OMB No. 1024-0018

United States Department of the Interior
National Park Service

National Register of Historic Places
Multiple Property Documentation Form

This form is used for documenting multiple property groups relating to one or several historic contexts. See instructions in How to Complete the Multiple Property Documentation Form (National Register Bulletin 16B). Complete each item by entering the requested information. For additional space, use continuation sheets (Form 10-900-a). Use a typewriter, word processor, or computer to complete all items.

__X__ New Submission ____ Amended Submission

A. Name of Multiple Property Listing

Oregon Coast Highway Bridges, 1927-36

B. Associated Historic Contexts

(Name each associated historic context, identifying theme, geographical area, and chronological period for each.)

C. B. McCullough and Construction of the major Oregon Coast Highway Bridges, 1919-36.

C. Form Prepared by

name/title Robert W. Hadlow, Ph.D., Senior Historian, Oregon Department of Transportation

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D. Certification

As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this documentation form meets the National Register documentation standards and sets forth requirements for the listing of related properties consistent with the National Register criteria. This submission meets the procedural and professional requirements set forth in 36 CFR Part 60 and the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation. (☐ See continuation sheet for additional comments.)

______________________________ ____________
Signature and title of certifying official Date

____
State or Federal agency and bureau

I hereby certify that this multiple property documentation form has been approved by the National Register as a basis for evaluating related properties for listing in the National Register.

______________________________ ____________
Signature of the Keeper Date

United States Department of the Interior
National Park Service

National Register of Historic Places
Multiple Property Documentation Form

Table of Contents for Written Narrative

Provide the following information on continuation sheets. Cite the letter and the title before each section of the narrative. Assign page numbers according to the instructions for continuation sheets in *How to Complete the Multiple Property Documentation Form* (National Register Bulletin 16B). Fill in page numbers for each section in the space below.

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(If more than one historic context is documented, present them in sequential order.)

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(Provide description, significance, and registration requirements.)

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(Discuss the methods used in developing the multiple property listing.)

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State Historic Preservation Office, other State agency, Federal agency, local government, university, or other, specifying repository.)

E. Statement of Historic Contexts

(If more than one historic context is documented, present them in sequential order.)

C. B. McCullough and Construction of the major Oregon Coast Highway Bridges, 1919-36.

> The railroads usually measure a stream, and then send out a hand-me-down blueprint for a bridge to be built to predetermined standards. In Oregon our engineers have been trained to go to the stream, build a bridge for utility and economy, and at the same time design it so it will blend with the terrain.
>
> *Conde B. McCullough*

Most people who hear Conde B. McCullough's name will think first of the six major bridges that he created for the Oregon Coast Highway in the first half of the 1930s. These structures were the pinnacle of his achievement as a designer and a lasting monument to his contributions to the state. This was McCullough's most prolific period of bridge building, a culmination of years of studying and designing structures. It capped a decade and a half in which he led the Oregon State Highway Department's (OSHD) publicly mandated mission to build the state's modern highway system. In those years, he authored two engineering textbooks, received awards for his designing expertise, earned a law degree, and constructed several large bridges, including the six major structures, to complete the Oregon Coast Highway. The architectural and engineering greatness of McCullough's Oregon Coast Highway bridges vaulted him and the state of Oregon to the forefront of twentieth-century structural engineering at the national and international levels. Few other engineers have shown such talent.[1]

The Beginning of Modern Road Building in Oregon

In 1919, when he became state bridge engineer, C. B. McCullough understood Oregon's drive to "lift its feet out of the winter's mud and summer's dust." The OSHD's first staff, beginning in 1913, had included Henry L. Bowlby as state highway engineer, Samuel C. Lancaster as assistant state highway engineer, and Charles H. Purcell as state bridge engineer. While Lancaster was designing the Columbia River Highway, Bowlby and Purcell canvassed the state gathering information to establish a designated state road system. Along the way, they found deplorable bridges at many locations and concluded that "customary bridge [building] methods" needlessly cost Oregon's taxpayers thousand of dollars annually. Purcell noted that bridge company representatives sold county courts, which oversaw road construction and maintenance in the pre-automobile era, costly and often inferior structures. Many were ill-suited for their locations because the "courts 'fall for' the talk put up to them by these salesmen." Bowlby and Purcell sought additional legislation authorizing the highway commission to design and supervise bridge construction on all publicly owned routes in Oregon. They hoped that quality bridge construction on the Columbia River Highway, the Pacific Highway, and other state "trunk routes" might garner public support for a stronger highway commission.[2]

Increasingly, Oregonians were coming to believe that a powerful highway commission could implement a comprehensive road and bridge construction and maintenance program and produce additional funding through bond issues. Oregon voters approved such a plan in 1917. But in the end, federal law provided the impetus for change.[3]

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[1]The six major bridges were the Rogue River (Gold Beach) Bridge, the Yaquina Bay (Newport) Bridge, the Alsea Bay (Waldport) Bridge, the Siuslaw River (Florence) Bridge, the Umpqua River (Reedsport) Bridge, and the Coos Bay (McCullough Memorial) Bridge.

[2]Ralph Watson, compiler, *Casual and Factual Glimpses at the Beginning and Development of Oregon's Roads and Highways* (Salem: Oregon State Highway Commission, [1951] 29-30; [Charles Purcell] "Preface," 5 (quote), "Investigation of Recent County Bridge Construction," 177-90, and [Purcell] "Bridges Designed and Built by the State Highway Commission," 168-76, in Oregon State Highway Commission, *First Annual Report, for 1913-14*. Purcell reached conclusions similar to McCullough's from a few years earlier in Iowa.

[3]Bowlby resigned as State Highway Engineer on 31 March 1915 amid allegations of poor management. Hugh Myron Hoyt, "The Good Roads Movement in Oregon: 1900-1920," Ph.D. diss. (University of Oregon, 1966), 249. With the reorganization, the State Engineer oversaw the work of the highway department until 1917, when the legislature created the modern state highway commission. State Engineer John H. Lewis, in his 1914-16 report, made a strong case for a more powerful state highway commission by describing, in great detail, the plight of taxpayers unknowingly purchasing expensive, poorly constructed bridges. "State Highway Department," *Sixth Report of the State Engineer, for 1914-16 [of Oregon]*, 7-24. The state

In 1916, Congress passed the Federal-Aid Road Act, committing the federal government, through the Office of Public Roads (OPR), to nationwide highway building. The Act appropriated $75 million in federal matching funds over several years. States would receive portions of this on a project-by-project basis for grading and paving road surfaces, and constructing bridges on post roads. But the Act required that the OPR approve state highway commissions and departments before they could participate in the program.[4]

In February 1917, the Oregon legislature placed all state highway system construction and maintenance in the hands of a three-member citizen commission appointed by the governor. It also placed on the ballot a $6 million bonding act to finance the OSHC and its department's increased responsibilities. A majority of Oregonians, disgusted with previous road laws and paltry funding, approved the referendums on a June ballot.[5]

The new Oregon State Highway Commission selected Herbert Nunn as its highway engineer to oversee day-to-day departmental activities. Because of wartime emergency conditions, Nunn directed a disproportionate amount of road resources to completing and improving the state's long-distance routes that Bowlby and Purcell had identified a few years before. They were essential for motor trucks transporting war materiel. Specifically, these routes included the Columbia River Highway, from Astoria east to Umatilla; the Pacific Highway, from Portland south to the California state line; and a coast highway from Astoria to Brookings.[6]

Since Charles Purcell's resignation in 1915 as state bridge engineer, staff engineers oversaw bridge construction. Meanwhile, bond sale proceeds and early federal-aid matching funds increased the pace of highway projects in Oregon, and a boost in automobile license revenues eased worries about retiring the mounting bond obligations.[7]

Oregonians viewed the scale of the enterprise and wished it were greater. The 1919 legislative assembly increased the highway bond by $10 million. It enacted a one-cent-per-gallon tax on all fuels used in motor vehicles and designated the revenue exclusively for highway improvement. This measure, Oregon's "gas tax," became the first of its type in the country. North Dakota, New Mexico, and Colorado followed suit, and within ten years, all forty-eight states had adopted similar laws. Finally, lawmakers submitted a referendum calling for a coastal defense route, the Roosevelt Coast Military Highway, as an outgrowth of post-World War I emergency preparedness and a renewed sense of isolationism.[8]

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legislature combined his job with that of the State Engineer, who oversaw water resources in the state. See "An Act Abolishing the Office of State Highway Engineer," Chapter 337, *General Laws of Oregon*, 1915, 537; Seely, Building the American Highway System, 46-48.

[4]Bruce E. Seely, *Building the American Highway System: Engineers as Policy Makers* (Philadelphia: Temple University Press, 1987), 46-48.

[5]"An Act to Provide a General System of Construction, Improvement and Repair of State Highways. . . ," Chapter 237, *General Laws of Oregon*, 1917, 447-57; "An Act to Provide for the Construction of Roads and Highways in the State of Oregon. . . ," Chapter 423, *General Laws of Oregon*, 1917, 897-905; Watson, Casual and Factual Glimpses, 28; OSHC, *Third Biennial Report, for 1917-18*, 7-8; Hoyt, "The Good Roads Movement in Oregon," 230-31.

[6]For projects on post roads, involving Federal-Aid Road Act dollars, the OSHD prepared plans and let contracts for work on bridges and roads subject to the OPR's approval. *Third Biennial Report, for 1917-18*, OSHC, 19.

[7]Later, Purcell became a field engineer for the OPR's Portland office before becoming an engineer for the California Department of Highways. In the 1930s he oversaw the design and construction of the San Francisco-Oakland Bay Bridge. "Report of the State Highway Engineer," *Third Biennial Report, for 1917-18*, OSHC, 17-25. Howard Holmes later over-saw bridge construction for the Montana Department of Highways and became its State Highway Engineer in 1941. "Background of a State Highway Engineer," *Pacific Builder and Engineer*, July 1941, 65.

[8]Watson, Casual and Factual Glimpses, 29; "An Act to Provide for the Construction of Roads and Highways in the State of Oregon. . . ," Chapter 173, *General Laws of Oregon*, 1919 241-49;; "An Act to Provide a License Tax on Gasoline, Distillate, Liberty Fuel and Other Volatile and Inflammable Liquids . . . for the Purpose of Operating or Propelling Motor Vehicles," Chapter 159, *General Laws of Oregon*, 1919. See Edmund P. Learned, "Gasoline Taxes: Theory, Practice, and Hazards," *Engineering News-Record* 104 (2 January 1930: 12-16; and John Chynoweth Burnham, "The Gasoline Tax and the Automobile Revolution," *Mississippi Valley Historical Review* 48 (December 1961): 435-59, especially 437-40. Hoyt also discussed political aspects of the fuel tax issue, see "The Good Roads Movement in Oregon," 231-39; "An Act to Provide for the Construction of a Highway to be Known as 'The Roosevelt Coast Military Highway'. . . ," Chapter 345, *General Laws of Oregon*, 1919, 610-13. The route was named after Theodore Roosevelt, the recently deceased president of the United States who strongly subscribed imperialism.

Because the coastal highway was ineligible for Federal-Aid Road Act funds, state voters approved a $2.5 million bond obligation, which was to match federal military highway funds to finance the shoreline route. Federal money never materialized, however, and the state government's authority to sell construction bonds lapsed.

C. B. McCullough as the State Bridge Engineer

In April 1919, the Commission chose Conde B. McCullough as state bridge engineer. From 1906 to 1910, McCullough studied civil engineering at Iowa State College under the respected and progressive educator Anson Marston. Marston trained his students in a curriculum that emphasized the applied aspects of the field as well as its philosophical underpinnings. Technical ability combined with well-rounded education, Marston believed, provided the foundation for creating sensible highway bridge designs for local, state, and national interests. McCullough's training under Marston and Professor John E. Kirkham, a respected civil engineer, prepared him to become one of the nation's most accomplished bridge designers. He learned from his mentors that experts should give unselfish service to society.

In 1910-11, McCullough worked for the Marsh Engineering Company of Des Moines, where he learned firsthand the intense rivalry among private companies to win bridge-building contracts from conty governments. James B. Marsh promoted his reinforced-concrete arch structures as superior to his competitors' designs, thereby influencing McCullough's future artistic ambitions.

From 1911 to 1916, McCullough worked for the Iowa State Highway Commission (ISHC) as its bridge engineer and assistant highway engineer. He was a member of a team of talented young Iowa State College graduates serving under Thomas H. MacDonald, who later advanced to become chief of the U.S. Bureau of Public Roads (BPR), the successor agency to the OPR, and determined federal highway policy for the next four decades. McCullough and his colleagues instituted a forward-thinking, efficient, and economical highway building program for Iowa, far advanced over the piecemeal, ineffective, and wasteful county-based approach of the past. He also became an expert in worldwide reinforced-concrete bridge technology when he prepared a 600-page brief on the subject for a lawsuit involving the ISHC and noted bridge engineer Daniel Luten. The state succeeded in defending McCullough's former employer, James Marsh, against patent infringement allegations that Luten had made against his rival.

In 1916, McCullough completed requirements for the degree of "Civil Engineer" from Iowa State, which acknowledged the expertise he had gained in the field since earning his bachelor's degree. Shortly, McCullough headed to Corvallis, Oregon, where he chaired a fledgling structural engineering program at the Oregon Agricultural College (later known as Oregon State College and Oregon State University). There, he instituted the values he had learned from Marston at Iowa State. In 1919, when McCullough left the college for state service, the OAC newspaper reported that he was "considered the best man in [concrete construction] in the country.[9]

Shortly, McCullough assembled a staff for his "bridge department" that included friends and former classmates from Iowa State and four of the five spring 1919 graduates from the OAC structural engineering program. Over the next decade and a half, McCuulough maintained a close relationship with the state college, where he tapped the best and brightest graduates for posts as designers and resident engineers on construction projects.

As he had learned in Iowa, McCullough found that the best bridge type for a site involved many factors. He argued that the economics of bridge building was "unquestionably the highest, most difficult and most important feature of bridge engineering," because it was "the very corner stone [*sic*] of economy." McCullough did not want to waste taxpayers' money. Accordingly, he paid a great deal of attention to stream behavior, navigational requirements, traffic considerations, architectural features, *and* state funding.[10]

Stream characteristics at a crossing determine the length of a proposed bridge and the types of approaches, abutments, and anchorage it requires. This is important, for example, because reinforced-concrete arch bridges need firm

[9] *Oregon Agricultural College Barometer*, 15 April 1919.

[10] Conde B. McCullough, *Economics of Highway Bridge Types* (Chicago: Gillette Publishing Co., 1929), 1-2 (quotes).

foundations. Even the slightest uneven settling of piers or bents can seriously over-stress arch rings, causing possible structural failure. In addition, McCullough also considered sight distance, traffic movement, and traffic density in arriving at a final design. The structural members of a wooden covered bridge or a steel through truss, he warned, could easily obstruct driver vision on sharply curved roadway approaches. Routes with truck or commuter traffic require bridges with large carrying capacities. Foresight, McCullough believed, was fundamental to determining if a design accommodated existing and future traffic needs in terms of density, load factors, and width.[11]

He also promoted the idea that “architectural features and scenic considerations,” as he called them, helped dictate the selection of bridge type. In descending order, McCullough ranked bridge categories by their “architectural possibilities”—masonry arches, reinforced-concrete deck arch spans, steel-plate girder spans with concrete decks and railings, reinforced-concrete girder spans, steel-truss spans, and timber bridges. His schooling at Iowa State, his work with James Marsh and the “rainbow arch,” his work at the ISHC, and his personal preferences, based on experience, all influenced his ranking of bridge types. McCullough advanced these concepts during his teaching years in Corvallis, influencing the thinking of his students and subsequent employees.[12]

The route of a road in relation to a bridge site, McCullough believed, should also influence type selection. “If the alignment is such that the structure is plainly visible in side elevation from the approaching highway,” he explained, “more attention should naturally be paid to [one] which gives a pleasing side elevation outline than if only the roadway were ordinarily visible.” Similarly, he also accounted for a bridge’s proximity to parks, vacation resorts, and other leisure activity locations. Increasingly, tourism brought revenue to Oregon. Well-maintained highways, with pleasing bridges, drew more tourists, who increased the consumption of goods and services and contributed to the all-important gasoline tax receipts.[13]

Finally, the choice among design types hinged on addressing total costs, both construction and maintenance. McCullough found that bridge types in the top categories of his hierarchy had lower long-term maintenance expenses, but initial construction costs were often higher. He believed that in the long run high-priced maintenance and shorter life span made the least expensive bridge as costly as, or more costly than, the most expensive bridge. “Perhaps the selection of a cheaper construction type,” he wondered “may be false economy.”[14] A timber trestle span of relatively inexpensive, untreated, and locally cut wood might have a life span of ten to twenty years. A more expensive reinforced-concrete arch span for the same crossing, requiring less maintenance, might last forty to eighty years. Steel-truss spans cost less than reinforced-concrete structures, but they had higher long-term maintenance costs because of their shorter life span of thirty-five to sixty-five years.[15]

Within his first six years as bridge engineer with the OSHD, McCullough’s small department designed nearly six hundred bridges at a cost of $6.4 million. Most were relatively short reinforced-concrete deck-girder spans. Initially, McCullough’s goal was to provide structures for as many of the smaller streambeds as possible, advancing the OSHD’s goals of grading and paving as many segments of the state’s trunk routes as feasible. The number of bridges completed in Oregon in the early 1920s decreased with each year, but the mean length grew. So did the cost. The cost per span in the 1921-22 biennium averaged $8,000; this increased to nearly $12,000 by 1923-24. During these years, McCullough completed many single- and multiple-span deck arches throughout the state, on the Pacific Highway, the Columbia River Highway, and the Old Oregon Trail Highway. In addition, he designed the Gunite-covered steel through arch span over the Willamette River, on the Pacific Highway, between West Linn and Oregon City.[16]

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[11] All plans for bridges over navigable streams, bays, and inlets required the U.S. War Department’s, and later the U.S. Coast Guard’s, approval for meeting minimum vertical and horizontal standards for ship clearance. Ibid., 3-5, 10-16.

[12] McCullough, *Economics of Highway Bridge Types*, 23.

[13] McCullough, *Economics of Highway Bridge Types*, 22, 23 (quote).

[14] C. B. McCullough, “How Oregon Builds Highway Bridges,” *Oregon Motorist*, February 1930, 14-15, 27; McCullough, *Economics of Highway Bridge Types*, 23 (quote).

[15] McCullough, *Economics of Highway Bridge Types*, 154-71.

[16] “Bridge Department,” *Fourth Biennial Report, for 1919-20*, OSHC, 49; “Bridge Department,” *Fifth Biennial Report, for 1921-22*, OSHC, 60;

The Oregon Coast Highway Bridges of the 1920s and early 1930s

By the early 1920s, the pleasure-seeking public, clamoring for improved travel between Portland and the beaches, promoted coastal highway construction. Work had begun in earnest in 1921 on a new road designed by the state's highway department. Despite having no connection to the national defense network, the route continued to carry the name "Roosevelt Coast Military Highway." Year in and year out, OSHD crews graded and paved piece after piece of the four-hundred-mile route. In 1926, it was renamed the Roosevelt Coast Highway, dropping the word "Military." Soon the route was also known as "US 101." By 1931, Oregon geographer and historian Lewis A. McArthur suggested that it be renamed the "Oregon Coast Highway." McCullough's initial contributions included numerous short-span bridges and a few larger reinforced-concrete structures. [17]

Most notable among McCullough's early bridges on the Oregon Coast Highway date from 1927. They were a 150-foot reinforced-concrete deck arch across the mouth of Depoe Bay and a similar structure over Rocky Creek, both in Lincoln County. In 1928, McCullough and his staff created another deck arch over Soapstone Creek in Clatsop County. All three exhibited features characteristic of his reinforced-concrete deck arches seen throughout the state: open spandrels with arched curtain walls; paired arch ribs; and pre-cast decorative railings and brackets. They were embellished with the classical and Gothic architectural details on piers, spandrel columns, and parapet rails that form signature elements for his structures.[18]

Among the bridges on the coast highway, none challenged McCullough's ingenuity more than three small stream crossings, one over the Wilson River in Tillamook County and two others at Big Creek and Ten Mile Creek in Lane County. Streambeds at all three locations were nearly identical in width and composition. Their 100-foot-wide channels, with sandy foundations, prevented McCullough from using traditional arches, which required abutment piers to counter lateral thrust. The high water level of all three streams was close to roadway grades, which ruled out alternative reinforced-concrete deck-girder spans. Finally, the harsh coastal environment, with its corrosive salt air, precluded the use of steel-truss spans. Accordingly, McCullough created identical 120-foot tied arches for all three crossings. They were some of the first bridges of this type in the United States and were the first in the Far West. Construction on the Wilson River Bridge began in September 1930 and was completed by June 1931, at a cost of $34,000. The two other bridges were completed by the end of the same year.[19]

McCullough's design resembled the tied-arch version of Iowa engineer James Marsh's "rainbow" bridge, both in form and function. (McCullough had worked for Marsh in the 1910s and learned much from him about arch bridge construction.) Unlike traditional fixed through arches, its curved ribs and road deck functioned as an integrated structure, much like an archery bow and string. The road deck—the string—held the outward thrust of the arch ribs—the bow—in compression. The entire superstructure rested atop inexpensive, lightly constructed piers that required little thrust-containing reinforcement. McCullough's design differed little in theory from Marsh's, but it diverged greatly in material composition. For example, he substituted more efficient steel reinforcing bars for Marsh's steel plating and latticework. He promoted economy without compromising modern highway traffic standards by using a hinge, or rotation point, near the top of each arch rib to simplify construction.[20]

"Bridge Department," *Sixth Biennial Report, for 1923-24*, OSHC, 59-61.

[17]Howard M. Corning, ed., *Dictionary of Oregon History* (Portland: Binsford and Mort Publishing, 1989), 183.

[18]Federal Writers' Program of the Work Projects Administration, *Oregon: End of the Trail*, American Guide Series (Portland: Binsford and Mort, 1940), 363; "Report of State Highway Engineer" and "Description of Work of the State Highway Department," *Seventh Biennial Report, for 1925-26*, OSHC, 71-72, 369; *Eighth Biennial Report, for 1927-28*, OSHC, 371-72; *Ninth Biennial Report, for 1929-30*, OSHC, 262-63; Dwight A. Smith, James B. Norman, and Pieter T. Dykman, *Historic Highway Bridges of Oregon*, 2nd ed. (Portland: Oregon Historical Society Press, 1989), 101-02.

[19]Conde B. McCullough, "Design of a Concrete Bowstring-Arch Bridge, Including Analysis of Theory," *Engineering News-Record* 107 (27 August 1931): 337-39. For costs and construction schedules, see Job Record Cards for Wilson River Bridge (No. 1499), Big Creek Bridge (No. 1180), and Ten Mile Creek Bridge (No. 1181), BS, TS, ODOT.

[20]McCullough, "Design of a Concrete Bowstring-Arch Bridge, Including Analysis of Theory," 337-39; Robert W. Hadlow, "Wilson River Bridge at Tillamook, 1931, Tillamook County, HAER No. OR-39, Report," Historic American Engineering Record, National Park Service, 1990, 4-6.

For these bridges, McCullough chose French engineer Armand Considère's version of a hinge, consisting of bent reinforcing bar bundled with steel hoops and encased in high-strength concrete. McCullough believed that the Considère hinge functioned more efficiently than other designs. The bending movement in arch ribs induced by concrete shrinkage or dead load was focused on its hour-glass shape and the hinges, which were immobilized once construction was completed, prevented these forces from weakening the structure. McCullough used the Considère hinge on subsequent bridges on the Oregon Coast Highway.[21]

Other small coast highway bridges posed similar problems. Twelve miles north of Florence in Lane County, the OSHD planned to relocate an especially winding section of the Coast Highway's original alignment. The new section would pass over the deep canyon of Cape Creek and seven hundred feet through Devil's Elbow, a headland, before continuing south along the coast. The tunnel and bridge project became known as the "million dollar mile" because of high construction costs. The Cape Creek Bridge alone cost $187,500.

McCullough looked at many possible design alternatives before deciding to build a bridge consisting of a reinforced-concrete arch with two-tiered viaduct approaches. The site proved difficult to span because it had steep embankments. In addition, weak foundations prevented the use of rubble fill approaches for an arched span over the stream. In one design proposal McCullough considered using creosote-soaked timber construction for the approach spans, but the BPR, cosponsor of the project, objected, preferring hollow concrete towers and fill. McCullough argued that this design, without cross-bracing, was susceptible to lateral movement and unsuitable because of the location's unstable substrata.[22]

Eventually, the BPR accepted McCullough's proposal to build a 619-foot, two-tiered viaduct and central arch. The viaduct sections consisted of two-tiered girder span approaches, which mimicked the style of Roman aqueducts, particularly the Pont du Gard, near Nimes, France, surrounded a 220-foot open-spandrel reinforced-concrete parabolic deck arch, which rose 104 feet over the stream channel. The design was as much practical as it was architectural. The vertical support members dispersed the viaducts' loads on the unstable foundations, and cross-bracing between the piers and panels prevented lateral movement. Architectural details, including semicircular arched curtain walls on the approaches, elbow brackets supporting the deck, and pre-cast railing panels, were standard elements of structures designed by McCullough during the 1920s and 1930. The Cape Creek Bridge was McCullough's and Oregon's only Roman-style concrete viaduct. It was constructed in thirteen months, opening on 30 April 1932.[23]

Rogue River (Gold Beach) Bridge

Roy A. Klein, the state highway engineer from 1923 to 1932, often promoted the Roosevelt Coast Highway, stating that it was the "outstanding and most important objective" of Oregon's road-building program. The route extended the full length

[21]McCullough, "Design of a Concrete Bowstring-Arch Bridge, Including Analysis of Theory," 337-39. Recent authors refer to McCullough's three bridges as the first tied arches in the United States. These claims are inaccurate. All-metal bowstring arches have existed since the mid- to late-nineteenth century. In addition, Marsh's bowstring arch bridge used this same concept in concrete and steel. But as suggested in the text, McCullough stands out for advancing the tied-arch form in concrete and steel reinforcing bar. The Washington State Highway Department first used a reinforced-concrete through tied arch in 1934 over the Duckabush River, in Jefferson County, on State Route No. 9. See Hadlow, "Wilson River Bridge," 7-9. See also "Duckabush River Bridge, State Route No. 9," Drawings, Bridge Design, Washington State Department of Transportation, Olympia, Washington, copies held by author.

[22]McCullough believed that a reinforced-concrete north viaduct was the best alternative because it would permit earlier use of the highway, present "a much more desirable appearance", "eliminate the uncertainty as regards the placement of such a high fill on movable sub-strata," eliminate the expense of continually adding more fill to one that would shrink over time, and, finally, it provided the best economic alternative for the site. Conde B. McCullough to Roy A. Klein, State Highway Engineer, 27 April 1931, copy in "Cape Creek Bridge File, No. 1113," ES, TS, ODOT. Cape Creek Bridge was constructed over a stream that empties into the Pacific Ocean between a large headland called "Devil's Elbow," and Heceta Head, a point named after the eighteenth century Spanish mariner and explorer Bruno de Hezeta who sailed near these shores in 1775. The region experienced little settlement by people of European descent until 1894, when a lighthouse and tender's residence were constructed on Heceta Head. Lewis A. McArthur, *Oregon Geographic Names*, 6th ed. (Portland: Oregon Historical Society Press, 1992) 403; U.S., Works Progress Administration, *Oregon: End of the Trail*, revised ed., Portland [Binsford and Mort], 1940, 377. For costs, see "Oregon State Highway Commission Bridge Maintenance, Repairs and Renewals [1934]." Cape Creek Bridge (No. 1113), Maintenance Files, BS, TS, ODOT.

[23]"Engineering Antiquities Inventory for Cape Creek Bridge," TMs [photocopy], ODOT, 1982; Smith, Norman, and Dykman, *Historic Highway Bridges of Oregon*, 108; E. S. Hunter, Assistant State Highway Engineer, ODOT, to David Plowden, 14 June 1973, copy in "Cape Creek Bridge File, No. 1113," ES, TS, ODOT.

of Oregon by the early 1930s and bridged many bodies of water, but the road surface was not a continuous ribbon of asphalt or concrete. Travel frequently became a muddy affair, and slow, inefficient ferries operating across two bays and four rivers contributed to traffic delays.[24]

Ferries had crossed the Rogue River between Gold Beach and nearby Wedderburn since the nineteenth century. Beginning in 1927, McCullough's bridge department took over from private concerns ferry operations at Gold Beach and five other points along the Oregon coast (Coos Bay, in Coos County; the Umpqua River, in Douglas County; the Siuslaw River, in Lane County; and Yaquina Bay and Alsea Bay, in Lincoln County). The goal was uninterrupted service and the state operated the ferries nonstop, sixteen hours a day. The ferries transported between eight and thirty-two automobiles per crossing, except for dry periods or high water that closed operations and stranded motorists for hours at a time.[25]

Private citizens and chambers of commerce along the coast complained bitterly about the slow, unreliable ferry service at the two bays and four estuaries. One critic labeled the crossing between Gold Beach and Wedderburn an abomination. He lamented that the Coast Highway would "never amount to anything until there is a bridge built [at Gold Beach]." California vacationers bypassed the Oregon coast, he charged, using instead the Redwood Highway (US 199) and the Pacific Highway (US 99). Unreliable ferry service was depriving the region of tourist dollars it deserved. In 1929, the McMinnville Chamber of Commerce launched a plan calling for reissuing old construction bonds to finance the completion of the Roosevelt Coast Highway. Replacing the antiquated ferry system at the six crossings with bridges was the only way Oregon could benefit from the $11 million already spent on the coast highway.[26]

State officials finally called for constructing at Gold Beach what was projected to become the largest Pacific Coast bridge between San Francisco and Astoria, Oregon. Completing the route became one of the state highway commission's primary objectives during the 1930s.

Characteristically, McCullough mixed aesthetic and practical considerations in the design of the 1,898-foot bridge. His Art Deco-embellished multi-span structure of seven reinforced-concrete deck arches would harmonize with the rolling hills of the coastal mountains and resembled his other large arch bridges, namely those on the Pacific Highway over Myrtle Creek and the North Umpqua River, and the Umatilla River Bridge on the Old Oregon Trail Highway. At Gold Beach, however, McCullough hoped to economize on materials by employing a relatively obscure decentering technique for reinforced-concrete deck arches, one never previously used in the United States. He employed a technique that French engineer Eugène Freyssinet had recently perfected. The project was an experiment in bridge design jointly sponsored by the BPR and the OSHD that upheld the agencies' research mandate to determine the advantages and disadvantages of Freyssinet's technique. Moreover, McCullough and his federal colleagues sought to better understand arch rib behavior after decentering, when falsework and forms were removed, and how the weight of the road deck and spandrel columns on the arch rings affected the distribution of rib stress. They also hoped to learn to what degree formwork prevented the ribs from moving after decentering and how temperature changes and shrinkage affected rib concrete from the time when it was first poured until it was fully cured.[27]

The Freyssinet technique involved prestressing the arch ribs with hydraulic jacks placed at their crowns. The goal was to compensate for deformations due to shrinkage of concrete, differential temperature changes, movement of supports, and elastic and plastic shortening. The result, in theory, was that the ribs would shorten to a point equal to, but not beyond, their original position. The ribs would carry their own dead load without extraordinary stresses induced at the skewbacks.

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[24] *Eighth Biennial Report, for 1927-28*, OSHC, 66 (quote); *Ninth Biennial Report, for 1929-30*, OSHC, 13-14.

[25] "Report of State Highway Engineers," *Eighth Biennial Report, for 1927-28*, OSHC, 72-73.

[26] See various letters, File 8-PF1; Robert L. Withrow, Editor, *Gold Beach Curry County Reporter*, to H. B. Van Duzer, Highway Commissioner, 15 December 1928, File 8-4; and J. G. Eckman to Oregon State Highway Commission, 13 August 1929, and attached undated newspaper article in File 8-4, 76A-90/3, HDR, OSA.

[27] Another term for falsework is centering. When it and forms are removed during construction the process is called striking the centering or decentering. Gemeny and McCullough, *Application of Freyssinet Method of Concrete Arch Construction*, 7-8.

McCullough came to see the Freyssinet arch rib precompression technique as more than an economizing measure, though economy remained a goal in all of his designs. More importantly, the experiment contributed significant engineering data regarding the vexing properties of elastic arch bridges. It also allowed him to create a light, airy-looking structure that skipped across the estuary. McCullough spoke on the experiment's results at numerous conferences, authored several professional articles and a major technical bulletin on the project. His work at Gold Beach was a genuine contribution to world-class bridge design.

Opening of the Isaac Lee Patterson Bridge coincided with the OSHC's proclamation that the recently renamed Oregon Coast Highway was complete. Now motorists traveled on a combination of paved and graveled surfaces the length of the state and crossed minor streams by bridge. The popularity of the scenic route prompted speculation that the state would soon replace ferry service at Coos Bay, Reedsport, Florence, Newport, and Waldport with structures similar to the Patterson Bridge.[28]

During the next several years, McCullough's status as one of the nation's most respected bridge designers made him a regular participant in American Society of Civil Engineers conference sessions. The Highway Research Board of the National Academy of Sciences and the American Association of State Highway Officials appointed him to committees on bridge research and bridge specification standards. He also wrote another textbook. But creating large bridges between 1933 and 1936 to span the five remaining water obstacles on the Oregon Coast Highway, became his greatest accomplishment as state bridge engineer.

Designing and Funding Five Big Bridges

In April 1932, local citizens, headed by Robert L. Withrow, editor of the *Curry County Reporter* and secretary of the Gold Beach chamber of commerce, began planning a one-day event marking completion of the bridge and the Oregon Coast Highway. Oregon's U.S. Senator Frederick Steiwer asked President Herbert Hoover to participate in the ceremony by operating a historic gold telegraph, which transmitted a signal, relayed from station to station across the country, unlocking a barricade erected across the bridge. The local committee planned a short program with prominent state and regional officials, followed by a luncheon. They organized motorboat races, band concerts, and a dance for the expected crowds of five to ten thousand. The *Coos Bay Times*' banner headlines boasted the "Oregon Coast Highway Now Open for World Travel."[29]

Optimism abounded with the dedication of the Isaac Lee Patterson Bridge in April 1932 and the Oregon Coast Highway's ceremonial opening in May of the same year, and interest grew in additional construction along the route. Coastal

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[28]Ibid. The Oregon State Highway Department kept its own collection of newspaper clippings on highway department topics from 1916 to 1919. Beginning in 1932 it employed a Portland clipping service to assemble and file copies of articles from Oregon newspapers that covered any highway department topic. These were mounted on pages, with notation of publication date and the periodical's name. The OSHD maintained this professionally assembled clipping file from 1932 to 1950. The collection, 1916-19 and 1932-50, is located, in twenty-four records cartons as: Oregon State Highway Department Clipping File [CF-OSA], 78A-54, Highway Division Record, Oregon State Archives, Salem, Oregon. See Robert L. Withrow, "Throngs See Coast Road Link Opened," *Portland Oregon Journal*, 29 May 1932, CF-OSA.

[29]Betty Van Leer, "Spanning the Mighty Rogue," 18; Withrow, "Throngs See Coast Road Link Opened," "Rogue Bridge Name Honors Former Governor," in Rogue Coast Supplement to the *Gold Beach Curry County Reporter*, 26 May 1982, 20. Initially, the planning committee had a difficult time finding monetary support for its dedication ceremony. The Oregon Coast Association promised $200 to cover expenses, but the OSHC denied former Oregon governor A. W. Norblad's request that it give $250 for the cause. Fiscal exigencies caused the commission to written April that it had "no legal authority" to expend funds for purposes of this kind, but it "fully supported" the enthusiasm for a dedicatory celebration. See Robert L. Withrow, to Leslie M. Scott, OSHC, 2 April 1932, A. W. Norblad to Scott, 31 March 1932, and Oregon State Highway Commission to Norblad, 14 April 1932, Folder 8-4, 76A-90/3, HDR, OSA. The OSHC truly dampened the local organizers' spirits. Secretary Withrow believed that the commission had its priorities wrong. He argued that the state of Oregon had a vested interest in seeing that the opening celebrations for the $600,000 bridge and the $17 million highway be a success. Completion of both projects, he believed, might breathe new life into once isolated fishing villages experiencing severe economic problems brought on by the Great Depression. Robert L. Withrow to C. B. McCullough, 23 April 1932, and 26 April 1932, Folder 8-4, 76A-90/3, HDR, OSA. The Patterson Bridge's cost of nearly $600,000 was part of the $2,575,520 spent on bridges along US 101 up to May 1932. The latter sum was a portion of the $17 million expended on the entire highway. Withrow to McCullough, 6 May 1932, Folder 8-4, 76A-90/3, HDR, OSA; "Spanning over the Mighty Rogue," 19. See also an untitled article by Withrow in *Portland Oregon Journal Magazine*, 22 May 1932, CF-OSA, for a recapitulation of the events leading up to the completion of the Oregon Coast Highway and the Patterson Bridge. A program of events for the dedication is found in "Oregon Coast Highway Now Open for World Travel," *Marshfield Coos Bay Times*, 27 May 1932, CF-OSA. As the twenty-eighth approached, donations poured in from private citizens for the celebration. The local committee's financial worries vanished, see *Gold Beach Curry County Reporter*, 2 June 1932, CF-OSA.

residents and visitors applauded the OSHD spans over Cape Creek, the Wilson River, and numerous other streams and canyons, and they gloried in the miles of asphalt that replaced muddy ruts. An editor of the Portland-based *Oregon Journal* waxed eloquent, stating that "the mountains of the Coast range often thrust themselves sheer into the sea and the new highway turns at times thrillingly to thread their passes." But they expected more. "Three million dollars more must be invested in bridges to replace ferries [at Coos Bay, Reedsport, Florence, Waldport, and Newport]," the *Oregon Journal* inferred, "before the job will be truly done."[30]

By this time, however, the state highway department was suffering from the economic depression that followed the stock market crash of 1929. State highway revenues from various taxes in 1930 had totaled over $12 million, but in 1932 they dropped to just over $9 million. Despite the need for more projects, Oregonians asked for lower, more affordable vehicle license fees, which of course reduced highway improvement funds. The OSHD forecast road construction and maintenance revenues of just $8.6 million for 1933. Federal matching funds remained, but shortfalls in state contributions to joint projects limited dollars available to Oregon.[31]

In the late summer of 1932, Oregonians sought federal help. Congress had recently approved the Relief and Construction Act, which, in part, set aside $120 million in loans for state road construction and maintenance. It also created the Reconstruction Finance Corporation (RFC) to loan funds to states for toll bridges and other large-scale projects requiring long-term repayment schedules. The Oregon Coast Highway Association petitioned the OSHD to apply for RFC loans to finance bridge construction at the five remaining ferry crossings on the highway. Local chambers of commerce endorsed the association's plan because it called for building the structures of wood, harvested from local timber stands and cut in local mills.[32]

McCullough endorsed the Coast Highway Association's general plan for replacing the five ferry crossings with bridges. He calculated that sixteen-hour daily ferry service was costing taxpayers $110,000 annually; round-the-clock service that would accommodate projected traffic increases would more than double the expenses. At Coos Bay, for example, ferries had transported over 54,000 cars and 145,000 passengers in 1930. Numbers increased rapidly, so that by 1935 they would transport over 345,000 cars and over one million passengers. With abundant inexpensive building materials, idle labor, and available RFC loans, the state wisely pursued construction plans. A toll of twenty-five cents per vehicle spread over six to ten years, McCullough believed, would generate the $3 million necessary for bridge construction costs. Increased out-of-state tourist travel would brighten prospects even further in the coming years.[33]

The three-member highway commission split on the bridge construction scheme. Its chairman, Leslie M. Scott, believed that tolls might divert traffic away from the coast highway to inland routes, saddling the state with the loan debt and its citizens with higher taxes. The other two members saw bridges, with or without tolls, as a better alternative to the slow and unreliable ferry service. Oregonians from the western third of the state firmly backed the toll bridge plan, but residents from central and eastern sections echoed Scott's fears.[34]

The argument over loan-financed bridge construction collapsed in September 1932, when the RFC declared the proposal ineligible for funding. The state's repayment plan included money from gasoline and vehicle license taxes, which violated

[30]"Highway of History," editorial, *Portland Oregon Journal*, 28 May 1932, CF-OSA.

[31]"Report of State Highway Commission," *Tenth Biennial Report, for 1931-32*, OSHC, 13-16.

[32]Seely, *Building the American Highway System*, 88-89. "U.S. Loan May Cover Coast Bridge Needs," *Eugene Register-Guard*, 6 August 1932; "Coast Bridge Plan Backing Tendered," *Eugene News*, 19 August 1932; "Coast Route Bridge Loan Endorsed," *Astoria Astorian-Budget*, 9 August 1932; "Sawyer Has Coast Toll Plan That Will Not Increase State Debt," *Portland Oregonian*, 25 August 1932, CF-OSA.

[33]Ernest W. Peterson, "Coos Bay Bridge Oregon's Second Largest Project," *Portland Oregonian*, 10 may 1936, s. 1, p.4; "U.S. Loan Urged for Coast Spans," *Portland Oregonian*, 23 August 1932, CF-OSA.

[34]"Road Association Endorses 4 Toll Spans on Coast," *Marshfield Coos Bay Times*, 29 August 1932. See "The Coast Bridges," editorial, *Springfield News*, 1 September 1932 and "About Those Coast Bridges," editorial, *Astoria Astorian-Budget*, 10 September 1932, CF-OSA, for examples of public opinion on the toll bridge proposal.

the RFC's guidelines for self-supporting projects. Ironically, state law prohibited Oregon from borrowing from the RFC in the first place. For the moment the dream of five new Coast Highway bridges was dead.[35]

Despite the setback, the Oregon Coast Highway Association remained hopeful that the RFC would provide federal financing for the coastal bridges. In 1933, Joseph M. Devers, legal counsel for the OSHD, researched state law for a way to permit Oregon to legally participate in an RFC loan program, even if it meant creating a private toll group to manage the bridges—but to no avail. Meanwhile, many expected imminent congressional approval of President-elect Franklin Delano Roosevelt's public works legislation, which was expected to distribute $2 to 3 billion for highway projects and other programs. Samuel Michael Patrick Dolan, one of McCullough's former colleagues at Oregon Agricultural College and an energetic coast highway promoter, suggested that the state submit a grant application the moment the public works program was enacted.[36]

By May 1933, at Devers' urging, the OSHD began preparing requests for assistance under the soon-to-be created Public Works Administration (PWA). The department asked for a 30 percent outright grant and a 70 percent loan of the estimated $3.4 million in construction costs for five new coastal bridges. Because of the project's labor-intensive nature, Devers and McCullough believed that the proposal was appropriate for PWA funding. They estimated it would employ 750 workers for up to two years and that it would create an additional 375 jobs supplying materials to the construction sites. Both believed that a federally funded multiple-bridge construction project would alleviate the severe economic conditions in the coastal villages and, more generally, the entire state. They also predicted sustained economic growth along an improved Oregon Coast Highway from increased tourist revenues.[37]

As June approached, the state highway commission, determined to build the bridges through RFC loans or PWA loans and grants, called on Oregon's U.S. Senator Charles N. McNary for help. The Navigation Act of 1906 required congressional approval for proposed bridges across shipping channels under War Department jurisdiction. On 11 May 1933, Senator McNary introduced five nearly identical bills authorizing Oregon to "construct, maintain, and operate" the proposed bridges along the Oregon Coast Highway. Purposely, the bills omitted mention of funding except for paying any construction loans from toll revenues. They moved swiftly through Congress, and on 12 June President Roosevelt signed them into law. But bridge construction remained a long way off, because Oregon now needed the War Department's approval for design plans and federal appropriations for construction funds.[38]

[35]See "Federal Funds Denied," *Portland Oregonian*, 22 September 1932; and "Coast Bridges Can't Receive Federal Money," *Journal* (Newport), 28 September 1932, CF-OSA. Meanwhile, problems with the ferry service mounted. On 3 October 1932, the *Astorian-Budget* reported, in a United Press copyright story, that "Fifty occupants of 12 automobiles" on the beach at Newport awaited the "high tide to float the ferry, marooned on a sand spit." It had "broke down with engine trouble and drifted onto the sand bar before a pilot boat could come to its aid. Passengers stayed aboard for several hours in the hopes it would get off the bar, but finally were taken ashore by the coast guard [*sic*]." "Coast Group Still Seeks Five Bridges," *Astorian-Budget* (Astoria), 3 October 1932. Finally, inadequate markings on the vehicular approach to a ferry landing at Coos Bay caused a fatal automobile accident on 1 October 1932. See "Plainer Ferry Markings Asked," *Marshfield Coos Bay Times*, 4 October 1932; and "State Ponders New Devices on Coast Highway," ibid., 14 October 1932, CF-OSA.

[36]"Road Session is Tomorrow," *Astoria Astoria-Budget*, 5 April 1933; Harry N. Crain, "Federal Aid Funds to Provide Money to Complete Roads," *Salem Capital Journal*, 1 May 1933. On Dolan's activities, see "Devers Says Sam Dolan Initiated Coast Bridges," *Corvallis Gazette-Times*, 27 March 1934, CF-OSA.

[37]The 30-to-70 ratio was the standard split between the grant and loan portions of PWA financing packages. Harry N. Crain, "Liberalized Loan Conditions Boost Bridge Prospects," *Salem Capital Journal*, 26 May 1933; "Coast Route Toll Bridges Get Approval," *Portland Oregon Journal*, 1 June 1933, CF-OSA.

[38]"Toll Bridge Across the Umpqua River near Reedsport, Oreg.," *Senate Report 118*; "Bridge across Yaquina Bay, near Newport, Oreg.," *Senate Report 119*; "Toll Bridge Across Alsea Bay near Waldport, Oreg.," *Senate Report 120*; "Toll Bridge Across Coos Bay near North Bend Oreg.," *Senate Report 121*; "Bridge Across Siuslaw River near Florence, Oreg.," *Senate Report 122*, 73d Cong., 1st sess., Serial 9769; "3,400,000 Asked for Bridges," *Portland Oregonian*, 26 May 1933; Harry N. Crain, "Approval of Loans for Coast Bridges Now Believed Sure," *Salem Capital Journal*, 1 June 1933, CF-OSA.

McCullough informed the press in early June that his plans were far enough advanced to allow him to begin bridging over Alsea Bay, at Waldport, within thirty days after a federally approved loan agreement. He confidently added that by the end of the summer he could contract construction of the remaining four spans, pending funding.[39]

The *Portland Oregon Journal* reported that State Highway Engineer Robert H. Baldock believed "the bridge structures in question" were the most important that the OSHD had ever undertaken. But he was far less optimistic than McCullough, arguing that the department needed a minimum of six months to finish designing the bridges and begin constructing them. The OSHD needed to offer more than one alternative for War Department approval. "Different schemes," Baldock counseled, "must be tried in order to provide for the public the most suitable and economical structures for each location involved." Officially, the OSHD projected completing bridge designs within three months, since the sooner its plans received final War Department approval, the greater would be its chance for receiving high priority in the competition with other states for PWA loans and grants. Oregon had no other large-scale public works projects even in the planning stages. With its many unemployed, the state had no time to spare on marginal projects. Sheldon F. Sackett, a long-time backer of the coast highway, echoed official views. In his *Coos Bay Times* "Crow's Nest" editorial column, he argued that "bridges are the most feasible proposal the state has available for immediate construction."[40]

McCullough lost no time hiring extra draftsmen for his design team. In its 20 June 1933 issue, the *Salem Capital Journal* reported that capitol custodians were "shocked when a group of bridge engineers appeared for work . . . this morning at 6, earliest hour in memory." McCullough hired more additional draftsmen than he had tables, so that they worked in two shifts, one from 6 A.M. to 3 P.M. and the other from 3 P.M. until midnight.

Since the late 1920s, McCullough had gradually enlarged his bridge department to meet the OSHD's growing highway-building program. He often returned to Oregon State College in the spring, a colleague recalled, to "interview seniors." "With his feet on the chair and casually smoking a cigarette, [McCullough] would chat with the young men. Somehow the best and the brightest often found their way to the state highway department." One member of the class of 1929, Ivan Merchant, began a long career with the OSHD shortly after graduation, starting as a construction inspector on the Isaac Lee Patterson Bridge project at Gold Beach. By 1933, McCullough had promoted him to the design team for the coast bridge project.[41]

In assembling a professional drafting department, McCullough strove to employ designers with considerable architectural training, because they were better able than others to conceptualize design ideas on paper. Edward S. Thayer, Dexter Smith, and Merchant were among McCullough's principal draftsmen. Thayer had been with the bridge department since the early 1920s. Smith had taught mechanical drawing and structural engineering courses at Oregon State College until 1929 and came to Salem in 1931 as McCullough's expert in tracing or "inking" final designs onto linen oilcloth. The draftsmen deferred to McCullough's intimate involvement in designing each bridge. "Mac would lay out the overall job," Merchant recalled. "He would pick up a piece of paper and a pencil and say, 'Now . . . this is about what you are going to do.' . . . And he drew this spandrel arch in there and the roadway . . . and there it is. 'Go ahead' [he said]. . . . And about every two or three weeks," Merchant explained, "he'd come back to see how you were getting along." On the lighter side, at the drafting table, P. M. Stephenson recalled that, "We used to have a lot of fun. [McCullough would] come to look at what you were doing. [He'd] look over your desk and see what you were designing and he'd always reach over and get your pencil and start scribbling, stick [the pencil] in his pocket and walk off. So after we got to know him better, as he'd

[39]"Senate Approved McNary Toll Bridge Authorization," 7 June 1933, and "Bridge Engineers on Double Shift," *Salem Capital Journal*, 20 June 1933 (quote), CF-OSA.

[40]"Five Bridge Designs to Be Rushed," *Portland Oregon Journal*, 19 June 1933 (quote); "Senate Approved McNary Toll Bridge Authorization," 7 June 1933; Sheldon F. Sackett, "Crow's Nest," editorial column, *Marshfield Coos Bay Times*, 20 June 1933, CF-OSA.

[41]For Merchant quote see interview, Louis F. Pierce with Ivan D. Merchant, 1980, TMs, transcript held by Pierce, Junction City, Oregon. Merchant stayed with the OSHC bridge department until 1972, when he retired after 42 years with the department, the last 14 years as State Bridge Engineer, in which he followed in the footsteps of Glenn S. Paxson and P. M. Stephenson. Merchant died in Salem on 25 May 1997. In the spring of 1929, McCullough offered a senior seminar on elastic deformations of arch bridges, a topic he knew well. See the category "Civil Engineering," in *Schedule of Lectures, Recitations, and Laboratory Periods, Third Term 1928-29*, Oregon State Agricultural College, n.p. Karen Growth [Groth], "Conde B. McCullough, An Engineer with Soul," *Historic Preservation League of Oregon Newsletter*, no. 41, Summer 1986, 5 (quote).

start to move, we'd reach over and grab [the pencil] out of his pocket, never said anything, just reach over and grab it out of his pocket."[42]

The double-shift designers finished plans for bridges over Alsea Bay and the Siuslaw River by August 1933. McCullough expected to complete those for the Umpqua River Bridge by mid-August and the Coos Bay and Yaquina Bay bridges by 1 October. Some thought construction might begin in late fall. But a slow-acting bureaucracy indefinitely delayed federal approval of the Oregon Coast Highway bridge project's $3.4 million PWA loans and grants. The OSHD raised its request to $4 million, citing price increases on construction supplies.[43]

In mid-August, McCullough spoke enthusiastically about the project at a Marshfield Chamber of Commerce luncheon. He praised local citizens and officials for cooperating with the highway commission, and he lauded the coast highway. According to one reporter, McCullough described it as an "unsurpassed advertising medium for the entire state as well as an important transportation link." Oregonians "underestimate the scenic grandeur of the route," McCullough asserted. He reported that engineers and world travelers had informed him that the Oregon Coast Highway was "the most beautiful route in the United States if not the entire world." He saw it as one of the nation's greatest potential tourist attractions.[44]

In mid-September, the OSHD submitted its plans to the PWA's Oregon office in Portland, two weeks ahead of the ninety-day schedule set in June. Cost estimates for materials and labor had risen once again, this time by 25 percent to $5.1 million. Nevertheless, J. M. Devers, after returning from a meeting in Washington with PWA officials, forecast early construction start-ups. Finally in early April 1934, the PWA approved the coast bridge project's construction plans and financial package.[45]

Meanwhile, in early October 1933, McCullough had quieted public fears that the project might fall through when he unveiled sketches of the proposed structures. For the northernmost bridge spanning Yaquina Bay at Newport, his designers had created a 3,260-foot bridge consisting of a series of reinforced-concrete deck arches rising to a 600-foot steel through-arch flanked by a pair of steel deck arches. For Waldport, they had designed a 3,028-foot structure. It included reinforced-concrete deck-girder and deck-arch approaches to three reinforced-concrete through tied arches over the navigable channel of Alsea Bay.[46]

The Siuslaw and Umpqua rivers supported significant shipping traffic, requiring spans that could accommodate tall sailing vessels. McCullough's designs featured bridges with movable center sections. For the deep narrow channel of the Siuslaw, his designers created a 1,650-foot structure featuring deck-girder approaches to a central section of two reinforced-concrete tied arches on either side of a double-leaf bascule drawbridge. At Reedsport over the Umpqua's wide

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[42]McCullough mentioned his hiring of designers with architectural training in C. B. McCullough to Aymar Embury, II, 6 May 1938, Office of General Files, ODOT. For Merchant quote see interview, Louis F. Pierce with Ivan D. Merchant, 1980. For Stephenson quote, see Louis F. Pierce with P. M. Stephenson, 1980, TMs, transcript held by Pierce, Junction City, Oregon.

[43]"Plans for Two Coast Bridges are Complete, *Salem Oregon Statesman*, 2 August 1933, CF-OSA. Harold Ickes, administrator of the PWA, announced on 22 June that the protocol for distributing loans and grants was not firmly in place. He asked states to hold off submitting public works proposals. He delayed again throughout the summer, raising tempers of representatives from several states. See "Devers Enroute Home after Presenting Loan Projects Data," *Salem Capital Journal*, 23 June 1933, and Harry N. Crain, "Loans for Bridges to be Among First Belief of Devers," ibid., 1 July 1933; "State Boosts Bridge Request," ibid., 2 August 1933, CF-OSA.

[44]"McCullough Lauds Co-operation of Civil Port Units in Bridge Project," *Marshfield Coos Bay Times*, 15 August 1933, CF-OSA.

[45]"Coast Bridge Plans Completed," *Newport News*, 14 September 1933; "Soaring Prices of Materials Boost Bridge Estimates," *Salem Capital Journal*, 8 September 1933. One speculates that President Roosevelt's inflationary policies of the early New Deal caused the rise in labor and material costs that prompted the revised funding request. "Bridge Building Anticipated Soon," *Salem Oregon Statesman*, 9 September 1933; "Contracts on Coast Bridges Received Here," *Salem Capital Journal*, 4 April 1934, CF-OSA.

[46]For newspaper publicity of the proposed bridges see "Sketches of Five Bridges to Span Major Ocean Inlets Along Oregon Coast Highway," *Portland Oregon Journal*, 3 October 1933 and "Coast Route Spans Appear Near," *Portland Oregonian*, 4 October 1933, CF-OSA. See Kenneth J. Guzowski, "Alsea Bay Bridge, Lincoln County, HAER No. OR-14," and "Yaquina Bay Bridge, Lincoln County, HAER No. OR-44, Report," Historic American Engineering Record, National Park Service, 1990.

and shallow shipping channel, they designed a 2,213-foot bridge that included a steel tied-arch swing span flanked by pairs of reinforced-concrete tied arches.[47]

Finally, at Coos Bay, McCullough and his designers created a 5,337-foot structure including a series of reinforced-concrete deck-arch approaches to a central trussed-steel cantilever section measuring 1,700 feet. The wide bay and the requirements of high shipping clearance made this type of construction the only kind practicable. In addition, crews could easily assemble the 793-foot main section and its adjacent spans without blocking the main channel with falsework.[48]

None of the proposals for the bridges called for wooden construction and this angered some coastal communities and regional lumbermen's associations. The Great Depression brought economic collapse to the Pacific Northwest, with 90 percent of Oregon's timber companies nearly bankrupt. Half or more of the state's timberlands were tax delinquent. Locals objected to building bridges out of steel and concrete when lumber was plentiful and inexpensive.

McCullough reportedly had inflamed the lumbermen in the summer when they learned that an early plan for a wooden bridge over Alsea Bay was only a token effort. He chose instead the designs he released in October. The editor of the *Pacific Coast Lumber Digest*, C. C. Crow, chastised McCullough as one "who has for many years had a free hand in building these concrete monuments to suit his every fancy." The *Salem Capital Press*, an inveterate opponent of the OSHD, wrote that the state should build wooden bridges and use the remainder of the federal money for improving other portions of the state highway system. It accused McCullough of building "massive concrete monuments . . . for himself at an outrageous cost to the people of the state." While California planned to use 30 million board-feet of Oregon lumber in the San Francisco-Oakland Bay Bridge, the paper continued, "Oregon's arbitrary and pig-headed bridge engineer demands California cement and steel or no bridges."[49]

The atmosphere worsened when a National Lumber Manufacturers' Association representative verbally abused McCullough at a state highway commission meeting in Portland. Commission chairman Leslie M. Scott finally banged his gavel and brought the room to order. "I won't have this engineer bullyragged by you or anyone else," Scott announced, and then he explained in great detail how little the state would benefit from building wooden bridges along the coast highway. Bridge lumber would require creosote treating that was only available from suppliers in Washington. First-cost savings for constructing just the approach spans of timber would be insufficient to outweigh the long-term benefits of construction from steel and concrete. Moreover, he noted that there was more than enough work for local timber interests in providing an estimated 10 million board-feet for falsework and forms. Scott continued that the 30 million board-feet ordered for the San Francisco-Oakland Bay Bridge was for falsework and forms, not a wooden bridge. Finally, the argument ended when it was revealed that the War Department's Corps of Engineers would not approve plans for large-span bridges constructed of wood over navigable waters.[50]

From late 1933 into 1934, McCullough all but campaigned for the construction of the five coastal bridges. He received numerous invitations for speaking engagements at luncheons and dinners, and he happily accepted them. At one such gathering at North Bend, he revealed his own views of the coast bridge project. The *Coos Bay Times* quoted him as saying that the 400-mile coast highway was the "finest major route in the world." When asked specifically about his

[47]"Coast Route Spans Appear Near," *Portland Oregonian*, 4 October 1933, CF-OSA; Gary M. Link, "Siuslaw River Bridge, Lane County, HAER No. OR-10, Report," Historic American Engineering Record, National Park Service, 1990, 7-9, and "Umpqua River Bridge, Douglas County, HAER No. OR-45, Report," Historic American Engineering Record, National Park Service, 1990, 7-9.

[48]Gary M. Link, "Coos Bay Bridge (McCullough Memorial Bridge), Coos County, HAER No. OR-46, Report," Historic American Engineering Record, National Park Service, 1990, 7-9.

[49]"Concerted Effort for Wooden Bridges Urged by Martin," *Eugene Register-Guard*, 6 July 1933; "Want Bridge Built of Wood, Lumber Interests May Wreck Setup to Obtain Five Coast Spans if They Persist," *North Bend Harbor*, 6 July 1933; "Lumbermen to Meet to Protest Concrete for 5 Coast Bridges," *Cottage Grove Sentinel*, 7 July 1933 (quote), CF-OSA. The *Sentinel* also reported that McCullough, in talking to Crow, arrogantly referred to the lumber industry as the "lousy lumber industry" and that the coast highway bridges would be of steel and concrete or not built. "'Lousy' Lumber Seems Suitable for California," editorial, *Salem Capital Press*, 7 July 1933 (quote), CF-OSA.

[50]"Highway Session Hot On Bridges," *Portland Oregonian*, 12 July 1933 (quote); Harry N. Crain, "Selfish Interest Bared in Protest over Bridge Plan," 12 July 1933; and "Backers of Coast Road Bridges Saw Wood Not Wanted," *Salem Capital Journal*, 8 July 1933; "Road Unit Seeks to Push Project," *Marshfield Coos Bay Times*, 7 July 1933, CF-OSA.

proposed bridges, he pictured them not merely as structures carrying traffic, but as "jeweled clasps in a wonderful string of matched pearls."

From October 1933 to April 1934, OSHD officials, coastal communities, and others agonized over what they perceived as federal incompetence as a communications failure between Washington, D.C., and Portland PWA officials hampered either group from advancing the Oregon bridges project. Harold Ickes vehemently denied accusations that red tape was delaying the vital public works projects in Oregon and other parts of the country. Some believed that the Portland PWA office was concealing something because it remained unwilling to brief the press on the bridge project's status.[51]

In reality, the Portland PWA office, working with field engineers from the BPR, was hastily inspecting hundreds of sheets of construction drawings and work schedules that McCullough and his designer had finished in September. Many of the plans were passed back and forth between Salem's bridge department and the federal offices in Portland until both sides agreed that they met criteria established by the American Association of State Highway Officials (AASHO), the War Department, and the PWA. Federal officials quickly became more skilled in reviewing grant project plans. For example, of the $400 million allotted nationwide for PWA-financed road projects, the BPR had approved contracts totaling only $34 million by September. In just two months, the program dramatically increased its efficiency, with the roads bureau releasing over $236 million for more than four thousand projects employing 276,000 people.[52]

In any event, the Portland PWA office forwarded McCullough's bridge plans to Washington in late October 1933. On 6 January 1934, over two months later, the PWA approved the $5.1 million financial package, with the state receiving 30 percent as an outright grant and 70 percent as a loan secured through bonds and payable through toll revenues. Some coastal communities feared that tolls might have a detrimental effect on the California tourist trade. It was estimated that a carload of five people would pay $4.00 in tolls alone to drive from Coos Bay to Newport and back. Others, including the BPR chief Thomas H. MacDonald, objected in principle to tolls on public highways. But other Oregonians, far removed from the coast, argued that statewide automobile owners should not be required to finance the *coast's* bridges through higher license fees and fuel taxes.[53]

The PWA turned the issue over to Oregon lawmakers. The state legislature initially approved issuing special revenue bonds to the federal government bearing 4 percent interest that equaled projected toll collections. An improved bond market, however, persuaded them to issue long-term general obligation bonds free from toll revenue repayment at 2.624 percent interest, thereby saving $1,586,902 on financing costs.[54]

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[51]"The Five Coast Bridges," editorial, *Portland Oregonian*, 5 October 1933. See also "Bridges and Red Tape," editorial, *Portland Oregonian* 13 October 1933, CF-OSA.

[52]"Bridge Projects Being Speeded Up by Oregon PWA," *Coos Bay Times* (Marshfield), 9 October 1933. The war of words escalated when former Oregon governor Oswald West, early promoter of the Columbia Gorge Highway and champion of the coast highway bridge project, went head-to-head with Bert E. Haney, chairman of the Oregon State PWA advisory board. West accused Haney, a Democratic candidate for governor, of stalling the project for political gains. He argued, "No man . . . should be permitted to run for governor on the flattened stomachs of the hungry." Haney, he believed, "Sees in the distribution of the [PWA] funds an opportunity to play politics." Haney, though, denied all of West's "baseless" charges. See "Oswald West Fears 4 Oregon Bridges will be Lost through Pigheadedness," *Portland Oregonian*, 12 October 1933, CF-OSA.

[53]"Plans for 5 Bridges in Hands of PWA," *Salem Capital Journal*, 31 October 1933; "PWA Funds Granted for Five Bridges," *Portland Oregon Journal*, 7 January 1934. For comment against for tolls see "Tolls Unfavored by Road Group," *Marshfield Coos Bay Times*, 12 June 1933; "Make Coast Bridges Free," *Portland Oregonian*, 13 December 1934 and "No Tolls for Coast Bridges," editorial, *Eugene Register-Guard*, 24 January 1934; and "Bridges Should be Free," *Salem Capital Press*, 12 January 1934. For MacDonald's comments on tolls, see "Speed Plans for 5 Bridges Along Coast," *Salem Capital Journal*, 19 June 1933; "Another Hurdle Taken," editorial, *Astoria Astorian-Budget*, 5 December 1933. For comment favoring tolls see "The Coast Bridges," editorial, *Springfield News*, 1 September 1932 and "Bend Demands Votes Against Toll Measure," *Salem Capital Journal*, 8 February 1935. In editorializing on toll bridges versus ferries, the *Oregon City Enterprise* reported that there was nothing wrong with the slow and unreliable ferries. "Only those who insist on burning up the roads register impatience at the slight delays. The sensible traveler finds helpful respite in the enforced stops and the occasional traveler a bit of novelty in the ferries." "Toll Bridges for Ferries," 30 August 1932, CF-OSA; Siuslaw Span Part of $25,000,000 Road Investment," *Eugene Register-Guard*, 17 May 1936.

[54]OSHC, *Twelfth Biennial Report, for 1935-36*, 16-17; OSHC, *Eleventh Biennial Report, for 1933-34*, 17-18. See also, "Board Plans Free Tolls for Bridges," *Portland Oregon Journal*, 21 February 1935. The *Coos Bay Times* issued probably the most convincing series of editorials making the case for free bridges; see "The Birth of the Coast Bridges," 10 January 1935; "Free Bridges Bill All-Important," 11 January 1935; "General Revenue Would Pay Cost," 12 January 1935; "Tolls Menace To Gain in Travel," 14 January 1935; "'Break Faith' Charge is Error," 15 January 1935; "Free Spans

Recognition for McCullough's Work—Honorary Doctorate and American Steel Institute Award

On 4 June 1934, William J. Kerr, Chancellor for Higher Education in Oregon and former president of Oregon State College (OSC), presented McCullough with an Honorary Doctor of Engineering degree. He cited McCullough as an "international authority on bridge design." Kerr lauded McCullough for his ability to beautify Oregon with "magnificent examples of modern bridges," which distinguished the state as a "progressive exponent of bridge building." He acknowledged McCullough's membership in "leading honorary and technical societies in engineering" and his authorship of several "books, major reference works and technical articles in the field of bridge engineering" as equally noteworthy achievements. In November, McCullough's John McLoughlin Bridge over the Clackamas River, at Gladstone, received an excellence in design award from the American Institute of Steel Construction (AISC). Both these honors vaulted McCullough and Oregon's bridge program into the national spotlight.[55]

McCullough had designed the John McLoughlin Bridge in 1932 as part of the OSHD's expressway project on US 99E between Portland and Oregon City. The location with its rolling tree-covered hills lent itself to a bridge with strong architectural features. McCullough's plans called for a 720-foot bridge with a central 240-foot steel tied arch flanked by a pair of similar 140-foot spans. The road deck was wide enough to accommodate four lanes of traffic. Arch-shaped openings in the fluted main piers and ornate Art Deco-style entry pylons served as precursors to the architectural treatment on the large coastal bridges.[56]

What distinguished this structure was its unique tied-arch system. Though similar in design to the three reinforced-concrete bridges at Wilson River, Big Creek, and Ten Mile Creek, it featured steel box girder construction. In addition, McCullough and Orrin C. Chase, his chief designer for this project, created a novel system whereby the tension members of the tied-arch span connected to the arch ribs at both ends of each span by a series of steel eyebars. The rods were arranged below the wearing surface of the deck, through holes cut in the web of the deck beams. Previously, McCullough had used steel reinforcing bar embedded in the concrete deck to connect the arch ribs. His design provided a slight reduction in materials over an alternative simple steel through-truss span.[57]

The tied arch design that McCullough chose used slender, delicate hangers to gracefully suspend the deck from the arch ribs, thereby presenting the motorist a relatively unobstructed view of the landscape. It also afforded side elevation outlines more open than ever thought possible with a steel truss. Engineering aspects of the bridge helped create its architectural merit for which it received the prestigious honor. McCullough would repeat this design in two almost identical three-span steel arch bridges—the South Umpqua River Bridge at Winston, in Douglas County, in 1934; and the Eagle Creek Bridge, on the Columbia River Highway, in Multnomah County, in 1936.[58]

The AISC designated the McLoughlin Bridge as America's "Most Beautiful" steel bridge completed in 1933, costing less than $250,000. The Institute had begun the award program six years earlier, placing plaques on structures in various categories based on cost as worthy examples of steel bridge design. In presenting a steel plaque to the OSHD and a medal to McCullough on 28 November 1934, AISC representative W. E. Emmett stated that the bridge stood as "an achievement of the Oregon state highway department [*sic*] and its personnel who have done so much for the advancement of bridge building not only in their own state but throughout the United States." In this same vein, he added, "Dr. McCullough . . . has become a recognized authority on bridge construction everywhere." By 1934, it was clear that

Win Staunch Support," 16 January 1935; and "Oregon Cannot Afford Tolls," 17 January 1935, CF-OSA.

[55]For the text of Kerr's conferring speech see "Mc—Degrees, Honorary" File, Oregon State University Archives, Corvallis. See also press coverage of McCullough's degree conference in "C. B. McCullough Honored by Degree from State College," *Portland Journal of Commerce*, 7 June 1934, CF-OSA.

[56]Smith, Norman, and Dykman, *Historic Highway Bridges of Oregon*, 109.

[57]"Steel Bridge Awarded Prize is of Three Hinged Tied Arch Type," *Engineering News-Record* 113 (23 August 1934): 248.

[58]Ibid.

McCullough was more than an engineer. The public and his professional colleagues exhibited high regard for him as a master bridge designer who crafted beautiful bridges, which he sculpted out of concrete and steel.[59]

The Five Bridges are Constructed

Bids were opened for the coastal bridges in the spring of 1934, and by August all five were under construction. McCullough provided staffs of field engineers to oversee the progress on each structure and contractors employed eight hundred men on-site and another seven hundred in related jobs on the multi-bridge project. Despite the economic depression, costs for labor and materials increased project estimates to $5.6 million.[60]

Conde B. McCullough's five large coastal bridges represented the pinnacle of design, both aesthetically and technically. More than his previous structures, this group of bridges featured the possibilities of reinforced concrete. Because of the plasticity of this medium, designers like McCullough could cast concrete with any desired form, not necessarily mimicking masonry construction. He embellished the structures with Art Deco ornamental pylons and spires; and piers, spandrel brackets, and arched railing panels with stylized classical or Gothic forms. Lines were clean and modern with only a hint of the *voussoirs* of the past. Such attention to aesthetic detail in the mid-1930s was, according to one observer, "an artistic expression of optimism in a period of austerity." Landscaped waysides, approached from grand staircases leading from plazas, united the architectural space of the steel and concrete structures with the sandy shores and timbered hills of the natural settings. The repetitive arch form made the bridges appear as continuations of the undulating coastal mountains.[61]

In terms of advanced engineering concepts, McCullough used the Considère temporary construction hinges that he had employed on tied arches over the Wilson River, Big Creek, and Ten Mile Creek. They were practical forms of technology for constructing the deck arches and tied arches throughout the project. Once again, McCullough employed techniques whose success had been demonstrated in earlier projects, including vibrating machines that rid freshly poured concrete of air pockets and gave it uniformity. At the same time, the project was purposely labor intensive to fulfill PWA requirements. Workers used handsaws instead of power saws to cut lumber for falsework and wheelbarrows instead of mechanized buckets to transport wet concrete from mixers to forms.[62]

The Yaquina Bay Bridge at Newport, 155 miles south of Astoria and the Columbia River, consisted of a series of five reinforced-concrete ribbed deck arches (1-265', 1-232', 1-204', 1-180', and 1-160') opening on to three steel spans—two 350-foot deck arches flanking a 600-foot parabolic through arch. The structure continued to an observation plaza on the north end with a grand staircase slowly wrapping itself around the pier abutment and leading to a wayside picnic area below. At each end of the central arch, pairs of long, slender stepped entry pylons in the Art Deco-style extended from

[59]"Steel Plaque is Presented for New Span," *Oregon City Enterprise*, 28 November 1934 (quotes). Actually, McCullough was not present for the award ceremony because of illness. See "McLoughlin Span Lauded as Plaque for Beauty Awarded; Scott Accepts," *Portland Oregonian*, 28 November 1934, CF-OSA. Mervyn Stephenson recalled that McCullough submitted to the American Institute of Steel Construction's competition a water colored sketch of the bridge. On it he tinted the steel arches green. In reality, the OSHD covered the exposed metal portions of this bridge, and all others, with inexpensive black lead paint. When the McLoughlin Bridge won the competition, McCullough sent out crews to repaint the metal arches green to match the watercolor. From then on, for decades, the OSHD painted metal portions of its bridges green—now known as "ODOT Green" in some color chip charts for bridge coatings. Stephenson interview, 16; "Bridge Program Hailed as Major Step in Progress," *Marshfield Coos Bay Times*, 17 January 1934, CF-OSA.

[60]"$685,040 Low Offer on First Coast Bridge," 5 April 1934 and "Bids on Last Coast Bridge to be Opened at Meeting on June 7," *Salem Capital Journal*, 24 May 1934; "Start to be Made on Coast Bridges," *Salem Oregon Statesman*, 27 July 1934. For the increases in cost estimates, see "PWA to Allot Extra Costs of Coast Bridges," *Salem Capital Journal*, 10 May 1934, CF-OSA.

[61]Guzowski, "Yaquina Bay Bridge," HAER-1990. Thomas H. MacDonald was a great supporter of highway beautification. As of 1 January 1934, the federal government, through the Bureau of Public Roads, required that at least 1 percent of all federal funds allocated for highway projects be devoted to roadside beautification. Because of this, wayside parks became an integral part of Oregon's coast bridge project. The Works Progress Administration oversaw a portion of Oregon's roadside beautification program through relief employment. See "To Beautify Highways," editorial, *Portland Oregon Journal*, 4 November 1933, CF-OSA. See also, "WPA Projects," and "Roadside Beautification," *Twelfth Biennial Report, for 1935-36*, OSHC, 47-48 and 69-70.

[62]C. B. McCullough, "Self Liquidating Plan for Oregon's Coast Highway," *Engineering News-Record* 114 (6 June 1935): 814-15; C. B. McCullough, "Remarkable Series of Bridges on Oregon Coast Highway," *Engineering News-Record* 115 (14 November 1935): 679.

massive piers, their height already exaggerated by a stepped-back design and vertical scoring, or fluting. Smaller pylons marked the entrances to the central three-arch section of the bridge. Gothic-arch railing panels and pier bracing complemented the more contemporary architectural style. One observer envisioned the bridge as "arching across the water like a ballerina taking several smallish but impressive leaps, one great soaring, breathtaking leap, followed by a succession of smaller leaps to the opposite bank." It cost $1.3 million.[63]

The Alsea Bay Bridge, 20 miles south of Newport, linked the fishing village of Waldport with wooded cliffs to the north. There, a long string of deck-girder spans broke into a series of three 150-foot ribbed deck arches, a pair of 154-foot tied arches flanking one 210-foot tied arch, and three more 150-foot ribbed deck arches, all of reinforced concrete. Fluted entry pylons marked the bridge's entrances, and stepped obelisks spired with slender tapered Port Orford cedar tips rose at each end of the group of lattice-canopied tied arches. The deck arches, identical to those on the Yaquina Bay Bridge, rhythmically spanned the spaces between the piers with Gothic-arched openings whose repetitiveness seen from under the deck gave the illusion of grandeur on a cathedral-like scale. Short staircases at the south end of the structure led pedestrians to the long, wide beaches of Waldport. The bridge cost $778,000.[64]

The smallest of the five PWA structures was the Siuslaw River Bridge at Florence, 54 miles south of Waldport. Two 154-foot reinforced-concrete tied arches, identical to those on the Alsea Bay Bridge, flanked a double-leaf bascule drawbridge. The movable midsection provided a 140-foot horizontal clearance between piers for ocean-going ship traffic. The draw-span was similar to McCullough's 1920 bascule bridges over Youngs Bay near Astoria, and over the Lewis and Clark River near Warrenton. In addition to signature entry pylons on the large coast bridges, McCullough disguised pairs of mechanical sheds, two at each end of the draw, as stylized obelisks. They contained the gears and motors that moved the bridge's midsection and provided quarters for the operator. The bridge cost $527,000.[65]

The simplest of the five structures was the Umpqua River Bridge at Reedsport, 20 miles south of Florence. There, lowlands and a wide shallow shipping channel necessitated using a central swing span, similar to one that McCullough had created years before over the Coquille River. Two pairs of the 154-foot reinforced-concrete tied arches flanked a 430-foot steel tied-arch center structure, with a tender's shack nestled in the cross bracing of the arch ribs. The only ornamentation on this bridge, other than the Gothic-arch treatment of the piers and railing panels, and scored sway bracing, was the relatively plain pylons marking the entrances to the central spans. The structure cost $581,500.[66]

The southernmost and largest of the bridges was the mile-long structure spanning Coos Bay, 31 miles south of Reedsport. The enormous width of the bay, with its 40-foot-high approaches, enabled McCullough to design a 150-foot vertical shipping clearance at mid-span without a movable structure. A series of thirteen reinforced-concrete deck arches, similar to the approach spans of the Yaquina Bay and Alsea Bay bridges, flanked the 1,700-foot steel-trussed midsection. Two large tower piers, each consisting of 34 tons of steel and concrete, rose 280 feet above the water level and supported the ends of the cantilevered structure.

The bridge bore all the architectural treatments found on the other coastal spans. True to form, McCullough provided spacious flowing staircases with intermediate landings for pedestrian traffic that descended from plazas to grassy areas

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[63]Dexter Smith created the reinforced-concrete deck arch approaches for the Yaquina Bay Bridge. They were also used on the Alsea Bay Bridge and the Coos Bay Bridge. Ivan Merchant was only twenty-seven years old when he designed the Yaquina Bay Bridge's central arches. R. H. Baldock, "Bridge Builders' Secrets," O*regon Motorist*, May 1936, 11; Guzowski, "Yaquina Bay Bridge," HAER-1990; Elizabeth Shellin Atly, "C. B. McCullough and the Oregon Coastal Bridges Project," TMs, 1977, 12-14, copy held by author; *Twelfth Biennial Report, for 1935-36*, OSHC, 59.

[64]For a complete discussion of the bridge's features, see O. A. [*sic*]. Chase, "Design of Coast Highway Bridges," *Civil Engineering* 6 (October 1936): 647-51. See also Baldock, "Bridge Builders' Secrets," *Oregon Motorist*, May 1936, 10; and Atly, "C. B. McCullough and the Oregon Coastal Bridges Project," 12-14; *Twelfth Biennial Report, for 1935-36*, OSHC, 59.

[65]Link, "Siuslaw River Bridge," 7-9, HAER-1990; Atly, "C. B. McCullough and the Oregon Coastal Bridges Project," 16-17. McCullough previously co-authored a long U.S. Bureau of Public Roads report on the mechanical portion of moveable bridges. With Albin Gemeny and W. R. Wickerham, he wrote *Electrical Equipment on Movable Bridges*, Technical Bulletin No. 265, for the BPR in 1931; OSHC, *Twelfth Biennial Report, for 1935-36*, 59.

[66]Link, "Umpqua River Bridge," 7-9, HAER-1990; Atly, "C. B. McCullough and the Oregon Coastal Bridges Project," 19-21; "Umpqua River Bridge is Third Costliest of Five Coast Structures," *Reedsport Courier*, 25 September 1936, CF-OSA. *Twelfth Biennial Report, for 1935-36*, OSHC, 59.

near the ends of the structure. Here, as with the other bridges, McCullough paid close attention to the piers' shape and form because he knew that park visitors would see them up close. The Coos Bay Bridge cost $2.14 million.[67]

David Plowden, an acclaimed critic of bridge design, labeled the Coos Bay structure "an outstanding example of the large steel cantilever." It was one of the few American bridges of this type to employ curved top and bottom chords, giving maximum shipping clearance and overcoming the "basic disparity between the bridge's steelwork and the concrete arch approaches." Plowden added succinctly, "Few later bridges of its type have been as outstanding."[68]

The regional press gave the coast bridge project thorough coverage. Professional and trade journals such as *Engineering News-Record* and *Western Construction News and Highways Builder* featured the bridges in descriptions of design and construction techniques.

In response to the aesthetics, architecture, and natural beauty of the Oregon Coast Highway, the state organized the OSHD Travel and Information Division in 1935. Highway commissioners hoped that advertising the state's modern road system might increase tourist traffic, boosting gasoline tax revenue and pumping money into the state's sickly economy. The Division printed 234,000 booklets and maps describing the many virtues of Oregon's scenic beauty, including the bridges of the Columbia River and Oregon Coast highways. It distributed the pamphlets to tourist and travel bureaus, service stations, automobile clubs, and individuals. It also received free advertising, depicting Oregon as a vacationland in major regional newspapers and national magazines. The tourism promotion budget of $48,000 in 1936 was small compared to the $750,000 it helped generate in nonresident gasoline tax revenues. It was estimated that out-of-state visitors spent over $18 million in Oregon during that year. Revenues continued to rise until World War II curtailed leisure travel.[69]

All five bridges were completed by the fall of 1936, within the two-year schedule forecast at the project's onset. The Yaquina Bay Bridge opened for traffic on 6 September 1936. Like the others, except for the Umpqua River Bridge, which unexpectedly opened without fanfare, the Newport bridge was the subject of a community-wide dedicatory celebration also marking the end to ferry service along the Oregon Coast Highway. On 3 October, state and regional dignitaries attended a day of speeches, luncheons, and parades. Even the Coast Guard cutter *Pulaski*, two Navy destroyers, and a squadron of seaplanes paid visits.[70]

McCullough's bridges have sparked widespread praise for their aesthetic treatment. Plowden wrote that his structures represented "the most interesting concentration of concrete bridges in America," adding the qualification that McCullough, like many of his contemporaries, frequently added ornamentation that "marred the beautiful simplicity of his engineering." Others disagreed, believing McCullough had a specific reason for embellishing his bridges with Art Deco-style pylons, obelisks, and piers. He "was much too thoughtful to throw gewgaws onto his work to please others. . . . [They] show too much intelligence for that." Instead, the ornamentation enabled the viewer to "feel not only the awesome presence of nature indicated in the flowing form of the bridge, but the unique, sometimes whimsical power of human intelligence that

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[67]Total length of the approach spans, each of a different dimension, was 2,700 feet. The cantilevered section included 458-foot approach sections flanking a midsection of 793 feet. Link, "Coos Bay Bridge (McCullough Memorial Bridge)," 7-10, HAER-1990; Baldock, "Bridge Builders' Secrets," *Oregon Motorist*, May 1936, 7. McCullough and the OSHC proposed including parks near the ends of each bridge not only for recreational use of motorists and pedestrians, but also to curb private business encroachment. They hoped that the parks might act as buffers by preventing entrepreneurs from cluttering the landscape near the bridges with structures that detracted from both the spans' picturesque ness and the scenic attraction of the bays and estuaries. See "McCullough Tells Rotary Club of Coast Bridges," *Corvallis Gazette-Times*, 23 November 1933, CF-OSA. McCullough explained his attention to detail on the piers in "Remarkable Series of Bridges on Oregon Coast Highway," 679. *Biennial Report for 1935-36*, OSHC, 59.

[68]David Plowden, *Bridges: The Spans of North America* (New York: W. W. Norton and Company, 2002), 287.

[69]"Tourist Travel Stimulation," *Twelfth Biennial Report, for 1935-36*, OSHC, 72-73.

[70]All bridges opened for traffic a few weeks or months before actual completion. See *Twelfth Biennial Report, for 1935-36*, OSHC, 54-59. The dignitaries included John Williams, Chief of the Siletz Indians. On the dedications, see "Dedication of Bridge Occasion in Building Highway," *Salem Capital Journal*, 3 October 1936, and "Newport Pays Honor to Last Coast Bridge," *Portland Oregon Journal*, 4 October 1936, and *Newport News*, 8 October 1936, CF-OSA.

coexists with nature." In other words, McCullough's bridges did more than connect highways; they united river and stream banks with structures whose symmetry and balance complemented the natural setting.[71]

Shortly after completing the coast bridges, McCullough described to a friend his impression of the engineer's role in society that revealed much about his philosophy of bridge building. "From the dawn of civilization up to the present," McCullough complained, "engineers have been busily engaged in ruining this fair earth and taking all the romance out of it. They have cluttered up the landscape with hideous little buildings and ugly railroads." The simple elegance of his bridge designs provided an antidote to the problem. "If we only knew the truth," he added cynically, "the decline of ancient Babylon and the desolation of Sodom and Gomorrah were probably dated from the time when they formed the first engineering society." He hoped that his work would not contribute to the decline.[72]

In the early 1930s, Conde B. McCullough had won widespread acclaim as a researcher and designer of highway bridges. The reviews for his *Elastic Arch Bridges*, the recognition that the McLoughlin Bridge gained, and the honorary doctorate awarded him—all were testimony to his expertise unequalled in the United States. His greatest challenge was creating five large bridges for the Oregon Coast Highway. Construction of these cost-efficient but elegant structures provided jobs for hundreds of the state's unemployed, and once completed, helped transform coastal fishing villages into tourist destinations that increased tax revenues and strengthened local economies.

Inter-American Highway Bridges

McCullough turned his attention to the international bridge-building world on a federally-sponsored project to construct three short-span suspension bridges for the Inter-American Highway. He had left the state in October of 1935 on BPR chief Thomas H. MacDonald's instructions, embarking on a fifteen-month assignment, designing bridges for Central America's Inter-American Highway. His structures over the Río Chiriquí in Panama, the Río Choluteca in Honduras, and the Río Tamasalupa in Guatemala were site-specific designs that took advantage of the inherent constructability advantages of suspension bridges. They also included architectural embellishments characteristic of his Oregon structures. What sets McCullough apart from his colleagues, however, is that he used Fourier series, or sine series, method of exact stress analysis in determining the structures' specifications, based on load requirements, roadway widths, and total length. He demonstrated that it streamlined the designer's approach and gave more accurate calculations than the more traditional and less reliable elastic theory. Using this method, McCullough argued, made suspension bridges practical and practicable solutions for short crossings because the sophisticated mathematical analysis helped reduce the often costly design work associated with this structural type.

Oregon bridge building was never the same after McCullough's 1937 promotion to assistant state highway engineer upon his return to Oregon from Central America. Under Glenn Paxson, the bridge department created unimaginative structures with almost no regard for aesthetics. Paxson's business-as-usual comments about the Coos Bay Bridge's architectural qualities reflected as much his own viewpoint as it did a change of priorities in American bridge design philosophy. One bright spot was the 1940 widening of the Depoe Bay Bridge, where Paxson's bridge department successfully grafted a ribbed deck arch onto McCullough's 1927 structure.

Meanwhile, McCullough reluctantly moved away from designing Oregon's bridges to administration. He immersed himself in a study of short-span suspension structures because he hoped that other state bridge engineers would take seriously his belief that they could be as much a part of modern highway design as the larger, grander bridge types. Through deliberate isolation from his superior, Robert Baldock, McCullough continued his productivity as a researcher. His long tenure in state-sponsored highway building programs in Iowa and Oregon gave him an enlightened perspective on management issues. He demonstrated, moreover, how public agencies that were expected to operate efficiently and economically could produce public works projects of grace and beauty. Conde B. McCullough was one of the few twentieth-century bridge engineers who left such an enduring mark on the American landscape. McCullough died in May

[71]Plowden, *Bridges: The Spans of North America*, 327; Christopher Boehme, "The Oregon Coast Bridges," *Pacific Northwest*, July 1988, 22 (quote).

[72]C. B. McCullough to J. E. Mackie, 7 September 1937, Office of General Files, ODOT.

1946 from a stroke. At the time, he was looking forward to a return to Central America to design additional bridges for the Inter-American Highway. In 1947, the Coos Bay Bridge was renamed the McCullough Memorial Bridge in honor of his great contribution to completion of Oregon highways.

Cathodic Protection

Of McCullough's major works in Oregon, only a handful have been lost. Some, however, have been modified with new parapet walls or additions that detract greatly from their original composition. The loss of one structure in particular, the Alsea Bay Bridge, proved the impetus for Oregonians and the Oregon Department of Transportation (ODOT) to seek methods to preserve other monumental McCullough spans.

Sadly, the hostile salt air environment at the oceanside caused extensive damage to McCullough's bridge at Waldport during the fifty-five years that it carried vehicles across Alsea Bay. In 1972, active corrosion of the steel reinforcing in the pier foundations prompted ODOT to begin a cathodic protection program to slow the deterioration. The technology known at the time, however, was not enough to save the bridge. By the early 1980s, the bridge was in desperate shape. Spalling on the deck's underside had become so advanced that falling concrete posed a threat to boaters. Soon, load restrictions were posted. After a long project development process—including the release of an environmental impact statement, public participation, and special studies—ODOT, in the mid-1980s, decided against rehabilitating the old structure and chose instead to replace it. After evaluating many options, including cable-stayed spans, girder spans, deck arches, and through arches, ODOT, with the blessing of the town of Waldport, replaced the decaying bridge with a 2,910-foot structure, including a 350-foot steel through-arch resting on Y-shaped piers. Groundbreaking on the $42.6 million bridge took place in 1988. Special procedures on the new Alsea Bay Bridge, which was completed in the fall of 1991, give it a seventy-five- to one-hundred-year life expectancy. Demolition of the old bridge climaxed on 1 October 1991 with the dynamiting of two of the three tied-arch spans.[73]

In the 1980s, ODOT recognized that a significant number of its historic highway structures—along the Oregon Coast Highway, the Historic Columbia River Highway, and in the Portland metropolitan area—were deteriorating in ways conventional methods could not control. The spectacular beauty of McCullough's arch spans on the Oregon Coast Highway and the fear that they would be lost to corrosion damage compelled ODOT to make a fundamental change in its approach to historic bridges. The department undertook a comprehensive inventory of its older bridges, identifying those that had true historic features and should be preserved. Of over a thousand extant bridges in Oregon constructed before 1941, the study identified one hundred forty-five as eligible for listing in the National Register of Historic Places and fifty-three as potentially eligible. As a result, ODOT began to restore, rather than rehabilitate or replace, these bridges.

The department hoped to prevent a repeat of the painful episode with the Alsea Bay Bridge. A new engineering unit within the ODOT Bridge Section (the legacy of McCullough's "Bridge Department") performed a thorough evaluation of the eighteen arch bridges on the Oregon Coast Highway, because they were most at risk. ODOT then took a dramatic step forward in historic bridge preservation, developing and employing methods to halt the ocean-induced damage to the Oregon Coast Highway bridges, restore them to their original condition, and preserve them from future corrosion damage. The department demonstrated practicable solutions, often accomplished for less than the cost of replacing the structures.

The Bridge Section's program employs practical methods for shotcrete and pumped concrete repairs, precasting of replacement components, composite strengthening and cathodic protection of structures. The goal is to preserve both the intended function and the original construction of Oregon bridges formally identified as significant historic resources. This is because the citizens of Oregon have demanded that the department do more than simply meet legislative requirements or design standards.

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[73] Andy Booz, "Profile: Phil Rabb—Blending Form, Function, Public Ideas," *VIA* (Oregon Department of Transportation), September 1990; "Alsea Bay Bridge, Waldport, Oregon, Oregon Coast Highway (US 101), Final Environmental Impact Statement," (Salem: Oregon Department of Transportation and the Federal Highway Administration, 1986), 2F-5F. HNTB was also a descendant firm of Waddell and Harrington, later in part, Harrington, Howard, and Ash. Carmel Finley, "Seattle Company makes Low Bid on Alsea Bridge," *Portland Oregonian*, 13 May 1988; Hasso Hering, "Alsea Bridge Nearing Completion," *Albany (Oregon) Democrat-Herald*, 29 June 1991; "Old, New Spans Revered," *VIA* (Oregon Department of Transportation), October 1991; Charlotte Snow, "Demolition Sinks Landmark Bridge at Alsea," *Salem Statesman-Journal*, 2 October 1991

After deteriorated concrete is removed, it must be replaced with a new material. Patching materials must closely approximate the strength and conductivity of the original concrete or they will accelerate the existing corrosion and cause the patched area to spall off within a few years. Shotcrete, pneumatically applied concrete, appears to work very well in Oregon. Shotcrete is very easy to hand tool to restore architectural details lost with the removal or spalling of original concrete. Placing forms and pumping concrete also works well for less detailed areas. ODOT adds salt to the concrete so that its conductivity will be similar to that of the underlying concrete, which has absorbed salt from the sea air. Reinforcing steel within concrete will corrode and ultimately fail, especially if chlorides (for example, salt) are allowed to infiltrate the concrete. Placing another, chemically more active, metal at the surface of the concrete forces that metal to corrode instead of the reinforcing steel. The steel that is protected functions as the cathode and the metal that corrodes sacrificially functions as the anode. Connecting a direct current power supply between the two improves the protection. For the Oregon Coast Highway bridges, ODOT most often employs arc-sprayed zinc on the exterior of the bridges as the anode because it is applied much like spray paint, faithfully preserving intricate architectural surface details. Thus far, ODOT has completed work several bridges on the Oregon Coast Highway, including those at Yaquina Bay, Depoe Bay, Cape Creek, Big Creek, Rocky Creek, and Gold Beach.[74]

McCullough's Oregon Coast Highway Bridges in the National and International Contexts

Since the mid-1980s, when ODOT completed its comprehensive survey of Oregon's historic highway bridges, McCullough and his bridges began receiving much overdue attention from historians, engineers, and architects. In 1985, the Oregon Historical Society and ODOT published Dwight Smith's, James Norman's, and Pieter Dykman's *Historic Highway Bridges of Oregon*. The volume, which appeared in a second edition in 1989, draws attention to the best of Oregon's bridges, many of which are structures designed by McCullough. In 1993, Eric N. DeLony, long-time chief of the National Park Service's Historic American Engineering Record, published *Landmark American Bridges*, a volume showcasing the best of American bridge construction. He saw McCullough's work as "a remarkable outpouring of creativity and skill matched by few state highway departments in the country." DeLony believed that McCullough's Oregon Coast Highway structures are "some of the best and most innovative concrete and steel bridge designs in the world."[75]

In 1998, the Oregon State University College of Engineering inducted McCullough into its Engineering Hall of Fame. Membership is granted only to those OSU alums and others "who have made sustained and meritorious engineering and/or managerial contributions throughout their careers."

In 1999, in honor of its one hundred twenty-fifth anniversary, the periodical *ENR*, once known as *Engineering News-Record*, published a list of the top people who had made outstanding contributions to the construction industry since 1874. "Their efforts," *ENR* believed, "helped shape this nation and the world . . . by developing new analytical tools, equipment, engineering or architectural design." Ten bridge engineers made the list, and among them was C. B. McCullough. "These leading designers dared to span great lengths," wrote *ENR*, "with the most elegant, constructible and economical solutions possible." The periodical cited McCullough's use of the reinforced-concrete tied arch as his most innovative contribution. He was listed among such international engineering greats as Othmar H. Ammann, James Eads, Eugene C. Figg, Robert Maillart, Leon Moissieff, Jean M. Muller, David B. Steinman, Man-Chung Tang, and Michel Virlogeux.[76]

In his volume *Bridges the Spans of North America*, David Plowden wrote that, "Up to the 1970s, with the exception of Conde B. McCullough's work in the 1930s, it is not unfair to say that no American concrete bridge has ranked with her masterpieces in steel." Plowden believed that in the twentieth century, while most American engineers were building "ponderous concrete arches," their European counterparts, especially the Swiss Robert Maillart, were "freeing concrete design from tradition." They created structures "of great beauty and strength, with the added advantage of being

[74]For addition information on the Oregon Department of Transportation's bridge preservation program, see Frank J. Nelson, "The Oregon Department of Transportation Program for Restoring and Preserving its Historic Bridges," Conference Proceedings, "Preserving the Historic Road in American: The Second National Conference on Historic Roads," Morristown, NJ, 6-9 April 2000.

[75]See Eric DeLony, *Landmark American Bridges* (New York: Bulfinch Press and the American Society of Civil Engineers, 1993): 125 (quotes), 127-35. DeLony was so impressed by McCullough's work that he used images of the Coos Bay Bridge for the volume's dust jacket.

[76]See "Top People of the Past 125 Years," *ENR*, 30 August 1999, 27 (quote), 47-48.

extremely economical." His contemporary, French engineer Eugène Freyssinet, who created the precompression technique that McCullough employed on the Rogue River Bridge, went on to perfect the prestressed-concrete girder, which many consider to be "the most significant structural advance of the twentieth century." Plowden believed that McCullough was one of the few American engineers who were receptive to European developments. In his bridges at the Wilson River, Ten Mile Creek, Big Creek, Alsea Bay, and the Siuslaw River, McCullough "introduced the tied arch to America." Plowden concluded that the Oregon Coast Highway has "the most interesting concentration of concrete bridges in America." McCullough's bridges represented "the most advanced technique in America at the time."[77]

Late in his career in Oregon, McCullough summed up his life's work:

> 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.[78]

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[77] See Plowden, Bridges: The Spans of North America, 304, 326-27.

[78] "Conde B. McCullough—Bridges," editorial, Register-Guard (Eugene), 7 May 1946.

F. Associated Property Types:

(Provide description, significance, and registration requirements)

Bridges nominated under this MPS are constructed of reinforced concrete and/or steel. They include the following structures.

1. Depoe Bay Bridge No. 02459, 1927. One 150-foot reinforced-concrete deck arch; total length 312 feet. Widened in 1940 with a parallel reinforced-concrete deck arch span and approaches.
2. Rocky Creek Bridge No. 01089, 1927. One 160-foot reinforced-concrete deck arch; total length 360 feet.
3. Wilson River Bridge No. 01499, 1931. One 120-foot reinforced-concrete tied arch; total length 180 feet.
4. Big Creek Bridge No. 01180, 1931 One 120-foot reinforced-concrete tied arch; total length180 feet.
5. Ten Mile Creek Bridge No. 01181, 1931. One 120-foot reinforced-concrete tied arch; total length 180 feet.
6. Rogue River Bridge No. 01172, 1932. Seven 230-foot reinforced-concrete deck arches; total length 1,898 feet.
7. Cape Creek Bridge No. 01113, 1932. One 220-foot reinforced-concrete deck arch; 399 feet of reinforced-concrete deck girder spans on two-tiered concrete columns; total length 619 feet.
8. Siuslaw River Bridge No. 01821, 1936. One 140-foot double-leaf bascule steel draw span; two 154-foot reinforced-concrete through tied arches; total length 1,568 feet.
9. Umpqua River Bridge No. 01822, 1936. One 430-foot steel through truss tied arch swing span; four 154-foot reinforced-concrete through tied arches; total length, 2, 206 feet.
10. Yaquina Bay Bridge No. 01820, 1936. One 600-foot steel through arch; two 350-foot steel deck arches; 1-265’, 1-232’, 1-204’, 1-180’, and 1-160’ reinforced-concrete deck arch; total length 3,223 feet.
11. Coos Bay Bridge No. 1823, 1936. One 793-foot and two 457-foot steel cantilever truss spans; 1-151’, 2-170’, 2-189’, 2-208’, 2-227’, 2-246’, 2-265’ reinforced-concrete deck arches; total length 5,305 feet.

Registration Requirements

To be eligible for inclusion in this multiple property submission, bridges must have been originally constructed between 1927 and 1936 on the then current alignment of the Oregon Coast Highway No. 9 (US 101). They must have been designed by Oregon State Highway Department bridge engineers under the direction of Conde B. McCullough, State Bridge Engineer (criterion A). They must also possess high degrees of original integrity of design and materials in their main spans (criterion C). McCullough is most associated with arch bridges. Reinforced-concrete arch spans must comprise the primary or secondary main spans of the bridges included in this submission.

G. Geographical Data

The geographical area covered by this multiple property listing includes ten bridges on the existing alignment of the Oregon Coast Highway No. 9 (US 101), from the Columbia River to the California state line (MP 0.00 to MP 363.11). It also includes one bridge on Otter Crest Loop, which was an earlier alignment of the route and now functions as a frontage road. The individual bridges are listed below:

1. Wilson River Bridge No. 01499, MP 64.23, Tillamook, Tillamook County
2. Depoe Bay Bridge No. 02459, MP 127.61, Depoe Bay, Lincoln County
3. Rocky Creek Bridge No. 01089, MP F130.00, Otter Crest Loop, vicinity of Otter Rock, Lincoln County
4. Yaquina Bay Bridge No. 01820, MP 141.68, Newport, Lincoln County
5. Ten Mile Creek Bridge No. 01181, MP 171.44, vicinity of Yachats, Lane County
6. Big Creek Bridge No. 01180, MP 175.02, vicinity of Heceta Head, Lane County
7. Cape Creek Bridge No. 01113, MP 178.35, vicinity of Heceta Head, Lane County
8. Siuslaw River Bridge No. 01821, MP 190.98, Florence, Lane County
9. Umpqua River Bridge No. 01822, MP 211.11, Reedsport, Douglas County
10. Coos Bay Bridge No. 01823, MP 233.99, Coos Bay, Coos County

11 Rogue River Bridge No. 01172, MP 327.70, Gold Beach, Curry County

H. Summary of Identification and Evaluation Methods

(Discuss the methods used in developing the multiple property listing.)

The bridges included in the Multiple Property Submission were first identified in the early 1980s during the course of the Oregon Department of Transportations' historic bridge study, which inventoried, evaluated, and assessed the state, county, and local highway bridges in Oregon to determine which structures were National Register eligible. About 500 bridges, including all of the pre-1941 truss, arch, suspension, and movable bridges, were field inspected and were the subjects of historical research. Slab, beam, and girder bridges, which account for about 80 percent of the pre-1941 bridges, were examined by a random and representative sampling. All pre-1921 bridges and all bridges in Salem, Portland, and on the Oregon Coast Highway were field inspected and researched.

After the field inspection and research phase, the bridges were placed in one of three categories: Category I, National Register eligible; Category II, Possibly National Register Eligible; Category III, National Register ineligible. The result was that 141 bridges were placed in categories I and II. The remaining bridges were placed in Category III. Category I and II bridges were the subject of additional research and evaluation. This included measuring integrity and historic significance. The Oregon Coast Bridges were identified as an important thematic group.

In 1985, the Keeper of the National Register determined that 66 bridges were eligible for the National Register. These included the following bridges that are part of this MPS: the Wilson River Bridge No. 01499, the Depoe Bay Bridge No. 02459, the Rocky Creek Bridge No. 01089, the Yaquina Bay Bridge No. 01820, the Cape Creek Bridge No. 01113, the Siuslaw River Bridge No. 01821, the Umpqua River Bridge No. 01822, the Coos Bay Bridge No. 1823, and the Rogue River Bridge No. 01172.

Ten Mile Creek Bridge No. 01181 and Big Creek Bridge No. 01180 were designated Category II bridges in the historic bridge study and were not included in the 1985 submission to the Keeper's office. Subsequently, in 1994, Big Creek Bridge was determined eligible for the National Register. Finally, the Alsea Bay Bridge No. 01746, completed in 1936 as part of the group including the Yaquina Bay Bridge, the Siuslaw River Bridge, the Umpqua River Bridge and the Coos Bay Bridge, was determined eligible for the National Register in 1981. However, it was demolished in 1992.

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