United States Department of the Interior
National Park Service

National Register of Historic Places Multiple Property Documentation Form

Not Listed

This form is for use in documenting multiple property groups relating to one or several historic contexts. See instructions in *Guidelines for Completing National Register Forms* (National Register Bulletin 16). Complete each item by marking "x" in the appropriate box or by entering the requested information. For additional space use continuation sheets (Form 10-900a). Type all entries.

_X_ New Submission ____ Amended Submission

A. Name of Multiple Property Listing

Reinforced Concrete Box Girder Bridges in Washington State

B. Associated Historic Contexts

Early Reinforced Concrete Box Girder Bridges in Washington State, 1930-1960

C. Form Prepared by

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organization AECOM date June 8, 2017

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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 for Planning and Evaluation. (__ See continuation sheet for additional comments.)

Signature of certifying official Date

Washington State Historic Preservation Office
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 of the National Register Date of Action

Reinforced Concrete Box Girders in Washington State
Name of Multiple Property Listing

WASHINGTON
State

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E. Statement of Historic Context

Preface

This Multiple Property Documentation Form was prepared as mitigation for the demolition of the Cedar Creek Bridge located in Clark County, Washington. Determined eligible for the National Register of Historic Places , the bridge was the subject of a Memorandum of Agreement between the United States Army Corps of Engineers, Washington Department of Archaeology and Historic Preservation, and Clark County.

This cover sheet is intended to be used independently from several of other Multiple Property Documentation Forms that were previously prepared in the State of Washington. This includes Washington State Highway Bridges, 1941-1950 and Historic Bridges and Tunnels in Washington State (through 1940).[1] It also supplements the National Cooperative Highway Research Program's "A Context for Common Historic Bridge Types" that was prepared for bridges built after 1945.[2]

Reinforced Concrete Bridge Construction in the West, 1880-1930

Reinforced concrete bridges were first erected in the United States as early as 1889 (Alvord Lake Bridge) in San Francisco but it was not until the early twentieth century that utilization of reinforced concrete became a more common method of bridge construction.[3] With internal metal reinforcement, improved metallurgy, and refined construction methods, engineers became adept at designing innovative bridges that could support longer spans with cast-in-place or prefabricated girders.[4] Bridge engineers initially utilized concrete to emulate masonry bridge designs and that could withstand similar compressive loads and stresses as their stone antecedents. For much of the early twentieth century, concrete was fashioned into a number of architecturally pleasing bridge forms that could serve as embellishment, particularly for bridges situated in highly visible locations, such as those designed by Conde McCullough on the Oregon Coast.[5] As the century progressed, however, engineers began to utilize concrete in novel ways to extend roadway widths, provide more efficient and cost-effective designs for bridge spans up to 100 feet in length, and incorporate more modest aesthetics to minimize bridge visibility in scenic natural settings.[6] This movement toward minimalism reflected the growing influence of the Modernist art and architectural movements that also found expression in engineered structures. Indeed, "bridge designers sought economy and simplicity in

1 N/A, Historic Bridges and Tunnels in Washington State (through 1940), National Register of Historic Places Thematic Resources Nomination, Prepared in 1979-1980 and listed in 1984; Robin Bruce, Craig Holstine, Robert H. Krier, and J. Byron Barber, "Washington State Highway Bridges, 1941-1950," National Register of Historic Places Multiple Property Documentation Form. Prepared in 1991 and listed in 1995.
2 Parsons Brinckerhoff and Engineering and Industrial Heritage, *A Context for Common Historic Bridge Types* (Prepared for the National Cooperative Highway Research Program). October 2005.
3 Richard L. Cleary, *Bridges* (New York: Norton, 2007).
4 Cleary.
5 Robert H. Hadlow , *Elegant Arches, Soaring Spans: C. B. McCullough, Oregon's Master Bridge Builder* (Corvallis: Oregon State University Press, 2001).
6 JRP Historical Consulting Services. *Historic Context Statement: Roadway Bridges of California: 1936 to 1959*. Prepared for State of California Department of Transportation Environmental Program, Sacramento California. January 2003, 50;
Holstine, Craig and Richard Hobbs. *Spanning Washington: Historic Highway Bridges of the Evergreen State*. Pullman: Washington State University, 2005.

structural features, clean lines, and a lack of ornamentation" during this period.[7] To some degree in California and Washington, concrete's economy was further driven by the shortage of inexpensive steel structural components , particularly in the post-World War II period, and the rapid development of interstate highways.[8]

Innovations in Reinforced Concrete Bridge Construction: The Hollow Box Girder in Washington, 1930-1960

The transition in bridge design and construction to reinforced concrete box girder bridges (RCBG) began in Washington in the 1930s and progressed into the 1950s. During this period, bridges built in Washington utilized a variety of concrete slab, beam, and girder structural configurations. The continuous span, reinforced concrete, hollow box girder first emerged as an important regional bridge sub-type in 1936 when Pierce County erected the Purdy Bridge (HAER WA-101; NRHP-listed) near Gig Harbor. The bridge featured a 190-foot center span supported by box girders.[9] Only four states, including Washington and California, utilized the box girder prior to 1950.[10]

The construction of concrete girder, beam and flat slab bridge designs increased the use of concrete in Washington and other far western states much earlier than in other parts of the country, which continued to build mostly steel bridges. By the 1930s, reinforced concrete was widely used in Washington, which lacked the "steel tradition" that was widespread in the East and Midwest. Consequently, the Portland cement industry thrived in the Pacific Northwest.[11] From the 1930s to early 1940s, the flat-slab bridge type became increasingly popular for the country's small highway bridges, creating a nationwide reliance on reinforced concrete for standard highway bridge design. By the 1950s, concrete almost completely replaced steel as the primary bridge construction material.[12]

During the 1940s, the structural dynamics and properties of concrete bridge construction prompted newly accepted mathematical formulas to calculate difficult design concepts, as well as advances in scientific analysis. "By the beginning of the decade, state engineers had adopted a new method of balancing and distributing fixed-end moments (force x distance) in continuous structures, a mathematical system introduced in the 1930s by Hardy Cross, a professor at the University of Illinois."[13] Using Hardy's technique, engineers could rapidly and accurately calculate the moments and shear forces to determine tension and compression in structures.[14] The precision of the Hardy Cross method made it an important mathematical tool in bridge designs, particularly in the design of

7 Holstine and Hobbs 2005: 16; Dana L. Holschuh, "Cultural Resources Survey of the Cedar Creek Bridge Replacement Project Area, Clark County, Washington, prepared for Clark County Department of Environmental" (Vancouver, WA: Archaeological Services LLC, 2015), 21.
8 JRP 2003, 53-54; Cleary 2007.
9 William Michael Lawrence, Purdy Bridge (Purdy Spit Bridge), HAER No. WA-101 (Washington, D.C.: Historic American Engineering Record), 1993, (serves as National Register of Historic Places documentation, available at https://npgallery.nps.gov/AssetDetail/NRIS/82004274).
10 Oris H. Degenkolb, *Concrete Box Girder Bridges* (Iowa State University Press, 1977); Mead and Hunt, National Register Evaluation of Nebraska Bridges 1947 to 1965 (including the reassessment of select pre-1947 bridges), 19. Report prepared for Nebraska Department of Roads. May 2007. Found at http://www.nebraskahistory.org/histpres/reports/Bridge-Report.pdf.
11 Holstine and Hobbs 2005.
12 Holschuh 2015, 22; Holstine and Hobbs 2005; Parsons Brinkeroff 2005.
13 Phillip Seven Esser. "Hadley, Homer More (1885-1967), Engineer" HistoryLink Essay 5419, 2003. Available at: http://www.historylink.org/index.cfm?DisplayPage=output.cfm&file_id=5419
14 Bruce et al 1991, E-4.

continuous reinforced concrete bridges.[15]

While Washington was one of only four states that utilized the box girder design prior to 1950, by 1960, twenty-six states had utilized the method.[16] While working for the Portland Cement Association, engineer Homer More Hadley became integral to the proliferation of RCBG bridges throughout Washington, particularly in Pierce County. Hadley developed close ties to Pierce County Engineer Forrest R. Easterday in the 1930s and the county swiftly adopted the box girder design, particularly for bridges requiring longer spans. The Pierce County engineers and Hadley frequently contributed to *Engineering News Record*, *Western Construction,* and *Pacific Builder and Engineer* in the late 1930s and were eager to convey the benefits of box girder construction to audiences through case studies such as the Purdy Bridge (1936), Mashell River Bridge (1936), and Gehring Road Bridge (1938).[17] Other local county road agencies, such as those in Yakima and Grays Harbor, also erected RCBG bridges in the 1930s. Washington Department of Highways soon followed by erecting its first longer-span box girder bridge over the Naches River in 1938.[18] A broader adoption of the RCBG bridge type in Washington did not occur until after World War II. In 1946, Clark County constructed its first two RCBG structures with spans exceeding 50 feet over Cedar Creek and the Washougal River. Longer span RCBG bridges were built during the late 1940s in King, Yakima, and Clallam counties.

Although World War II virtually halted bridge building in the United States, immediately following the war, Hadley continued using the hollow box girder concrete design in Washington State bridges. One of his first postwar bridges, Cedar Creek Bridge (Bridge No. 65) (1946) is a continuous 75-foot span, two-cell, single box girder, with a 25-foot cantilever that carries traffic along N.E. Etna Road over Cedar Creek. The bridge reflects the continuity of box girder bridges designed in Washington State immediately after World War II. Bridges constructed between 1945 and 1950 typically consisted of concrete slabs and reinforced concrete rigid frames that required minimal steel or timber, as bridge designers sought economy and simplicity in structural features, clean lines, and minimal ornamentation.

Starting in the 1950s, an important transition period occurred in the use of hollow box girder bridges. The hollow box girder concrete bridges erected prior to 1950 are distinguished from those erected in the mid to late-1950s by their lack of pre or post-stressing. The pre-stressed box girder bridge represented an important innovation in structural concrete. French engineer Eugene Freyssinet is generally acknowledged as having developed some of the earliest bridge designs that utilized pre-stressed concrete in box girder bridges in the 1920s.[19] However, the adoption of pre-stressed concrete in the United States did not begin until 1950. Its most significant application was the Walnut Lane Bridge in Fairmont Park in Philadelphia, Pennsylvania, with construction begun in 1949 and

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15 Holschuh 2015, 22.
16 Degenkolb 1977; Mead and Hunt 2007, 19.
17 E.A. White, “High Concrete Bridge for Low Cost” *Engineering News Record* (September 1, 1938); Forrest R. Easterday, “County Finds Concrete Box Girder Bridges Economical” *Pacific Builder and Engineer* 13 (7 January 1938): 38-40.
18 William Michael Lawrence, McMillin Bridge (Puyallup River Bridge) HAER No. WA-73 (Washington, D.C. Historic American Engineering Record 1993).
19 Carl W. Condit, *American Building: Materials and Techniques from the Beginning of the Colonial Settlements to the Present*, 2nd Ed. (Chicago: University of Chicago Press, 1982); Degenkolb 1977;

opening to traffic in 1951.[20] It is notable that the Oregon Department of Transportation and federal Bureau of Public Roads designed and built the Rogue River Bridge at Gold Beach in 1932 using Eugene Freyssinet's pre-stressing method of decentering and stress control for the concrete arch structures. This method, however, did not specifically place the reinforcing rods in tension as did later pre-stressing methods.[21] After 1950, pre-stressing swiftly became prevalent in box girder bridge designs, emerging as a ubiquitous structural design for road bridges by the 1960s.[22] The standard box girder bridges constructed in Washington prior to the 1950s, therefore, were an important precedent for future bridges that utilized pre and post-stressing innovations.[23]

Important Engineers, Contractors, and Firms

Homer More Hadley

Most of Washington's reinforced concrete box girder bridges can be attributed to Homer More Hadley, an accomplished and innovative engineer who built numerous mid-twentieth century bridges throughout Washington State using a variety of construction methods and materials. Hadley was born in Cincinnati, Ohio in 1885, and raised in Toledo. He worked as a surveyor in North Dakota and as a topographical engineer for the U.S. Geological Survey in the southwest. Before settling in Seattle, Washington, he worked on a survey crew for the Great Northern Railroad and Copper River Railroad in Alaska, and for the Canadian Northern Railroad in Vancouver, British Columbia. Hadley studied intermittently for three years at the University of Washington. During World War I, Hadley built concrete ships and barges in Philadelphia for the Emergency Fleet Corporation. After the war, while employed as an engineer in Seattle School District's architectural office, he worked briefly under the nationally significant school district architect Floyd A. Naramore who arrived in Seattle in 1919. During the school construction boom in the 1910s and 1920s, and fueled by successive bond measures, the Seattle School District applied a variety of reinforced concrete construction technologies to their facilities.[24] Perhaps drawing upon his experience with concrete structures and while still working for the district, Hadley proposed a controversial floating bridge supported by concrete pontoons across Lake Washington. He introduced the controversial bridge proposal at a meeting of the American Society of Civil Engineers on October 1, 1921, but it was castigated by critics who called it "Hadley's Folly."[25] Although not Hadley's design, the Mercer Island Bridge/Lake Washington Floating Bridge was ultimately built, and it opened in 1940, setting the precedent for future floating bridges.

In 1920, Hadley left the Seattle School District and began working for the Portland Cement Association, promoting the increased use of cement for large-scale projects. He traveled to Japan in 1923 after the Great Kanto earthquake to study the earthquake's effects on different types of structures. While employed with the Portland Cement

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20 PennDOT 1997; JRP 2003, 53; Tyson Dinges, *The History of Prestressed Concrete: 1888-1963*. Master's Thesis: Kansas State University. 2009, 45.
21 Hadlow 1990; JRP 2003, errata correction.
22 JRP 2003, 57; Dinges 2009, 55.
23 The term "standard" here is meant to differentiate the reinforced concrete hollow box girder bridges constructed from 1930 to 1960 from those box girder bridges that utilized pre and post-tensioning concrete reinforcement technologies. "Standard" does not appear in period sources but is used here for clarification purposes.
24 The Johnson Partnership, Seattle School District Number 1, General Historical and Building Context (Seattle, WA: The Johnson Partnership, 2014), A3-7.
25 Esser 2003.

Association, Hadley began designing innovative concrete bridges in Washington State, mostly Pierce County, beginning in the mid-1930s. One of his first was the McMillin Bridge (1934), a reinforced concrete through truss bridge.[26] At the time, its 170-foot main span was the "longest reinforced-concrete span, exclusive of arches, that has been built to date [1936] in the United States" and demonstrated the use of concrete for a design that traditionally conformed to the structural properties of timber and steel.[27] Hadley also suggested the design for the Purdy Bridge (1936), constructed over Henderson Bay. The Purdy Bridge is one of the few remaining box girder bridges within the United States and has the longest single span among concrete-girder forms.[28]

Immediately following World War II, Hadley continued using the hollow box girder concrete design in Washington State bridges. One of his first postwar bridges was Cedar Creek Bridge (Bridge No. 65) (1946), a continuous 75-foot span, two-cell, single-box girder, with a 25-foot cantilever that carry traffic along NE Etna Road over Cedar Creek. As previously stated, the bridge reflects the continuity of box girder bridges designed in Washington State immediately after the war. In 1946, Hadley retired from the Portland Cement Association and began working as a private engineering consultant. As a member of the Earthquake Committee, Seattle Section, American Society of Civil Engineers, he participated in reporting and making recommendations on the 1949 Pacific Northwest earthquake. During the late 1950s and early 1960s, Hadley and his son Richard designed several buildings in Juneau, Alaska, all of which survived the Great Alaskan Earthquake of 1964. Later in his career, he began designing steel bridges, including the Parker River Bridge, erected over the Yakima River between Benton City and Kiona. In 1962, the Iron and Steel Institute awarded the bridge first prize for "the most beautiful bridge of its class in the United States."[29]

Hadley's contributions to the field of engineering are not only reflected in his bridge designs, but in patents, publications, and listings of his works in the National Register of Historic Places (NRHP). Between 1936 and 1968, the United States Patent Office issued six Hadley patents: one related to a "concrete laying machine" – one of the first paving machines conceived in the United States – in addition to five for inventions related to bridge and building construction. [30] Hadley's article entitled "Concrete in Sea Water: A Revised Viewpoint Needed" was published in 1942 in the *Transactions of the American Society of Civil Engineers*, and he likely contributed material to "Continuous Hollow Girder Concrete Bridges" in 1941 and "A Handbook for Engineers" in 1942, both issued by the

26 It should be noted that Soderberg (1979) describes the McMillin Bridge as "significant, not only because of its hollow box construction, but also because it demonstrates the use of concrete for a design that traditionally evolved and conformed to the structural properties of timber and steel." Later authors, such as Lawrence (McMillin Bridge 1993), consistently refrain from characterizing the bridge as exhibiting hollow box construction. Washington State Department of Transportation (WSDOT) bridge engineer Robert H. Krier noted that while the pier shafts featured circular voids in the McMillin Bridge, the truss members of the structure consisted of solid concrete sections with no voids (pers. comm. December 15, 2015). The bridge, therefore, would not be considered an example of hollow box construction.

27 Berry and Runciman 1936 as quoted in Lawrence 1993a; Soderberg 1982, 23.

28 Esser 2003; Hadley 1936; Soderberg 1982, 23.

29 Esser 2003.

30 Hadley 1936; Homer M. Hadley, "United States Patent: 2109009 – Cellular Form For Embedment in Concrete Construction", February 22, 1938; "United States Patent: 2179554 – Internal Form and Reinforced Concrete Construction", November 14, 1939; "United States Patent: 2731824 – Bridges and Box Girders Therefor", January 24, 1956; "United States Patent: 3138899 – Structurally Integrated Composite Members", June 39, 1964; "United States Patent: 3385015 – Built Up Girder Having Metal Shell and Prestressed Concrete Tension Flange and Method of Making Same", May 28, 1968 (original assignee - Margaret S. Hadley).

Portland Cement Association.[31] These publications reflected Hadley's role in promoting the box girder construction method in nationally distributed publications. In addition, Hadley's steel delta girder designs were featured in the *Modern Steel Construction* April 1962 article entitled "Delta Girders Offer Advantages for Long Spans" and presented at the 1964 American Institute of Steel Construction (AISC) conference in a paper entitled "The Bridge Delta Girder: Single-Webbed and Double-Webbed".[32] Hadley worked until his death in July 1967.

Forrest R. Easterday

Forrest R. Easterday served as the county engineer during a key period of hollow box girder bridge design and use in Washington and was an author of several articles regarding concrete box-girder bridges. Born to a pioneer family in Tacoma, Washington, Easterday lived in the city of his birth for most of his life. In addition to working as the Pierce County Engineer, he served as a state legislator, a Pierce County Commissioner, and Tacoma City Councilor. He also worked on government projects in Alaska and South America. Easterday died at the age of 75 in 1964.

George Runciman

Prominent Seattle structural engineer George Runciman was an adept bridge designer and engineering firm executive. Runciman graduated from the University of Idaho and subsequently received a Bachelor of Science degree in Civil Engineering from the University of Washington in 1924. He engineered the designs of many structures throughout the region as well as several Seattle buildings such as the Grosvenor House, the Vance, Lloyd and Logan Buildings, and the Health Sciences Building at the University of Washington.[33] When Pierce County constructed several box girder bridges in the 1930s, Runciman's engineering firm W.H Witt, served as the designing engineers. Runciman served as the president of the company during this formative period and designed several structures such as the Purdy Bridge (1936, HAER No. WA-101), the Eatonville Bridge (1936), and the Buckley Overpass (1936). He died in 1965 at the age of 73.[34]

Engineering Firms and Construction Contractors

In a review of literature associated with the 20 identified box girder bridges in Washington, several contractors and engineering firms were identified for their roles in design and construction. One of the most prominent was the Seattle engineering firm of W.H. Witt Company. This legacy company of present-day (2017) Magnusson Klemencic Associates designed the Gehring Road Bridge, Eatonville Cutoff Bridge over the Mashal River (1936), Purdy Bridge, Buckley Overpass (1936), and Sixth Street Bridge (1937),[35] The Nieman Company, Incorporated, of Vancouver,

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31 Homer M. Hadley, "Concrete in Sea Water: A Revised View point Needed." *Transactions of the American Society of Civil Engineers* 107, no. 1 (January 1942): 345-358; Portland Cement Association, *Continuous Hollow Girder Concrete Bridges*, Portland Cement Association, Chicago, 1941; Monetary Times Print Company, *Roads and Bridges*, Toronto, 1942.
32 *Modern Steel Construction,* "Delta Girders Offer Advantages for Long Spans," Vol. II, no. 2 (April 1962);
Hadley 1964; Esser 2003.
33 Law rence 1993, 15.
34 "George Runciman," *Seattle Times*, 14 September 1965; *Polk's Seattle City Directory* (Seattle: R. L. Polk and Co., 1934 to 1993);
35 "Magnusson Klemencic Associates" Available at https://en.w ikipedia.org/w iki/Magnusson_Klemencic_Associates, view ed on June 6, 2017.

Washington provided the wooden falsework plans for the Cedar Creek Bridge. S.R. Gray served as the contractor for the Gehring Road Bridge.

Identified Reinforced Concrete Box Girder Bridges in Washington

An analysis of identified box girder bridges erected in Washington between 1930 and 1960 illustrates how box girder bridge designs evolved during this period. Twenty bridges constructed in Washington with reinforced concrete hollow box girders were identified as either listed in the NRHP, determined eligible for the NRHP, discussed in the two MPDFs or HAER documents, or noted by the Washington Department of Transportation as examples of important box girder bridges (see attached Table 1. Historic Concrete Box Girder Bridges in Washington). Additional examples of box girder bridges are mentioned in newspaper articles and public notices but were not recorded during field investigations. For instance, a local newspaper announced the 1950 dedication of the Meydenbauer Bay Bridge near Bellevue.[36] Public notices also help identify potential RCBG bridges. For instance, a 1951notice requests bids for a "Reinforced Concrete Box Girder Bridge on 0.127 mile of a Jefferson County Road, PORTAGE CANAL BRIDGE, Access Road Project No. AD-2."[37] While notices provide useful information, it may be necessary to conduct field investigations and additional research to verify that the bridges are not examples of pre or post-stressed box girder bridges due to the emergence of these box girder bridge types in Washington during the 1950s.[38] The Tacoma firm Concrete Tech, for instance, was integral to the proliferation of pre-stressed concrete bridges in Washington starting in the 1950s. Historic period designs, plans, or specifications should be reviewed in order to determine if the bridge integrated pre or post-stressed concrete technologies.

F. Associated Property Types

Name of Property Type
Reinforced concrete box girder bridges (RCBG) built in Washington State between 1930 and 1960.

RCBG Bridge Sub-types (See Figures 7 and 8)

- Single Rectangular Cell
- Twin Rectangular Cells
- Twin Separate Rectangular Cells
- Hybrid or Combination Designs

General Description and Range/Variation
Reinforced concrete box girder bridges represent a tightly defined group of structures erected between 1930 and 1960 and reflect a trend towards simplicity and efficiency in design and construction. The bridge type typically carries two to four vehicular traffic lanes over rivers and creeks but may also serve as a viaduct over sloped terrain or over other transportation infrastructure.

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36 Several newspaper articles and newspaper notices were provided by Washington State Architectural Historian Michael Houser. See for example, "New Bellevue Bridge Will be Dedicated" *Seattle Daily Times*, February 9, 1950, 9. The bridge appears to have been replaced in 2002.
37 Public Notice, *Seattle Daily Times*, March 23, 1951.
38 One notice from the November 26, 1958 issue of the *Seattle Daily Times*, for instance, verifies "that 3,577 linear feet of Pre-stressed Concrete Girders" would be needed for a bridge on "Primary State Highway No. 2 in King County, AUBURN TO SOOS CREEK."

RCBG bridges may be categorized by four primary character-defining features, which reflect their design and technological evolution: the number of box girders, the number of cells within each box girder, and length of the main span. During the 1930s and 1940s, RCBG bridge design in Washington ranged from twin rectangular cell box girder to two separate, single-cell box girders to four separate single-cell box girders. The main span lengths ranged from 70 ft. to 190 ft. During the 1940s, RCBG bridge design spans tended to be shorter, ranging from 64 ft. to 118 ft. In the 1950s, RCBG bridges began to appear in hybridized designs that included hollow box girders joined by solid concrete girders.[39]

Some of the bridges exhibit a continuous bottom soffit that obscures the interior structural components – namely the number and size of the respective internal cells. Bridges without soffits, such as the Sixth Street Bridge, permit ready identification of the size and number of cells. The most significant of this bridge type vary in terms of the number and length of spans. Some of the longer bridges feature up to four spans with spans ranging in size from 190 ft. (Purdy Bridge) to 75 ft. (Cedar Creek Bridge). Bridge rails for the earlier bridges were typically constructed of wood, but most safety rails have since been replaced with metal "w" rails. The bridges discussed in this MPDF and listed in Table 1 are Washington State Department of Transportation (WSDOT) or local agency-owned bridges built in Washington between 1930 and 1960. Other examples likely exist, but have yet to be identified.

<u>Areas of Significance</u>

Bridges eligible for listing under this submittal will have demonstrated significance in one or more of the following areas:

- Community Planning and Development: Significance related to the process and development of social, civic, and political events that shaped the character of Washington, including the expansion of economic opportunity, community development, and the physical growth of the region.

- Transportation: Significance related to the process and development of transportation systems that enabled the movement of people, goods, and services within the city, county, and state.

- Engineering: Significance related to the development of new or improved technologies or construction techniques related to bridge design and construction.

<u>Registration Requirements</u>

Minimum Eligibility Requirements

The minimum eligibility requirements are:

- Constructed, and currently located, in the state of Washington
- Built between 1930 and 1960
- Consisting of reinforced concrete
- <u>Not</u> employing pre or post-stressed reinforced concrete
- Having a main (continuous) span measuring at least 50 feet in length to have engineering merit.

39 Some period sources and magazines suggest that bridge designers were utilizing trapezoidal shaped box girders in their bridge designs. None of the 20 bridges that were identified in preparation for this MPDF featured that detail. If identified within the period of the MPDF, it would constitute a potentially significant bridge type.

In order for a bridge to be included in the MPD, the structure would need to satisfy 1) all of these minimum registration requirements, 2) retain significance within its respective historic context and meet at least one applicable National Register of Historic Places Criterion, and 3) retain historical integrity.

NRHP Criteria for Evaluation

A reinforced concrete box girder bridge must meet at least one of the NRHP Criterion for significance:

- **Criterion A.** The bridge has a clear association with the development of transportation resources that have made a noteworthy contribution to the broad patterns of state's transportation history. For example, Criterion A may be met when a bridge reflects county or state efforts to improve river or creek crossings in the most efficient and cost-effective manner or the bridge type opened new transportation routes or crossings that were previously not developed due to excessive costs or lack of technological or engineering expertise. Additional Criterion A factors would include:
    - A box girder bridge as part of a larger city, county, and state-wide bridge or road building campaign or program.
    - Historic events associated with the bridge contributed to the advancement of bridge design technology, materials, construction techniques, workmanship, engineering innovation, or site challenges.
    - Role of the bridge in community development and planning of the locality, state, region, or nation, including World War II-related significance, particularly if the bridge permitted traffic loads or crossings that were previously not possible.
    - The demonstrated ingenuity of state and local transportation agencies as expressed in completed highway bridge construction, despite the difficult and challenging circumstances engendered by wartime and post-war conditions.
- **Criterion B.** The bridge is associated with the lives of significant persons in history (other than the designer or builder). This criterion is unlikely to be utilized because most significant individuals associated with the bridges are those who built or designed them; or
- **Criterion C.** The bridge embodies the distinctive characteristics of a type, period, or method of construction, or represents the work of a master, or possess high artistic values, or represents a significant and distinguishable entity whose components may lack individual distinction. For example, a bridge that constitutes one of the first postwar, single box, double cell bridges in the state to feature a span greater than 75 feet in length may meet Criterion C for embodying the distinctive characteristics of a period or method of construction. Additional Criterion C factors could include:
    - Designer and/or builder were considered renowned engineers and contractors.
    - Design and construction efforts commonly used for a specific purpose or reason, i.e., any World War II conditions or measures that influenced these efforts.

- Representative of a specific type.
- Rarity and uniqueness of the bridge type. Distinctive quality of the bridge.
- Sole remaining example of a specific bridge type.
- Arrangement of functional members to achieve a strictly utilitarian appearance.
- Structural integrity, especially regarding alterations that may have compromised materials, design, or function.
- The successful use of new design techniques and material fabrications developed during the previous decade; or served as prototypes for new construction methods, architectural styles, and aesthetic standards that have continued to the present day;
- Elements that illustrate the transition from past preferences in bridge design to new models of utilitarian expression, or represent especially harmonious compatibility of manmade structures with their natural surroundings; or

Historic Integrity Requirements

The bridge must also retain sufficient historic integrity to convey its significance. Historic integrity is the property's retention of physical qualities that allow that property to convey its significance in engineering, transportation, and/or community planning and development. Evaluations of bridges under Criterion C, for instance, would focus on integrity of original design, materials, and/or workmanship. The evaluation of integrity recognizes and accepts the comparative application of seven aspects — location, design, setting, materials, workmanship, feeling, and association. Since this MPD presupposes that resources will primarily be determined significant under Criterion C for engineering and technological characteristics, five of the seven aspects are more critical to the integrity of the bridges than others, specifically location, design, setting, materials and workmanship. In the case of bridges evaluated under this MPD, only those structures retaining substantial connection to the original design in the following aspects should be deemed as retaining sufficient integrity to relate their historic significance.

A specific bridge has integrity only when it meets a majority of the following aspects of integrity:

- **Location**: The bridge should remain in its original location and continue, in general, to serve as originally intended. Bridges relocated during the historic period (between 1930 and 1960) should be treated as if they had remained in their original locations for integrity purposes.
- **Design**: The bridge elements that convey its original design, including the original plan, orientation, materials, style, and structural systems must remain. Additions must not detract from the bridge's overall design, function, or architectural character. Seismic stabilization and other required updates to bridges do not exclude them from eligibility unless these updates prevent the bridge's design from being clearly conveyed. All visible aspects of the design, including elements of the superstructure (e.g., bridge rails) and substructure, should be original, with only minimal and essentially compatible alterations that do not obscure the original design. Examples may include attached water pipes, electrical conduit and similar minor systems, particularly when located away from the exterior girders. Other modifications, such as replacements of bridge railing, transition elements, or approach guard rails would not likely diminish a

bridge's significance as these changes would not impact a bridge's ability to convey the original character unless it significantly exceeds the scale or is disproportionate to the original structure such that it detracts from the bridge's minimal above-deck profile.

- **Setting**: The bridge should retain aspects of its physical setting or environment that are reminiscent of its period of significance. Significant modifications to the built or natural landscape surrounding the bridge that encroach upon its relationship to the larger transportation network and landscape could compromise the bridge's integrity of setting and diminish its ability to convey its significance. A bridge that retains high integrity of design, but the highway on either end has been widened or slightly re-aligned, can still clearly convey its significance. Alterations to the setting of a bridge would not be sufficient to render the resource not eligible.
- **Materials**: The bridge must retain the majority of the original material with which it was constructed or designed. Alterations to the material surface of the bridge, including updated paving, does not automatically exclude the bridge from eligibility, particularly if those updates occurred during the historic period (or the bridge substantially retains its original design form without any intrusively retrofitted structural features, such as added bracing, cross-ties, strengthening bolts, etc.). Bridges substantially altered within the period of significance but after the bridge was originally built should be evaluated with reference to the whether the alterations contribute to the bridge's significance.
- **Workmanship**: The bridge must retain physical evidence of the crafts and technology of the period during which it was built.
- **Feeling**: The bridge should reflect the historic aesthetic of its period of significance to sufficiently convey its historic nature to the observer. The structure should recognizably belong to a certain time period.
- **Association**: The bridge should represent a direct link to an important person or event. Integrity of association requires that the bridge's physical features exhibit the characteristics and features present at the time that the association was made.

G. Geographical Data

This statewide MPD is focused on a specific resource type in the state of Washington. All resources in the state share a similar history, characterized by a shared evolution in building materials, structural technology, improved safety designs.

H. Summary of Identification and Evaluation Methods

The inventory for this MPD included a review of the WSDOT bridge inventory, Washington Historic Resources Inventory, National Register of Historic Places, and secondary sources. No field investigation was performed.

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Table 1. Hollow Box Girder Bridges Erected in Washington, 1930-1960 (Source: Various)

Name	Year built	County	Type	Main Span Length (ft.)	Source
Purdy (#302/105)	1936	Pierce	Concrete Box (two combined cells)	190	Listed in NRHP, HAER, WA-101
Squally Creek/Gehring Road (#14203A)	1937	Pierce	Concrete Box (two separated single cells)	90	Krier and George 2007
Mashell Bridge (#24164A) (carries Alder Cutoff Rd.)	1937	Pierce	Concrete Box	70	Krier and George 2007
Sixth Street Bridge	1937	Grays Harbor	Concrete Box (four separate boxes – with transverse beams)	73	Krier and George 2007
Winnifred Street Bridge (#1130)	1941	Pierce	Concrete Box (single box with two cells)	75	Listed in NRHP
Cedar Creek (#65)	1946-2016	Clark	Concrete Box (single box with two cells)	75 feet	Holschuh 2015; Ranzetta and Jones 2016; Krier et al 1992
Toppenish –Zillah Bridge (carries Meyers Road) (# 485)	1947	Yakima	Concrete Box (single box with two cells)	118 feet (4 interior spans)	Listed in NRHP
Donald – Wapato Bridge (#396)	1948	Yakima	Concrete Box (two separate boxes with single cells)	90 (middle span)	Listed in NRHP
Patton/Green River (#3015)	1950	King	Concrete Box and Steel Box (two separate boxes with single cells)	100	Krier et al 1992
Stuck River (#24204A)	1949	Pierce	Concrete Box	71 (total) 3 spans	Krier and George 2007
15th Avenue Bridge (Seattle)	1949	King	Concrete Box (two separate boxes with single cells)	106	Mishkar et. al. 2009
Hoko River (#112/10)	1950	Clallam	Concrete Box	64	Krier et al 1992
North Twin (#3142)	1951	King	Concrete Box(two separate boxes with single cells)	80 feet	HPI

Name	Year built	County	Type	Main Span Length (ft.)	Source
South Twin (#3143)	1951	King	Concrete Box	?	King County Cultural Resources 2001
North Fork Snoqualmie River (#1221)	1951	King	Steel Box and Concrete Box	77 (total) 1 span	George 2001
Portage Canal Bridge (# 116/5)	1951	Jefferson	Steel Box	250	HPI
Oak Park/Washougal River (#500/24)	1954	Clark	Concrete Box (single box with two cells)	140 (total) 4 spans in main structure	George 2001
Judd Creek (#3184)	1953	King (Vashon Island)	Concrete Box	113 total (five spans)	HPI
Mabton-Sunnyside/ Yakima River (#241/5)	1954	Yakima	Concrete Box (single box with two cell)	159 (5 spans in main structure)	George 2001
Benton City - Kiona/Yakima River (#225/1)	1957	Benton	Steel Box & Cable-stayed (four boxes with single cells)	170	George 2001

Figure 1. Cross section of two cell, hollow box girder bridge, Cedar Creek Bridge, Etna, Washington. Original construction drawings, courtesy of Clark County, Washington. Box girders consist of twin rectangular cells within a single soffit.

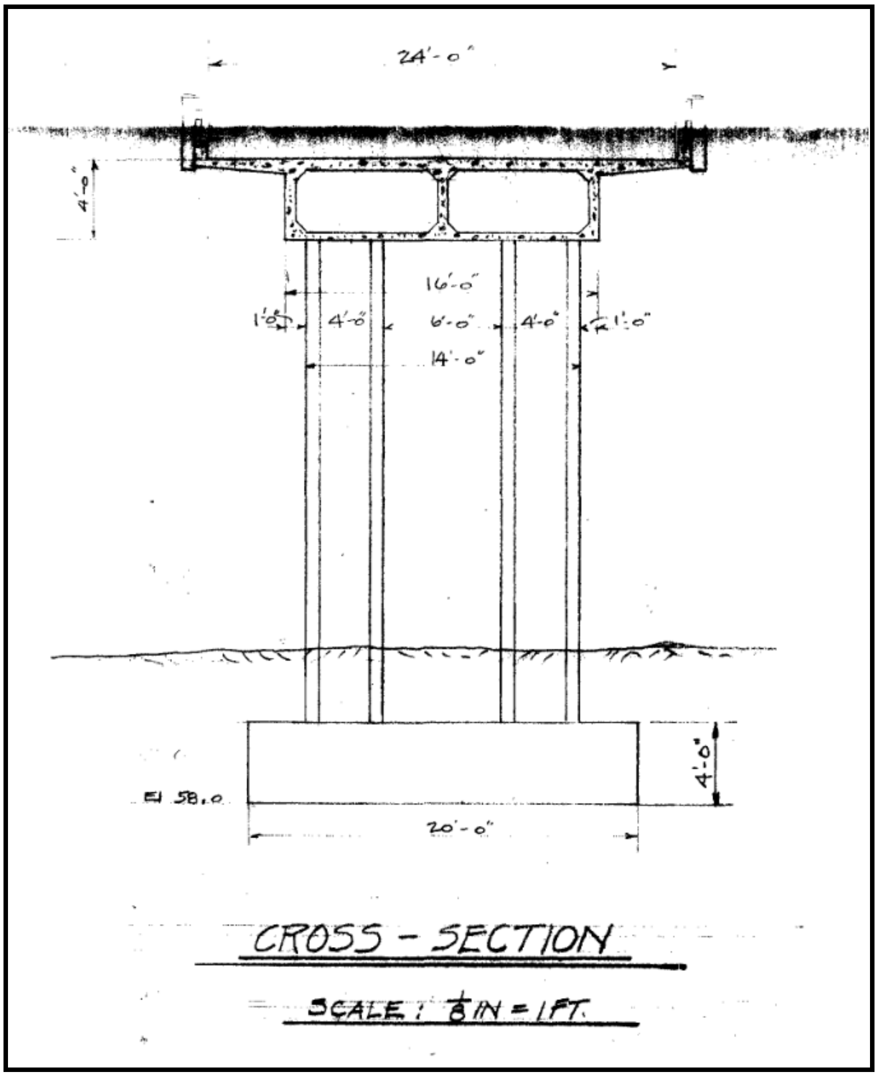

Figure 2. Longitudinal view of the Cedar Creek Bridge. Original construction drawings courtesy of Clark County, Washington.

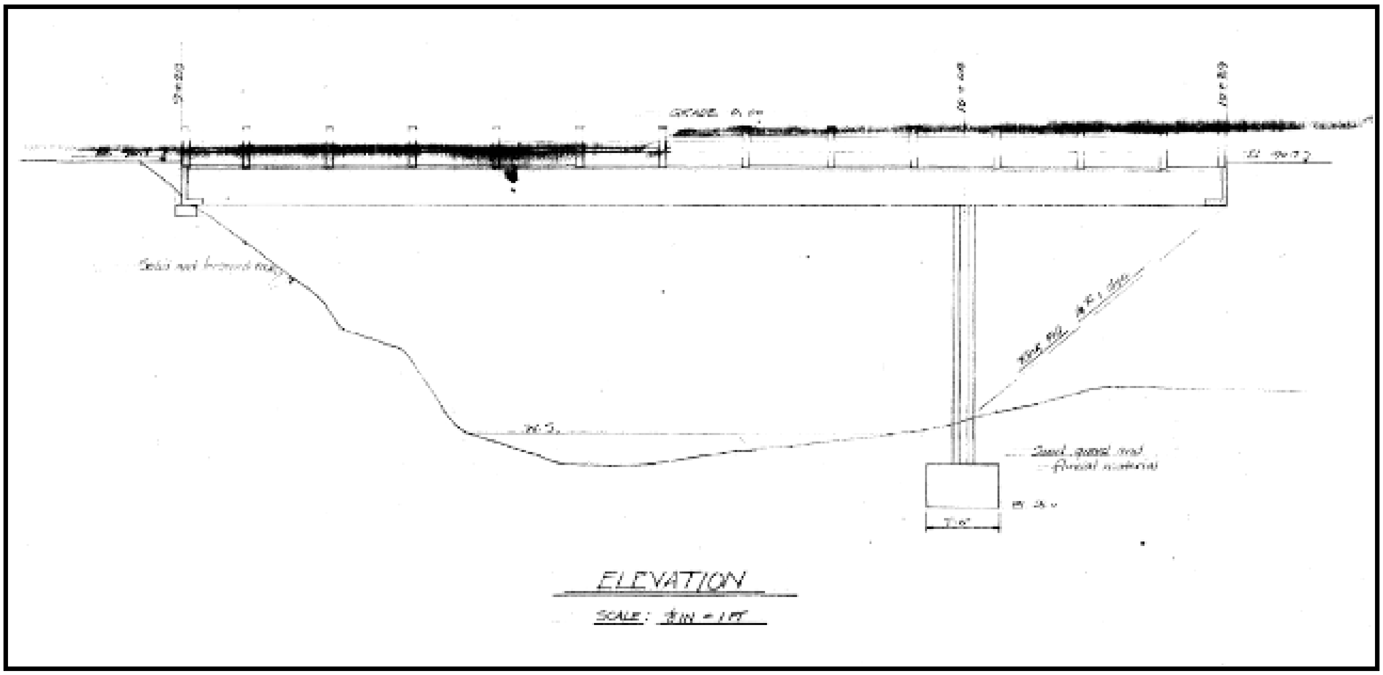

Figure 3. Purdy Bridge, Pierce County, Washington (built 1936). Photograph courtesy of the Library of Congress, HAER No. WA-101. Box girders consist of twin rectangular cells within a single soffit.

Figure 4. Squally Creek/Gehring Road Bridge (#14203A) (built 1938). Photograph courtesy of *Engineering News Record*, September 1, 1938 (p 265). Box girders consist of twin separate rectangular cells.

Figure 5. Historic photograph of the Winnifred Street Bridge (#1130) (built 1941), Pierce County, Washington. Photograph courtesy of world wide web, accessed October 2016, http://www.theirminesourstories.org/?cat=4. Box girders consist of twin separate rectangular cells.

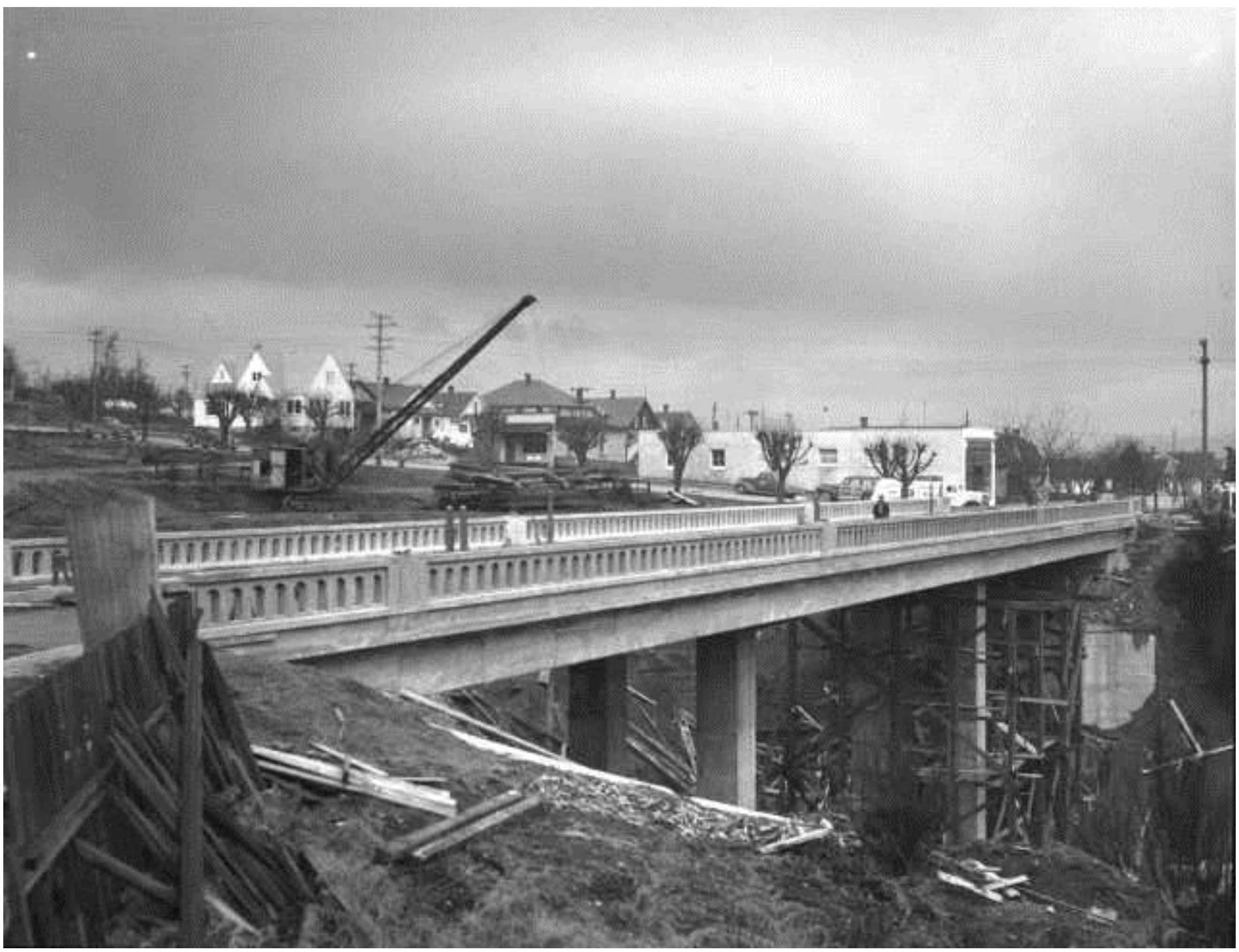

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Figure 6. View of piers and hollow box girders, 15th Avenue Bridge (1949), Seattle, King County, Washington. Photograph found in Mishkar, et. al. 2009. Box girders consist of twin separate rectangular cells.

Figure 7: Reinforced Concrete Hollow Box Girder Typology (in profile/section view) for bridges identified in Washington. Trapezoidal shaped cell/boxes have not been found in bridges identified to date in the state but may exist within the 1930-1960 time frame. Drawings courtesy of Michael Houser, Washington Department of Archaeology and Historic Preservation.

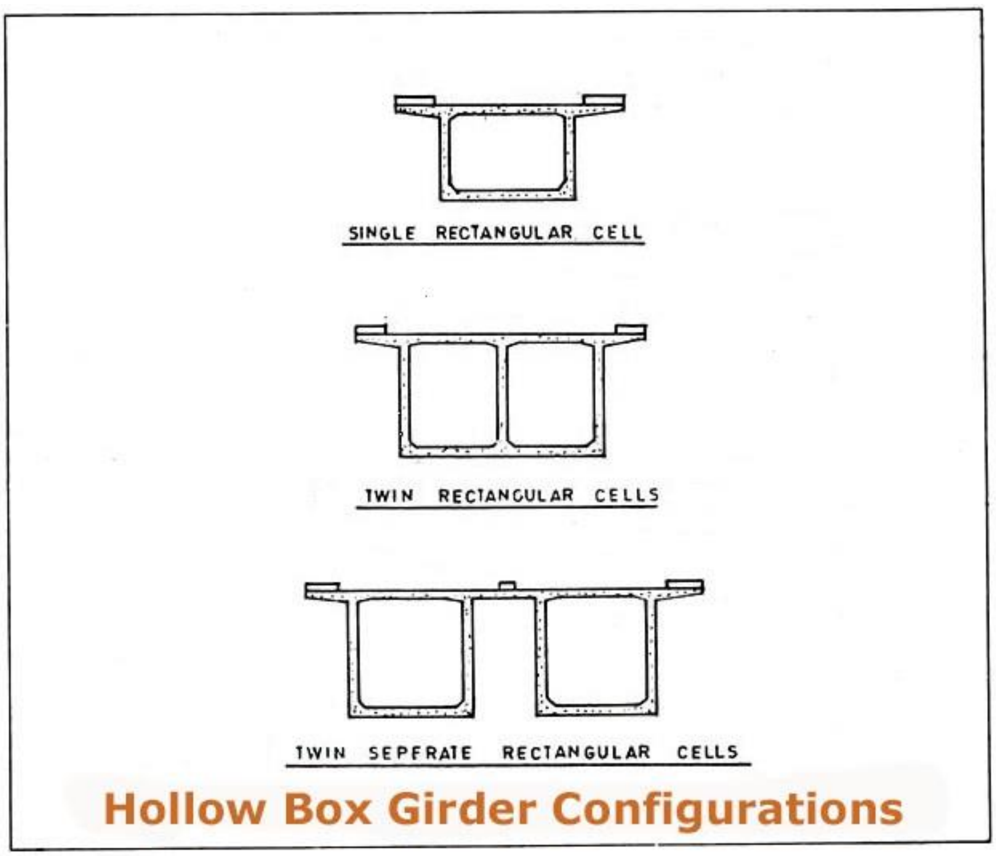

Figure 8: Profile/Section simila to the Benton City-Kiona Bridge. Hybrid hollow box girder configurations are also included in this MPDF. The Benton City-Kiona Bridge – the third cable stay bridge in the United States and the first to consist of concrete and steel in addition to its box girder spans – is an example that illustrates Hadley's application of box girder, solid girders, as well as cable stays.