Douglas County, seven 112-foot reinforced-concrete deck arches, total length 884'

1924 **Grand Ronde River Bridge**, Union County, one 134-foot reinforced-concrete deck arch, total length 312'

1925/1951 **Umatilla River Bridge**, Umatilla County, three 110-foot reinforced-concrete deck arches, total length 439'

1925 **Fifteenmile Creek Bridge**, Wasco County, one 120-foot reinforced-concrete deck arch, total length 148'

1926 **Crooked River High Bridge** (HAER OR-35), Jefferson County, one 330-foot steel deck arch, total length 464'

1927 **Gold Hill Bridge** (HAER OR-37), Jackson County, one 143-foot reinforced-concrete barrel arch, total length 443'

1927/1940 **Depoe Bay Bridge** (HAER OR-36), Lincoln County, one 150-foot reinforced-concrete deck arch, total length 312'

1927 **Rocky Creek Arch**, Lincoln County, one 160-foot reinforced-concrete deck arch, total length 360'

1928 **Soapstone Creek Bridge**, Clatsop County, one 108-foot reinforced-concrete deck arch, total length 152'

1930 **Klamath River Bridge**, Klamath County, three 100-foot reinforced-concrete through arches, total length 370'

1931 **Wilson River Bridge** (HAER OR-39), Tillamook County, one 120-foot reinforced-concrete through tied arch, total length 180'

1931 **Ten Mile Creek Bridge**, Lane County, one 120-foot reinforced-concrete through tied arch, total length 180'

1931 **Big Creek Bridge**, Lane County, one 120-foot reinforced-concrete through tied arch, total length 180'

1931 **Caveman Bridge**, Josephine County, three 150-foot reinforced-concrete half-through arches, total length 550'

1932 **Bridge at Mouth of Rogue River** (HAER OR-38), Curry County, seven 230-foot reinforced-concrete deck arches, total length 1,898'

1932 **Hood River Bridge**, one 100-foot reinforced-concrete deck arch, total length 188'

1932 **Cape Creek Bridge** (HAER OR-41), Lane County, one 220-foot reinforced-concrete deck arch, total length 619'

1933 **Santiam River Bridge** (HAER OR-42), Marion and Linn Counties, three 220-foot reinforced-concrete through arches, total length 780'

1934 **South Umpqua River Bridge**, Douglas County, three 180-foot steel through tied arches, total length 548'

1936 **Umpqua River Bridge** (HAER OR-45), Douglas County, one 430-foot steel through truss tied arch swing span, four 154-foot reinforced-concrete through tied arches, total length 2,206'

1936 **Siuslaw River Bridge** (HAER OR-10), Lane County, one 140-foot double-leaf bascule steel draw span, two 154-foot reinforced-concrete through tied arches, total length 1,568'

1936 **Alsea Bay Bridge** (HAER OR-14), Lincoln County, one 210-foot and two 154-foot through tied arches, six 150-foot deck arches, all reinforced-concrete, total length 3,011'

1936 **Coos Bay Bridge** (HAER OR-46), Coos County, one 793-foot and two 457-foot steel cantilever truss spans, thirteen 265-foot reinforced-concrete deck arches, total length 5,305'

1936 **Yaquina Bay Bridge** (HAER OR-44), Lincoln County, one 600-foot steel through arch, two 350-foot steel deck arches, five 265-foot reinforced-concrete deck arches, total length 3,223'

ENDNOTES

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31. See also HAER OR-38, Depoe Bay Bridge.

32. See various letters, Folder 8-PF1, RG-H4, 76A-90/3, Oregon State Archives; Robert Withrow, Editor, Curry County Reporter (Gold Beach, Oregon), letter to H.B. Van Duzer, Oregon State Highway Commission, 15 December 1928, Folder 8-4, RG-H4, 76A-90/3, Oregon State Archives; Oregon State highway Commission, Twelfth Biennial Report, 1934-35, p.115.

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